P3-158 ABATE, PJ*; RAMSAY, CN; Mitchell College; *peter.abate@my.mitchell.edu*

Morphometric analysis of the non-indigenous bryozoan Tricellaria inopinata

Life history traits in colonial animals, such as erect cheilostome Bryosoa, are extremely variable as many factors contribute to both the growth of the colony, and the growth of individual zooids within the colony. While photographic and tagging studies have been shown to be successful in measuring colonial growth, these methods are less reliable for flexible, joined, three-dimensional species. Counting individual zooids in a colony or measuring zooid length is very difficult and laborious, thus making ecological studies surrounding these organisms challenging. Through morphometric analyses, we sought to determine whether a correlation exists between a specific growth metric to use as a proxy for the total number of zooids. *Tricellaria inopinata* is a non-indigenous bryozoan which was recently introduced to the North-western Atlantic shores and has been an ecological and economic threat to nearshore waters. After identifying eight metrics to model the total number of zooids within *T. inopinata* colonies, preliminary results suggest the total number of branches and total length of major branches were significantly correlated with the total number of zooids. Using these findings, the total number of zooids of *T. inopinata* and other species of colonial bryozoans can more easily be assessed, which may facilitate further ecological experiments on these three-dimensional colonial organisms.

P2-34 ABDULELAH, SA*; CRILE, KG; AWALI, S; KHALIL, HH; BELANGER, RM; University of Detroit Mercy; *abdullsa3@udmercy.edu*

An investigation of olfactory sensory neuron morphology in the crayfish (Faxonius virilis) following atrazine exposure

Atrazine is an herbicide that is heavily applied in agricultural areas in the Midwestern United States and can run-off and seep into surrounding aquatic habitats. Concentrations of atrazine can reach concentrations of >300 ppb. Previous research in our lab has shown that exposures to 80 ppb atrazine cause lasting deficiencies in the chemoreception of food and mate odors. Due to the fact that atrazine impairs chemosensory responses, the goal of this study was to determine the effect of atrazine on olfactory sensory neurons located in the lateral antennules of crayfish. In this experiment, we used three 15-day exposures (0, 80, and 300 ppb) to atrazine. Post treatment, lateral antennules were fixed, decalcified and cryoprotected. Medial segments were then sectioned on a cryostat. Antennule sections were stained with antibodies against tubulin, a protein found in neurons, and DAPI, a nuclear stain and imaged. Additionally, we used DiO to help determine the number of neurons present after treatment. Our preliminary data suggests that atrazine exposure causes degeneration of olfactory sensory neuron bundles or clusters, leading to impairments in chemosensory abilities.

P1-284 ABELS, JR*; RICHARDSON, SS; BIRD, NC; Univ. of Northern Iowa; *abelsjaa@uni.edu*

Histological Anatomy and Structural Integration in Four Distinct Cypriniform Weberian Apparatus Morphologies

The Weberian apparatus is a novel hearing adaptation found in otophysan fishes, a large group of freshwater fishes comprised of approximately 8000 species. Cypriniform fishes, the largest otophysan order, are abundant in the freshwaters of Asia, Europe, North America, and Africa. Such environmental variability has led to modification of skeletal structures in non-auditory portions of the apparatus (lesser so in the auditory elements), likely due to heavy constraint for the maintenance of functionality (Bird and Hernandez 2007). Within Cypriniformes, four distinct morphologies have been identified: Open (typical of Cyprinidae), Anterior Shield (typical of Gyrinocheilidae, Catostomidae, and Botiidae), Single-Capsule (typical of Cobitidae), and Double-Capsule (typical of Nemacheilidae and Balitoridae). Little information exists detailing the construction and integration of these morphologies at the tissue level. We used HBQ quad-stained paraffin histology and whole-mount clearing and staining to document and analyze the hard and soft tissue of the Weberian apparatus in species representing six genera (*Danio*, *Gyrinocheilus*, *Ambastia*, *Pangio*, *Schistura*, and *Sewellia*) that characterize all morphologies. We found minimal changes to the Weberian ossicles, swim bladder, and otic sensory structures across morphologies (typically relative changes in size, not shape). Several differences in the non-auditory structures were found among the species of the same morphotype, such as size and shape of lateral openings in the swim bladder capsule, and communication zones between right and left capsules. These results reveal unrecognized variability in the integration of the Weberian apparatus across different morphotypes.

P1-31 ABIRI, NF*; GALLOWAY, K; PORTER, ME; Florida Atlantic University; *nabiri2015@fau.edu*

Effect of orientation on the flexural stiffness of lionfish, Pterois volitans, dorsal spines using 3D printed models

The red lionfish, *Pterois volitans*, is native to the Indo-Pacific region, and has quickly proliferated along the Western Atlantic Ocean, Caribbean Sea, and Gulf of Mexico. It has been shown to negatively affect the ecosystems it invades by decreasing biodiversity. Lionfish have 13 dorsal stings (the defense apparatus) which are comprised of a spine of mineralized collagen surrounded by a dermal sheath. The spines are tapered and have anterolateral grooves that create an anchor-like cross-section and store venom. We hypothesized that the cross sectional shape of the spines optimizes their ability to resist bending. For this study, we quantified lionfish spine flexural stiffness (EI), which takes into account both shape (I) and material (E), at varying locations of lateral point load. Due to the anchor-like cross-section, we predicted that EI of the spine will increase when the lateral point load is applied at the anteromedian ridge, where I will be the largest. We generated a digital 3D model of the 12th dorsal spine of a *P. volitans* and printed magnified (11.46x) resin models. We applied point loads at two locations on the spine models and compared them to models of I-beams. I-beams are frequently used in construction because of their high I, which increases EI relative to a solid beam. Similarly, lionfish spines have a large portion of their cross-section area located away from the neutral axis allowing for high I and EI with less material. Mechanical testing of lionfish spines is essential to understand the form and function of unique shapes found in nature.

P1-293 ABRAHAM, JO*; STAVER, AC; Yale University; *joel.abraham@yale.edu*

Drought-Response Strategies of Savanna Herbivores

Climate models have predicted increases in the frequency and severity of drought globally, with potential impacts on diverse systems, including African savannas. Among other things, droughts pose a concern for the conservation of the large mammal communities therein, and as such, understanding the behaviors that mammalian herbivores utilize to mitigate drought effects is vital. To evaluate herbivores responses to drought, we examined herbivore diet composition and landscape use in Kruger National Park, South Africa, during and after a severe but heterogeneous drought that occurred from 2014 to 2016. We found that mixed feeders responded to drought by increasing their consumption of C3 trees, shrubs, and forbs, while grazers and megaherbivores moved away from severely droughted areas towards drought refugia. Results suggest that, while herbivores can respond to drought behaviorally, their responses may be partially constrained by their body size and feeding ecology. Grazers may be at particular risk, since frequent and severe droughts may not always generate drought refugia, especially in smaller and/or fenced reserves. Conservation schemes should recognize these constraints and work to facilitate the diverse responses of herbivores to drought.

P1-224 ADAMS, CIM*; JEUNEN, GJ; KNAPP, M; Univ. of Otago, New Zealand; *clare.adams@postgrad.otago.ac.nz*

Can haplotypes be recovered from environmental DNA?

Understanding population dynamics is imperative for conservation and management purposes. Recent development of the non-invasive environmental DNA (eDNA) technique allows for extracting organismal DNA from environmental samples such as water or soil. While successful in obtaining biodiversity data, few studies have proven the ability to obtain haplotype diversity. In this study, we aim to develop an eDNA approach for describing haplotypic variation in marine species of commercial and conservation interest, Pāua (*Haliotis iris*) and the New Zealand fur seal (NZFS) (*Arctocephalus forsteri*). We are developing a controlled laboratory experiment to obtain multiple haplotypes in varying ratios from water. Water will be spiked with differing ratios of Pāua and NZFS PCR products at a concentration of 100 copies/μL, and eDNA methodology will be used to extract the DNA. Once samples are sequenced, we will develop a bioinformatics pipeline to retrieve population genetic data of these target species. Relative sequence abundance will be compared to initial haplotypic ratios. The relationship between haplotype abundance and relative sequence abundance will be analyzed. Through developing a methodology for discerning haplotypes from water samples, we hope to widen the door for non-invasive genetic monitoring via eDNA.

P2-15 ADHIKARI, H*; SIA, T; DAVIDSON, B; Swarthmore College; *hadhika1@swarthmore.edu*

Actin dynamics facilitate localized trafficking of growth factor receptors

Actin dynamics play vital role in regulating the trafficking of receptor proteins, which ultimately impacts the way cells signal. We study signal processing in embryos of the invertebrate chordate, *Ciona robusta*. In *Ciona*, asymmetrically dividing heart founder cells undergo differential induction to produce heart progenitor and tail muscle lineages. Previous research has shown that Arp2/3 activity, which nucleates branched actin, is required to localize induction in the *Ciona* founder cells. We are investigating the role of branched actin dynamics on the localization of fibroblast growth factor (FGF) receptors, upstream of induction. ARP2/3 inhibitor studies indicate that actin dynamics are required to suppress degradation and regulate polarized trafficking of fluorescently tagged FGFR. We are currently examining whether myosin motors contribute to these actin-dependent steps in FGFR trafficking. Our findings suggest that mutations impacting actin dynamics may drive changes in membrane trafficking and cell signaling associated with oncogenesis.

P2-211 ADJERID, K*; SOOD, N; DE VITA, R; SOCHA, JJ; Virginia Tech, Pulaski High School; *adjerid@vt.edu*

Variation of Young's modulus and taenidial density in the tracheae of a darkling beetle

Some insects facilitate active ventilation by rhythmically compressing their tracheal tubes. When collapsed, the tubes take on an uneven pock-mark like appearance, with patterns that vary across tracheae, individuals, and species. We hypothesize that deformation patterns result from variation in material or structural properties of the tubes. The semi-chitinous walls of the tracheae are reinforced with rings of stiffer sclerotized chitin fiber bundles called taenidia, which vary in branching, width, and orientation. To investigate tracheal properties, we first measured Young's modulus along the lengths of excised sections of tracheae using atomic force microscopy (AFM). We then measured variation in packing density of the taenidia using SEM images of the same tracheal sections. Preliminary results show that the Young's modulus varied substantially along the length of the excised sections of tracheae (1.67 ± 2.67 GPa; n=7). Moduli were distributed bimodally, with relatively little variation about the low mean (0.66 ± 0.30 GPa) and greater variation about the high mean (7.40 ± 1.27 GPa). The inter-taenidial spacing varied between 1 to 5 μm. In some specimens, the average spacing increased gradually (~0.11 μm per 100 μm of trachea), whereas in others, it changed rapidly (by up to ~1.33 μm per 100 μm). It is possible that regions with low taenidial density or low Young's modulus may serve as initiation sites for tracheal compression, but this hypothesis remains to be tested. Supported by NSF 1558052 and 1301037.

P2-250 AKESSON, KC*; WARD, AB; MEHTA, RS; Univ. of California, Santa Cruz, Adelphi Univ. ; *kakesson@ucsc.edu*

Investigating Axial Diversity and Movement in Elongate Amphibious Fishes

The ability of fully aquatic animals to overcome the water to land transition raises a fundamental question - how is movement facilitated on land? Body elongation has evolved repeatedly within aquatic vertebrates with some of the earliest tetrapods having more elongate forms. The repeated evolution of fishes with elongate bodies poses pivotal questions about how body shape affects life strategies and habitats and how body shape may enable fishes to cope with a dynamic environment. Here, we investigated the underlying axial diversity in fishes with eel-like body plans that are known to make terrestrial excursions to varying degrees. In addition to an elongate body, these fishes tend to have reduced or lost their pectoral fins, which results in movements that tend to be propelled exclusively by the body. We measured a set of external characteristics as well as traits that comprise the axial and appendicular skeleton for 30 species of fishes representing diverse ecological and evolutionary histories. For a subset of these fishes, we conducted locomotor trials on a wet pebble substrate to characterize variability in movement patterns to better understand the relationship between morphology and motion. Our preliminary data suggests that external characteristics varied more across elongate species than we previously anticipated but that dorsoventral flattening of the body versus a taller more laterally compressed body resulted in similar locomotor patterns. It has been previously posed that irrespective of how elongate a fish is, lateral undulation in the terrestrial environment may be characterized by anterior to posterior waves. Our preliminary work shows that this is the case even when examining species that have comparable lengths but different means of elongating the body and subtle differences in secondary axis reduction.

P2-193 AKINKUOTU, RT*; MENDONCA, MT; Auburn University; *rta0009@auburn.edu*

Interaction of violacein produced by various Chromobacterium ribotypes and chytrid fungus at different temperatures

Chytrid fungus, *Batrachochytrium dendrobatidis* (Bd) has been one of the major source of amphibian decline worldwide. This fungus grows and colonizes the keratin layer of the amphibian skin. Different kinds of bacteria inhabit the skin of amphibians, where some of these bacteria can cause inhibition of the activities of Bd. A violacein-producing bacteria (*Janthinobacterium lividum*) is one of the most studied anti-Bd bacteria but there are Chromobacterium spp that equally produce (a) similar metabolite(s) and have received less study. We identified 4 ribotypes of *Chromobacterium* (*C. sphagnii*, *C. substugae*, *C.vaccinii*, *C. amazonense*) isolated from skin swabs of cricket frogs collected from wetlands in the Tuskegee National Forest during several sample periods throughout the year. We tested the violacein-type metabolite produced by each of these 4 ribotypes against three of the most pathogenic strains of Bd at a series of 4 different temperatures (12°C, 16°C, 20°C, 24°C). We hypothesized that the violacein-type metabolites produced by the different ribotypes of *Chromobacterium* will vary in their ability to inhibit Bd and this variation will be temperature dependent. The bioassay was done using cell-free supernatants from three-day old tryptone broth cultures of each ribotype. When the Bd cultures had reached maximal growth, we challenged each with the supernatants of each of the ribotypes. *C. sphagnii* exhibited the most inhibitory effect, reducing growth by 60% during the bioassay for three of the Bd strains at 20°C We also observed slow growth of Bd as well as its inhibition at 12°C for all 4 ribotypes. This study shows that these set of violacein-type producing bacteria are also abundant and important in mitigation of Bd infection of amphibians.

P3-74 ALJEBOURE, SS*; MCALISTER, JS; College of the Holy Cross; *ssalje19@g.holycross.edu*

Investigating Maternal Effects in the Sea Anemone, Nematostella vectensis, from Chronic Exposure to 17 -Estradiol.

An organism's phenotype is the product of its genotype, the environment that the organism experiences as well as the environment experienced by its mother. The effects of the maternal environment on phenotype expression in offspring are termed maternal effects and they can have critical impacts on offspring development, growth, and performance. Maternal exposure to stress and toxins can result in physiological, behavioral, and developmental changes in offspring. In most marine invertebrates, the effects of acute or chronic exposure to these agents are unknown. We aimed to determine whether chronic maternal exposure to the endocrine-disrupting chemical, 17 -estradiol, has effects on the growth, behavior, feeding, and potentially the development of adults and offspring of a common saltmarsh invertebrate, *Nematostella vectensis*. In our study, anemones were exposed for 35 days to one of 7 treatments: seawater control, DMSO control, and 0.1, 1, 10, 100, 1000 ng/mL of 17 -estradiol. Anemones were spawned prior to, and at 1, 3, and 5 weeks during the exposure period; unfertilized eggs were collected from females and frozen for later biochemical constituent analyses, which are ongoing. During the exposure period, anemones in the highest doses of 17 -estradiol displayed deflated morphologies and tentacle retraction, behaviors that were dissimilar to anemones exposed to low concentrations of 17 -estradiol or the two control treatments. These behaviors may have impacted maternal provisioning of eggs with biochemical constituents, particularly lipids, as 17 -estradiol is a lipophilic molecule. The results from this study provide information on how chronic exposure to marine toxins can potentially lead to altered behavioral and developmental outcomes in mothers and their offspring.

P2-221 ALLEN, JW*; DAVIS, JS; High Point University; *jallen1@highpoint.edu*

Comparative Morphology of Jaw Adductors in Chiropteran and Carnivoran Dietary Specialists

Mastication is a complex process that involves the use of three dimensional jaw movements to direct precise occlusion between teeth to break down food. Several studies have noted that in mammalian species with a fused mandibular symphysis, late activity of the balancing-side zygomaticomandibularis produces transverse masticatory jaw movement. This is thought to produce lateral transverse bending or "wishboning" forces at the mandibular symphysis, which can be resisted by ossification of this joint. The current study investigates the hypothesis that mammals that have specialized on plant-based diets and have a fused mandibular symphysis will also have a larger, more complex zygomaticomandibularis than their closest animalivorous relatives. In this study, contrast-enhanced microCT scans of representative dietary specialists from orders Chiroptera (bats) and Carnivora (carnivorans) are used to compare size and orientation of the primary jaw adductors, with particular emphasis on the compartments of the masseter (including zygomaticomandibularis). We find that within the carnivoran sample, our hypothesis is supported, but within the chiropteran sample, this signal is somewhat more complicated: while the zygomaticomandibularis does form a larger proportion of the masseter in frugivorous species, the masseter itself is much larger in the animalivorous species. We discuss possible functional explanations for our observations.

P3-33 ALLRED, LA*; KANE, EA; OUFIERO, CE; Georgia Southern Uni., Towson Uni.; *la01413@georgiasouthern.edu*
Comparison of Swimming Energetics Between Damaged and Healthy Bluegill Sunfish (Lepomis macrochirus)
Locomotion is key to survival of many fishes and depends upon their ability to use their body and fins to generate thrust. Economic swimmers should exhibit lower metabolic rates at a given swim velocity, allowing energy to be used for other tasks. However, previous studies disagree on whether fin damage impairs swimming energetics. A common metric to assess swimming performance and energetics is critical swimming speed (U_{crit}) which forces fish to swim continually at increasing incremental speeds. However, the energy used at higher speeds may be confounded by the duration of the trial. The purpose of this study is to find out if fin damage impacts swimming energetics and whether differences are repeatable using modifications to the U_{crit} protocol. Bluegill sunfish (*Lepomis macrochirus*) are common in the United States and have been used in previous studies on swimming performance. Bluegill were collected from a hatchery using a monofilament cast net, which caused fin damage (n=6 damaged fish), and an electrofisher, which did not damage fins (n=6 healthy fish). Fish were randomly exposed to 6 ecologically relevant flow speeds (5-30 cm/s) in a swim tunnel respirometer for 10 minute intervals with 5 minutes of rest between speeds. All fish were tested again at least 2 weeks later using different randomization of speed intervals. We predict that damaged fish will repeatedly display higher metabolic rates at each speed compared to healthy fish. Allowing rest periods between randomized changes in speed should reduce exhaustion as a limiting factor and increase repeatability of measurements. This study has the potential to shed light on the consequences of fin damage for locomotor performance in bluegill.

P2-118 ALVAREZ, Y*; ADAMS, NL; California Polytechnic State University, San Luis Obispo; *yaalvare@calpoly.edu*
Mother knows best: Maternal investment causes differences in UV-tolerance of intertidal and subtidal populations of sea urchins
Planktonic larvae of many marine organisms are increasingly being exposed and required to respond to a changing physical environment. As *Strongylocentrotus purpuratus* adults occupy intertidal and subtidal waters, many questions remain about how populations residing at different depths adequately prepare their offspring to cope with different levels of UVR. In this study, *S. purpuratus* adults were collected from two intertidal and two subtidal (15 m) sites from the central coast of CA to compare UV tolerance in offspring. UVA (321-400 nm) and UVB (280-320 nm) measurements at the four collection sites were at minimal or absent levels in subtidal sites. Our study found that offspring from intertidal populations have a less severe developmental delay when exposed to environmentally relevant levels of UVR using artificial lighting than offspring from subtidal populations. The mean percent cleavage delay for UV-treated embryos relative to the controls was 17.6% for intertidal sites and 23.4% for subtidal sites. Although these embryos are members of the same species and share a common genetic background, they differ in their phenotype and chances of survival due to differences in maternal resources. This suggests that environmental UV cues or additional environmental cues experienced by intertidal mothers may reduce the negative effects of UV exposure during early development. To further explore the role of maternal investment, we are using a proteomic approach to assess differences in protein expression between eggs from intertidal and subtidal populations. This will offer insight into how protein variation provides embryos with a rapid response to stress during early development.

P1-141 AMBROSE, A*; ORTIZ, C; CORDERO, C; CHMABERS, C; MARKLAND, S; OSBORN, A; SHIRLEY, K; TWOMBLY ELLIS, J; TSCHEULIN, T; GIRAY, T; BARTHELL, J; AGOSTO-RIVERA, J; Savannah State University , University of Puerto Rico Rio Piedras, University of Kansas, Oklahoma State University, College of New Jersey, Colorado College , Cornell University , University of the Aegean , University of Central Oklahoma; *alexandria.ambrose13@gmail.com*
The role of circadian rhythms on the temporal organization of foraging behavior in three carpenter bee (Xylocopa) species in a Mediterranean Island Ecosystem
Bee pollinators are an indispensable aspect of the environment, by providing pollination services to the plant communities that shape our ecosystems. As the environment undergoes changes, including climate change, having a better understanding of the endogenous circadian rhythms in pollinator species could allow us to sustain pollination of plant species in both agricultural and natural systems. Like other animal species, pollinator species have their own circadian rhythm in which they have a peak or trough of foraging activities throughout the day. These peaks or troughs can be influenced by environmental cues. We hypothesized that if circadian rhythms play a major role in the timing of foraging behavior in *Xylocopa* species, then their activity patterns in the lab (in the absence of environmental timing cues) would resemble their patterns in the field. To test the hypothesis, we compared *Xylocopa violacea*, *Xylocopa olivieri*, and *Xylocopa iris* forging patterns in the field to their activity in the lab under constant environmental condition. We found that *X. olivieri* and *X. iris* activities in the lab closely resembled their foraging patterns in the field. *X. violacea* activity in the lab was longer in duration than in the field. All three species were more active during the middle of the day in the lab than they were in the field. The resemblance between foraging behavior in the field and the intrinsic activity pattern in the lab under constant conditions indicates that circadian rhythm plays a major role in the timing of foraging behavior among these species.

P2-92 AMBROSE, A.; CHAMBERS, C.; CORDERO MARTINEZ, C.; MARKLAND, S.; OSBORN, A.; SHIRLEY, K.; TWOMBLY ELLIS, J.; SILVA ECHEANDIA, S.; GIRAY, T.; GONZALEZ, V.; HRANITZ, J.; BARTHELL, J.*; Savannah State University, University of Kansas, University of Puerto Rico, Rio Píedras, Oklahoma State University, The College of New Jersey, Colorado College, Cornell University, University of Puerto Rico, Rio Píedras, Bloomsburg University, University of Central Oklahoma; *jbarthell@uco.edu*
Foraging Patterns of Three Carpenter Bee Species at Chasteberry (Vitex agnus-castus) Bushes on the Greek Island of Lesvos
We observed three species of carpenter bees foraging at the chasteberry bush, *Vitex agnus-castus*, on the Northeast Aegean island of Lesvos (Greece). Observations were made at 30-minute intervals during a 14-hour period (sunrise to sunset). Simultaneously (but reported elsewhere) we observed activity patterns of the same bee species in the laboratory for endogenous, circadian rhythms. We found distinct patterns among the species that appeared to correspond with the size of each species. The largest bodied species, *Xylocopa violacea*, was most commonly seen during the earlier and later periods of the day while the smaller bodied *X. iris* was dominant during the middle of the day. The third species, *X. oliveri*, was restricted to very early or very late periods of the day, including during dim light. We predict that a mixture of ecological and genetic factors causes differences in foraging times. Larger bodied species have a physiological advantage during cooler periods of the day (given their reduced ability to radiate heat) while smaller bodied species can forage during the hottest time of day when larger species are rare or absent. Subsequent results of the thermotolerance of these species are consistent with this conclusion. Our results also suggest, however, that *X. oliveri* has greater endogenous constraints on its range of foraging times than the other two species. For these reasons, we believe these species represent an ideal study system for understanding the foraging dynamics of pollinators within flowering plant communities.

P2-147 AMODEI, NF*; TOBALSKE, BW; POWERS, DR; George Fox University, University of Montana; *namodei16@georgefox.edu*

Use of Post-Hovering Behavior to Dissipate Accumulated Heat in Hummingbirds

Hummingbirds generate a large amount of heat during flight due to the low mechanical efficiency of their flight muscles and they must dissipate that heat to avoid overheating. Heat can be dissipated passively (convection, conduction, and radiation) and by evaporation (respiratory and cutaneous). When environmental temperatures are high, passive heat dissipation is eliminated leaving evaporation as the only option for thermoregulation. In hummingbirds, respiratory evaporation accounts for < 40% of metabolic heat production, requiring the balance of metabolic heat production to be dissipated by cutaneous evaporation. Aerodynamically positioned feathers restrict passive heat dissipation during flight, but it is unknown if cutaneous evaporation will be affected as well. We studied evaporative heat dissipation at temperatures near the limits for passive heat dissipation in hovering calliope (*Selasphorus calliope*), Rivoli's (*Eugenes fulgens*), and black-chinned (*Archilocus alexandri*) hummingbirds using open-flow respirometry and video recordings. Cutaneous evaporation was estimated as total evaporation minus respiratory evaporation. Our measurements in calliope hummingbirds suggest that they are unable to sufficiently upregulate cutaneous evaporative water loss to compensate for the extra heat produced during hovering. Observations of all species studied suggest that post-hovering behaviors might be important for rapidly dumping heat following a hovering bout in warm conditions.

P3-175 AMONETT, SD*; BALENGER, SL; University of Mississippi; *sdamonet@go.olemiss.edu*

Maternal Effects in Response to Mycoplasma gallisepticum Infection in Eastern Bluebirds

Neonates lack adaptive immunity and are vulnerable to pathogens. Mothers can transfer passive immunity to offspring by transmitting antibodies (Abs) via milk or yolk. Mothers previously or currently infected with a pathogen transfer Abs to newborns, granting them immunological protection until they can synthesize their own. In birds, Abs are deposited before eggshell formation within the mother's oviduct. Similarly, mothers may transmit pathogens that colonize the oviduct. It was recently found that wild eastern bluebirds (*Sialia sialis*) are common hosts of the avian pathogen *Mycoplasma gallisepticum* (MG). We sampled 40 nestlings laid by MG-positive mothers and found 15% of nestlings were positive for MG Abs. The MG bacterium is known to be vertically transmitted in poultry. It colonizes the oviducts of infected hens and is transmitted to embryos during egg formation. My study will monitor a population of eastern bluebirds to test: the adaptive nature of specific MG antibodies, if infected female bluebirds harbor MG bacteria in their oviduct and transmit MG to their eggs, and the differences in both antibody and disease transmission between first and second broods. I will quantify MG Ab concentrations in eggs, nestlings, and adults. I will use PCR to identify active MG infections in female birds. If egg transmission of MG is occurring, then maternal Abs would provide critical immunological support to embryos exposed during development. This study will provide insight into non-genetic, maternal effects on offspring survival and growth in response to a costly infection.

P3-55 AMPLO, H.E.*; CRAWFORD, C.H.,; FLAMMANG, B.E.; Rutgers University-Newark, New Jersey Institute of Technology; *hea7@njit.edu*

Head, Shoulders, Elbows, Fins: Frogfish Fin Morphology

Frogfishes (Family Antennariidae) are highly derived teleost fishes that utilize multiple modes of locomotion, including ambulating on their pectoral fins, in order to move through diverse habitats. Previous literature describes the pectoral fin as having both a shoulder-like and an elbow-like portion, the functions of which are key to frogfishes ability to "walk" with their pectoral fins.These pectoral fins contain small scapula and coracoid bones united by cartilage and three fin radials, the third being distally expanded, articulating with a cartilaginous bar that attaches to a variable number of pectoral fin rays. Frogfishes are also unique in that they have developed 14 muscles associated with the pectoral girdle instead of the 3 muscles typical among neoteleosts, which may aid in their ability to rotate their fins severely around these joints. However, the internal morphology of these unique locomotor adaptations are not well described, or illustrated. In this study, the pectoral fin and pectoral girdle of the shaggy frogfish, *Antennarius hispidus*, are described using microCT scanning, PTA staining, and clear and stain techniques in order to describe the unique shoulder-like and elbow-like morphologies within the frogfish fin. Future work will include kinematic and electromyographic analyses to explore how this novel pectoral fin structure allows Antennariid fishes to employ their pectoral fins for walking-like locomotion, and explore the evolutionary life history of this unique group of fishes.

P3-103 AN, D*; HUSOVIC, A; ALI, L; WEDDLE-PITTMAN, E; NAGLE, L; AHEARN, GA; Univ. of North Florida; *gahearn@unf.edu*

Ocean acidification: Synergistic inhibitory effects of protons and heavy metals on ^{45}Ca uptake by lobster branchiostegite membrane vesicles

This paper describes ion transport mechanisms present in the plasma membranes of lobster (*Homarus americanus*) branchiostegite epithelial cells and the effects of pH and heavy metals on the uptake of ^{45}Ca by these processes. Partially purified membrane vesicles (PPMV) of branchiostegite cells were produced by a homogenization/centrifugation method. ^{45}Ca (1 mM) uptake was highest at pH 8.5 and decreased in a step-wise fashion at pH 8.0, 7.5, and 7.0 with lowest uptake occurring at pH between 6.0 and 7.0. ^{45}Ca uptake was a biphasic process consisting of a saturable mechanism at low [Ca] and a linear process at higher [Ca]. ^{45}Ca influxes (15 sec uptakes) at both pH 8.5 and 7.5, in the presence of 100 µM verapamil (Ca channel blocker), were both hyperbolic functions of [Ca], with the Michaelis-Menten constant (Km) significantly greater at pH 7.5, suggesting competitive inhibition between protons and ^{45}Ca during uptake. Increasing zinc concentrations (5 to 500 µM) reduced apparent carrier-mediated 1 mM ^{45}Ca uptake at pH 8.5 and 7.5 completely, the remaining uptake being accounted for by channel uptake and non-specific isotope binding. Uptake of 1 mM ^{45}Ca at pH 8.5, 7.5, 7.5 + Zn, and 7.5 + Zn + Cu in the presence of 100 µM verapamil displayed a step-wise reduction of ^{45}Ca uptake with addition of each treatment until only non-specific isotope binding occurred with all cation inhibitors. Results suggest that branchiostegite uptake of ^{45}Ca takes place by carrier-mediated and channel proteins. Carrier-mediated ^{45}Ca uptake is synergistically abolished by the combination of increased acidity and heavy metals.

P1-279 ANABLE, N*; GIBB, A; MINICOZZI, M; Northern Arizona University; *nra62@nau.edu*

Kinematics of Burying Behavior in the Pacific Staghorn Sculpin

Many marine fishes from divergent teleost lineages hide in the substrate to avoid predators or to ambush prey, but the mechanisms by which fishes insert their bodies into the substrate are still poorly understood. We examined the kinematics of burial in the Pacific staghorn sculpin (*Leptocottus armatus*) and asked: how does the deep-bodied sculpin bury its body into the substrate? We filmed *L. armatus* individuals (n=7) voluntarily burying using two high speed cameras (recording images from synchronized dorsal and lateral views) and tracked points on the fish over time using a MatLab routine (DLT data viewer, created by Ty Hendrick). Displacement data for each tracked point (head, tail and body) were subsequently smoothed with a quintic smoothing spline to derive velocity and acceleration. The Pacific staghorn sculpin buries by raising its head and tail simultaneously, then forcefully bringing both ends of the body downward, onto the substrate. During the down-stroke, the sculpin appears to simultaneously force water out of the ventral margin of the opercles (gill cover) to inject water into the sand. Pacific staghorn sculpins also use their pectoral fins to push sand laterally out from underneath the body and they alternate fin movements over time. Dorso-ventral body movements and pectoral fin movements are repeated cyclically at approximately 0.75-second intervals until the fish is approximately 60% buried. It appears that Pacific staghorn sculpins use a combination of undulations, injection of water into the substrate from the cranium, and physical removal of substrate by the pectoral fins during burial behaviors. These data provide ecologically significant insights into the behavior of this species, but also may provide new mechanisms to bury human infrastructure and equipment (bridges or ship anchors) into sandy substrates.

P3-82 ANDERSON, T*; GLASS, J; JOHNSON, D; STAHLSCHMIDT, Z; USDA-ARS, Univ. Pacific; *tavis.anderson@ars.usda.gov*

Predicting variation in life-history traits using multilayer environmental and physiological networks

Shifts in complex environments characterized by multiple co-varying factors present organisms unique challenges. The dynamic interplay among life-history traits, underlying physiological mechanisms, and the environment remains a fundamental, though poorly understood, issue. We quantified the effects of temperature (field-parameterized heat wave vs. control diel cycles), diet (low vs. high food availability), and immune activation (LPS challenge vs. no challenge) on parameters of life history (investment into growth, reproduction, and flight musculature) in the sand field cricket (*Gryllus firmus*), which exhibits a wing dimorphism that mediates a flight-fecundity tradeoff. We further quantified physiological parameters of total protein concentration and phenoloxidase activity, and metabolic rate. To predict how physiology and environments interactively influence life history, we used a hierarchy-aware unsupervised feature learning approach. We built a multilayer network where each layer represented interactions among individual life-history traits and physiology within different conditions (e.g., one layer was derived from individuals that experienced a heat wave, low food availability, and immune challenge): network nodes were linked across layers resulting in a multilayer network. An unsupervised machine learning algorithm was trained to automatically predict life-history trait values using features derived from the network. We also measured degree centrality, clustering coefficients, centrality scores, and diffusion to determine the relative importance of each parameter in the network to life history. We show that accounting for dynamic environmental variation and underlying physiology improves the power to predict variation in life-history traits linked to fitness.

P2-65 ANDRES, A*; SEIBEL, BA; SLESINGER, E; SABA, G; SABA , V; MORRIS, J; University of South Florida, Rutgers University, Rutgers University, NOAA, Mote Marine Laboratory; *alyssaandres@mail.usf.edu*

How Low Can Predators Go? Hypoxia Tolerance of Coastal Shark Species of Varying Lifestyle

Environmental oxygen availability, relative to requirements, is an important determinant of habitat suitability for marine organisms and provides a measure of effective metabolic scope for all life functions beyond basic maintenance. As the balance between metabolic oxygen demand and environmental supply changes with climate, energetic trade-offs occur to facilitate survival, or alternative habitat is sought to alleviate metabolic constraints. As the global incidence of low oxygen waters, known as hypoxic zones, increases each year, it has become crucial to understand how marine organisms respond to hypoxia. Coastal shark species of varying lifestyle such as blacktip sharks (*Carcharhinus limbatus*), and spiny dogfish sharks (*Squalus acanthias*)) may be vulnerable to hypoxia due to oxygen-intensive behaviors, such as high-speed swimming, migration, etc. Hypoxia, in conjunction with temperature-induced increases in oxygen demand, may limit performance and viable habitat of coastal shark species. In order to accurately forecast shark niches, and habitat selection in the face of these climate shifts, we must first determine species-specific tolerances to hypoxia. Hypoxia tolerance was measured using Pcrit, defined as the critical oxygen partial pressure at which oxygen demand equals supply. Using respirometry, we determined Pcrit for *C. limbatus* and *S. acanthias*, and examined how Pcrit varies with ventilation method and temperature. Furthermore, we quantified behavioral responses to hypoxia and the blood stress response associated with acute exposure to critical oxygen levels. Results from this study provide a physiological basis for predicting viable metabolic habitat for these species, and insight into the physiological consequences of hypoxia-induced stress.

P2-40 ANSELMO, CM*; BUTLER, JM; MARUSKA, KP; Louisiana State University; *cansel5@lsu.edu*

The Lateral Line System Mediates Reproductive Interactions in the African Cichlid Fish, Astatotilapia burtoni

The mechanosensory lateral line system of fishes is essential for sensing nearby water movements, and functions in schooling, orienting in currents, locating prey, and detecting and evading predators. However, less is known about its role in social interactions. Previous work in our lab demonstrated that the cichlid *Astatotilapia burtoni* uses mechanosensory information detected by the lateral line system to mediate male-male territorial interactions. Many fishes also produce water movements during courtship and reproductive interactions, but we know little about the role of the lateral line system in reproduction in any of the ~30,000 species of fishes. To examine the role of mechanoreception in reproduction, we compared behavioral interactions and neural activation patterns associated with courtship in lateral line-intact and -ablated females. We quantified reproductive behaviors of both sexes: female response to male courtship, average proximity of the fish pair, and spawning rates. Preliminary data suggests that the lateral line affects reproductive behavior in both sexes, such that males perform fewer courtship behaviors towards ablated females than towards intact females, and ablated females have an altered response to male courtship attempts. To investigate neural processing of reproductively-relevant lateral line information, brains were collected after behavior trials and stained for the immediate early gene *cfos* as a proxy for neural activation. We are comparing neural activation patterns in sensory and socially-relevant brain regions in lateral line-intact and ablated groups. This study is the first to integrate behavioral and neural activation analyses to show the importance of the lateral line system in mediating reproductive communication in any fish species.

P3-180 ARMFIELD, BA*; CARROLL, A; COHN, MJ; University of Florida; *barmfield@ufl.edu*

Hedgehog Signaling Initiates Genital Tubercle Development

Abnormalities of the external genitalia are among the most common birth defects in humans, affecting approximately 1/250 live births. Development of external genitalia begins with the emergence of paired genital swellings on either side of the embryonic cloaca. The genital swellings then merge to form the genital tubercle, the precursor of the penis and clitoris. Interactions between the endodermal urethral plate epithelium and the surrounding mesenchyme coordinate outgrowth and patterning of the external genitalia. Sonic hedgehog (Shh) is expressed in the urethral epithelium and plays an essential role in the growth of the genital tubercle. Deletion of Sonic hedgehog results in absence of external genitalia in mice, although Shh mutants still form the initial paired genital swellings, indicating that Shh is not required for initiation of genital outgrowth. In a characterization of the transcriptome of the urethral plate epithelium, we found that Indian hedgehog (Ihh), another hedgehog family member, is co-expressed with Shh. To determine if Ihh could compensate for the loss of Shh to promote initiation of genital swellings in Shh mutants, we conditionally deleted both Ihh and Shh in mice. Using 3D imaging (nanoCT) and cell lineage analysis, we found that the double knockout had a more severe genital phenotype than the Shh or Ihh mutants. Specifically, we show that Shh;Ihh homozygous conditional knockouts fail to initiate genital budding and have an expanded cloaca. Comparison of gene expression in Shh/Ihh single and double mutants shows that Ihh can partially compensate for Shh to activate the genital outgrowth circuit. Together these results indicate that coordinated activity of Shh and Ihh is required for initiation of external genital development in mice.

P2-75 ARNONE, A/A*; SATTERLIE , R/A; University of North Carolina Wilmington, University of North Carolina Wilmington ; *aaa7982@uncw.edu*

Innervation of wing musculature by modulatory neurons in the pteropod mollusk Clione limacina

The neural network underlying the locomotory system in *Clione limacina*, a pelagic marine gastropod, is an ideal system for investigating the mechanisms controlling rhythmic motor behaviors. Understanding the organization and modulation of this network is necessary to explain the variations in swimming behavior of this and other animals with rhythmic locomotory movements. *Clione* exhibits four different swimming states including passive sinking (no swimming activity), slow swimming, fast swimming, and startle/escape swimming. These different behaviors are influenced by several biologically active modulatory neurons, as well as by serotonin. Modulatory neurons have been identified in whole mount using immunohistochemical techniques, but we do not know which muscle groups they innervate in the wing tissue. Here we use conventional thick sectioning and electron microscopy to match each modulator with the muscle type found in the *Clione* wing. Light microscopy results indicate that the neuropeptides FMRFamide, SCPb and myomodulin are associated with the smooth retractor muscles, which produce retraction and inhibition of swimming. Similarly, serotonin and the neuropeptide buccalin are associated with the swim musculature.

P3-136 ASHLOCK, LW*; PESPENI, MH; University of Vermont; *Lauren.Ashlock@uvm.edu*

Developmental and transgenerational impacts of extreme temperature events in copepods

Acartia tonsa occupy shallow coastal waters, characterized by regular and rapid fluctuations in water temperature. With climate change, mean water temperature and variance in temperature are expected to increase, leading to an increasingly variable environment. While there is evidence that environmental temperature impacts adult thermal tolerance in *A. tonsa*, it is not known if and how extreme temperature events during specific life stages impact adult thermal performance within and across generations. Here, we collected copepods from Penobscot Bay, Maine and allowed them to acclimate to lab conditions for one generation. We then exposed their offspring to short-term extreme temperature events during different stages of development. We assessed adult survival and fecundity of unexposed parents, F1 individuals after developmental temperature treatment, and F2 individuals held under control conditions throughout development. Survival and fecundity assessments were made at a range of temperatures so as to examine the influence of parental and developmental temperature on thermal performance curves. Preliminary results demonstrate that developmental temperature impacts adult thermal tolerance and the impacts of developmental temperature are specific to the life history stage exposed to the extreme temperature event.

P2-119 ASSIS, VR*; GARDNER, S; GOMES, F/R; MENDONçA, M/T; University of Sao Paulo, Auburn University; *v.regina.a@gmail.com*

Gene Expression of Proinflammatory Cytokines: How are Cane Toads Dealing with Infections under Acute Stress Situations?

The physiological reactions in amphibians to stressors and the consequences of glucocorticoid elevation on their immune responses are still poorly understood. To assess the effects of acute stress on immune reactions in amphibians, invasive cane toads from Florida received either a transdermal application of corticosterone (CORT), the primary glucocorticoid in amphibians, or peanut oil followed by an immune challenge (lipopolysaccharide (LPS) or saline injection; N=6/group). Two hours after the exogenous CORT administration and LPS challenge, we measured the expression of proinflammatory genes (i.e., interleukin (IL) 1 , IL6, IL8, IL12 and tumor necrosis factor alfa (TNF)), as well as plasma CORT and plasma bacterial killing ability (BKA). CORT levels were significantly higher in animals in the CORT+LPS treatment when compared to the Oil+Saline (Control) group as well as the Oil+LPS treatment ($F_{2,12}=33.466$; $p \leq 0.001$). BKA was higher in Control animals ($F_{2,12}=6.741$; $p=0.008$) when compared to Oil+LPS and CORT+LPS. There was upregulation in 3 of the 5 pro-inflammatory genes investigated on the LPS+CORT animals compared with Controls: IL1 was upregulated by log2fold factor of 4 ($p=0.018$); IL6 upregulated by log2fold factor 4.8 ($p=0.005$); and IL8 upregulated by log2fold factor 4.7 ($p=0.018$). Thus, LPS alone didn't trigger a significant change in gene expression, but the combination of LPS and acute increase in circulating CORT caused by the exogenous CORT administration stimulated the immune response. The multiple immune genes being upregulated have different roles, including phagocytic stimulation. These results may warrant investigation to whether CORT alone triggers differentially expressed immune genes in cane toads.

P3-68 ATKINS, EL*; TINHAN, TC; WELLS, RJD; ALVARADO-BREMER, JR; Texas A&M University Galveston ; *ericaknowles@tamu.edu*

Estimating levels of gene flow of a large coastal shark, Carcharhinus leucas, in the Gulf of Mexico

Population structure of the Bull Shark (*Carcharhinus leucas*) in the Gulf of Mexico (GOM) was examined using genetic and genomic data. Tissue samples were collected throughout the GOM, along with the inclusion of reference samples from the western Pacific and Caribbean Sea. Since *C. leucas* is believed to exhibit female philopatric behavior towards their natal site, we characterized the patterns of variation in the mitochondrial DNA (mtDNA) genome by inferring the phylogenetic relationships of representative samples using mtDNA control region (CR) sequences. The results suggest the population in the GOM has lower haplotypic diversity than those in the Caribbean Sea and in the western Pacific. To determine whether sex-biased dispersal exists, we also examined variation in the nuclear genome by characterizing single nucleotide polymorphisms (SNPs) using double digest restriction based DNA (ddRAD) sequencing. We discuss the inferred patterns of migratory behavior and levels of gene flow within and between the GOM, Caribbean Sea, and the Pacific using both mtDNA and genomic data.

P2-62 AULETTA, A*; MESCE, KA; Univ. of Minnesota, Twin Cities; *aulet002@umn.edu*

An Examination of Biogenic Amines in the Nervous System of the Scorpion Centruroides sculpturatus (Scorpiones: Buthidae): Insights Into the Evolution of Neural Signaling in the Arthropoda

Underlying the exquisite diversity of complex arthropod behaviors are intricate neuromodulatory systems that can finely adjust those behaviors to meet specific demands. Although such systems are well described in some arthropod groups, they are poorly known in others, including the subphylum Chelicerata. Since the Chelicerata are the most basal of extant arthropod groups, a better understanding of their neuromodulatory systems is key for determining how complex modulatory systems evolved within the Arthropoda as a whole. We have investigated the presence, distribution, and functions of several behaviorally important neuromodulators—the catecholamines (dopamine and norepinephrine) and octopamine— in a representative chelicerate, the scorpion *Centruroides sculpturatus* (Scorpiones: Buthidae). We have localized catecholaminergic and octopaminergic neurons in the CNS of the scorpion via immunocytochemistry, and quantified levels of catecholamines in the CNS via ultra-performance liquid chromatography-mass spectrometry. Using recently available genomic data for *C. sculpturatus*, we also identified putative genes and transcripts for enzymes in catecholamine and octopamine biosynthesis, as well as receptors for these modulators. In addition, extracellular electrophysiological recordings indicate that catecholamines and octopamine elicit different physiological responses in the scorpion, which may underlie distinct behavioral programs not yet fully understood. When compared to data from other organisms, our results suggest that chelicerates may retain several ancient features of neuromodulatory systems thought to have been present in the common ancestor of Bilaterian animals, but lost in other arthropods.

P3-88 AWALI, S*; ABDULELAH, SA; CRILE, KG; YACOO, KE; TORRES, VC; DAYFIELD, DJ; ALMOUSELI, A; EVANS, KR; BELANGER, RM; University of Detroit Mercy; *awalisa@udmercy.edu*

Exposure to environmentally-relevant concentrations of atrazine causes changes in cytochrome P450 and glutathione-S-transferase activity in the hepatopancreas of crayfish (Faxonius virilis)

The herbicide atrazine is commonly applied to crops in the U.S. Midwest in order to control broad leaf weeds. Atrazine enters local streams and rivers through runoff, seepage, evaporation and regional transport, subsequently affecting aquatic organisms. To examine the effects of atrazine on expression and activity levels of the oxidative enzymes cytochrome P450 (CYP1A1) and glutathione-S-transferase (GST), we used the used the keystone species crayfish as a bioindicator. Crayfish were treated with 0, 10, 40, 80, 100 and 300 ppb atrazine for 1, 2, 4, 7 and 10 days. According to results, there was a significant increase in CYP1A1 expression levels succeeding treatments of 100 ppb for one day, 10 ppb for two days, and 40 ppb for four and ten days. At seven days of exposure, there were no significant differences of CYP1A1 expression levels for all concentrations. Moreover, our results indicate a significant increase in GST expression following treatments of 300 ppb for one, two, four, seven, and ten days, as well as 10 ppb for two days. Overall, detoxification enzyme expression and activity levels are affected following environmentally-relevant exposures of atrazine. Exposure to atrazine may ultimately lead to increased energy demands and alter population fitness.

P1-251 AWBREY, JD*; FRANCE, SC; University of Louisiana at Lafayette; *jawbrey@louisiana.edu*

Evolution of the Octocorallian Family Acanthogorgiidae (Gray 1857)

Acanthogorgiidae (Gray, 1859) are a family of sea fans found throughout the oceans and at a wide range of depths. The family comprises about 130 species, currently divided among 5 genera. No phylogenetic analysis of Acanthogorgiidae has previously been conducted, although inclusion of some species in broader analyses of the Octocorallia suggest the family is not monophyletic. Here we provide a first explicit phylogenetic examination of the family to test for monophyly and to better understand their evolution and taxonomy. Sequences from the mitochondrial MutS gene were collected from 4 of the 5 acanthogorgiid genera and added to a dataset of 86 GenBank sequences from acanthogorgiids and several GenBank sequences representing other families of holaxonian octocorals and analyzed using both Maximum Likelihood and Bayesian Inference methods. The results of these analyses will be discussed in detail.

P2-71 AYALI, A*; TALAL, S; GEFEN, E; Tel Aviv University, University of Haifa-Oranim; *ayali@post.tau.ac.il*

Interactions Between Carbon Dioxide and Oxygen Sensing in the Control of Locust Ventilatory Pattern Generation

Insects exchange respiratory gases through an extensive network of tracheae that open to the surface of the body via segmental spiracles. In actively ventilating insects, such as the locust, respiration involves the well-coordinated activity of spiracular muscles and ventilatory muscles, responsible for abdominal pumping movements. Our previously reported data indicated a strong coupling between the spiracular and the ventilation pattern generating circuits (CPG), and provided insights into their modulation by concentrations of respiratory gases. Here, we directly tested the interactions between CO_2 and O_2 sensing in the control of the locust ventilatory motor patterns through *in-vitro* isolation of the thoracic ganglia, where ventilatory CPG are located, and their associated main tracheae. We perfused the main tracheae with various gases mixtures while recording the rhythmic activity from the motor nerves controlling spiracle and ventilatory muscles. Initially, using aerated saline we recorded no change in the fictive ventilatory activity to increasing tracheal CO_2 levels (at 6% O_2) within the physiologically relevant range. In contrast, when the saline was bubbled with 6% O_2 in N_2 (or in anoxic saline), a significant increase was recorded at 3.5% CO_2, indicating a role for hemolymph gas concentration. Reducing tracheal O_2 levels (in 0% CO_2) resulted in significantly increased ventilatory activity only at 2% O_2. However, the response to 3.5% CO_2 was significantly higher at tracheal levels of 3% O_2, and lower at 9% O_2, compared with 6% O_2. Furthermore, efferent ventilatory output increased 3-fold at 2% O_2 and 2% CO_2, whereas 2% O_2 alone caused a 20% increase only and 2% CO_2 alone did not elicit any response. Together, these findings indicate central sensing of both respiratory gases, and interaction in their effects on respiratory output from the CNS.

P1-93 AZZOLINI, JL*; DENARDO, DF; Arizona State University; *jlazzoli@asu.edu*

Effects of Chronic Water-Deprivation on Oxidative State in a Drought-Tolerant Snake

Many environmental stressors, including hypoxia, anoxia, ecotourism, and temperature fluctuations, have recently been analyzed in the context of how they impact oxidative state. Studies have found that these stressors can, in fact, impose oxidative stress. However, despite the physiological importance of water, the effect of dehydration, a common environmental stressor for species that undergo seasonal droughts, on oxidative state has largely been unexplored. We chose to investigate the effect of water deprivation on oxidative state using Children's pythons (*Antaresia childreni*), which are native to Northern Australia and experience yearly dry seasons. Children's python become dehydrated at times during the dry season and dehydration improves innate immune performance, leading to our question of whether dehydration might also affect oxidative state. We collected a blood sample from 15 male Children's pythons at the start of the study when they were hydrated, then subjected them to 52 days without food or water, a duration that is ecologically relevant. After 52 days, we collected a second blood sample to ascertain the effect of dehydration on oxidative balance. We then provided them with water *ad libitum*, and collected blood samples at 3 and 7 days post re-hydration to ascertain the timing of recovery from the dehydration event. Our work provides foundational results that enable us to begin to understand the relationship between water balance and oxidative state.

P2-190 BALLARD, E.J.*; BARRETT, L.M.; DEAROLF, J.L.; THOMETZ, N.M.; BRYAN, A.; REICHMUTH, C.; Hendrix College, Conway, AR, Univ. of San Francisco, CA, Alaska Dept. of Fish and Game, Fairbanks, Univ. of California, Santa Cruz; *ballardee@hendrix.edu*

Hybrid fibers in the bearded seal longissimus dorsi muscle

Bearded seals (*Erignathus barbatus*) are shallow diving pinnipeds that mostly stay in depths of about 100 meters or less. Being benthic feeders, they scour the ocean floor searching for food sources like polar cod, sculpins, shrimp, spider crabs, and a variety of other invertebrate species. Their benthic habits are a unique aspect of the life of bearded seals in the Arctic, which makes their diving ability an interesting topic of study. Specifically, understanding the physiology of bearded seal locomotor muscle could provide key insights into these abilities. Thus, the goal of this study was to quantify the percentages of hybrid fibers, fibers expressing more than one myosin heavy chain, in the longissimus dorsi (LD) of bearded seals. To achieve this goal, samples of bearded seal LDs were stained for their myosin ATPase activity after alkaline pre-incubation and their reaction to two myosin heavy chain antibodies: SC-71 (type IIA - fast-twitch oxidative-glycolytic), and A4.951(type 1 - slow twitch). Then, images were taken from identical regions in each of these samples using a Zeiss Axio Imager AI microscope and AxioVision v. 4.7 software. On the images, we identified slow- and fast-twitch fibers that were staining for both A4.951 and SC-71 and determined the percentages of these fibers in the LDs of the seals. Using ImageJ, we also measured the diameters of both types of hybrid fibers. From these data, we calculated overall averages of the percentages and diameters of the slow and fast-twitch hybrid fibers. Studying the hybrid fibers in the LDs of bearded seals will give us valuable insight into the unique diving abilities of the bearded seal.

P3-6 BALLENTINE, WM*; DORGAN, KM; University of South Alabama, Dauphin Island Sea Lab; *wballentine@disl.org*

Effects of Infauna on Sound Speed and Attenuation in Marine Sediments

Infauna alter the physical properties of marine sediments in many ways. Compact mud burrows, tubes built from shell hash, large subsurface galleries, and local changes in porosity are a few examples of these alterations. Structural changes such as these may be detectable non-invasively through their effects on the acoustic properties of sediment. Here, we investigate how infauna may affect the sound speed and attenuation in sediments using laboratory mesocosm experiments with controlled manipulations. These manipulations are intended to mimic how potentially important functional groups of infauna affect sediment structure while minimizing the variability inherent in working with live animals. In both manipulated and control mesocosms, sound speed and attenuation were measured at multiple depths and at high frequencies (100-400 kHz) with wavelengths (4-15 mm) corresponding to the scales of expected impacts of individual infaunal organisms. Manipulations include construction of tubes from shell hash to mimic *Owenia* polychaete tubes, burrowing via excavation and compaction, and sediment irrigation. Physical obstructions, like a shelly tube, were the most easily detectable manipulations, although irrigation and burrowing were still detected at higher frequencies.

P3-142 BALLINGER, MA*; TREIDEL, LA; NACHMAN, MW; University of California, Berkeley; *mallory.ballinger@berkeley.edu*
Physiological, morphological, and behavioral plasticity to cold acclimation in temperate and tropical house mice
Understanding the contributions of phenotypic plasticity in adaptive evolution is a major goal in evolutionary biology. Since their recent introduction to the Americas, house mice (*Mus musculus domesticus*) have rapidly adapted to diverse habitats and climatic regimes. Mice inhabiting temperate regions have evolved larger body sizes, smaller ears, and shorter tails compared to mice in tropical regions. Phenotypic plasticity has likely played a major role in the house mouse's ability to rapidly adapt to these novel environments, yet, this hypothesis remains largely unexplored. To test this hypothesis, we reared wild-derived inbred populations of house mice collected from temperate (New York and Canada) and tropical (Brazil) environments in both a warm (21C°) and cold (4C°) environment. Following acclimation, we assessed the degree of plasticity in body size, tail length, nest-building, and mitochondrial metabolism. This design allows us to determine if the potential for adaptive plasticity differs with population and test the prediction that phenotypic plasticity following acclimation will mirror the evolved differences observed between temperate and tropical populations. Overall, our results reveal how plasticity evolves among populations adapted to different climates and shed light on how plasticity may have contributed to the house mouse's rapid colonization of such disparate environments.

P1-105 BALTZLEY, M; LATHAM-SCOTT, K; WANDERSCHEID, N*; RAMOS, M; BATENHORST, E; Western Oregon University; *nwanderschied14@mail.wou.edu*
The Effects of Larval Population Density and Social Interactions on Adult Fecundity in Drosophila melanogaster
Drosophila melanogaster is a model organism for studying sexual and mating behaviors. Previous research has shown that raising flies in isolation affects the development of the olfactory and visual systems. Because changes to the olfactory and visual systems could affect mating, we hypothesized that population density and social interactions as larvae will affect the fecundity of adult flies. To test this hypothesis, we raised larvae in a high density, a medium density, and in isolation. None of these population densities were food limiting. After eclosion, we set up nine different pairwise crosses of the adults (high-density female x high-density male, medium-density female x high-density male, etc.). We are recording the effect of larval density on eclosion patterns, body size, and fecundity. Our preliminary data suggest that females raised in a moderate density environment as larvae may be the most fecund. We will continue to run these crosses for a total of 10 replicates of each pairwise cross to gather more data for analysis. This research will contribute to the understanding of the effects of population density and social interactions on fruit fly behavior.

P2-202 BARBER, KS*; MIDDLEBROOKS, ML; BELL, SS; PIERCE, SK; University of South Florida, University of Tampa, University of South Florida & University of Maryland; *ksbarber@mail.usf.edu*
Feeding specificity of the sacoglossan sea slug Elysia papillosa
Elysia papillosa is a kleptoplastic, sacoglossan sea slug always found, associated with either of two species of the siphonaceous green alga, *Penicillus capitatus*, but also less frequently, with the co-occurring *P. lamourouxii*. In order to determine if *E. papillosa* was actually consuming either of the two algal species in the field, total DNA was extracted from individual slugs immediately upon collection from Sunset Beach, Tarpon Springs, FL and the gene sequence of *rbcL* (large subunit of ribulose bisphosphate carboxylase-a chloroplast geneomic gene) was determined by PCR. These PCR sequences were BLAST searched for matches to algal species *rbcL* sequences. The *rbcL* sequence from slugs collected off of *P. lamourouxii* matched (98-100% sequence identity) to *P. lamourouxii rbcL*. Similarly, *rbcL* in slugs collected with *P. capitatus* matched the *rbcL* sequence of *P. capitatus*. Therefore, *E. papillosa* were consuming the same algal species from which they were collected. In a laboratory feeding experiment, *E. papillosa* fed *P. lamourouxii* over three weeks grew significantly longer than those fed *P. capitatus*. These findings suggest that although feeding by *E. papillosa* on *P. lamourouxii* occurs in the field and results in larger slugs, *P. capitatus* is more attractive to slugs.

P3-43 BARNS, BM*; MARTINI, J; RANKIN, B; DELAURENTIS, T; BAIER, D; Providence College, RI, Lincoln Memorial University, Harrogate, TN, Dana Farber Cancer Institute, Boston, MA, Providence College,RI; *bbarns@friars.providence.edu*
Mobility and stability of the turkey (Meleagris gallopavo) humeroulnar joint
The elbow joint in birds is typically considered to work as a simple hinge. However, some evidence from flying birds suggests greater complexity of movement. Additionally, the nature of the flapping wing likely places unusual demands on the elbow joint compared to other tetrapods. As the wing sweeps downward, the upward aerodynamic force would be expected to be greater on the distal wing, thereby generating a moment about the abduction/adduction axis of the elbow, perpendicular to its primary flexion/extension axis. We hypothesized specializations in the morphology and/or arrangement of the elbow ligaments to stabilize against this loading pattern, with particular focus on the ventral collateral ligament. In this study, we use X-ray Reconstruction of Moving Morphology (XROMM), to quantify the passive range of motion in turkey elbow by manipulating disarticulated wings. We also mapped ligaments onto digital models to explore their orientation during wing movement and explore which morphological features limit range of motion. We found ca. 90 degrees of flexion/extension, ca. 50 degrees of abduction/adduction movement, and ca. 40 degrees of long axis rotation at the humeroulnar joint (n = 4 wings). The range of abduction/adduction decreases with increasing extension of the elbow, suggesting that the ventral collateral ligament stabilizes the joint more effectively when the wing is fully extended as it is during downstroke of flapping flight. In order to achieve uniformity within interpretation of motion data for each trial, a standardized elbow joint coordinate system was established. This joint coordinate system used the inertial axes and key anatomical landmarks of the humerus, ulna, and radius, as the basis of its foundation.

P2-284 BARREIRA, SN*; BAXEVANIS, AD; NHGRI/NIH; *sofia.barreira@nih.gov*

Exploring the Role of Ribosomal Gene Repeats in the Context of Regeneration

Repetitive DNA has been implicated in chromatin organization, regulation of gene expression, genome replication, and the maintenance of genome integrity, but large repeats are often not found in reference genomes. Establishing the organization and distribution of repetitive DNA within a genome is crucial to fully understanding cellular function and for identifying new targets for therapeutic genome editing. Importantly, the process of regeneration depends on proper cell growth throughout the numerous cycles of cell division that, in turn, depends on the timely and flawless assembly of ribosomes. *Hydractinia*, a colonial marine cnidarian, is a proven model for the study of regeneration. Its stem cells are pluripotent and have homologs to human genes associated with the ability to self-renew and differentiate. We have identified a complete ribosomal gene consensus sequence in *Hydractinia*, and determined the genomic architecture of its rDNA repeats. A comprehensive protein domain structural analysis indicates that *Hydractinia*, does not possess the canonical UBF protein, a transcription factor that is known to bind to rDNA and is required for the recruitment of the Pol I transcription machinery during ribosome biogenesis. This opens the possibility that *Hydractinia*, might employ a different mechanism for regulating transcription of rDNA genes and nucleolar formation than that used by higher eukaryotes, perhaps providing important insight as to the regenerative capacity of this organism. This overall approach and comparison of these repeats and transcription factors between regenerative and non-regenerative organisms might reveal mechanisms that are primitive and shared among animals (or evolutionarily derived ones). This will help address key questions in regeneration and prompt the development of new clinical approaches to improve human health.

P2-217 BAUMAN, TJ*; STAAB, KL; McDaniel College; *tjb004@mcdaniel.edu*

Cartilage-like Connective Tissues in the Hyoid Region of Cypriniform Fishes

Suction feeding in cypriniform fishes may not fit other hydrodynamic models and the hyoid region likely plays a crucial role in generating intraoral subambient pressure to generate flow and pull food into the mouth. In unrelated acanthomorph fishes the hypaxial muscles were shown to generate power behind suction feeding and because those forces are transmitted through the hyoid, it has become of more interest. In cypriniforms the hyoid region may be of more functional relevance because some species are lacking the characteristic head lift movement in suction-feeding acanthomorphs. The hyoid apparatus includes multiple bones, joints, and linkages composed of diverse connective tissues that likely play differing functional roles. To characterize the composition of the tissues within the hyoid region in cypriniforms we examined three species: goldfish, *Carassius auratus*, zebrafish, *Danio rerio*, and blacknose dace, *Rhinichthys atratulus*. Based on histological stains of the hyoid apparatus we found varying types of cartilage-like connective tissues in functionally relevant structures. For instance, the ceratohyal of all species contained a medio-laterally oriented region of densely packed cells that stained consistently high for mucopolysaccharides, but this cartilage-like element did not fill the entire bone. The medial edges of the hypohyals are covered in a tissue that is distinct from the sternohyoideous tendon in between. This articular tissue is also comprised of densely packed cells with less extracellular matrix and lower affinity for the mucopolysaccharide stain. Throughout the entire hyoid region in all species, the hyoid elements were composites, staining for a range of mineralized and cartilage-like materials. These findings are important because they can inform our understanding how cypriniforms suction feed.

P1-12 BELANGER, RM*; GRABOWSKI, GM; JOSHI, GS; TUTTLE, JE; University of Detroit Mercy, ; *belangra@udmercy.edu*

Exploring the pathophysiology of diabetes: Development of an inquiry-based laboratory module

The NSF calls on scientific educators to actively involve students in their learning process, rather than make them passive learners. Histotechnology is a commonly used tool in medical research, pathological testing, and pharmaceutical development. We developed a three-week, inquiry-based laboratory module that equips our students with the knowledge of tissue sampling, processing and imaging so that they are ready for careers in the biomedical sciences. We induced diabetes in rats by injecting them with streptozotocin while control rats were injected with buffer solution. Students compared pre- and post-injection weights following one week of treatment, as well as final blood samples for glucose and insulin concentrations using an ELISA. Additionally, pancreatic tissue was collected, fixed, and paraffin embedded. Students sectioned and stained prepared slides using a hematoxylin/phloxine protocol. The number of islet beta cells were compared between control and treated rats. Blood glucose measurements demonstrated that treated rats had significantly higher blood glucose levels and lower beta cells numbers, while the ELISA tests indicated that treated rats had significantly lower blood insulin concentrations. Following this three-week laboratory module, students scored higher on competency tests and presented an individual report with images and quantitative data analyses that included insulin concentrations, blood glucose levels, and histological images of pancreatic islets, in addition to beta cell quantification. In summary, students who completed this three-week laboratory module were able to experimentally investigate and link the clinical symptoms of type 1 diabetes which include weight loss, increased blood glucose and decreased insulin levels and relate them to the underlying physiological cause, the destruction of pancreatic beta cells.

P2-277 BELFIORE, NM*; NOORDSIJ, LC; University of Tampa; *nbelfiore@ut.edu*

Comparative Genomics of Four Mustelid Species

North American river otters (*Lontra canadensis*) have the second largest latitudinal range of any otter species, from boreal Canada to southern Mexico. This broad range corresponds to broad dietary, physiological, and behavioral patterns. By contrast, it follows a restricted mating period, and a narrower birthing period. This species undergoes delayed implantation, in which the fertilized embryo sits dormant inside the uterus of the mother until approximately 40 days before the optimal birth season is anticipated, when it implants and begins to gestate. This pattern fits the constraints of living in the far north, with a very short warm season, when it would be critically important to give birth and raise nurslings only during optimal weather. It is particularly interesting that this pattern of delayed implantation is not found in other closely related otter species whose ranges are more extensive than that of the North American river otter, such as the Eurasian otter (*Lutra lutra*). In this preliminary study, we obtained genomic libraries generated by paired-end IlluminaTM sequencing at approximately 30X coverage from the North American river otter, the Eurasian otter, the African clawless otter (*Aonyx capensis*), and the American mink (*Neovison vison*). The African clawless otter does not undergo delayed implantation, while the mink, a member of the same family, but separate subfamily does undergo a limited implantation delay. We generate reference-guided assemblies of these species to compare the genomic content and structure from 69M sequences from the North American river otter, 102M sequences from the African small clawed otter, 70M sequences from the Eurasian otter, and 165M sequences from the American mink. The domesticated form of the European polecat (*Mustela putorius*), or the ferret, is used as a reference genome.

P1-247 BENEDICT, C*; LAROCHE, R; TITUS, B; GUSMãO, L; MEYER, C; ABDULLAH, ML; BARTHOLOMEW , A; DALY, M; REIMER , JD; YANAGI , K; RODRíGUEZ , E; Auburn University, University of Houston, American Museum of Natural History, American Museum of Natural History, National Museum of Natural History, University of Science and Technology, American University of Sharjah, Ohio State University, University of the Ryukyus, Natural History Museum and Institute-Chiba; *charlottebenedict3@gmail.com*

Phylogenetic relationships among the clownfish-hosting sea anemones reveals at least four independent origins of the symbiosis

The systematics and evolution of the ~30 described species of clownfishes have been heavily studied, the clownfish-hosting sea anemones are poorly represented in phylogenetic studies of sea anemones. Currently there are 10 morphologically described clownfish-hosting sea anemones within five genera. These include Entacmaea, Heteractis, Stichodactyla, Cryptodendrum, and Macrodactyla. Although the current anemone taxonomy suggests multiple independent evolutionary origins of symbiosis with clownfishes, no anemone phylogenetic dataset has included representatives of more than 5 taxa in a single analysis. Here we use broad biogeographic sampling and newly generated mtDNA and nuDNA datasets to investigate the phylogenetic placement of 9/10 clownfish hosts within Actinioidea. We test the hypothesis derived from the current taxonomy that symbiosis with fishes evolved independently across Actinioidea, and we also test the monophyly of each anemone genera. Our phylogenetic reconstruction confirms that symbiosis with fishes evolved independently across the Actinioidea. Our data suggest at least four independent evolutionary origins of symbiosis with clownfishes. We recover the genus Heteractis as paraphyletic while confirming the monophyly of Stichodactyla. While our dataset represents the most extensive investigation into the clownfish hosting sea anemones, many family-level relationships and below are poorly supported. Genomic markers with greater resolution will provide greater phylogenetic insight into anemones within the Actinioidea and the lineages symbiotic with clownfishes.

P1-219 BENESH, KC*; MAHON, AR; Central Michigan University; *benes1kc@cmich.edu*

Impact of Reduced Genomic Datasets on Population Genetic Analysis of SNP Data from the Invasive Grass Carp

Advances in sequencing technology have allowed for greater amounts of genomic data to be obtained from organisms at an increasingly more feasible cost. However, the amount of processing power and time required for analysis of this information has simultaneously increased. While utilization of whole genomes from even a limited number of individual for population studies is not yet feasible, reduced representation genomic scans are becoming more and more common. In this study, the impact of reduction schemes on population genomic analyses of a non-modal organism, grass carp (*Ctenopharyngodon idella*), is investigated. A high coverage single nucleotide polymorphism (SNP) dataset was generated using 2b-RAD sequencing. Genome scans were generated from a small number (n=23) of grass carp collected from Lake Erie. Reads were then used to construct a *de novo* reference sequence, which subsequently identified SNPs throughout the genome. To determine the population structure of grass carp, analyses including a Discriminant Analysis of Principal Components (DAPC) were performed. To investigate the effect that sequence read number has on determining population structure, the number of reads was reduced in a stepwise fashion and re-analyzed. A single putative population was resolved, and this was corroborated in all dataset reductions that we analyzed. Often specimen quality and/or quantity can limit the amount of genetic material available for analysis, such as in conservation studies or those involving invasive species that are expanding into new habitats. Understanding how reductions in datasets can impact the accuracy of inferences made about populations provides insight into the mechanics and statistics of reduction schemes on large genomic datasets.

P3-106 BENRABAA, S.A*; MYKLES, D.L; Colorado state univeristy; *saabmora@rams.colostate.edu*

Effect of blocking TGF /activin signaling on hemolymph ecdysteroid titers and expression of Halloween and ecdysteroid-responsive genes in the molting gland (Y-organ) of the blackback land crab, Gecarcinus lateralis

Molting is controlled by ecdysteroids synthesized and secreted by the molting gland, or Y-organ (YO). Halloween genes encode enzymes that catalyze the synthesis of ecdysteroid hormones. Ecdysteroid receptor *(EcR/RXR)* binds active molting hormone, which induces serial activation of ecdysteroid-responsive genes. During premolt, TGF /activin signaling mediates the transition of the YO from the activated to the committed state, as SB431542 blocks this transition. *G. lateralis* were eyestalk-ablated to induce molting and injected with vehicle (DMSO) or SB431542 at Day 0. In controls, ESA increased hemolymph ecdysteroid titers at 3, 7 and 14 days post-ESA. There were significant increases in the mRNA levels of *Gl-Nvd* at 7 and 14 days post-ESA and other Halloween genes (*Gl-Spo*, *Gl-Phm*, *Gl-Dib*,*Gl-Sad*), as well as *Gl-CYP18a1*, *Gl-ALAS*, *Gl-NADK*, *Gl-BR-C*, *Gl-EcR*, and *Gl-RXR*, at 14 days post-ESA. SB431542 reduced hemolymph ecdysteroid titers at 7 and 14 days post-ESA compared to control animals, but titers were no different from controls at 1, 3, and 5 days post-ESA, indicating that SB431542 had no effect on YO activation. SB431542 blocked the increases in RNA levels of *Gl-Nvd*, *Gl-Spo*, *Gl-Phm*,*Gl-Dib*,*Gl-Sad*, *Gl-CYP18a1*,*Gl-ALAS*, *Gl-NADK*,*Gl-BR-C*,*Gl-EcR*,and *Gl-RXR* by ESA. SB431542 had no effect on mRNA levels of the ecdysteroid-responsive genes *Gl-HR3*, *Gl-HR4*,*Gl-E74*,*Gl-E75* and *Gl-FTZ-F1*. These data suggest that an activin-like TGF factor stimulates YO ecdysteroidogenesis in the committed YO by up-regulating Halloween genes and the *Gl-BR-C* ecdysteroid-responsive gene. Supported by NSF (IOS-1257732).

P3-135 BERGSTROM, CA; Univ. of Alaska Southeast, Juneau; *cabergstrom@alaska.edu*

Are ecological consequences of whole-body asymmetry polymorphism similar in both derived and basal flatfish species?

The link between morphological variation and divergence in niche space partly depends on functional significance of the trait in question. Flatfishes (Order Pleuronectiformes) possess novel morphological variation in the form of whole body asymmetry not seen in other vertebrates. If and how this trait affects ecological diversity within the order is not well understood. Asymmetry direction varies among species and to date there is little known of how direction might impact the function, ecological niche, and adaptive landscape of these fishes. Only seven of >800 species of flatfishes are polymorphic for direction of body asymmetry. Two derived congenerics (*Platichthys stellatus*; *P. flesus*) exhibit geographically variable frequencies of left- and right-eyed morphs, and there is evidence of ecological segregation between them. Unlike the geographically variable and unequal frequencies of asymmetry morphs of these derived species, asymmetry morphs of *Psettodes erumei*, a member of the basal family Psettodidae, are reported to be equal in frequency and yet robust reports of this are rare in the literature. This raises the question: is asymmetry polymorphism being maintained by similar evolutionary mechanisms among flatfish species? Here I tested if, consistent with the derived *Platichthys* sp., sidedness is associated with niche divergence within the basal species *P. erumei*. Fish were collected from four localities in Taiwan, Thailand, and Malaysia. Photographs were analyzed for body shape variation, and trophic level was assessed with stomach contents and stable isotope analysis. The degree of divergence between morphs in the basal species *P. erumei* was compared to that within derived species, and insights into the evolutionary mechanisms responsible are discussed.

P3-30 BERLES, P*; HEYMANN, EW; NYAKATURA, JA; Humboldt Universität zu Berlin, Deutsches Primatenzentrum, Göttingen; *patricia.berles@hu-berlin.de*

Differential habitat utilization in two sympatric tamarins (Callitrichidae, Primates) in Amazonian Peru: Leaping behavior and Importance for morphological Studies

Different sympatric species of tamarins in Amazonian Peru form mixed-species groups during daily forages in the rain forest. These closely-related species have previously been documented to exhibit differences in foraging height and locomotor activity which may also be reflected in their postcranial morphology. To further investigate this system, we quantified habitat utilization with a focus on leaping behavior in free-ranging *Saguinus mystax* and *Leontocebus nigrifrons* . The aim of the work was to determine the relationship of leaping behavior with habitat use and how this is determined by the properties of the habitat. We collected data on the leaping behavior, support properties, and foraging height of the monkeys during a 5-month field study in the Amazonian in northeastern Peru at the Estación Biológica Quebrada Blanco. Our results showed that *S. mystax* spends significantly more time in the upper forest strata and uses the predominant supports at a noticeably higher rate than *L. nigrifrons* . In contrast, *L. nigrifrons* is predominantly active in the lower forest strata and accordingly exhibits a high number of trunk-to-trunk leaps. However, both species preferred their predominant leaping behavior even if the respective supports were not abundant in a specific forest layer. We hypothesize that these observed behavioral differences also involve differential functional demands caused by kinematic and dynamic differences in horizontal and vertical leaps, respectively. Based on these findings morphological differences in muscle architecture, bone shape, and bone structure can be expected and will be traced down in ongoing analyses.

P1-122 BERSIN, TV*; CORDOVA, KL; JOURNEY, ML; BECKMAN, BR; LEMA, SC; Cal Poly, San Luis Obispo, NOAA Fisheries, NOAA Fisheries; *tbersin@calpoly.edu*

Effects of nutritional stress on the sensitivity of liver IGF-1 production to GH in a Pacific rockfish

The growth hormone (GH) / insulin-like growth factor-1 (IGF-1) axis regulates somatic growth in vertebrates by activating growth-promoting pathways in almost all tissues. Nutritional stress in the form of reduced food quantity or quality has been shown to inhibit growth in part by blocking GH induction of hepatic IGF-1 production, but the mechanism(s) of that inhibition are not well understood. Here, we examined how food deprivation (fasting) affected GH induction of liver IGF-1 production in juvenile gopher rockfish, *Sebastes carnatus*. Rockfish were maintained under conditions of either feeding (9% mass fed per g fish mass) or fasting for 14 d, and then injected intraperitoneally with recombinant seabream GH (2 µg per 1 g mass) or saline control. Liver IGF-1 mRNA levels were generally lower in fasted fish than in fed fish, and GH upregulated hepatic IGF-1 mRNAs 2.2-fold in fed fish, but only 1.4-fold in fasted fish. Liver mRNA levels for two proteins that mediate downstream effects of GH in the liver, janus kinase 2 (JAK2) and signal transducer and activator of transcription 5 (STAT5), did not vary with fasting or GH treatment. However, transcripts encoding hepatocyte nuclear factor-3 (HNF3), a transcription factor linked to IGF-1 expression, were at higher abundance both in fed fish and in fish receiving GH. Transcripts encoding IGF binding protein acid labile subunit (IGFALS), which enables IGF-1 interactions with IGF binding proteins, were unaffected by fasting, but increased in both fed and fasted fish treated with GH. These findings point to the downregulation of distinct pathways involving HNF3&beta and IGFALS as possible contributors inhibiting liver IGF-1 production under conditions of nutritional stress.

P2-174 BERTUCCI, EM*; MASON, MW; RHODES, OE; PARROTT, BB; Univ. of Georgia; *emily.bertucci@uga.edu*

Effects of low dose irradiation on the global DNA methylome in medaka (Oryzias latipes)

Ionizing radiation (IR) is a ubiquitous environmental stressor under which all life evolved. Further, radiological accidents at Chernobyl and Fukushima along with occupational and biomedical exposures are sources of IR that humans and wildlife must contend with. Historically, studies on the impacts of radiation have primarily focused on mutagenic effects and responses to acute doses of radiation, thus, adaptive organismal responses to environmentally relevant exposures are not well understood. Epigenetic mechanisms are capable of mediating organismal responses to environmental factors and DNA methylation plays important roles in gene regulation and promoting chromosomal stability. Further, although evidence is limited, studies suggest that variation in the DNA methylome might be heritable across generations. Here, we analyze changes to the DNA methylome due to low dose rate exposures in medaka (*Oryzias latipes*). We hypothesized that low, chronic doses of IR would result in global shifts in the DNA methylome. To test this, medaka were exposed in a replicated mesocosm array to environmentally relevant dose regimes (2, 20, or 200 mGy/day) and were subsampled at three- and six-months. In addition, following a six-month exposure, a subset of fish were allowed a three-month recovery period and were bred to produce an F1 generation. Global DNA methylation was quantified in hepatic tissues across all doses at all time points. Whereas gonadal regression was observed in fish exposed to the highest dose rates, a significant effect of dose on global DNA methylation was not detected. Findings suggest that phenotypic impacts of IR were not mediated by global shifts in the DNA methylome in our study.

P2-128 BILYK, KT*; CHENG, CH-C; Western Kentucky University, University of Illinois at Urbana Champaign; *kevin.bilyk@wku.edu*

Evolutionary Impacts of Chronic Cold on the Antarctic Notothenioid Chaperome and its Regulatory Mechanisms

Antarctic notothenioid fishes show a variety of extraordinary physiological gains and losses driven by their evolution in the chronic cold waters of the Southern Ocean. Both these gains and losses are mirrored in the chaperome, where impacts are found both in expression at native temperatures as well as its capacity to reorganize expression in response to heat stress. While past work has suggested that greater native expression of some molecular chaperones coexists with the extraordinary loss of the Heat Shock Response (HSR), a clear understanding is lacking in the nature and extent of changes across the diverse families of molecular chaperones, and within the regulatory framework controlling their expression during periods of cellular stress. Using the basal temperate notothenioid Eleginops maclovinus as the reference ancestral notothenioid state, we found widespread increases in native expression of chaperome and key proteostasis genes in the Antarctic species Pagothenia borchgrevinki and Chionodraco rastrospinosus. However, these increases are generally small the sole exception is one ancestrally inducible member of the HSP70 gene family, which interestingly correlates with the insertion of a transposon into the gene's 5'UTR intron. In both known copies of ancestrally-inducible HSP70 genes, canonical Heat Shock Element motifs are conserved in the proximal upstream sequence, suggesting defects leading to HSR loss reside elsewhere. Investigation of the coding sequence for the transcription factor HSF1, central in the HSR, showed that modifications among the two Antarctic species were concentrated in the regulatory and transactivation regions of the gene suggesting HSR loss may lie at the level of HSF1 activation of the cascade.

P3-54 BIONDI, AA*; BEMIS, KE; CRAWFORD, CH; FLAMMANG, BE; New Jersey Institute of Technology, Virginia Institute of Marine Science; *aab53@njit.edu*
Mola mola Mismatched Muscle Mechanics
Mola mola (Ocean Sunfish) fish are recognizable by their distinct morphological characteristics, including large lobate dorsal and anal fins which fuse in place of a non-existent caudal fin. *Mola mola* swim using synchronous flapping of the dorsal and anal fins, which generates lift-based thrust similar to the swimming of penguins and manta rays. The Ocean Sunfish is able to dive to depths of 600 meters and cruise at a speed of 3.2 km/h. Recent work on *M. mola* anatomy shows extremely disproportionately sized muscles inserting into the relatively equal aspect ratio dorsal and anal fins. This raises the question: how do *Mola* generate equal forces through synchronous flapping if the muscle mass powering the dorsal fin is nearly twice that of the anal fin? To elucidate the locomotor biomechanics of this large species, we microCT scanned two *M. mola* specimens and dissected two *M. mola* to measure muscle mass, muscle fiber angles, and physiological cross-sectional area (PCSA) to estimate maximum force production. Here, we present the results of our myological investigation and our biomechanical model explaining locomotor force generation in *M. mola*. This work will directly inform the design and actuation of our bioinspired Molabot, which we will use to empirically test the relationship between fin muscle force production and swimming thrust in these unique swimmers.

P1-13 BIRD, NC; Univ. of Northern Iowa; *nathan.bird@uni.edu*
The Ever-Evolving Comparative Vertebrate Anatomy Final Project: An Alternative to Comprehensive Lecture Finals
Classic methods of assessing comprehensive knowledge in courses such as Comparative Vertebrate Anatomy usually entail a cumulative final exam, where all information presented during the semester is fair game. This can have several drawbacks for many students, due to the considerable length of time that has passed since the first few lectures, and the anxiety that comes with a high-stakes final. In many cases, such an exam tests the student's ability to memorize, rather than learning and mastery of content. Over the past several years, I have experimented with an alternative to the final exam, centered on a "Make Your Own Species Project" concept. This project utilizes inquiry-based learning in a student-centered learning setting. Students either choose or are assigned a current living vertebrate, and must research the anatomy of this species to set the ancestral morphology. Students then imagine a descendent species 100 million years in the future possessing different locomotion, diet, and size relative to their ancestral species. From there, the students have control of what exact changes are made, and how to make it all work, accounting for function and evolutionary process along the way. To encourage students to think outside the box, a single 'novelty' is allowed, which is exempted from the evolutionary rule requirement. In this way, students must continually refer back to previous anatomical systems to ensure changes in one system don't require necessary changes in a previous system, encouraging a deeper understanding of how the vertebrate body is integrated across multiple systems. In the past, students have sketched their creations or paired with a student from the arts. Currently, students are utilizing Micro-CT and 3D printing to create their new species and bring them to life.

P2-137 BIRCH, S*; PLACHETZKI, D; University of New Hampshire, Durham , University of New Hampshire, Durham; *sjb1061@wildcats.unh.edu*
The Genomic Characterization of Larval Settlement in the Biofouling Invertebrate Ectopleura larynx
The hydroid *Ectopleura larynx* has an indirect lifecycle that produces a dispersive larval stage called actinula. Actinulae larvae select the substrate upon which they settle by integrating sensory cues from the environment. Previous research has investigated the settlement biology of actinulae larvae, however, to date, no study has combined sensory behavior experiments with molecular genetics. Here we examine the molecular genetics underlying the behavioral response to environmental cues during settlement of actinula larva. We hypothesize that that light and biofilm-derived chemical cues are detected by cnidarian opsin and T1R taste receptors respectively and that these genes will be differentially expressed in sensory neurons as actinula development proceeds to settlement. We test these hypotheses using RNAseq on various stages of actinula development through settlement and combine these data with behavioral experiments that examine the effects of light intensity, wavelength and biofilm-derived chemical cues on the propensity to settle. In addition to behavioral experiments, we incorporate confocal imaging of actinula larva at various stages. We integrate these data to shed light on the interplay between behavior, genetics, and the sensory environment in the settlement of the actinula larva of *Ectopleura*.

P3-179 BITTENCOURT, JB*; ARMFIELD, BA; STANLEY, EL; COHN, MJ; University of Florida; *juliabitt@ufl.edu*
Nanoscale Computed Tomography (NanoCT) Analysis of Lower Genitourinary Tract Development
Congenital malformations in the genitourinary system occur at a high frequency, yet our understanding of the molecular development of the lower urinary tract lags significantly behind other systems. As an example, hypospadias, a condition in which the urethral opening of the penis is on the underside rather than at the distal tip, occurs in approximately one out of every 120 live male births, yet the developmental etiologies remain unknown. To better understand the morphological and molecular changes that occur to the lower urogenital tract during development we are working on the Genitourinary Development Molecular Anatomy Project (GUDMAP, www.gudmap.org). GUDMAP is a NIDDK U01 consortium of laboratories that provides the research and clinical communities with tools to facilitate genitourinary research. Our lab has combined non-invasive imaging using nanoCT scans with histological and molecular methods for analyzing morphological changes throughout embryonic development in both male and female genitourinary tracts. NanoCT scanning acts as a nondestructive method of high resolution, three-dimensional analysis of genitourinary organ development that will inform our understanding of normal organ formation and will enable the identification of abnormal developmental processes in congenital disorders and deformities in future research.

P1-147 BLENDERMAN, J P*; GUMM, J M; Stephen F. Austin State University, Stephen F. Austin State University; U.S. Fish and Wildlife, Ash Meadows Fish Conservation Facility; *jblenderman@outlook.com*

Personality in the Mantis Shrimp Neogonodactylus oerstedii

Animal personality is frequently defined as the existence of consistent behavioral differences between individuals. A well-studied personality trait is boldness/shyness, with bolder individuals being more willing to engage in risky behaviors. This is often measured through foraging, predation, and startle tests. A growing number of studies suggest the presence of personality among invertebrates, including crustaceans. Different personality types can have differential fitness based on environmental conditions such as predation rates and food availability, and thus, are predicted to coexist when conditions are variable. Mantis shrimps (order Stomatopoda) have a versatile repertoire of behaviors used in shelter defense, foraging, and aggression, providing an ideal system in which to study behavioral variation between individuals. This study investigated individual differences in behaviors that may be associated with boldness in the mantis shrimp Neogonodactylus oerstedii. Three assays were carried out to measure behaviors related to boldness: (1) exploration of a novel area containing an unoccupied shelter; (2) reaction to a startling event, and latency to resume foraging afterward; and (3) response to an invasive novel object. To test for individual consistency, individuals were tested twice in each assay, with no less than 14 days between an individual's first and second trials. Analyses presented will establish 1) if individuals are different from each other, 2) if individuals are consistent in their behavioral profiles, and 3) if there are correlations between behaviors. If these conditions are met, it will indicate the presence of personality in this species.

P1-173 BOCKRATH, RE*; MARSHALL, CA; GHALAMBOR, CK; Colorado State University; *rachbock@rams.colostate.edu*

The effect of salinity on heterospecific and conspecific aggression in two closely related guppy species, Poecilia reticulata and Poecilia picta.

Behavioral dominance in the form of heterospecific and conspecific aggression between species is thought to be an important ecological process shaping the abundance and distribution of organisms, but few studies have examined how such interactions change across different contexts. *Poecilia reticulata* and *Poecilia picta* are closely related fish species that can tolerate a wide range of salinities, but on the island of Trinidad, *P. reticulata* is confined to freshwater habitats whereas *P. picta* is found in freshwater and brackish water. Here we investigated whether changes in behavioral dominance (measured as aggression) could explain why *P. reticulata* is excluded from brackish water. Levels of aggression were compared within species across two different salinities - their home salinity where they are kept, and the away salinity of 15 ppt. We find no evidence that *P. picta* is behaviorally dominant to *P. reticulata* in brackish water. Instead we observed significant individual level variation, where some individuals were consistently aggressive across different salinities independent of whether they were interacting with hetero- or conspecifics. Such results suggest individual personalities play a bigger role in aggressive interactions compared to species differences.

P2-178 BOGANTES, V.E.*; LI, Y.; HALANYCH, K.M.; Auburn University, Auburn University; Yale University; *veb0007@auburn.edu*

Amino acid synthesis facilitates host-symbiont interactions in Lamellibrachia luymesi (Siboglinidae, Annelida)

The siboglinid *Lamellibrachia luymesi* van der Land and Nørrevang 1975 is a tubeworm found on cold seeps in the Gulf of Mexico. Like other siboglinids, *L. luymesi* lacks a digestive system and relies on chemoautotrophic sulfide-oxidizing bacterial endosymbionts for nutrition. Phylogenetic studies show that symbiont lineages are specific to major groups of siboglinids, implying some degree of adaptation by the holobiont to different habitats and resources. Despite previous studies, the dependence and metabolic contributions between the host and symbiont are still poorly understood. A recent study on the hydrothermal vent mussel *Bathymodiolus azoricus* analyzed the amino acid biosynthesis pathway in the mollusk and its bacteria endosymbiont, and found that most of the genes required for the production of amino acids were absent in the host but present in the endosymbiont, suggesting that the symbionts are capable of providing all the required amino acids to the host. Similarly, we hypothesize that *L. luymesi* endosymbionts supply most of the amino acids required by the host. To address this issue, we have sequenced the genomes of *L. luymesi* and its endosymbiont. A "blastp"- based bioinformatic pipeline was used to identify amino acid biosynthesis related genes. Preliminary results show that 95% (73 out of 75) of the genes associated with amino acid biosynthesis were found in the endosymbiont, while only 13% were found in the host. Interestingly, this study suggests evolutionary convergence in the biosynthesis of amino acids between two very different organisms.

P1-283 BOGGS, TE*; POWERS, AK; GROSS, JB; University of Cincinnati; *boggste@mail.uc.edu*

Canal Neuromasts Influence the Development and Position of Suborbital Bones in the Blind Mexican Cavefish, Astyanax mexicanus

The lateral line is a crucial sensory system present in many aquatic vertebrates. This sense enables organisms to detect local changes in water flow and pressure which is vital for predator evasion, prey capture and other social or environmental interactions. This system is substantially expanded in *Astyanax* cavefish compared to closely-related surface-dwelling forms, suggesting this non-visual sensory system is under strong selection in cave forms. Additionally, cave forms also harbor multiple abnormalities in their skulls, specifically in the suborbital (SO) bone complex. Owing to the vicinity of lateral line sensory organs (neuromasts) to the SO bones which underlie them, we explored if there was a developmental interaction between this system and facial bones. We utilized two live fluorescent stains to visualize the lateral line system, and developing bones, to produce a comprehensive longitudinal analysis of bone/neuromast growth within individuals. We discovered that dermal SO bones initiated ossification at the position of specific canal neuromasts. Interestingly, abnormalities in the lateral line led to abnormalities in the SO series. For instance, adjacent bones of the SO series in cavefish frequently fused together. In these cases, the distance between canal neuromasts was significantly shorter than in cases where bony fusion did not occur. We also observed that in certain cavefish individuals, the sixth bone of the SO series was entirely absent. This was only observed when the normally associated canal neuromast was also absent. This work suggests that canal neuromasts provide a fundamental "pre-pattern" for the position of SO bones in vertebrates. Aberrations to this pattern explain multiple abnormalities in the craniofacial complex of an obligate cave-dwelling animal.

P1-103 BONKA, A*; WIBBELS, T; NAVARRO, E; MONTANO, J; ROSAS, M; MARIN, G; ACOSTA, H; LOPEZ, M; PENA, LJ; BURCHFIELD, P; ILLESCAS, F; Univ. of Alabama at Birmingham, Gladys Porter Zoo, Brownsville, TX, Gladys Porter Zoo, Brownsville, TX, CONANP, Ciudad Victoria, Tamaulipas, MX, CDEN, Ciudad Madero, Tamaulipas, MX ; *abonka@uab.edu*

Quantifying Arribada Nesting Behavior Using Unmanned Aerial Vehicles (UAVs)

The Kemp's ridley sea turtle (*Lepidochelys kempii*) neared extinction in the 1980s, however due to intense conservation efforts the population has begun to rebound. This rebound has included increasing size of mass nesting events (i.e. arribadas). As the size of the arribadas grows, it is important to understand the dynamics of these mass nesting events. The dynamics of these mass nesting events have implications for the biology and conservation of this species. In the current study commercially available UAVs were used to document the dynamics of a relatively large-scale arribada during the 2018 nesting season at Rancho Nuevo. Two quadcopter UAVs (DJI Phantom 3 Pro, DJI Phantom 4 Pro) were used to survey an arribada nesting area during May 2018. Both quadcopters had 4k video capabilities that recorded to an SD card. The UAVs were flown using the Litchi flight app on an iPad Mini 4 tablet. Videos was analyzed to quantify nesting dynamics during different time periods of the arribada. The results show the utility of using UAVs for documenting the magnitude and dynamics of relatively large-scale arribadas. This research was conducted as part of the ongoing Kemp's Ridley Bi-National Conservation Program.

P2-246 BOTTON-DIVET, L*; HOUSSAYE, A; HERREL, A; FABRE, AC; CORNETTE, R; Humboldt Universität zu Berlin, Museum National d'Histoire Naturelle Paris, Natural History Museum London; *leo.botton-divet@mnhn.fr*

Integration Across the Mustelids' Locomotor Apparatus (Carnivora: Mustelidae)

The locomotor apparatus is, as is the whole organism, an integrated structure. The co-variation of its parts is regulated. In this context, evolutionary response to a functional demand on a part is limited by the functional demands on the other parts. The integration pattern itself may, however, evolve to allow differential changes in its parts. Specialization of pair of limbs to locomotion in a particular environment should induce a reduction of the overall integration while maintaining a strong integration within the limb itself. We investigated changes in the long bone co-variation pattern in mustelids belonging to four different locomotor ecologies (terrestrial, semi-arboreal, semi-fossorial, and semi-aquatic). Despite the differences in locomotor ecology, mustelids show a strong integration and changes in the co-variation patterns are scaling with the between-species divergence time, with the exception of the (*Mustela putorius, M. eversmanni, M. lutreola*) clade where changes in the co-variation pattern increased strongly in a short amount of time. Allometries have only a low impact on the pattern. The co-variation patterns differ between locomotor ecologies, but few of these variations match the hypothesis of a reduction of integration due to functional specialization. As the definition of the functional modules found in literature comes from the study of terrestrial locomotion, we suggest that future studies on the functional modules during locomotion in other environments might shed a new light on the results of this study.

P2-136 BOUCHARD, SS*; BRODERICK, GA; KIMBERLY, EC; Otterbein University; *sbouchard@otterbein.edu*

Competition and predation induce changes in metabolic rate and organ size in red-eyed treefrog larvae

Amphibian larvae exhibit a high amount of developmental plasticity in response to variable environments. In this study, we examined the effects of competition and predation threat on metabolism and organ size plasticity in red-eyed treefrogs (*Agalychnis callidryas*). Larvae were reared at high and low density in 30 L outdoor tanks at the edge of the rainforest (N = 14 tanks per density) at the Smithsonian Tropical Research Institute in Gamboa, Panama. Half of tanks within each density (N = 7) contained a caged *Belostomatid* predator and half did not (N = 7). Each predator was fed *A. callidryas* hatchlings daily to facilitate the release of kairomones into the tanks. There were significant negative effects of both density and predation on larval growth. The metabolic rates of larvae reared at low density were twice as high as those reared at high density. These metabolic rates were associated with significantly heavier livers, pancreases and brains. There was also a much smaller, yet significant, negative effect of predation on metabolic rate. Predation also induced slightly heavier brains, but had no effect on liver or pancreas size. Differences in metabolic rate may be attributed to organ size plasticity. Additional analyses will include more detailed measurements of brain anatomy and tail morphology.

P1-259 BOWEN, V; MCMAHON, T/A; BROSNAN, E/B; NORDHEIM, C/L; FERNANDEZ-DENMARK, S*; GRIM, J/M; University of Tampa; *jgrim@ut.edu*

Tissue-specific changes in catalase activity of amphibian hosts during the time course of chytridiomycosis

Chytrid fungus (*Batrachochytrium dendrobatidis*) is globally decimating amphibian populations by disrupting the long-term electrolyte transport gradient of skin tissue, thus hindering osmotic regulation and leading to cardiac arrest. Short term, livers of infected amphibian hosts show changes in gene expression just six days after fungal infection, yet it remains unclear how these changes influence the levels of pro- and anti-oxidant processes in these organisms. The present study utilized controlled, long term (6 week) laboratory infections of Cuban treefrogs (*Osteopilus septentrionalis*) with chytrid fungus in order to explore changes in enzymatic antioxidants and general measures of immune system robustness. We quantified the activity levels of catalase (CAT), a key antioxidant enzyme, in skeletal muscle and liver and used histological techniques to assess changes in densities of immune cells in spleen and liver. CAT activity generally decreased in skeletal muscle, but was increased in liver just 8 days into the six-week infection and remained elevated throughout. Further, granulocyte densities decreased in spleen, revealing a potential loss of overall immune system health following six weeks of infection. Together these preliminary data indicate that infection of amphibians with chytrid fungus results in physiological consequences that are tissue-specific, and also reveal that the activity of CAT is affected relatively quickly after initial exposure.

P3-64 BOYNTON, AM*; CARRIER, DR; University of Utah, Salt Lake City; *boynton.alicia@gmail.com*

The locomotor function of cervical muscles in humans

The locomotor function of the neck muscles of humans is not understood. We hypothesized three possible roles: 1) stabilization of the head on the trunk; 2) stabilization of the neck against moments imposed by extrinsic arm muscles, and 3) stabilization of the trunk against torques imposed by extrinsic leg muscles. To examine these hypotheses, we measured activity of several cervical muscles with surface EMG and analyzed changes in activity in response to manipulations of the locomotor forces as subjects ran on a treadmill. To access the postural role of the cervical muscles during running we increased the mass of head by 20%. To address the impact of moments imposed on the neck by swinging of the arms, subjects held their arms at their sides as they ran. To determine the extent by which cervical muscles help stabilize the trunk against moments imposed on the pelvis, we applied forward-, rearward-, and vertically-directed forces to the subject's pelvis with elastic tethers. Muscle activity recorded during manipulation trials was compared to activity recorded during unencumbered running at the same speed. We found no significant change in muscle activity when subjects ran with added head mass or with limited arm swing. Activity increased in the cervical strap muscles when subjects ran with increased forward-directed forces (requiring elevated leg protraction moments) and increased rearward-directed forces (requiring elevated leg retraction moments). Running with added rearward force also resulted in elevated activity of the semispinalis, levator scapulae, and rectus abdominis. These results are consistent with the suggestion that the primary function of the cervical muscles during human running is to help stabilize the trunk against the moments imposed on the pelvis by extrinsic muscles of the legs.

P3-93 BRALLEY, JP*; CORY, W; WELCH, AM; College of Charleston; *bralleyjp@g.cofc.edu*

Behavioral Effects of Fluoxetine and Sertraline and their Photodegradants on Southern Toad (Anaxyrus terrestris) Tadpoles

Pharmaceutical pollution is an emerging environmental concern, with a variety of mediations appearing in surface waters around the world. In the environment, exposure to UV radiation can transform these compounds into related molecules, which can be more toxic than the original compound. Despite increased attention to the effects of pharmaceutical pollution on aquatic life, very little is known about the ecotoxicology of pharmaceutical transformation products. Antidepressants, including the widely-prescribed selective serotonin reuptake inhibitors fluoxetine (Prozac) and sertraline (Zoloft), have been regularly detected in the environment and have been shown to cause a variety of behavioral changes in organisms ranging from mollusks to fish to tadpoles. We investigated the effects of these compounds and their UV-phototransformation products on the behavior of amphibian larvae, which are particularly vulnerable to aquatic pollution due to their permeable skin. Southern toad tadpoles were exposed to solutions of fluoxetine and sertraline, with or without phototransformation, and behavioral assays were conducted to examine startle response, aggregation behavior, and refuge use. These behaviors are relevant to sertraline's mode of action, similar to behavioral changes observed in other organisms exposed to similar antidepressants, and potentially important to tadpoles' vulnerability to predation. The results of this research will help us better evaluate the level of risk posed by these antidepressants in the aquatic environment.

P3-76 BRANDFON, SH*; CIRINO, LA; MILLER, CW; University of Florida ; *sbrandfon@ufl.edu*

The effect of juvenile and adult diet on female fecundity and longevity

Environments change seasonally and so do the resources that are provided to herbivores. Prickly pear cactus is a seasonal plant that has unripe fruit (suboptimal) in the spring and ripe fruit (optimal) in the fall. Thus, leaf-footed cactus bugs, *Narnia femorata*, that feed on this plant are subjected to varying nutrition throughout the year. The objective of this study is to understand how separate and combined juvenile and adult natural diets effect the longevity and fecundity of *N. femorata*. Juveniles were placed on either suboptimal or optimal diets. Adult females in the suboptimal group were then split into suboptimal or optimal diets. *N. femorata* were observed every day for feeding and egg laying for 84 days. Preliminary results suggest that females on adult diets are the most fecund and live the longest. Females on suboptimal diets are the least fecund. Females that were switched from a suboptimal to an optimal diet were able to reproductively recover and lay more eggs than the fully suboptimal diet group. This study suggests that animals that have suffered from suboptimal diets as juveniles, will be able to partially recover with an optimal diet in adulthood.

P3-125 BRANDT, E.E.*; KAMATH, A; ELIAS, D.O.; University of California, Berkeley, Department of ESPM; *eebrandt@berkeley.edu*

Thermal Ecology in Miniature: Microhabitat Usage in the Context of Physiological and Behavioral Performance in a Spider

Temperature can have wide-ranging and dramatic effects on ectothermic animals. These effects span levels of biological organization, from metabolism to interspecific interactions. As deserts have temperatures that can vary widely across temporal and spatial scales, animals living in them particularly interesting to examine in this context. However, there is a gap in knowledge in understanding how thermal microhabitats vary at the scale of the animal in question. These studies are especially lacking among small animals. In this study, we used a focal observation paradigm to investigate activity budgets, substrate use, and sex-specific differences in relevant thermal microhabitats in the jumping spider *Habronattus clypeatus*. We are beginning to gain a nuanced understanding of how temperature influences sexual behavior in this system, so it is especially suited to such field-based studies. We combine field data with lab experiments to explore physiological thermal limits, thermal performance data, and thermal preferences to understand the interplay between these animals' physiological limits, preferences and the environment that they actually experience. We compare behavior, substrate use, and thermal microhabitat use between sexes and life stages, and suggest ways in which thermal microhabitat use in particular may interact with sexual behavior in this species. We suggest that variation in these aspects of thermal ecology could lead to profound downstream effects on behavior, survival, and even species persistence over time.

P1-236 BRÜCKNER, A; Caltech; *bruckner@caltech.edu*
Using Weapons Instead of Perfume? - How the Myrmecophilus Bug Pamillia behrensii (Miridae) Gets Along With its Host Ant
In and around ant nests such called 'myrmecophilous' animals try to overcome their hosts defense. For those who succeed, the companionship with their host guarantees powerful protection and access to food. As ant defensive behavior is mainly mediated by chemicals - for instance species specific cuticular hydrocarbons (CHCs) or alarm pheromones - ant-associated parasites can either crack their hots chemical code by modifying their own CHC-profiles or use pro-active strategies like chemical weaponry for distraction and repellency. While the chemistry of many ant-parasite interactions has been detailed recently, the chemical mediators of the rare association of ants and ant-resembling Heteropterans are mostly unknown. That is why I studied the mirid bug *Pamillia behrensii* which has been reported to live associated with velvety tree ants (*Liometopum occidentale*) an ecologically dominant and aggressive ant species native to the Southwest. More specifically I used behavioral, chemical and molecular approaches to disentangle the relationship of *P. behrensii* and its host ant. Chemical profiling of cuticular hydrocarbons of both bugs and ants revealed no chemical mimicry, yet additional GC/MS analysis of volatile compounds of the bugs metathoracic glands as well as feeding trials with armed and artificially disarmed bugs showed a defensive function of the gland exudates. Further field observations and first molecular evidence suggest that *P. behrensii* might be a Batesian mimic. In summary, the bugs mainly live loosely associated directly next to ant nests and are regularly aggressed by ants (CHC mismatch). Yet, bugs usually survive and escape these attacks by releasing their defensive chemical as repellents against (host) ants. Hence, the use of chemical weaponry rather than a chemical code-cracking perfume enables *P. behrensii* to get along and live close by its host ant.

P2-266 BRIGGS-HALE, JM*; ROOT, ZD; MEDEIROS, DM; Univ. of Colorado, Boulder; *julia.briggshale@colorado.edu*
The Evolution of Jaw Joint Precursors in a Jawless Vertebrate
Jaws are an evolutionary innovation found in the majority of vertebrates (gnathostomes) which facilitate the capture of prey. One of its key features is a central jaw joint that allows the articulation of its rigid skeleton, yet we are uncertain as to the origins of this joint. To address jaw joint evolution, we investigated the skeletal development of an early diverging jawless vertebrate, the sea lamprey *Petromyzon marinus*. During their larval stage, their skeleton contains tissue known as mucocartilage that shares morphological and genetic features with the jaw joint. We asked whether mucocartilage may be homologous with joint tissue in gnathostomes by investigating genes in sea lamprey that are related to joint development. To do this, we conducted *in situ* hybridizations on embryos for three genes of interest (BarxA, TrpsA, and GDF5/6/7b). We also performed alcian stains to visualize skeletal development. To assess the function of these genes, we used CRISPR-cas9 mutagenesis to assess differences in gene expression and cartilage development in mutants. Our *in situ* hybridizations show expression of BarxA and TrpsA in both mucocartilage and rigid skeleton, contrasting their more exclusive gnathostome orthologues. These results were reinforced in TrpsA and BarX mutants, which show global loss of cartilage. GDF5/6/7b is expressed early in the anterior head and ventral pharynx, coinciding with future sites of mucocartilage. However, GDF5/6/7b mutants show only a slight loss of these tissues and loss of expression of TrpsA. Our results suggest that genes involved in the vertebrate jaw joint were co-opted from more generalized roles in skeletal development. We discuss how mucocartilage may not be as homogenous as previously thought and how this may shape our understanding of the jaw joint.

P3-130 BREITENBACH, AT*; CARTER, AW; PAITZ, RT; BOWDEN, RM; Illinois St U, U Tennessee; *atbreit@ilstu.edu*
Heat Wave Timing, Continuity, and Length Affect Temperature-dependent Sex Determination in a Freshwater Turtle
Climate change has the potential to threaten thermally sensitive species, such as reptiles with temperature-dependent sex determination (TSD), if heat waves increase in frequency and length as predicted. In species with TSD, temperature affects sex determination most acutely during the thermosensitive period (TSP), which falls in the middle third of development as defined by constant temperature studies. Presently, we know little about how the timing during development or continuity of heat waves affects sex determination. We hypothesized that exposure to daily fluctuations of 25±3°C (which produce all males) and heat waves of 29.5±3°C that varied in either timing during development or continuity (in progress) would affect resulting sex ratios in *Trachemys scripta*. Exposure to a 15-day heat wave early or late in development did not significantly affect sex ratios (all less than 10% female), but heat waves occurring between days 24 and 45 resulted in an average sex ratio of 80% female. Further, the observed TSP was shorter than the TSP defined by constant temperature studies. We also quantified *Dmrt* and *aromatase* expression following 6, 9, 12, and 16 days of heat wave exposure to determine how heat waves affect gene expression. *Aromatase* expression was significantly up-regulated after 12- and 16-day heat waves, while *Dmrt1* expression did not significantly change over the course of the heat wave. These results clarify the timing and length of the TSP and provide information on the timing of up-regulation of *aromatase* expression under fluctuating, heat wave conditions. Further, these data provide detailed insight into the physiological effects of climate change, in the form of heat waves, on species with TSD.

P2-159 BRINKLEY, DM*; RIVERA, HE; TARRANT, AM; Amherst College, Woods Hole Oceanographic Inst.; *atarrant@whoi.edu*
Thermal Acclimation in the Anemone Nematostella vectensis
Fundamental to the survival of animals in temperate climates is the ability to acclimate to temperature changes. The metabolic thermal response is relatively well-characterized, and reversible cellular mechanisms of acclimation can be broadly distributed into two categories: changes in mitochondrial density, the size and number of mitochondria in a cell; and changes in mitochondrial efficiency, a variety of factors affecting the ATP production rate of individual mitochondria. Both strategies facilitate thermal acclimation, yet few studies have investigated their timing. How long does the acclimation process take? How do mitochondrial efficiency and density interplay to produce a response over time? These are the questions that we chose to investigate within *Nematostella vectensis*, a small, salt marsh-dwelling anemone that experiences seasonal variation of ≥35˚C. We transitioned animals from 18˚C to six temperatures between 6 and 33˚C and, weekly, assayed two physiological responses: oxygen consumption of individual animals, indicative of the extent of acclimation; and citrate synthase (CS) activity, a standard proxy for mitochondrial density. We hypothesized that animals would acclimate first by altering their mitochondrial efficiency and later by adjusting mitochondrial density. Over six weeks, we found that respiration rates diverge significantly between temperature groups as early as the second week ($p < 0.05$). In the same animals, however, CS activity does not significantly change. This suggests that, though *Nematostella* do acclimate, mitochondrial density does not play a role in their initial acclimation response. Whether they regulate mitochondrial density on longer time scales remains an open question.

P2-56 BRINKMAN, BE*; NGWENYA, A; FJORDBOTTEN, KM; STEPHEN, O; KOLB, B; IWANIUK, AN; Univ. of Lethbrige, Alberta, Rhodes Univ., South Africa; *Ben.brinkman@uleth.ca*

Hippocampal Neuronal Morphology and Spine Density Vary With Sex and Season in Richardson's Ground Squirrel (Urocitellus Richardsonii)

Brain anatomy is not static throughout the lifetime of an individual; both sex and reproductive status can alter the anatomy of brain regions and neurons within them. However, the extent to which sex and season affect neuron size and morphology in wild mammals is poorly understood. Richardson's ground squirrel exhibits seasonal variation and sex differences in behavior and seasonal neuroplasticity in brain region volumes, but whether that variation extends to neuron morphology was unknown. Using virtual microscopy, we imaged Golgi stained hippocampal pyramidal neurons from wild male and female ground squirrels caught during breeding and non-breeding seasons. From these images, we measured neuronal morphology and dendritic spine density of over 130 neurons. Within the CA1 region, females had larger cell bodies than males and non-breeding females had longer basal dendrites than breeding females. Dendritic spine density of basal and apical dendrites of CA1 neurons was also higher in non-breeding than breeding animals of both sexes. Within CA3, non-breeding males had larger neuronal volumes than breeding males and non-breeding animals of both sexes had higher basal spine densities than breeding animals. The seasonal differences likely reflect synaptic pruning during hibernation combined with high cortisol levels in the breeding season and parallels a similar pattern in hippocampal neurogenesis. The larger CA3 neurons with more spines in non-breeding males might also support food caching, a male-specific behavior in this species. We conclude that sex and season do interact to affect neuron morphology in ground squirrels, but that these effects are likely to vary across mammalian species.

P1-96 BRISTOW, M.L.*; GABOR, C.R.; HUERTAS, M.; Texas State University; *mlb325@txstate.edu*

Conspecific chemical communication in a live-bearing fish, Poecilia latipinna

Aquatic environments can be dark or turbid, making visual cues difficult to detect. In these cases, chemical communication is advantageous. *Poecilia latipinna*, a live-bearing fish, lives in waterbodies where visual communication is not always reliable. Male *P. latipinna* differentiate between receptive and non-receptive females. Moreover, we have preliminary data that shows males are attracted to female extracts. In other closely related live-bearers, chemical communication is an important factor in female mate choice. We hypothesized that *P. latipinna* use chemical communication to coordinate mating. To investigate this, we did two experiments, observing behavior, endocrine response, and gonadal histology. In the first experiment, we paired a female with two males and recorded mating behaviors for 10 mins. We took pre- and post-mating water samples from each fish to establish a water-borne steroid profile by ELISA. Our preliminary results show complex reproductive behavior in this species, paired with a post-mating decrease of estradiol and progesterone in females; both of which are regulators of ovulation. Additionally, we found that both males and females had relatively high concentrations of glucoronidated prostaglandin F2 (474.20 ± 194.55 ng/L/h/g). Prostaglandins putatively induce ovulation in fish. Therefore, in the second experiment we quantified female physiological response to male chemical cues. We placed each female in 5 L of water, exposed them to male extracts for 4 hours and took water samples at 0h, 0.5h, 1.5h and 4h. After 4 hours, we collected ovaries for histology. We predict to see changes in water-borne steroids and gonadal composition after chemical cue exposure. This study, combined with our previous research, suggests this species uses chemical communication to coordinate mating.

P3-110 BROCKMAN, TJ*; MENZE, MA; University of Louisville; *tjbroc03@louisville.edu*

Two Late Embryogenesis Abundant Proteins Do Not Protect Enzyme Activity During Desiccation in Cell Lysates

Late Embryogenesis Abundant (LEA) proteins are a class of highly hydrophilic intrinsically disordered polypeptides (IDP) that are found in many plants and some anhydrobiotic animals. Over 15 distinct LEA proteins, belonging to three different classification groups (1,3 and 6), have been found in *Artemia franciscana* and several of these proteins have been shown to be involved in the anhydrobiotic life history stage of these Branchiopods. The exact mechanisms by which specific LEA proteins protect brine shrimp embryos during desiccation is largely unknown. To gain understanding into the possible mechanisms of protection conferred by group 1 and 6 LEA proteins, enzyme assays were utilized to investigate the effect of *Af*LEA1.1 and *Afr*LEA6 on lactate dehydrogenase (LDH) activity in lysate of *Drosophila melanogaster* Kc167 cells after desiccation and rehydration. Cell lysates were utilized to probe for specific interactions between LDH and LEA proteins during water-stress in a proteome system. This may closer resemble potential interaction in the cytoplasm than observed in a binary protein study with purified enzymes and a specific LEA protein. Results show that *Af*LEA1.1 added to purified LDH protected the enzyme during desiccation and rehydration, however, when added to cell lysate, no protection of enzymatic activity was observed after rehydration compared to LEA-free control lysates. Similarly, no protection of LDH activity by *Afr*LEA6 was observed when the protein was added to cell lysates before desiccation compared to LEA-free controls. It appears likely that the protection of enzymatic activity observed by *Af*LEA1.1 in the binary protein system might be an overestimate and LDH is not a specific target of *Af*LEA1.1 under physiological conditions (supported by NSF *IOS*-1659970).

P3-162 BROWN, CE*; WHITEMAN, HH; DEBAN, SM; University of South Florida, Murray State University; *cbrown43@mail.usf.edu*

Within-pond Site Fidelity of Larval, Paedomorphic, and Metamorphic Arizona Tiger Salamanders, Ambystoma tigrinum nebulosum

Site fidelity has been widely reported in metamorphosed amphibians, but less is known about larvae and paedomorphic adults. Fully aquatic morphs of the Arizona tiger salamander, *Ambystoma tigrinum nebulosum*, occupy sup-alpine ponds with heterogeneous thermal profiles in the Colorado Rockies. Aquatic morphs of *A. t. nebulosum* are confined to permanent ponds; terrestrial morphs are known to move between permanent and semi-permanent ponds throughout the summer months. We studied within-pond site fidelity of PIT tagged juvenile, paedomorphic, and metamorphic Arizona tiger salamanders in five permanent and four semi-permanent ponds near the Rocky Mountain Biological Laboratory. Shallow, relatively warm regions near the perimeter of the permanent ponds, referred to as thermoregulation zones, were mapped due to apparent clustering of *A. t. nebulosum*. We found that both aquatic and terrestrial morphs of *A. t. nebulosum* do exhibit some level of site fidelity within ponds and that the distribution of differently sized animals within a pond may play a role in determining an individual's realized niche. Within-pond site fidelity does not appear to differ between males and females. Juveniles exhibit the lowest level of site fidelity, although this could be an artifact of juveniles being more easily scared from the thermoregulation zones by observers. Additional field seasons are needed to determine if within-pond site fidelity persists across active seasons and if individuals adjust their niche as size structure dynamics change over time.

P3-178 BRUSCH IV, GA*; HEULIN, B; DENARDO, DF; Arizona State University, Phoenix, AZ, University of Rennes, Paimpont, France; *Bruschg@gmail.com*

Dehydration During Egg Production Alters Egg Composition and Yolk Immune Function

Parent-offspring conflicts occur when resources are limited for allocation, and, historically, energy has been the primary currency of focus when examining these trade-offs. Water is a fundamental resource that has received far less consideration for parent-offspring conflicts. Previous research suggests that, when water is limited, reproductive females are compromised in favor of developing embryos. However, these studies limited their assessments to standard metrics such as clutch size and mass. We tested the hypothesis that the mother-offspring conflict over limited water resources leads to finer scale morphological and physiological impacts on the eggs. We predicted that water deprivation during gravidity alters female investment into her eggs, impacting egg water content and shell development. Additionally, we predicted that the yolk in these dehydrated eggs would have enhanced immune performance metrics, as has been documented in dehydrated adults. We found that eggs from water-deprived females were dehydrated as indicated by reduced percent water and greater yolk osmolality compared to eggs from females that received ad libitum water. We also found that eggs from dehydrated mothers had thinner shells and higher water loss rates. The impacts were not entirely negative as dehydrated eggs had higher antimicrobial capabilities. Also, thinner and more permeability eggshells might allow for elevated rates of rehydration from nest substrate. Overall, by examining an array of egg traits, we demonstrate that dehydration of gravid females impacts the eggs, not just the females as previously reported. As a result, the mother-offspring conflicts are indeed two-sided.

P3-116 BRYAN, A*; WILCOXEN, TE; SEITZ, J; NUZZO , JN; Millikin University, Illinois Raptor Center, Illinois Raptor Center; *abryan@millikin.edu*

Enhanced Hematological Condition in Birds of Prey Undergoing Rehabilitation is Independent of Vitamin Supplementation.

Antioxidants play a key role in protecting cells by inhibiting harmful oxidants, or free radicals, produced by metabolic processes. Antioxidants are especially important in vertebrates that are ill or are overcoming injury, such as birds of prey, that are taken into captivity for rehabilitation. In addition to the stress associated with injury, these animals incur the additional stress of being handled, which may drastically reduce their antioxidant capacity. In order to bring the raptors antioxidant levels into balance, a healthy diet is necessary. In many zoos and rehabilitation centers, the dietary supplement Vitahawk® is administered to boost Vitamin A, C, E, K, and B in captive birds. The objective of our study was to determine if Vitahawk® improves antioxidant and cardiovascular health in birds undergoing rehabilitation. Blood samples from birds were taken at admission and release to be used in a total antioxidant capacity (TAC) assay to determine differences between antioxidant capacity levels. Raptors receiving Vitahawk®. We found that non-Vitahawk® recipients had a 35% increase in antioxidant capacity from their time of admission to release, supporting that normal diet increases antioxidant capacity levels by itself. We did not find a significant difference between birds given Vitahawk® and those not given the supplement, suggesting that the supplemental vitamins and nutrients may not provide any additional benefit in a secure environment with an ample, consistent food source.

P1-191 BUCHANAN, JL*; KERNBACH, M; GOLAS, B; JOHNSON, PLF; SWEENY, AR; WANELIK, K; BUCHANAN, JUSTIN; University of Nebraska, Lincoln, University of South Florida, Colorado State University, University of Maryland, College Park, University of Edinburgh, University of Liverpool; *justin.l.buchanan@gmail.com*

Disentangling health and fitness

A group at the IDEAS RCN workshop prior to the 2018 Ecology and Evolution of Infectious Diseases conference met to address the question "What is Health?". Impacts on host fitness are often discussed within the fields of eco-immunology, disease ecology, and life-history theory. This definition is useful when phenotypic variation in fitness can be measured. However, in species such as humans, not only can fitness not be easily measured, but health encompasses much more than fitness and should be summarized using measures that account for quality of life. Recent work by David Schneider and collaborators defines disease as a spectrum, that simultaneously captures multiple aspects of homeostasis. Here, we extend this framework by including changes in disease over the host's life span. This extension allows us to model repeat infection, immune priming, and changes due to targeted interventions (e.g., vaccines). We propose that incorporating exposure history into the reactive scope framework would provide a novel and powerful integrated framework to enhance our ability to predict how changes in individual-level homeostasis maintenance (health) can scale-up to alter population-level disease and health outcomes.

P1-14 BURNETT, N.P.*; COMBES, S.A.; Univ. of California, Davis; *burnettnp@gmail.com*

Putting interviews to the test: What biases do you face when interviewing for a post-doc?

The post-doctoral training period is a critical career stage for researchers in the life sciences. Unfortunately, many scientists from under-represented groups leave academia before entering this career stage. One potential explanation for this trend could be inequality and bias during the interview process, a process that is highly unregulated at the post-doctoral stage as compared to graduate student and faculty interviews. We designed and implemented a nationwide survey of post-doctoral researchers working in the life sciences to examine the types of interviews they experienced and to test whether interview styles were associated with demographic characteristics of the candidates. We found evidence of biases in interview formats that were linked to the sex and race of the applicant, the sex of the principal investigator (PI), and the applicants' prior relationship to the PI. These results suggest that biased interviews in the life sciences may be contributing to the under-representation of women and other minority groups at the post-doctoral and faculty career stages. Implementing a standardized interview process for all post-doctoral applicants could prevent biases and increase the representation of women and other minority groups in senior career stages of the life sciences.

P1-161 BUTLER, RM*; SOLOMON-LANE, TK; HOFMANN, HA; University of Chicago, University of Texas; *rmbutler@uchicago.edu*
The Development of Social Status in a Highly Social Fish
Social hierarchies are common and have important fitness implications. Individual phenotype strongly influences status in the hierarchy, yet little is known about how behavior and other status-relevant traits develop. We used the highly social African cichlid fish *Astatotilapia burtoni*, a model system in social neuroscience, to ask how the early-life social environment affects juvenile behavior and the establishment of status. We found that juveniles form hierarchies in a context-specific manner. In groups where individuals differed in size, status relationships formed based on size, as in adults, such that larger fish were dominant over smaller fish. If a pair of size-matched fish was present within the group, social interactions—and status relationships—were not defined by a linear hierarchy. To better understand the neuromolecular underpinnings of status, we manipulated the nonapeptide arginine vasopressin (AVP), an ancient neurohormone that regulates aggression, affiliation, and status across social vertebrates, including adult *A. burtoni*. Following intracerebroventricular injection, we observed social behavior and quantified neural expression of genes involved in the regulation of social behavior and status. Pharmacological manipulation significantly affected group social dynamics. For example, administering an AVP antagonist to one fish shifted the pattern of interactions such that the larger fish had a higher agonistic efficiency. Patterns of neural gene co-expression reveal correlations with social behavior and status, as well as the consequences of manipulating AVP on gene network dynamics. This research is critical to uncovering the neural mechanisms that underlie juvenile social behavior and status, which may have long-term consequences for adult fitness.

P1-40 CABRERA, S*; EMLET, R; University of Florida, University of Oregon; *savannaecabrera3@ufl.edu*
Buoyancy and Swimming Behavior in Two Balanid Cyprids
For two species of barnacle cyprids, *Balanus glandula* and *B. crenatus*, potential differences in their distribution in the water column have been hypothesized to be caused by a difference in their specific gravity, swimming behavior, or a combination of both. This study sought to test these proposed explanations by measuring the sinking rates of the two species and by quantifying their location in a stable water column. To measure sinking rates, cyprids were placed in a stable water column, housed in a water jacket, and falling rates were calculated using the amount of time it took to fall two centimeters. Using a modified force-balance equation, specific gravity was calculated for the two species. To quantify the water column location, cyprids were dark-adapted for 20 seconds before being exposed to white light for a minute. After a minute, a score of 0-3 was given to each cyprid depending on where the cyprid was in a tank 24.5 cm tall. A score of 0 signified the floor, and a 3 signified the upper third of the water column. Cyprids of the two species did not differ in their specific gravity or sinking speed. Cyprids of *B. glandula* overwhelmingly preferred the top third of the water column, where as those of *B. crenatus* preferred to be in the bottom third. These results imply that cyprid distribution may be driven by behavior rather than inherent physical properties.

P1-94 CAINE, PB*; EDWARDS, KM; HATCH, SA; BENOWITZ-FREDERICKS, Z M; Bucknell Univ., Inst. Seabird Research & Cons.; *pbc008@bucknell.edu*
Long- and Short-term Effects of Food Intake on Circulating Energy Substrates in Free-Living Seabird Chicks
Blood levels of energy substrates can predict mass change and are often used as indicators of overall nutrition and health in birds. However, other factors such as sex, body mass, glucocorticoid-induced energy mobilization, and dietary intake may also influence circulating substrate concentrations. As more studies seek to connect avian condition or fitness to single measurements of energy substrates, understanding the factors that generate variation in these levels in wild animals is increasingly important. To this end, we conducted two experiments on free-living black-legged kittiwake (*Rissa tridactyla*) chicks. In the first experiment, we tested the hypothesis that energy substrate levels vary in response to long term-food availability. We compared plasma triglyceride levels of chicks from nests provided with long-term food supplementation to levels of age-matched chicks from unsupplemented nests. Chicks in nests without supplementation had significantly lower triglyceride levels than chicks in supplemented nests. In the second experiment, we hypothesized that recent food consumption has a stronger effect on levels of circulating energy substrates than acute fluctuations in glucocorticoid levels. An hour before experimentally elevating corticosterone in chicks, we recorded behavior at experimental and control nests to determine the time of the most recent feeding. We evaluated the relative contributions of time since feeding and corticosterone manipulation to plasma glucose, triglycerides, and cholesterol concentrations. If recent feeding and acute corticosterone elevation affect circulating levels of these metabolites, then they may not be accurate indicators of long-term nutritional status.

P3-127 CALHOUN, AC*; SADD, BM; Illinois State University, Normal, IL; *accalh1@ilstu.edu*
The Influence of Multiple Stressors of a Fungicide and Microsporidian Parasite on Bumble Bee Health
Pollination services provided by managed and wild bees are essential for agricultural and natural ecosystems. However, threats to pollinator health leading to population declines put these services in jeopardy. Several potential causes of declines have been suggested, including exposure to pathogens and agro-chemicals. Although individual effects are widely studied, interactions between pesticides and immunity may exacerbate the negative effects of individual exposures in environments where they co-occur. In bumble bees (*Bombus spp.*), a landscape analysis demonstrated a correlation between local use of the fungicide chlorothalonil and infection loads of the microsporidian pathogen *Nosema bombi* in declining species. This is suggestive of an interaction, but causation still needs to be established. By exposing microcolonies of *B. impatiens* in a fully reciprocal design to chlorothalonil and/or *Nosema*, we test if a sublethal dose of chlorothalonil influences *N. bombi* infection and exacerbates its negative effects. We predict that chlorothalonil will reduce immune function, leading to increased infection loads and transmission potential, with associated negative effects on health. This study will be the first to experimentally assess the combined stressors of *N. bombi* and chlorothalonil in bumble bees, and will provide information on how bumble bee health will be affected by variability in agro-chemical and pathogen environments.

P1-53 CALLISON, W.E.*; HOLOWKA , N.B.; LIEBERMAN , D.E.; Harvard University; *wcallison@g.harvard.edu*

Born to Run and Breathe: Thoracic Adaptations for Ventilation in Humans and Other Cursorial Mammals

Bipedal humans, like dogs and a few other cursorial mammals, are thought to have been selected for endurance running. As to be expected, the ability to run long distances requires the ability to inspire large amounts of air for sustained periods of time. During sustained high aerobic activities, humans can be required to breathe as much as 6.1-6.9 L of air/min per kilogram of body mass, and only a few other running adapted (cursorial) mammals, including dogs, wolves, camels and horses, are capable of such sustained aerobic capacity. We experimentally test the hypothesis that humans and dogs rely on thoracic volume changes to increase tidal volume during running to a greater extent than goats, a quadrupedal, non-cursorial species. While all three species use diaphragmatic breathing to increase tidal volume in order to augment respiration with increasing oxygen demand, dogs also use increased dorsoventral expansion of the thorax, and bipedal humans use both dorsoventral and mediolateral expansions of the thorax. 3D analyses of joint morphology across four mammalian orders also show that cursorial species independently evolved more concavo-convex costovertebral joint morphologies that allow for increased rib motion and greater thoracic expansion and contraction. Evidence for similarly derived concavo-convex costovertebral joints in *Homo erectus* corresponds with other evidence for the evolution of endurance running in the genus *Homo*.

P1-51 CAMP, AL*; OLSEN, AM; HERNANDEZ, LP; BRAINERD, EL; University of Liverpool, Brown University, George Washington University; *Ariel.Camp@liverpool.ac.uk*

Ventral body muscles power suction feeding in channel catfish

Many ray-finned fishes use their large body muscles to help power mouth cavity expansion during suction feeding. The dorsal (epaxial) body muscles can power expansion by shortening to elevate the cranium, and the ventral (hypaxial) body muscles by shortening to retract the pectoral girdle. While epaxial-powered cranial elevation has received much more study, in some species (including catfishes) it appears to be absent. Can these fish generate powerful suction expansion with the hypaxials alone, or are they limited to low-power feeding or a greater reliance on cranial muscle power? We measured 3D skeletal kinematics and axial muscle shortening using X-ray Reconstruction of Moving Morphology (XROMM) and fluoromicrometry, respectively, during suction feeding in channel catfish. The rate of mouth volume expansion was calculated from the XROMM animations using a dynamic digital endocast, and combined with intraoral pressure recordings to estimate suction expansion power. Catfish generated powerful strikes (10-12 W, similar to peak powers of largemouth bass and bluegill sunfish), without epaxial power. During suction expansion, the epaxials shortened minimally, and the cranium elevated less than 5 degrees relative to the body. The hypaxials shortened substantially (10% strain) to retract the pectoral girdle by about 12 degrees relative to the body. Some cranial muscles also shortened, but were too small to contribute meaningful power to mouth expansion. The hypaxials alone were capable of powering these strikes without exceeding 90 W/kg, a relatively low power output. Thus, powerful suction feeding doesn't require epaxial-powered cranial elevation, and the contribution of dorsal and ventral body muscles to suction power clearly varies across fishes.

P1-123 CAMPBELL, NA*; BOWDEN, RM; CASTO, JM; PAITZ, RT; Illinois St U; *nacamp2@ilstu.edu*

Deciphering the consequences of yolk testosterone metabolism in birds: Inactivation or modification of an active signal?

Maternal steroids transferred to eggs produce variable phenotypic effects in offspring. One maternal steroid that has garnered interest is testosterone due to its ability to elicit permanent, organizational effects in the brain and other tissues; however, vertebrate embryos actively regulate their maternal steroid exposure through steroid metabolism. We previously showed that in European starling (*Sturnus vulgaris*) eggs, testosterone is metabolized to etiocholanolone early in development which leads us to ask: When does this testosterone metabolism begin? And is etiocholanolone capable of influencing early growth of the developing embryo and extraembryonic membranes? To address the first question, 20 eggs were injected with tritiated testosterone (3H-T) and incubated for 0, 4, 8, and 12 hours to track the movement of testosterone early in development. To address the second question, 130 eggs were injected with either high (2.0 ng/egg), medium (1.0 ng/egg), or low (0.5 ng/egg) doses of etiocholanolone and sampled on days 3 and 5 of development to quantify the mass of the embryo and extraembryonic membranes. The conversion of testosterone to etiocholanolone was observed after only 4 hours of development. However, etiocholanolone manipulation had no significant effect on the growth rate of the embryos or extraembryonic membranes. This finding suggests that the conversion of yolk testosterone to etiocholanolone may be an inactivation pathway that buffers the embryo from the effects of maternal steroids.

P2-209 CAMPBELL, RA*; MIKHEYEV, AS; Okinawa Institute of Science and Technology; *robert.campbell@oist.jp*

3D Silk Gland Geometries for Comparative Spider Biology and Bio-inspired Material Processing

Spider silk is a diverse category of materials produced under different mechanical conditions. In orb-weaving spiders, up to six types of silk are produced by a combination of secretions from up to eight distinct silk glands. The "glandular affiliation hypothesis" indicates that discrete silk materials are produced and assembled in each gland. However, the time consuming nature of histology has largely limited the study of spider silk materials to external spigot and spinneret morphology on one hand, and silk proteomics and its genetic origins on the other. Information on internal gland morphology is necessary for understanding how fluid flow conditions combine with protein sequence variation and protein chemistry to produce different silk material properties. To date, only a few studies exist on the mechanical flow conditions responsible for protein assembly, and only one gland geometry from one spider species has been used to model fluid flow during spinning, the large major ampullate gland of *Nephila edulis*. Here we show that microCT can be used to rapidly isolate 3D silk gland geometries of multiple gland types. Such data enables the study of 3D comparative gland morphology across spider taxa. We propose the integration of comparative gland morphology into new studies of spider silk evolution. One exciting feature of the data is that it can also be exported for use in computational simulations of fluid flow and molecular assembly, potentially informing the development of bio-inspired material fabrication techniques as well as the study of fundamental biological questions.

P1-226 CAMPOS, CI*; MARTINEZ, MA; RUSSELLO, MA; WRIGHT, TF; New Mexico State University, University of British Colombia, Okanagan; *campos73@nmsu.edu*

Genetic Structure and Diversity in Wild and Captive Populations of the Critically Endangered Blue-Throated Macaw (Ara glaucogularis)

A key aspect in the conservation of endangered populations is understanding their underlying genetic structure. The blue-throated macaw is endemic to Bolivia and is one of the most endangered species of macaw, with an estimated 250 birds remaining in the wild. Like many parrots, the blue-throated macaw has sizeable populations in zoos and private ownership. This raises interesting questions about the genetic diversity within, and the genetic relatedness between wild and captive populations. Our goal is to assess genetic variation in wild and captive populations to inform conservation efforts for this highly endangered species. We genotyped 66 wild individuals from Bolivia and 54 captive individuals from the US, Canada and Bolivia at 12 polymorphic microsatellite loci to determine genetic diversity and relatedness. We examined population structure using a Bayesian clustering approach and calculated population F statistics to determine the extent of population structure. Our results using STRUCTURE show that wild Bolivian populations are genetically distinct from captive populations; this result was echoed by a significant pairwise Fst value of 0.059 between the two populations. Ongoing analyses will test for the presence of population bottlenecks and inbreeding in both captive and wild populations. These results will help inform ongoing efforts to manage wild populations and augment them with the release of captive-bred individuals.

P1-138 CANTU, I; GABOR, C*; Texas State University; *inc9@txstate.edu*

Effects of Acute and Chronic Predator Stress on Mating and Stress Hormones in Mosquitofish

Predators directly affect populations through mortality and indirectly through altered behavior and physiological stress response. Physiological and behavioral response may vary depending on whether the threat is perceived as an acute or a chronic stressor. Acute stress from predators can enhance reproductive success. In contrast, chronic exposure to predators can negatively affect reproductive success. Cortisol is the main stress hormone in fish and increases in response to predation threat and may facilitate antipredator behavioral response. We tested the hypothesis that chronic and acute predation threat would affect mating behavior of the livebearing mosquitofish, *Gambusia affinis*. We exposed mosquitofish (n=10-15/treatment) to Green sunfish, *Lypomis cyanellus*, a major predator for either 7 days or 30 min. We set up half of a tank with one male separated by a clear divider from two mature females (large and smaller).We placed the sunfish in the other half of the tank (clear divider) if the treatment was chronic exposure. On day 7, we placed the sunfish on the other half of the tank for the acute treatment for 15 min. In the presence of the predator, we removed the divider separating the male and females and recorded the number of mating attempts (gonopodial thrusts) towards each size of female for 15 min. We also examined mate choice using the same set-up but with no predator. Males thrusted significantly more towards the larger female over smaller females across all treatments. Interestingly males in the acute stress treatment, mated significantly more than males in the chronic or control treatments (which did not differ from each other). These results indicate that acute stressors increase mating behavior and that fish may have habituated to the threat of predators in the chronic treatment.

P3-184 CAOILI, EC*; QUIROGA-ARTIGAS, G; SCHNITZLER, CE; Whitney Lab for Marine Bioscience, University of Florida; *e.carter@whitney.ufl.edu*

Determining the Expression Patterns of Two Brachyury Paralogs in Hydractinia Head Regeneration

The gene *Brachyury* belongs to the T-box family of transcription factors and is a target of the canonical *Wnt* signaling pathway. First discovered in mouse, this gene is widely known for its conserved role in mesoderm formation and body axis patterning across bilaterian species. Despite its established function as a mesodermal marker, homologs of *Brachyury* have recently been discovered in diploblasts, including two paralogs (*HyBra1* and *HyBra2*) in the freshwater cnidarian *Hydra magnipapillata* (Bielen et al., 2007). RNAseq data from our lab and collaborators indicated that two paralogous *Brachyury* genes are also expressed in the colonial hydrozoan, *Hydractinia echinata*. Moreover, both of these genes are highly upregulated in blastema tissue during head regeneration at 24 hours post head removal. We plan to compare spatial and temporal expression patterns of both *Brachyury* paralogs using in situ hybridization and qPCR at different time points during head regeneration in our lab's model organism, *Hydractinia symbiolongicarpus*. Defining the expression patterns of these *Brachyury* genes during regeneration and in intact adult polyps will serve as an informative first step in investigating the role of this conserved gene in *Hydractinia*. We will compare our results to recent expression studies of *Brachyury* genes in other model cnidarians.

P2-270 CARLSON, BM*; HURTIG, JE; SZALAY, TE; MULLIN, MM; The College of Wooster; *bcarlson@wooster.edu*

That's a Fish of a Different Color: Using a Candidate Gene Approach to Investigate Color Variation in Betta splendens

Betta splendens, commonly known as the Siamese fighting fish, is a species widely known to the public, but comparatively poorly known to the scientific community, especially from a genetic standpoint. However, these fish are tractable in a lab setting, have a dedicated hobbyist community actively engaged in citizen science, and show excellent potential for use in scientific outreach to a wide variety of audiences, making them an extremely attractive study system. Notably, *Betta splendens* displays vibrant pigmentation in its natural state, but artificial selection has resulted in captive-bred populations showing a wide variety of pigmentation phenotypes that vary in both coloration and patterning. While hobbyists and pet owners prize these fish for their beauty, these derived pigmentation phenotypes are also of scientific interest. Past studies have shown that these changes are not merely aesthetic, but rather that they impact behavior (e.g., mate choice and schooling) and physiology (e.g., immune responses) as well. Despite the attention that this subject has received, the specific genes mediating these changes in pigmentation have yet to be identified. Here, we investigate of the genetics underlying several *Betta splendens* pigmentation phenotypes, picking up where the citizen scientists of the hobbyist community have left off. Using a candidate gene approach, we have newly sequenced large portions of several relevant genes and identified variation in both coding sequences and gene expression. This work, together with our ongoing efforts, promises to shed light on the genetic underpinnings of the widely varied pigmentation phenotypes observed in this species.

P3-168 CARPENETTI, JM*; STIERHOFF, EN; DIAMANTIDES, LC; WALLACE, JW; BUTLER, MW; Lafayette College, Easton, PA; *carpenej@lafayette.edu*

Survival of house sparrows seems to decrease only in response to high-intensity immune challenges

Immune challenges can have large consequences on animals, such as decreased survival, which could be due to intensity. However, some survival-based costs may not show until later in life. To test if degree of immune challenge was related to survival, we issued one of four different doses of an immune challenge to nestling house sparrows and quantified survival during the nestling and fledgling periods. We injected a saline solution of lipopolysaccharide (LPS), a bacterially derived molecule that stimulates vertebrate immune systems, in doses of 0.0, 0.01, 0.1, or 1.0 mg LPS/kg body mass to nearly 150 10-day-old house sparrows during the summer of 2018. We also attached unique radio frequency identification (RFID) tags to each nestling. For nestling survival, we checked nests daily for mortality or fledging. For post-fledging survival, we placed antennae on bird feeders to detect RFID tags, showing which birds were still alive post-fledging. We predicted that as immune challenge intensity increased, survival would decrease. While the intensity did not seem to affect nestling survival, we detected fewer fledglings that received 1.0 mg LPS/kg body mass during the fledgling period. We cannot explain this, but possibly the energy invested in the immune response compromised the bird's nutrient stores, increasing the chance of starvation post-fledging. The other doses did not show a survival difference, so we can infer that they did not have lasting effects. The trend manifested only at the highest dose, suggesting that less intense (and putatively common in nature) immune challenges may not have the same effects on survival.

P3-53 CARR, JA*; SULLIVAN, CM; TYTELL, ED; Salem State University, Emmanuel College, Tufts University; *carr.je@gmail.com*

Twitch Kinetics on the Descending Limb of the Length-Tension Curve of Skeletal Muscle.

Muscle intrinsically produces different amounts of force depending on its length and its velocity. These force-length and force-velocity relationships are often discussed when developing models of muscle function. My research examines a previously unsteady force-length relationship: how length affects the speed at which force develops. I measured a standard force-length curve in isolated muscle preparations from the silver lamprey, starting at the ascending limb, proceeding through optimal length, and down the descending limb to the point where peak muscle force was negligible. At each length, I stimulated the muscle to produce a twitch. From each of the twitches, the force produced by the muscle and the timing of various points relative to the stimulus was measured. During force development, the timing and force were measured at 50%, 90% and 100% maximal force. During force decay, the force and timing were measured at 50% and 90% relaxation. From these data, the rate of force development and decay was calculated at different portions of the twitch. Previous results show that on the ascending limb and the plateau region that the rate of force development increases as length increases and the rate muscle relaxation decreases with as length increases. We are currently extending these measurements onto the descending limb of the force-length curve, to determine whether this effect is due to myosin-actin overlap or some other biochemical effect such as titin winding. We hypothesize that if the changes in twitch kinetics are due to myosin-actin overlap, which increases on the ascending limb, then the rate of force development and the rate of muscle relaxation will decrease on the descending limb of the length tension curve as there is less and less myosin-actin overlap.

P2-127 CARRIER, TJ*; REITZEL, AM; Univ. North Carolina, Charlotte; *tcarrie1@uncc.edu*

Ecological Masking Of Animal-Associated Bacterial Communities

Morphological plasticity is a genotype-by-environment interaction that enables organisms to increase fitness across varying environments. When faced environmental heterogeneity, an animal holobiont may acclimate by shifting the composition of the associated bacterial community. By inducing morphological plasticity in three confamilial sea urchins, we test the hypothesis that the bacterial community co-varies with the expression and magnitude of plasticity. While each urchin has a species-specific bacterial community, the expression of plasticity resulted in the convergence on a phenotype-specific bacterial community, with community shifts being proportional to the expression of the trait. Moreover, associating with a phenotype-specific bacterial community was independent of ecological drift, diet quality, and developmental stage, even though the bacterial communities established by the eggs change gradually during embryonic and larval development. Animal-associated bacterial communities are also taxonomically distinct across host biogeography. Using larvae of the echinoid Strongylocentrotus droebachiensis from coastal locations in the Pacific and Atlantic Oceans, we test the hypothesis that host geographical origin better correlates with community composition than does local variation (e.g., diet and phenotype). Our comparisons of the bacterial communities associated with S. droebachiensis larvae suggest that geographic location better correlates with community composition than local biological (e.g., phenotype) and ecological (e.g., diet quantity) variation. Taken together, these results suggest that echinoid larvae associate with a phenotype-specific microbial community that is specific to but can be masked ecologically by host biogeography, implying that scaling and the potential for ecological masking should be considered when studying host-microbiome dynamics across an ecological landscape.

P3-65 CARRIER, DR*; BOYNTON, AM; Univ. Utah, Salt Lake City; *carrier@biology.utah.edu*

Is the Neck Part of the Human Core?

The musculoskeletal core provides a stable base that allows limbs to exert forces on the environment. We hypothesized that the human core is actually a musculoskeletal loop that begins at the pelvis on one side of the body and extends cranially, via active muscles, to the skull and then extends caudally down the opposite of the neck and trunk. To test whether or not the neck is part of the core we used surface electrodes to measure the activity of a set of cervical and trunk muscles during maximum effort counter-movement jumps. To determine whether cervical muscle activity during jumps function to control posture of the head and/or function to assist in stabilization of the trunk against the moments applied to the pelvis by the leg retractor muscles we compared muscle activity during control jumps to jumps in which we (1) increased the mass of the head by 20%, and (2) reduced peak accelerations by approximately 10% by pulling downward on the subject's hips with elastic tethers. When subjects jumped with mass added to their heads, changes in muscle activity varied from subject to subject and no consistent pattern was observed. When subjects jumped with increased vertical force, to reduce acceleration, activity increased significantly in both the strap (i.e., sternohyoid and sternocleidomastoid) and epaxial (i.e., semispinalis) muscles. These results do not support the hypothesis that the superficial muscles of the neck (i.e., those accessible with surface electrodes) play an important role in postural support of the head during active movement. Instead, our results suggest that these cervical muscles contribute to core stability in response to moments imposed on the pelvis by the extrinsic muscles of the leg. These results have implications to the locomotor function of the tetrapod neck and to the prevention of spinal injury.

P3-123 CARSON, KMH*; RASHID, SB; LAWSON, ER; MOSS, AG; Auburn University, Alabama, Auburn University, Alabama , University of Georgia, Athens, Auburn University ; *kmh0100@auburn.edu*

Purification and identification of an exceptionally resilient orange fluorescent protein from a novel species of anemone, a variant of the Gulf anemone Calliactis tricolor

GFP was one of the most useful discoveries of the 20th Century, due to its subsequent use in cell and molecular tagging applications, resulting in three Nobel Prizes in 2008 (Noble Media AB 2014). GFP and similar proteins, including anthozoan fluorescent proteins, have been used in numerous research efforts to probe cellular structure and function since its introduction. We have discovered a similar protein in a variant of the common anemone, *Calliactis tricolor*, from the Alabama Gulf Coast, which, unlike other anthozoan fluorescent proteins (Curr. Opin. Chem. Biol. 20:92; Curr. Opin. Biol. 12:505), is extraordinarily long-lived and resilient. The anemone's mouth and mesenteries produce intense orange fluorescence, peak emission at 510 nm and 570 nm when illuminated by blue light at 500 nm and 540 nm. The protein appears to be freely associated with the cytoplasmic space of mesentery cells; purification of the protein yields a ~10S trimeric quaternary complex with three bands at 31, 25 and 10 kDa as revealed by SDS-PAGE. LC-MS/MS reveals that the fluorescence moiety is novel and has effectively no homology to any previously known fluorescent protein; moreover the fluorescent group is found only in the largest subunit. Ongoing whole genome analysis and differential transcriptomic analyses seek to reveal genome organization and appropriate regulatory elements and should provide data for future incorporation of this group into cellular probes. Our work reveals that this is a very easy to purify, resilient and easily handled protein and a look into genome organization and identification. Funds: Internal Grants Program, OVPR, Auburn Univ.

P1-70 CARTER, M*; HOGAN, AVC; BALANOFF, AM; BEVER, GS; Johns Hopkins University School of Medicine, Baltimore; *mcarte61@jhu.edu*

Functional Correlates of Floccular Size in Pan-Aves

The avian vestibulocerebellum coordinates incoming vestibular information with movements of the head and eyes. It is a spatially and functionally segregated system with medial and lateral cerebellar regions coordinating visual responses to translational and rotational movements, respectively. The lateral region is expressed morphologically as the flocculus—a finger-like extension of the cerebellum projecting between the semicircular canals. The flocculus garners special interest as it is visible on an endocast and exhibits a high degree of size variation among both crown and stem taxa. Such variation raises the possibility that floccular size is correlated with functional and/or behavioral variables that may inform the paleobiology of fossil taxa. Two possibilities have been proposed: (1) floccular variation reflects processing demands of complex flight style, (2) floccular expansion is a response to increasing proprioceptive information generated by the wings. The first hypothesis was rejected in a recent study and we found no evidence to support hypothesis 2. Our data indicate floccular variation is largely explained by body size, and taxa diverging from this general scaling pattern likely do so under the influence of multiple factors. That stated, the semicircular canals and orbit both have strong structural ties with the flocculus that do appear to produce some level of covariation. Establishing morphological relationships between the different components of a sensory network opens considerable space for work in and out of the fossil record.

P2-134 CARUSO, JP; PODOLSKY, RD*; Salem State University, College of Charleston; *podolskyr@cofc.edu*

Effects of personal care product preservatives on the larval development and growth of sea urchins (Arbacia punctulata)

Personal care products (PCPs) comprise a wide variety of daily-use products that contain preservatives to prevent the growth of bacteria and mold. Parabens, the most commonly used preservatives, have been recently implicated in human health issues, causing PCP manufacturers to shift toward alternative preservatives in production and marketing. These compounds enter the ocean but their effects on marine organisms are not well known. This study aimed to test the lethal and sublethal effects of methylparaben (MP), the most widely used paraben, as well as two "safer" alternatives—2-phenoxyethanol (2-PE) and chlorphenesin (CPN)—on early development of the sea urchin *Arbacia punctulata*. Zygotes were added to stirred glass jars with five concentrations of 2-PE, CPN, and MP and allowed to develop in a 48-hour assay. Embryos were staged to record lethal effects, and larvae that had developed to the pluteus stage were measured using skeletal landmarks to estimate sublethal effects on growth. MP, CPN, and 2-PE showed lethal effects at log concentrations of 2, 2.5, and 3 ppm, respectively. Sublethal effects on skeletal growth were evident at log concentrations as low as 1.5 ppm and followed roughly the same order among compounds. Skeletal asymmetry also increased over the same concentrations. These effects on mortality and body size and shape could reduce success in the plankton for sea urchins and other marine invertebrates. Although environmental concentrations are generally lower than those at which harm was detected, more research is needed to understand effects of chronic exposure and the synergistic effects of multiple compounds or environmental stresses like UV and temperature.

P1-49 CASTANEDA, N*; MEHTA, R; University of California, Santa Cruz; *nocastan@ucsc.edu*

Morphology and Kinematics of Suction Feeding In Oxylebius pictus

Predator-prey interactions shape community dynamics through trophic transfer and changes in species composition. Morphology is a crucial factor in feeding interactions, often determining whether a predator can physically consume a prey. In the aquatic environment, fish overcome the density of water via suction feeding, rapidly expanding their buccal cavity to create a pressure differential, resulting in the prey being engulfed in an envelope of water. Suction will often become specialized to certain prey, prey size and prey escape responses, and over ontogeny, predators may change their diet. This study examines the ontogeny of feeding morphology and kinematics of the painted greenling, *Oxylebius pictus*, to understand how morphology and diet are contoured to feeding performance. Using morphometrics and kinematic video analysis, we find feeding performance differences with changes in fish size. On average, larger individuals induced higher prey velocities, yet smaller individuals had quicker, larger excursions. Maximum peak gapes corresponded with maximum velocities for each fish. However, we also find that measures of kinematic performance do not correspond with morphological potential calculated for alcohol specimens revealing behavioral mechanisms or physiological constraints in live fish. This study shows different life stages of the painted greenling are adapted to handle different prey, and certain constraints and behaviors alter feeding performance. Understanding feeding performance of different organisms gives ecologist a better understanding about responses to community changes.

P1-21 CAUDLE, HI*; MEHTA, R; UYENO, TA; CLARK, AJ; College of Charleston, University of California, Santa Cruz, Valdosta State University; *caudlehi@g.cofc.edu*

Are loose skins required for moray eel knotting?

Hagfishes and moray eels might be the only types of fish that use knotting to apprehend prey. Knotting involves concomitant bending and twisting, which apply a combination of tension, shear, and compression to the body's core and skin. In hagfish, the stresses on the skin and core are separated by a subcutaneous venous sinus, which gives the skin its slack appearance and provides space for the core to contort as needed without loading the skin in tension or shear. Hagfish skins placed in tension range from being equally to twice as stiff in the longitudinal axis as in the hoop axis. Conversely, the skins of cartilaginous and bony fishes are taut, preclude exaggerated body core deformations, and are often twice as stiff along the hoop axis. Hagfish also benefit from a derived arrangement of body core muscles that power knotting movements. It is unclear if these adaptations are present in species of morays capable of knotting. We address this question by examining the morphology and material properties of the skins from purple mouth morays (Muraenids that knot), and compared these data with those gathered from American eels (non-knotting Anguillids), Asian swamp eels (non-knotting Synbranchids), and hagfishes (Myxinids that knot). Moray eels are like non-knotting eel species in having taut skins that are firmly connected to serially arranged segments of expaxial and hypaxial muscles. However, like Atlantic hagfish skins, moray skins are isotropic and less stiff than non-knotting eel skins. In contrast to hagfish, knotting in moray eels requires neither loose skin nor complex arrangements of core muscles, therefore, the deformations needed for this behavior are likely achieved by different structural and mechanical features of the Muraenid skin and core.

P1-288 CELLINI, BO*; MONGEAU, J-M; Penn State University; *boc5244@psu.edu*

Decoding the Algorithms for Head and Body Coordination during Visually Guided Flight

In flies, head and wing-driven body movement are coordinated to stabilize gaze, yet the underlying algorithms that permit simultaneous control of the head and body remain elusive. Revealing the algorithms that control the pattern of head and body movement in flight is critical to reverse engineer gaze stabilization because these movement patterns actively shape the visual inputs that enter the brain. Furthermore, it can help us predict the computations that the brain implements to demultiplex sensory inputs for redundant control of multiple-degree-of-freedom flight systems. We use frequency domain analysis to elucidate the tuning and interplay between head and wing movement in rigidly tethered *Drosophila* in virtual reality. Frequency analysis of sinusoidal, visual stimuli showed that head yaw movements were tuned to low frequencies and strongly phase locked at low frequencies. Wing-beat amplitude signals were similarly tuned but were more out of phase than head movements. Coherence analysis and insensitivity to changes in amplitude of sinusoids together suggest that head movements can be modeled with linear dynamics. Wing-beat amplitude signals had an overall lower coherence with the stimuli. These differences could be attributed to the body being fixed while the head is free to move. Analysis of individual trials revealed that head saccade dynamics were broadly tuned. Measurements of the free response of the head demonstrate that the passive neck-head system is highly damped, which may have important implications for passive head stability in flight. Elucidating the algorithms for efficient gaze control during flight can inspire the development of more agile, vision-based aerial vehicles.

P1-275 CHABAIN, JJ*; SUMMERS, AP; KOLMANN, MA; Friday Harbor Laboratory, University of Washington, Georges Washington University; *jules.chabain@hotmail.fr*

What's The Point? Form and Function of the Caudal Barb in Stingrays

In animals, mechanical defenses can take various shapes, from the protective plates of the armadillo, the venomous spurs of the male platypus, and the quills of the porcupine. Stingrays choose an aggressive way to defend themselves with a whip-like motion of the tail, which drive a serrated spine, called a barb, into predators. Barbs are highly-modified dermal denticles and vary considerably in shape from from the tip to the base, and in terms of serrations shape and number. We used micro-CT scanning to visualize fine-scale barb morphology across 70 species of stingrays, representing around 30% of total taxon diversity, including freshwater potamotrygonids (*Potamotrygon*, *Plesiotrygon*), tropical dasyatid whiprays (*Dasyatis*, *Neotrygon*, *Fluvitrygon*), mollusk-crushing myliobatids (*Myliobatis*, *Rhinoptera*), New and Old World round rays (Urotrygonidae: *Urotrygon*, *Urobatis*; *Urolophidae*), and gymnurid butterfly rays. We then examined the evolution and morphological disparity of barb shape across a time-calibrated molecular phylogeny for all stingrays. We find that barb shape is highly variable, in particular the serrated length of the barb, length of the barb base, and overall number of serrations. Variability is also evident in barb cross-sectional shape, which varies from a flattened blade (*Urotrygon aspidura*) to a more complex, T-shaped bayonet (*Rhinoptera bonasus*). We find no overt morphological distinctions between the barbs of marine vs. freshwater taxa, instead finding more nuanced differences between taxa inhabiting pelagic, reef, deep riverine, and coastal habitats. We discuss using barb morphology as a taxonomic character, especially relevant given their prevalence in chondrichthyan fossil beds, and the ecological significance of the barb as a defensive structure.

P1-203 CHALLENER, RC; Bellarmine University, Kentucky; *rchallener@bellarmine.edu*

Variability in the State of Regenerating Arms of Asteroids in the Waters of Florida

Arm loss and regeneration in asteroids has been hypothesized to be an important factor that regulates population size. In order to better characterize the state of regenerating arms both between and within species found in the waters surrounding Florida, preserved specimens collected from 1963 - 2015 and stored at the Florida Fish and Wildlife Research Institute were assessed for the presence of regenerating arms. Out of 9316 specimens in the collections, 11.3 % had at least 1 arm regenerating. The incidence of regeneration (% individuals with 1 or more arms regenerating out of total specimens collected) varied between species (1.1 - 40.2 %), but occurred at all depths commonly sampled (< 100 m). Not surprisingly, less robust species such as the luidiids had higher incidences of regeneration and a higher number of arms per individual that were in a state of regeneration. Among species, the average body size (length of longest intact arm) of regenerating individuals ranged from 18.9 to 122.8 mm with *Luidia lawrencei*, the species with the greatest number of specimens (n = 1594) and number of regenerating individuals (n = 424), at an average of 85.4 ± 1.0 mm (mean ± s.e.m.) body size. The greatest number of regenerating individuals (all species) occurred at a salinity of 35.41 ± 0.10 (mean ± sem, n = 275). Several robust species were also found with regenerating arms, including species that have not been previously documented. In addition to regenerating arms, aberrations in the number of arms and in the regeneration process (e.g., split arms) were observed. Although the collection methods (timing, location, depth, method of collection) were not systematic, the results of this study highlight the knowledge that can be gained from access to institute and museum collections.

P3-81 CHAN, S.F.*; WANG, W; Guangdong Ocean University; *siuming573@sina.com*

Molecular characterization of the myostatin cDNA (MrMstn) from the fresh water shrimp Macrobrachium rosenbergii

The long and short forms full-length myostatin cDNA (MrMstn) for the fresh water shrimp Macrobrachium rosenbergii had been cloned and characterized. Amino acid sequence analysis revealed that the two cDNAs are identical in the overlapping propeptide region. Sequence alignment and phylogenetic analysis revealed that all myostatins are evolutionary related and their amino acid sequences are highly conserved at the C-terminal end. Results from expression studies indicated that MrMstn is widely expressed in different tissues including the eyestalk, hepatopancreas, muscle, and heart, etc. Furthermore, the expression level of MrMstn in the muscle is the highest in late post-molt stage (stage B). MrMstn could be detected in different life cycle stages including the ovary, early embryo, post-larvae, juveniles, subadult and adults. Additionally, the expression level decreased from early to advanced life stages. RT-PCR cloning of MrMstn from shrimp of different life cycle stages revealed that MrMstn cDNA is highly polymorphic. Different alternatively splicing variants could be identified in different tissues and different life cycle stages. Transcript variants that consist of truncated N-terminal or C-terminal end could be identified as well as deletion of different cDNAs. The synthesis of different alternatively spliced transcripts would increase the proteome diversity and might have a regulatory role in controlling the equilibrium of functional MrMstn in vivo. Although no muscle doubling was observed in the injected shrimp, as reflected from the low transcription rate of the myosin and b-actin, the expression of other genes such as myocyte enhancing factor and follistatin were affected. This study could further enhance our understanding of the role of myostatin in shrimp.

P3-71 CHANG, E.S.*; CARTWRIGHT, P.; University of Kansas , University of Kansas; *eschang1@gmail.com*

Identification of conserved genetic elements within the cnidarian class Hydrozoa and their utility for detection of cryptic genetic diversity in the holopelagic jellyfish Liriope tetraphylla

Given the amount of publicly available genomic sequence data, new avenues to incorporate pre-existing data with newly-sequenced data are especially relevant. One challenge in combining data sets for use in evolutionary applications is the assessment of which loci between different genomes are homologous with one another, and then assembling the relevant segments of the genome for those taxa only available as raw sequence data. We took a combined ultra-conserved-element bait-design approach and an automated target-restricted assembly approach to make use of low-coverage whole-genome data sets for population genomic analyses of the holopelagic hydrozoan *Liriope tetraphylla*. We combined previously-developed software pipelines to identify homologous loci in several pre-existing, fully-assembled hydrozoan genomes. We then identified these loci in our set of raw reads from globally sampled individuals of *L. tetraphylla*. We report the successful identification and assembly of conserved elements from several taxa across the subphylum and we tested the utility of these loci to address questions at multiple evolutionary scales in *L. tetraphylla*. Our results point to a novel use of raw sequencing libraries or assembled genomes from publicly available data sets. We anticipate future investigation into the nature of these conserved loci may allow their application to deeper phylogenetic questions within Hydrozoa.

P3-100 CHARMANTIER, G*; LORIN-NEBEL, C; MATHERS, N; GERBER, L; LEE, CE; Univ. of Montpellier, France, Univ. of Wisconsin, Madison, Univ. of Wisconsin, Madison; *guy.charmantier@umontpellier.fr*

Key ion transporters Na^+/H^+ antiporter (NHA), V-H^+-ATPase (VHA) and Na^+/K^+-ATPase (NKA) are implicated during evolutionary transitions from saline to freshwater habitats in the copepod Eurytemora affinis

Colonizations from marine to freshwater (FW) environments constitute major evolutionary transitions and pose osmoregulatory challenges for organisms. The copepod *Eurytemora affinis* has recently invaded FW habitats multiple times independently in the Northern Hemisphere. We found evolutionary shifts in osmoregulatory capacity in *E. affinis*, with increased hemolymph osmolality at lower salinities in FW populations relative to their saline ancestors. Novel osmoregulatory structures, the "Crusalis organs," were located at the 5 pairs of swimming legs. In their ionocytes, immunolocalization and *in situ* expression revealed the presence of basolateral NKA, apical VHA and apical NHA. VHA expression and activity were higher in FW populations relative to their saline ancestors, which arose from increased abundance of VHA per cell, rather than increased number of ionocytes. For the first time in a crustacean we revealed the presence of NHA, with eight paralogs of NHA in the comprehensive genome of *E. affinis*. Using specific antibodies, we localized the NHA-7 paralog in ionocytes of the swimming legs where it colocalized apically with VHA. Hence, we propose that NHA is involved in the uptake of Na^+ in FW using the electric gradient generated by VHA, in association with the transfer of Na^+ to the hemolymph by NKA. Such results provide insights into mechanisms of ionic regulation, with added insights into evolutionary mechanisms underlying physiological adaptation during habitat invasions.

P3-59 CHEU, AY*; BERGMANN, PJ; Clark University; *acheu@clarku.edu*

Ontogenetic allometry of locomotor performance in basilisks

Muscles generate the force needed for locomotion, which is crucial for an animal's ability to perform fitness-relevant tasks in a heterogeneous environment. In whole-organism performance, such as terrestrial walking or sprinting, different tasks require multiple muscles to be activated in patterns constituted by varying intensities and times. Direct relationships, redundancy and multitasking are inherent parts of muscle function. Direct relationships and redundancy occur when different muscles have specific roles, yet often work together to accomplish tasks and allow for movement. Multitasking happens when a single muscle contributes to multiple tasks. This multi-functionality of muscles and variation in activation pattern allow for the successful completion of a wide range of locomotor tasks with a single set of muscles in different ecological contexts. Terrestrial and aquatic locomotion can place different muscular demands on an animal. Aquatic locomotion often involves predominantly sinusoidal oscillations of the body to propel the animal horizontally through the water while terrestrial involves limb movements to carry the body over the substrate with lateral undulation playing a smaller role. Because the morphological properties of muscle do not change as an animal switches locomotor tasks, an important question is how does the function of a set of locomotor muscles differ between locomotor modes such as running, jumping, climbing, and swimming? We address this by looking at differences in in vivo motor patterns of the mm. caudofemoralis longus, pubioischiotibialis, gastrocnemius major, and tibialis longus in the hindlimbs of *Basiliscus vittatus* lizards while performing these modes of locomotion. We show that activation patterns vary during running, jumping, climbing, and swimming.

P3-94 CHIPARUS, SL*; ZAHOR, DL; GLYNN, KJ; CORNELIUS , JM; Eastern Michigan University ; *schiparu@emich.edu*

The influence of metal exposure on plumage coloration in several songbird species

Heavy metals are found naturally in the environment but can be elevated beyond normal levels due to anthropogenic activities. Heavy metals continue to pollute many ecosystems in spite of emission control measures, potentially due to historical exposure or the continued expansion of human development. Organisms exposed to metal pollutants may be negatively impacted if fitness is reduced. The spread of metal pollutants into important ecological systems demands biological indicators that give insight into the local environmental health. Carotenoid-based bright plumage in many songbird species is thought to be a visual cue to potential mates - signaling high fitness levels. This is because bright plumage may reflect efficient foraging for diet-dependent carotenoids and/or the ability to allocate carotenoids to plumage coloration as opposed to anti-oxidant protection. Studies have shown a decline in carotenoid-based coloration along metal pollution gradients, and an increase in melanin patch size with increased metal exposure. We will relate plumage coloration characteristics of urban and rural American Goldfinches (*Spinus tristis*) and American Robins (*Turdus migratorius*) to feather mercury levels. Identifying negative impacts of pollutants on wild animals are important for understanding the consequences of anthropogenic activities on wildlife.

P2-1 CHOMENTOWSKA, A*; MILLER, JS; Yale University, Amherst College; *anri.chomentowska@yale.edu*

Variation in interspecific reproductive barriers between Solanum species

Interspecific reproductive barriers (IRBs) prevent hybridization and establish species integrity. Recent research has suggested that molecular mechanisms of interspecific incompatibility in plants are intimately related to that of gametophytic self-incompatibility, a mating system that establishes obligatory outcrossing between individuals of the same species via pollen-pistil interactions. We investigated the presence and direction IRBs among closely related species in the wild tomato clade (*Solanum* section *Lycopersicon*). We conducted reciprocal crosses between self-incompatible (SI) *S. arcanum* and self-compatible (SC) population of mostly SI *S. peruvianum* which lacks the expression of the female determinant gene of SI (*S-RNase*), and measured fruit and seed set. Additionally, we conducted crosses between SI *S. arcanum* and SC *S. pimpinellifolium* which is polymorphic in functionality of pollen-side SI factor (Cullin1). We found that SI *S. arcanum* and SC population of *S. peruvianum* were compatible only in one direction. Crosses between SC *S. peruvianum* (dam) and SI *S. arcanum* (sire) resulted in an average of 46.9% fruit set, while the reciprocal cross failed to set any fruit. However, there were associated fitness costs of hybridization in the fruits produced. Unlike the results for crosses between SI *S. arcanum* and SC *S. peruvianum*, crosses between SI *S. arcanum* and SC *S. pimpinellifolium* were compatible in both directions regardless of Cullin1 functionality. The variation of IRBs shown here complicates assumptions about how mating systems can predict the outcomes of interspecific incompatibilities and suggests that the establishment of IRBs involves uncharacterized complexities. This study contributes to the integration of molecular mechanisms and evolutionary consequences of interspecific interaction.

P2-121 CHRISLER, AD*; GRANT, A; KIMBALL, MG; CAPASSO, DM; JOHNSON, EE; MALISCH, JL; St. Mary's College of Maryland, University of Nevada, Reno; *adchrisler@smcm.edu*

Predictors of glucocorticoid and glucose mobilization in response to an acute handling challenge in Mountain White-crowned Sparrows (Zonotrichia leucophrys oriantha)

Acute challenges initiate a suite of physiological responses including activation of the sympathetic nervous system and hypothalamic-pituitary-adrenal axis. Collectively these responses promote energy mobilization and resource allocation to support survival. Here we characterized the glucocorticoid and hyperglycemic response to a standard acute handling stressor in a free-living population of Mountain White-crowned Sparrows and modeled potential predictors of the glucose and glucocorticoid response to challenge. Sparrows were trapped in seed-baited potter traps at Tioga Pass Meadow, CA during the early-mid breeding season (May-June, 2018). Blood samples were collected at 0, 15 and 30 min post-capture. Blood glucose was quantified in the field using a FreeStyle Lite meter, and glucocorticoid levels were analyzed in the lab. Consistent with previous research in this population, blood glucose and glucocorticoid levels respond positively to challenge. Glucose increased 34% above baseline by 15 min and 54% 30 minutes post capture. Glucocorticoid levels increased 309% above baseline by 15 min and 500% by 30 min post-capture. Potential predictors of glucose and glucocorticoid mobilization were modeled using scaled body mass, fat score, hematocrit, sex, date and bleed delay time as variables. The most prominent predictor of both glucocorticoid and glucose mobilization was fat score. These results suggest that stored lipid-based resources influence the physiological response to stress. Future studies should examine additional energy substrates such as triglycerides and cholesterol to further tease apart the physiological response to challenge.

P2-102 CHRISTIANO, B.M.*; HOWEY, C.A.F; University of Scranton; *brandi.christiano@scranton.edu*

Do timber rattlesnakes with larger home ranges maintain higher baseline corticosterone levels?

Glucocorticoids are hormones that free up energy so that an organism can deal with a "stressor". As addressed by the Reactive Scope Model (Romero et al. 2009), "stressors" can include predictive daily, seasonal, or lifetime changes with regard to the life history of the organism. For example, organisms may maintain elevated glucocorticoid levels during times of the year when they are more active, searching out mates or foraging. The objective of our study was to determine if individual timber rattlesnakes (*Crotalus horridus*) that maintain larger home ranges and increased movement rates at the same time of the year also maintain higher baseline glucocorticoid levels. We radio-tracked timber rattlesnakes (n = 20) for two years (2016 and 2017) and collected blood samples from individuals in August of each year. We determined corticosteroid levels for each blood sample using a competitive enzymeimmunoassay in the lab. We determined movement rates and home range sizes using radio locations for each individual within ArcGIS. We compared individual movement rates and home range sizes with baseline corticosterone levels using a mixed-model linear regression. Results from this study can assist biologists in interpreting the effect of behaviors on an animal's physiology and further assist in the definition of a "stressor".

P3-140 CIERI , RL*; FARMER, CG; University of Utah, University of Utah; Trinity College, Dublin; *bob.cieri@utah.edu*

Investigation of pulmonary airflow patterns in monitor lizards using computational fluid dynamics (Varanidae)

Unidirectional pulmonary airflow, a condition where lung gases travel in the same direction through most of the airways and throughout the respiratory cycle, has long been of interest to comparative physiologists. Recent work has revealed a wide phylogenetic distribution of this trait, beyond the confines of Aves, to include crocodilians, green iguanas, and monitor lizards, and has raised new questions about the underlying fluid dynamical phenomena occurring in unidirectional lungs. Computational fluid dynamics, which simulates patterns of flow from prescribed boundary conditions and the laws of fluid motion, provide a powerful tool to study airflow through these complex and fascinating structures. In this study, computed tomography scans were segmented into a detailed computational mesh, representing the major and minor airways of monitor lizards, *Varanidae*. The surface of the computational mesh expanded and contracted to simulate lung motion during ventilation and provided the boundary conditions for flow. Simulations were carried out in open-source software on an 80-processor computing cluster. Our model yields unidirectional flow in many regions of the lung and reveals airflow patterns in chambers that are too small or are inaccessible to empirical study. Further computational modeling can be used to test hypotheses regarding unidirectional flow, such as the role of internal lung partitions and the pattern of lung motion during ventilation.

P3-75 CIRINO, LA*; MOORE, PJ; MILLER, CW; University of Florida, University of Georgia; *lacirino@ufl.edu*

The effect of dynamic diets on female reproductive traits

It is well known that poor early life nutrition has strong negative effects on reproduction. Adult nutrition can also affect reproductive output. Those few studies that have teased apart the effects of nutrition at different life stages on female reproductive output have done so through the use of artificial diets. Because of these artificial diets, it is less clear if animals can overcome poor early life nutrition as they take advantage of higher quality seasonal resources that become available later in life in the wild. To understand how separate and combined natural juvenile and adult nutrition affects female life history traits, we asked: What are the impacts of natural diets on female reproductive traits in leaf-footed cactus bugs? Juveniles were placed on two different cactus pad treatments: ripe fruited cactus pads (optimal) and unripe fruited cactus pads (suboptimal). Upon adulthood, a subset of the suboptimal diet females were placed on optimal diets. Preliminary analyses suggest that suboptimal juvenile nutrition does affect female receptivity with females more likely to mate at a younger adult age even though ovary mass and egg production does not differ between treatments. However, after females age for two weeks on their respective diets, female receptivity increases for all diet treatments and does not differ between them. Further, both optimal diet females and those females switched on to optimal diets in their adulthood appear to have less egg production and ovary mass than the suboptimal diet treatment. These results may represent a life history tradeoff where females allocate their limited resources to reproduction in early adult life due to their poor nutritional environment.

P2-144 CLARDY, TR*; HEINLE, MJ; THOMAS, BK; AL-NUWAIRAH, MA; DAS, PB; QURBAN, MA; HIKMAWAN, TI; PRIHARTATO, PK; ABDULKADER, KA; King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia, Environmental Protection Department, Saudi Aramco, Dhahran, Saudi Arabia; *tclardy@kfupm.edu.sa*

Response of zooplankton to a phytoplankton bloom in coastal waters of the Western Arabian Gulf

Phytoplankton blooms can have significant positive or negative effects on the structure and abundance of zooplankton communities. A diatom bloom comprised of *Skeletonema* sp. and *Thalassiosira* sp. was encountered off Khobar, Saudi Arabia. A suite of environmental and biological parameters within the bloom and at a reference site were measured to assess the effect of the bloom on zooplankton. The dominant copepod species at both sites, *Acartia ohtsukai*, showed a 15x reduction inside the bloom. The fitness of individual *A. ohtsukai* inside and outside the bloom was compared using body volume. Measurements of the prosome and urosome from 50 males and 50 females from each location were made to calculate the body volume of individual copepods. There were no significant differences in copepod volume between sites for either sex, indicating the bloom was not affecting the fitness of individual copepods. Both *Skeletonema* and *Thalassiosira* produce aldehydes that compromise embryonic development in copepod eggs. The reduction in zooplankton density associated with the bloom was likely a result of population-level effects on reproduction rather than a reduction in individual fitness.

P2-103 CLAUNCH, NM*; SCHOENLE, LA; OAKEY, S; DOWNES, C; MARTIN, LB; ROMAGOSA, CM; REED, RN; University of Florida, Hamilton College , University of South Florida, University of South Florida, Hamilton College, University of South Florida, United States Geological Survey, Invasive Species Branch; *nmclaunch@ufl.edu*

Stress responses of an infamous island invader, Boiga irregularis

The insular population of introduced brown tree snakes (*Boiga irregularis*) on Guam have largely depleted the native vertebrate fauna, yet continue to exist at relatively high densities. Under such conditions of stress, secretion of the glucocorticoid hormones may be altered, which can subsequently affect fitness. This well-studied population of snakes provides an avenue for long-term evaluation of glucocorticoid responses, and an opportunity to examine functional aspects of changes in corticosterone (CORT), such as innate immunity. In April 2018 we captured 37 brown tree snakes and collected baseline blood samples in under 7 minutes. Snakes were placed in cloth bags for one hour to induce an acute stress response and resampled. All blood was immediately centrifuged, serum separated, and flash-frozen in liquid nitrogen vapor phase, then transferred to a freezer at -80 C on return to the mainland. Bacterial-killing ability was assessed within 1 month of collection. We assessed percent killing ability of plasma incubated with *E. coli* and compared it to growth of *E. coli* in a positive control via spectophotometry. CORT concentration was assessed via enzyme immunoassay with a commercially-available kit. We evaluate the hypothesis that glucocorticoid hormone levels are altered over time in populations with depleted resources and overpopulation by comparing our data to data collected 15 and 25 years prior. Additionally, we examine the functional response of the complement pathway of the innate immune system via bacterial-killing ability of plasma as it relates to baseline and acutely-stressed CORT levels.

P2-274 CLEGG, DC*; CHI, RC; REITZEL, AM; Univ. of North Carolina, Charlotte; *dclegg1@uncc.edu*

Characterization and Expression of Transcription Factors in the Circadian Clock of Cnidarians

Transcription factors regulate expression of the genome through specific binding to particular sequence motifs as well as protein-protein interactions. Members of the bZIP and bHLH-PAS families of transcription factors have roles in diverse molecular processes, including the circadian clock and antioxidant response for many animals. Although comparative genomics has shown these gene families are present and diverse in cnidarians, we currently know little about the shared and unique functions for particular bZIP and bHLH-PAS proteins in this phylum. Here, we report on our studies of the expression and binding preferences for bZIP protein in the PAR family and bHLH-PAS proteins related to the circadian clock from the sea anemone *Nematostella vectensis*. We have successfully cloned and optimized expression for seven of these transcription factors as bacterial recombinant GST fusion proteins. We will also describe results from ongoing approaches to determine the diversity of DNA binding motifs for each protein. Results from these assays will aid in determining potential target genes for these transcription factors and how the expression of these genes varies over a diel lighting period.

P2-179 COFFIN, JL*; KELLEY, JL; JEYASINGH, PD; TOBLER, M; Kansas State University, Washington State University, Oklahoma State University; *jlcoffin3@gmail.com*

Responses of Fishes to Heavy Metal Contaminated Extreme Environments

Heavy metal pollution stemming from mining activities has profound biological effects, causing reproductive damage, behavioral changes, and increased mortality on an individual level, with cascading consequences for populations and ecosystems. The Tar Creek Superfund site in the Tri-State Mining District of Kansas, Missouri, and Oklahoma was declared due to heavy metal pollution from acidic mine runoff in the Tar Creek watershed. Resident populations of Western mosquitofish (*Gambusia affinis*) provide an opportunity to study organismal and evolutionary responses to heavy metal pollution at all levels of organization. Mosquitofish are the dominant species in polluted sections of Tar Creek and also occur in numerous proximate, uncontaminated watersheds, facilitating comparative analyses. We used high-throughput elemental profiling and RNA-sequencing in gill, liver, and brain tissues to address basic questions about organismal responses to heavy metal stress: 1) how does the extent of metal accumulation vary across tissues in *G. affinis*?; 2) how does metal accumulation differ between contaminated and uncontaminated populations of *G. affinis*?; and 3) what genes are differentially expressed between contaminated and uncontaminated populations? Future work will discern whether these observed gene expression differences are due to evolution or plasticity, which will allow us to investigate how heavy metal pollution might impact rapid evolutionary responses and understand the mechanisms that have allowed *G. affinis* to inhabit extreme environments.

P2-259 COHEN, KE*; ACKLES , AL; HERNANDEZ, LP; University of Washington , Michigan State University , The George Washington University ; *kecohen@uw.edu*

Origin, heterochrony, and diversification of otocephalan epibranchial organs

Epibranchial organs are paired food-aggregating structures thought to have evolved at least six times within actinopterygian fishes. Ranging in complexity from small slits on the ventral pharyngeal roof to complex spiraling structures, epibranchial organs are morphologically diverse. Despite this morphological diversity and broad distribution, little is known of the development and evolution of epibranchial organs. Here we investigate the origin of the epibranchial organ by comparing ontogeny within three different species. Anchoa mitchilli (Engraulidae) represents a more basal species with a simple epibranchial organ, Brevoortia tyrannus (Clupeidae) has a more anatomically complex epibranchial organ, and Hypophthalmichthys molitrix (Cyprinidae) represents the most complex epibranchial organ described. Despite the final adult morphology all epibranchial organs initially develop from an epithelial involution that is subsequently surrounded by muscle dorsal to the fourth and fifth pharyngeal arches. The epibranchials and infrapharyngeobranchials are hypertrophied to support the growing structure. There was a strong correlation between ossification rates of the branchial arches and the development and overall size of the epibranchial organ. Thus, in H. molitrix the fourth and fifth arches develop and ossify before the more anterior arches. The final structure is composed of all five arches whereas in both Brevoortia and Anchoa ossification of the arches begins later in development and only the fourth and/or fifth arches are included in the epibranchial organ. We hypothesize that the epibranchial organ originated from an involution into the pharyngeal tissue supported by a modified posterior branchial arch.

P3-32 COHEN, HE*; KANE, EA; Georgia Southern University; *hc02684@georgiasouthern.edu*

Damaged Goods: Do Injuries Affect Swimming Performance During Prey Capture in Bluegill?

Many animals must use some sort of locomotion in order to survive. However, injuries from predators, intraspecific attacks, and disease can affect locomotor performance. In fish, fins are used to swim and maneuver during behaviors such as catching prey, avoiding predation, and finding mates. An injury to their fins can potentially affect their ability to perform these behaviors and even cause mortality. Bluegill sunfish (*Lepomis macrochirus*) are a common freshwater species in North America, have been a model organism for performance studies, and often experience natural injuries. We investigate the effects of fin damage on swimming performance during prey capture in bluegill. We hypothesize that fish with injured fins will show a decrease in performance traits. Individuals were caught from a local hatchery where differences in capture technique resulted in fish with either healthy or damaged fins. Bluegill were recorded with a high speed camera at 500 fps while they captured prey. We predict that approach velocity and acceleration will be slower, predator-prey distance will be shorter, and time to prey capture will be longer in fish with damaged fins. These differences can have consequences for competing for food and capturing evasive prey. If differences aren't apparent, it may indicate that fish might compensate by using other fins.

P2-51 COLAVITA, M*; WITHERELL, H; ERICKSON, J; SCHREIBER, W; University of Louisville, Washington and Lee University; *colavitam18@mail.wlu.edu*

Measurement of Discrete Behaviors in Ants Using Spatially-Averaged Intensity Gradients

Animal behavior research often requires the capture and subsequent analysis of behavior recorded from live organisms. Quantifying the expression of behavior (especially in insects) can be challenging when using human observers alone. The purpose of this project was to develop a computer-automated analysis method for discrete behaviors (measured qualitatively) in ants which would yield a high level of coherence with the evaluations of a separate human observer. We were specifically interested in examining the expression of forward antennal movements in a sample of animal data (n = 4; 25 observations/animal) collected from a previous, unpublished study. Western harvester ants harnessed in a modified 100 μL pipette tip were exposed to a total of twenty-five presentations of an odorant stimulus and/or untreated cotton-tipped applicator. Forward movements of the antenna during stimulus presentations were scored as a binary outcome (yes/no) by a blind researcher. Videos were analyzed in MATLAB by defining a region of interest and measuring the spatially-averaged intensity and spatially-averaged intensity gradient for each frame of the video file. Threshold values were set to a multiple (1, 2, 3, 4, and 5x) of the noise level, which was computed using the median of the absolute deviation, and the expression of forward movement was determined by whether a measurement during the period of stimulus presentation exceeded the threshold value. Overall, this automated method yielded high levels agreement (μ = 85%) and inter-rater reliability with a human observer at low thresholds, but lower levels of agreement and inter-rater reliability at threshold values of 3 or more. This automated method will help accelerate rapid and accurate analysis of ant behavior in future studies.

P1-65 COLLAR, DC*; TREMAINE, S; HARRINGTON, RC; FRIEDMAN, M; Christopher Newport University, Yale University, University of Michigan; *david.collar@cnu.edu*

The Adaptive Landscape for Body Shape and Its Anatomical Determinants in Pelagiarian Fishes

Body elongation is one of the most prominent aspects of morphological diversification in fishes. Evolutionary transitions between disc-shaped, fusiform, and eel-like bodies involve some combination of changes to head shape or vertebral dimensions, but it is unknown whether major shifts in body shape require particular suites of anatomical changes. In this study, we investigate the evolutionary origins of the remarkable diversity of body shape within Pelagiaria—a radiation of open-ocean fishes containing 15 recognized families that span much of the range of body shapes exhibited among ray-finned fishes. Using a robust fossil-calibrated molecular phylogeny and a Bayesian method for estimating the adaptive landscape, we identify shifts in optima for overall body shape and for the anatomical components that determine it. We estimate a relatively deep-bodied pelagiarian ancestor, a shift to a fusiform optimum that is widely shared among lineages (e.g., tunas and mackerels, bluefish), and several transitions to elongated forms. One of these transitions—the one leading to the highly elongated Trichiuridae (e.g. cutlassfishes)—is associated with shifts in optima for most underlying anatomical components (i.e., lengthening of the head and abdominal and caudal vertebral regions). Other instances of body elongation, however, are associated with peak shifts for different subsets of anatomical components, revealing a mosaic of adaptive landscapes for the parts of the body that drive body shape diversification in Pelagiaria.

P1-194 COLLINS, M/G*; HULSEY, R/D; SMITH, K/M; CHILDRESS, M/J; Clemson University, Clemson University ; *mgcolli@g.clemson.edu*

A Tail of Two Territories: Sex Differences in the Territories of Stoplight Parrotfish, Sparisoma viride

Parrotfish are abundant herbivores that inhabit the coral reefs located in the Florida Keys. These herbivores have major impacts on coral reef ecosystems by regulating the abundance of competitive algae and indirectly benefitting corals. These hermaphroditic fish have a social structure in which one terminal phase male controls and protects a territory. Previous studies have shown that territory size may be determined by harem size (female defense polygyny) or, dietary preferences and reef complexity (resource defense polygyny). Our study tests which hypothesis best explains territory size in terminal and initial phase stoplight parrotfish (*Sparisoma viride*) on reefs located in the middle Florida Keys National Marine Sanctuary. We followed two terminal parrotfish and two initial parrotfish on four sites for ten minutes, estimating territory size by dropping markers. We also measured substrate cover, rugosity and conspecific density for each territory. Our results show that terminal phase parrotfish have significantly larger territories than intermediate parrotfish and intermediate phase territories only overlap the edges of terminal fish territories. We also found that terminal phase territory size was negatively correlated with conspecific density. These results suggest territory size among terminal phase stoplight parrotfish may be focused towards female defense polygyny, where territories are driven by the presence of a harem.

P1-154 COONFIELD, A.J.*; IYENGAR, V.K.; Villanova University; *acoonfie@villanova.edu*

Neighbors, Rivals, and Frenemies: Social Networks in the Maritime Earwig, Anisolabis maritima

The spatial distribution of conspecifics can provide important insights into aggression and competition in social species, particularly those in which both sexes possess weaponry. The maritime earwig (*Anisolabis maritima*) lives in high densities under beach debris in coastal ecosystems, and both sexes are aggressive yet differ drastically in both forceps morphology and temperament. Previous research showed that the differential behavior of the sexes affect the spatial distribution of small confined groups—females exhibit more hostile, territorial behavior than males, who tend to interact with one another more frequently—but interactions in more natural arrangements of free-moving individuals had not yet been examined. Given its natural history, the maritime earwig is well-suited for social network analyses, where the movement and proximity of individuals can be tracked to determine how complex interactions within and between the sexes influence social and reproductive behavior. In this study, we ran 30 trials of eighteen marked male and female earwigs collected from San Juan Island, WA, where half the groups had a 2:1 ratio of females to males and half the groups had a 1:1 sex ratio. Each arena contained four possible wood shelters, and we photographed the dispersion of individuals beneath them twice daily for 7 days. By tracking their positions and cohabitation patterns, we mapped social networks to analyze degrees of centrality and cliquishness within each group. We here report that the size and sex of individuals affected their social position and the nature of their connections within the group. Additionally, alteration of the sex ratio, and therefore the social environment, affected the social networks and overall group dynamics.

P1-158 CORDERO, C*; AMBROSE, A; ORTIZ, C; PETANIDOU, T; TSCHEULIN, T; GIRAY, T; HRANITZ, J; BARTHELL, J; GONZALEZ, V; AGOSTO, J; UPR, SSU, Univ. of the Aegean, BU, UCO, KU; *claudia.cordero2@upr.edu*

The response of circadian rhythms to humidity/temperature oscillations and the foraging patterns of specialist and generalist sweat bees

Plant-pollinator interactions are fundamental for conservation biology, agriculture, and ecology. The temporal synchrony between plants and their pollinators is a key aspect of their interaction. However, the specific factors that determine the synchrony between the timing of bee foraging activity and the timing of plant resource availability are not well understood. Biological clocks play an essential role in controlling physiological process in both pollinators and plants. We hypothesize that the temporal pattern of foraging behavior is mainly determined by the interaction between biological clocks and environmental factors such as light, temperature, and humidity, and also these interactions vary among specialist and generalist species. To test the hypothesis, we analyzed the locomotor activity of bees as an index of foraging activity under simulated light, temperature, and humidity oscillations. We conducted the experiment with the generalist social bee L. malachurum and the solitary specialist S. curvicornis. Overall, we found that the two species have different activity patterns: a unimodal pattern for S. curvicornis and a bimodal pattern for L. malachurum. In the case of S. curvicornis, we found that their internal clock run faster than 24 hours and that temperature and/or humidity reset the internal clock in a daily manner. In the case of L. malachurum we found that the bimodality of its pattern is intrinsically driven by the biological clock. Further studies are needed to dissociate the specific contribution of these environmental factors on the activity pattern of these species. This work was supported by the following grants: NSF-REU #1560389, NSF-PIRE #1545803, NSF-PRCEN #1736019, NSF-BigData #1633164 and #1633184, and NSF-PR-LSAMP #1400868.

P2-181 CORNELIUS, JM*; CAMERON, R; Eastern Michigan University; *jcornel7@emich.edu*

An experimental investigation of food unpredictability, housing and water-fasting on hematocrit levels in captive red crossbills, Loxia curvirostra

Hematocrit - or the percent volume of red blood cells in whole blood - is often referred to in papers as an indicator of body condition, yet it is responsive to a seeming myriad of factors, including factors that aren't necessarily related to body condition (e.g., elevation, metabolic demand and hydration). Some ambiguity may also arise from the fact that few studies directly investigate hematocrit but rather measure hematocrit because it is easy to do so and might prove interesting. We used an experimental approach to investigate the impacts of water availability, food availability and cage size (as an indirect manipulation of flight activity) on hematocrit levels in captive red crossbills (*Loxia curvirostra*). We found effects of food treatment and housing on changes in hematocrit and no difference following a short-term water restriction. We discuss these results in light of hypotheses about hematocrit and body condition.

P1-182 COURTS, LG*; KITTREDGE, MJ; PASK, GM; Bucknell University; *lgc009@bucknell.edu*

Cracking the CHC Code: Olfactory Communication in the Eusocial Harpegnathos saltator

Insects rely heavily on their sense of smell as a way to assess their surroundings and nearby organisms. In a lifestyle termed eusociality, bees, wasps, and ants form a hierarchy in which there are a limited amount of reproductive individuals and the rest become workers or nurses. Coordinated communication in the colony is mediated through the olfactory system, where each ant has a specific scent, acting as a "chemical ID", signifying one's own reproductive status, age, sex, etc. in the colony. These odors are made up of Cuticular Hydrocarbons (CHCs), which coat their exoskeleton. With the critical nature of smell for communication, there needs to be receptors to transmit and send the signal for higher level processing and recognition. *Harpegnathos saltator*, also known as the Indian Jumping Ant, has become a prime model for studying eusociality due to its reproductive behaviors, and the rapidly evolving 9-exon subfamily, which makes up the majority of CHC receptors. Focusing on specific HsOr lineages undergoing positive selection, we are examining how genetic variation can lead to differences in CHC sensitivity. Using an HsOr expression system in *Drosophila melanogaster*, we can functionally characterize odorant receptors within its genome. Utilizing electrophysiology, we can puff certain odors onto the fly that has a specific receptor, and see if there is a response based on their electrical signals that are being tracked. Through this work, we hope to understand how rapid evolution of olfactory receptors can facilitate the chemical communication required for the hierarchical lifestyle in ants and other eusocial insects. Building on this, by determining protein receptor structures, and identifying their function by accordance with smell, we may not only be able to preserve eusocial insect communities, but confront the issues of agricultural pests and human disease vectors.

P2-12 COYLE, J*; PORTER, ME; RODRIGUEZ, C; Florida Atlantic University High School, Florida Atlantic University, Pine Jog Environmental Education Center; *JASHCRA1@fau.edu*

Partnering with PreK-12 STEM education to propagate, track establishment and survivorship of native plants in Florida

The link between mycorrhizae, symbiotic fungi, and their host plants is well documented in many systems. Mycorrhizae provide direct physiological benefits to their hosts and also impact local soil conditions. In some families, such as orchids, the presence of mycorrhizae are critical even at the early stage of seed germination. In Florida, native orchid species are rapidly declining, largely due to habitat loss. The Florida Atlantic University (FAU) Pine Jog Environmental Education Center is using published micropropagation methods to grow and re-introduce native orchids into urban and natural areas across south Florida. As these orchids are re-established, mycorrhizal growth and morphotypes among species and planting conditions are monitored and studied. As a teaching tool, and to establish community activism, orchids are placed in local schools, including FAU's onsite lab school, A.D. Henderson, for students to propagate, study, and outplant. Students are active partners, cultivating plants and preparing them for distribution into urban and natural areas within their established native ranges. FAU High School students are learning microscopy techniques to quantify differences in mycorrhizal communities and overall plant conditions from orchids transplanted in natural compared to urban locations. These experiments engage students of all ages and expose them to hypothesis testing, experimental design, and propagation techniques. This project also encourages students to interact with the natural environment and consider the ecological consequences of urban development while re-establishing a declining native species.

P1-183 CROCKER-BUTA, S/P*; LEARY, C/J; University of Mississippi; *scrocker@go.olemiss.edu*

Hormonal and Social Correlates of Courtship Signal Quality and Behavior in Male Green Treefrogs

Circulating hormone levels vary among males competing for mates, but how this variation affects the signaling phenotype is poorly understood. In green treefrogs, *Hyla cinerea*, males competing for mates engage in vocal contests that increase corticosterone (CORT) and decrease androgens in contest losers, who adopt a non-calling "satellite" mating tactic. We previously showed that CORT administration to calling males reduces vocal effort and increases the probability of satellite behavior during simulated territorial intrusions, suggesting that elevated CORT compromises vocal quality and decreases the propensity to call in a context-dependent manner. However, the extent to which these effects reflect variation in vocal behavior of males in natural choruses is unclear. Here, we examined how hormone levels, social context, body size and condition relate to vocal attributes and behavior in calling males and in satellites after removal of calling "host" males. Results revealed that satellites had higher CORT, lower androgens, were smaller, and in poorer condition than hosts. Host removal resulted in vocalization in 74% of satellites. These males invested less effort in vocalization than hosts and CORT level best explained these differences. The remaining 26% of satellites did not vocalize after host removal and had lower androgens than satellites that vocalized. Results provide support for context-dependent effects (i.e., host presence/absence) of elevated CORT on the probability of vocalization and link high CORT to reduced vocal quality. In contrast, low androgens were associated with a low probability of vocalization regardless of social context and androgen level was a poor predictor of vocal attributes.

P1-180 CROCKER-BUTA, S/P*; HOLLOWAY, A; LEARY, C/J; University of Mississippi, Alcorn State University; *scrocker@go.olemiss.edu*

Female Green Treefrogs Prefer the Acoustic Courtship Signals of Unstressed Males

Variation in circulating levels of adrenal glucocorticoids can alter the expression of male sexual signals. However, whether variation in circulating glucocorticoid levels among courting males affects the probability of attracting females remains poorly understood. Here, we address this issue in the green treefrog, *Hyla cinerea*. Males of this species engage in aggressive vocal interactions that increase circulating levels of corticosterone (CORT) in rival male contest losers. We previously showed that CORT administration to calling males, simulating CORT production in vocal contest losers, decreases call duration and vocal effort, suggesting that elevated CORT compromises the attractiveness of male vocalizations. Using dual speaker playback experiments, we examined whether females show a preference for vocalizations characteristic of males with low versus high circulating CORT levels. Results from a total of 30 phonotaxis trials revealed that 24 females showed phonotaxis towards the speaker broadcasting calls characteristic of males with low CORT levels while only 6 females showed phonotaxis towards the calls characteristic of males with high CORT levels. These results indicate that females show a strong preference for the acoustic courtship signals of males with low CORT levels, suggesting that elevations in circulating glucocorticoids during male contests can diminish the probability of attracting females.

P1-30 CROFTS, S. B. *; LAI, Y.; HU, Y.; ANDERSON, P.S.L.; University of Illinois at Urbana-Champaign, Georgia Institute of Technology ; *scrofts@illinois.edu*

Taking a stab at quantifying sharpness in snake fangs

The sharpness of biological puncturing tools plays an integral role in their function, as initiating fracture in a target material depends on the shape of the tool tip. There are various approaches to measuring tool sharpness, but how the different aspects of morphology affect puncture has yet to be studied. To understand what features of puncture tool tip affect the puncturing force, we turn to vipers as a case study. Viper strike is a quick, venomous bite and release that incapacitates prey and reduces their likelihood of injury. To understand the relationship between fang tip shape and fracture initiation, we took a two-pronged approach: 1) by measuring total fang length, tip sharpness index, tip surface area, and average included angle of fangs from 19 species and comparing these to the amount of force required to initiate fracture; and 2) creating and testing engineered puncture tools to separate the functional impact of included angle and radius of curvature on puncture initiation. When comparing the effect of fang tip morphology, only included angle showed a significant impact of force to initiate fracture, relative to the other morphological measurements. For the engineered punches, both included angle and radius of curvature have a significant effect on the force required to initiate fracture, with included angle having a greater impact. These data suggest that fang included angle is the strongest predictor of the force required to initiate fracture. Radius of curvature, which is used to determine sharpness index, is also an important predictor, though the influence of this factor becomes less significant at larger included angles.

P1-27 CROGHAN, J/A; Ohio University; *jasmine.croghan@gmail.com*

Two Turtles, Two Diets, Two Biomechanical strategies: Jaw Biomechanics in a Generalist Versus a Durophagous Species of Emydid

The diet of durophagous turtles impacts the shape and size of the skull, enabling the higher bite forces these species require to access hard-shelled prey. In a recent comparison, the durophagous *Malaclemys terrapin* was demonstrated to have a larger head relative to body size and therefore greater bite force than the closely related diet generalist, *Trachemys scripta*. Here, I test the hypothesis that jaw lever mechanics, not just relative head size, differ between the species, contributing to the higher bite force of *M. terrapin*. Female specimens of both species underwent diceCT, allowing me to digitally dissect the jaw closing musculature. The resultant 3D digital models were used to calculate lever mechanics of the jaws and measure the volumes of the jaw closing musculature. *M. terrapin* have 155% larger muscles relative to jaw length than *T. scripta*, which is indicative of a higher bite force capability even when scale for head size. Surprisingly, the line of action of the major jaw closing musculature differs between the species by less than one degree, indicating that neither is at an advantage for force input into the jaw lever system. The out-lever of the jaw was 4% larger in *M. terrapin* while the in-lever was 6% longer in *T. scripta*, suggesting that the mechanical advantage of the jaws is in fact higher in *T. scripta*. These results support that *T. scripta* possesses a mechanically more advantageous jaw system, but that the overall greater muscle volume relative to head size in *M. terrapin* is a major contributer to the observed differences in bite force between these species. Whether muscle architecture lends additional influence to the bite force capabilities of *M. terrapin* remains to be explored.

P2-212 CRONIN, AJ*; ROBERTSON, JC; ROBERTSON, John; Westminster College, PA; *robertjc@westminster.edu*
Structure of the Pyloric Cecum in Acipenseriformes
We are interested in comparative study of structure and function in North American Acipenseriform fishes. Here, we characterize structural features of the pyloric cecum in three species - paddlefish (*Polyodon spathula*), Atlantic sturgeon (*Acipenser oxyrhynchus*) and lake sturgeon (*Acipenser fulvescens*). In many fish species, the pyloric cecum is a prominent digestive organ thought to have absorptive and possibly secretory functions. Using preserved specimens of juvenile fish of about the same age and size, we determined morphometric indices that relate pyloric cecum dimensions to digestive tract and whole body measures. In addition, we use histology and image analysis to compare pyloric cecum cell and tissue features in the three species. Comparing the pyloric cecum in different species may offer insight into digestive adaptations associated with the different ways of life and diets of these diverse Acipenseriformes.

P2-248 CROWNOVER, L. A.*; ANDERSON, C. V.; University of South Dakota, Vermillion; *Lucas.Crownover@coyotes.usd.edu*
Exploring Axial Skeletal Function and Evolution in Chameleons using Micro-CT Technologies
Chameleons are well known for numerous highly characteristic anatomical and behavioral features such as their projectile tongue, prehensile tail, independently rotating eyes, and color changing abilities. With over 200 described taxa in twelve genera, however, chameleons are extremely diverse in their own right and come in a great variety of unique shapes and sizes. Among the most variable skeletal features in chameleons is the number of presacral (cervical, thoracic and lumbar) and caudal vertebrae, as well as the number of sternal and parasternal ribs. In fact, chameleons are known to have 14-23 presacral vertebrae, 17-62 caudal vertebrae, 3-4 sternal ribs, and 5-11 parasternal ribs. This variation, however, is based on the examination of a limited number of taxa and has not been put into a proper phylogenetic or ecological context (e.g., more arboreal vs. terrestrial species). We gathered and examined micro computed tomography (micro-CT) scans from 233 chameleon specimens, representing 155 different species of chameleon and five additional subspecies. This sample represents seventy-five percent of all described chameleon species, including all genera, and a previously unmatched body of data on the structure and function of this lizard family. From this examination, we quantified the rib and vertebral numbers across the family, including variation within genera. We then tested whether this variation correlates most closely with ecological characteristics or phylogenetic relationships within the family. These results provide insight into the evolution and function of the axial skeleton in chameleons and the morphological evolution of the axial skeleton across disparate ecological environments.

P3-132 CUEVAS-SANCHEZ, A Y*; MILLER, A; DOWD, W W; Washington State University; *a.cuevas-sanchez@wsu.edu*
Heat induced stressors in a changing environment: Thermal preference and activity assay of Tigriopus californicus
Splash-zone copepods *(Tigriopus californicus)* experience a variety of environmental fluctuations including changes in salinity, temperature, pH, and dissolved oxygen. We predicted that individuals acclimated to warmer temperatures would develop a thermal preference for cooler water, while also decreasing their activity level. Egg-mass-bearing females (n=48) were subjected to one of four temperature treatments for two weeks: 15°C, 19°C, 23°C and one treatment oscillating between 15-23°C each day. We assayed both activity patterns and thermal preference on each individual to examine the effects of fluctuating and constant temperature acclimation on behavior. We quantified activity of individual copepods in a novel, high-throughput microplate-based assay to look at the effects of acclimation to fluctuating and constant temperature on activity patterns during a controlled heat ramp (18-26°C). Results to date indicate that females acclimated to warmer temperatures have a thermal preference that averages ~4°C below their acclimation temperature, and those acclimated to a fluctuating thermal regime prefer temperatures close to the mean of the daily cycle. Meanwhile, copepods acclimated to 15°C preferred temperatures slightly above their acclimation temperature. Although there is only a weak effect of acute temperature change on activity levels during a heat ramp, there is evidence of decreased overall activity in copepods acclimated to higher temperatures. Our ultimate goal is to assess the ecological and evolutionary implications of environmental stress physiology and developmental plasticity of offspring in these dynamic and changing intertidal habitats.

P3-60 CUFF, AR; DALEY, MA; MICHEL, KB; ALLEN, VR; LAMAS, LP; ADAMI, C; MONTICELLI, P; PELLIGAND, L; HUTCHINSON, JR*; Royal Veterinary College; *jhutchinson@rvc.ac.uk*
Electromyographic Analysis Of Appendicular Muscle Function In Extant Archosaurs
Archosauria (birds, crocodiles and all descendants of their common ancestor) is characterized by remarkable locomotor variation across its evolution since the Triassic. More sprawling, quadrupedal crocodiles and more erect, bipedal birds are prime examples of this variation. The functional implications of musculoskeletal anatomy have been widely studied, but more experimental data are needed on how muscles control locomotor movements in extant archosaurs. We present new electromyographic measurements from key appendicular muscles across a range of walking and running speeds in Nile crocodiles and numerous species of birds (tinamous, emus, guinea fowl, pheasants, turkeys and quail). We consider how extant archosaurs control limb movements, and how neuromotor control has likely evolved. Crocodiles, like most other tetrapods, use their pectoral muscles in an antigravity role. Crocodiles' iliotibial, digital flexor and gastrocnemius muscles are activated similarly to birds (including Palaeognathae); likely ancestral for Archosauria. Birds, regardless of clade or ontogenetic status, show conservatism among the hindlimb muscles studied; these motor patterns appear ancestral for Aves. Our analysis is important for revealing which muscles display neuromotor conservation vs. evolutionary specialization. These findings are vital for testing the validity of computer simulations and reconstructing how locomotor disparity evolved in Archosauria.

P3-90 CULLEN, JA*; HALA, D; MARSHALL, CD; Texas A&M University, Texas A&M University at Galveston; *jcullen@tamu.edu*
Influence of Feeding Ecology on Accumulation of PAHs and PCBs in Three Sympatric Shark Species
Organic contaminants, such as polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs), are ubiquitous within aquatic habitats and bind to organic material that can accumulate through food webs. Ecological tracers, such as stable isotopes $\delta^{13}C$ and $\delta^{15}N$, are useful to describe the resource use (foraging habitat and trophic position) of an organism within a given ecosystem. Although some previous studies have used stable isotopes to describe ecological sources of exposure to pollutants in fishes, this relationship remains unclear in sharks. Bull (*Carcharhinus leucas*), blacktip (*Carcharhinus limbatus*), and bonnethead (*Sphyrna tiburo*) sharks were selected for this analysis to compare sympatric species with different ecological niches from an industrialized basin (Galveston Bay, TX). Tissue-based burdens of 45 individual PAH and PCB congeners, as well as measures of $\delta^{13}C$ and $\delta^{15}N$, were quantified in muscle tissue of each species. We hypothesized that PAH and PCB burdens would vary among species as a result of differing isotopic niches and that $\delta^{15}N$ would be positively associated with increasing burdens of PCBs. A combination of univariate and multivariate analyses were conducted to discern the potential contributions of foraging habitat and relative trophic position to the accumulation of these pollutants. Patterns of pollutant burdens with isotopic niche were found within and among species.

P2-23 CUMMING, M*; SMITH, FW; University of North Florida; *n01403244@ospreys.unf.edu*
A Novel Developmental Mechanism Patterns Legs in Tardigrades
Panarthropoda is composed of three lineages of animals that possess legs—Arthropoda, Onychophora, and Tardigrada. Unlike onychophorans and tardigrades, arthropod legs are characterized by highly distinct morphologies along the proximodistal axis and joints. In both arthropods and onychophorans, the leg gap genes *Distal-less*, *dachshund*, *extradenticle*, and *homothorax* show regionalized expression patterns during leg development. *Distal-less* patterns the distal region of the leg, *dachshund* patterns the intermediate region of the leg, and *extradenticle* and *homothorax* work in combination to pattern the proximal region of the leg. These similarities reveal that a highly conserved developmental mechanism can underlie the evolution of very disparate leg morphologies. We investigated the leg gap genes in tardigrades to determine whether the mechanism identified in arthropods and onychophorans regulates development of the tiny legs of tardigrades. We identified single orthologs of *Distal-less* and *homothorax* in the genomes of two tardigrade species—*Hypsibius exemplaris* and *Ramazzotius varieornatus*. We identified three orthologs of *extradenticle* in these species. We could not identify a *dachshund* ortholog in these species, even though it is present in panarthropod out-groups, suggesting that this gene was lost in the tardigrade lineage. Using in-situ hybridization, we detected *Distal-less* signal in all developing tardigrade legs. Strong *homothorax* signal was restricted to the anteriormost leg pair. We detected weak signal in the second and third leg pair, and no signal in the fourth leg pair. Of the leg gap genes, only *Distal-less* appears to be required for development of all tardigrade legs. Therefore, our preliminary results suggest that, relative to the legs of arthropods and onychophorans, the tardigrade leg may only possess distal identity.

P2-66 CUNHA, FB*; WYLIE, D; GUTIERREZ-IBANEZ , C; IWANIUK, AN; Univ. of Lethbridge, Canada, Univ. of Alberta, Canada; *felipebrcunha@gmail.com*
How Do Neuronal Scaling Rules Apply to the Evolution of the Avian Cerebellum?
The rate at which the number of neurons increases with the overall size of the brain, and its constituent brain regions, varies across clades. This has led to the development of 'neuronal scaling rules', defined as the allometric relationship between neuron numbers and brain region volumes. Although these scaling rules appear to explain several aspects of brain diversification in vertebrates, it is unclear whether these scaling rules apply equally across different neuronal populations or to what extent neuron size follows brain region or clade specific scaling rules. To gain a better understanding of how neuronal scaling rules affect the evolution of species differences in brain region size, we quantified different aspects of the anatomy of the cerebellum, a key region for motor coordination that varies in size and morphology across species. Using unbiased stereology, we quantified the volumes of molecular, granule and white matter layers and the number and size of Purkinje cells across 60 species of birds. Phylogeny-based statistical analyses show that the different layers of the cerebellum evolve in a concerted fashion across all birds. In other words, when one layer increases in size, all the others increase at the same rate. Both the number and size of Purkinje cells, the sole output neurons of the cerebellar cortex, increase with cerebellum size, but Purkinje cells are added at a faster rate than they change in size. Last, more folded cerebella also had more and larger Purkinje cells. Thus, the evolution of larger cerebella is due to coordinated increases across cell layers as well as increases in the number and size of Purkinje cells according to a common set of neuronal scaling rules.

P1-156 CUPP, PV; Eastern Kentucky University; *paul.cupp@eku.edu*
Mate-guarding and Pair-bonding Behavior in Green Salamanders, Aneides aeneus
Male *Aneides aeneus* arrive at home crevices and establish territories through chemical deposits and often aggression with other males. Females usually follow soon after. Thus, male-female pairs are formed in single rock crevices or in adjacent crevices for periods of days or weeks mainly in May and October. Pair bonding occurs that likely involves chemical and tactile communication. Males and females may gain familiarity with each other. Male-female pairs are often in direct contact as males may have a limb or other body part resting on the back or tail of females. Also, heads of male and female may be oriented to opposite ends of crevice openings with posterior ends in contact. This may be a defensive response to predators. Pairing increases chances of courtship and mating, and allows for mate guarding thus reducing chances for polyandry and polygyny. Some aggression by males may occur such as biting and snout-pressing, which is similar to behaviors observed during courtship and mating. Males that have established and defended territories are likely more fit. Thus, mate-guarding behavior may be selected for in that females may choose more fit males. Aggressive defense of territories by males combined with the formation of male-female pairs and pair bonding indicates that mate guarding occurs in *A. aeneus*. This may enhance reproductive success of both males and females.

P1-97 CURRY, JE*; NAVARA, KJ; University of Georgia; *jcurry@uga.edu*
Natural sex ratio bias in Japanese quail, Coturnix japonica
Many studies in various avian species have reported sex ratios deviating from the expected 1:1 male to female ratio. This literature almost exclusively focuses on various factors that can influence sex ratio, such as food availability or mate attractiveness, while few studies examine sex ratios in the absence of these environmental and social cues. One such study in Eclectus parrots found that females in captivity produce long strings of only one sex before switching to the other. This extreme bias was observed in multiple females from multiple breeders. We hypothesize that this phenomenon of skewed sex ratios with no outside influences may occur in other birds. We tested this by observing three flocks of Japanese quail and monitoring sex ratios for two weeks under identical environmental and dietary conditions. The quail were pair housed in temperature and light controlled facilities and given free access to food and water. Eggs were collected, incubated, and sexed via dissection or molecular techniques. In our study, we refer to sex ratios below 0.4 as female biased and those above 0.6 as male biased. In flock one, we found 25 fertile pairs (those that produced at least seven fertile eggs in the two-week span). Of those, five were female biases while eight were male biased. In flock two we found 27 fertile pairs, of which six were female biased and seven were male biased. We tested to see if these biases could be explained by female body condition and found that sex ratios were independent of body mass. Data from third flock is still being analyzed, and these sex ratios will be compared to male and female body morphometrics. Given the multiple examples of bias in two separate flocks, we believe that Japanese quail may alter their sex ratios independent of currently known cues.

P1-153 CURTIS, KM*; MOORE, PA; MARTIN III, AL; Saginaw Valley State University, Bowling Green State University; *almarti2@svsu.edu*
The Effects of Population Structure on Crayfish Aggression
Animals participate in agonistic interactions to secure or maintain necessary resources. Crayfish fight vigorously when introduced, with aggressive behaviors decreasing in frequency and duration as the population stabilizes. This results in dominant and subordinate relationships between individuals; interactions between different sized crayfish cause the large animal to become dominant, while the small animal becomes subordinate. However, populations of crayfish are complex and are difficult to assess. Mutual- and self-assessment are ways animals evaluate conspecifics within a population. Theoretical models by Mesterton-Gibbons and Heap (2013) proposed that assessment and aggression within populations differ in relation to varying resource value. This study attempts to empirically address one piece of this puzzle, the influence of population structure on aggression. Populations of crayfish (4 large, 4 small, 3 small vs. 1 large, 2 small vs. 2 large, 1 small vs. 3 large) are provided with 4 identical shelters and are recorded for 24-hour trials for fight duration and outcome. Preliminary fight duration data suggests populations with primarily large animals (4 large, 3 large vs. 1 small) fight longer as compared to populations with equal or a greater number of small animals (2 large vs. 2 small, 1 large vs. 3 small). Additionally, numbers of fights are found to be greater in populations with all large animals. This data suggests populations consisting of larger crayfish increases the overall aggression of the population. This study, along with future studies involving differing resources, will provide empirical evidence to better understand how resources and assessment strategies collectively influence the intricacies of population structure.

P1-170 DAKIN, R*; HORTON, B. M.; VERNASCO, B. J.; MOORE, I. T.; RYDER, T. B.; Smithsonian Institution, Millersville University, Virginia Tech, Virginia Tech; *roslyn.dakin@gmail.com*
Understanding the androgen basis of individual differences in cooperation
Social behavior is a near-ubiquitous characteristic of vertebrates, and interaction dynamics are often driven by repeatable differences in behavior. Although variation in vertebrate social behavior has a well-known endocrine basis, most of the work on hormone-behavior relationships has focused on archetypal behaviors (e.g., aggression) in relatively simple social systems. As a result, we know little about how hormones modulate complex behaviors, like cooperation, that rely on repeated interactions within a dynamic social landscape. Here, we examined how testosterone (T) modulates social behavior in a lekking species, the wire-tailed manakin (Pipra filicauda), where territorial and non-territorial "floater" males form cooperative display coalitions. Our approach combined repeated hormone sampling, hormone manipulations and a novel automated telemetry system to measure social behavior. First, we asked if T could explain repeatable variation in male-male cooperation (i.e., the number of display partners and the frequency of interactions). Our results reveal that among-individual differences in circulating T predict behavior, but that these relationships are status-specific. Higher T correlates with increased cooperation among floater males but is inversely related to cooperative tendencies among territorial males. Additionally, T manipulations confirm that experimentally-elevated T can inhibit cooperation by territorial individuals with the strongest effects seen in males with lower endogenous T levels. We propose that these status-specific effects are due to differences in the neural activity of androgens and our results highlight how status specific differences in circulating T can influence cooperative behavior.

P1-149 DAN, M*; GIRALDO, YM; DICKINSON , MH; California Institute of Technology, Pasadena; *mdan@caltech.edu*
Seasonality in Drosophila Sun Navigation
The fruit fly, *Drosophila melanogaster*, flies across vast distances by means of a navigation system which is visually guided by celestial cues. As a non-diapausing insect, we wanted to shed light on how *Drosophila* might arrive at seasonally inhospitable habitats, such as the Mojave Desert, by testing whether seasonal temperature and light conditions affect *Drosophila* flight headings. We reared wildtype *Drosophila melanogaster* under divergent daylength and temperature conditions to simulate summer, winter and spring. After reaching adulthood, flies were tethered and placed in a flight simulator, which surrounds the fly with a visual panorama in which we displayed a simulated sun (bright spot) or a landing site (dark, vertical stripe). A machine-vision software tracked the fly's wing strokes, allowing the fly to control the azimuthal angular velocity of the stimulus. An analysis of flight headings suggests that flies reared under winter conditions tend to fixate the sun frontally, thus performing phototaxis, whereas summer and spring flies adopt a wider range of non-frontal headings, ie. menotaxis. Seasonal variations in flight heading were observed within a single generation, which led us to investigate whether other physical characteristics — wet mass and pigmentation — vary plastically. We found significant variation in wet mass between the seasonal treatments, with winter females weighing less and males weighing more than their spring and summer counterparts. Comparing the reflectance percentage of abdomen and thorax pigmentation, we found significantly darker regions on the winter flies. In conclusion, our data lends support to the hypothesis that seasonal developmental conditions can affect navigation strategy and physiology.

P2-131 DANZIGER, A*; FREDERICH, M; University of New England, Biddeford, ME; *adanziger1@une.edu*
Using eDNA and FlowCam Analyses for Green Crab Monitoring
The invasive Green crab, *Carcinus maenas*, and Asian shore crab, *Hemigrapsus sanguinaeus*, have rapidly increased their populations, particularly on the coast of Maine, leading to a significant and detrimental effect on coastal intertidal areas. We have monitored both populations in Biddeford Pool over 6 years. Our data show that both species are established in the area and have reproductive seasons that overlap, but peak about 4 weeks apart during early summer. In addition, green crabs were shown to be egg bearing in the winter months. To determine if their eggs are viable year-round, and produce viable larvae, we designed a remote-controlled boat with an attached plankton suction device that can be deployed in shallow and deep waters. The plankton suction device is comprised of a 60 cm 4 inch acrylic pipe with a BlueRobotics T100 thruster, 200 µm plankton net, and a General Oceanics mechanical flowmeter. Samples collected with the RC boat-driven plankton sucker were analyzed using a FlowCam particle imaging system. Due to a lack of crab larvae abundance in the FlowCam-analyzed samples, we designed an environmental DNA (eDNA) protocol to detect the presence of green crabs in the water column. Focusing on the COI1 gene of green crabs and other crustaceans in Maine, such as the Asian shore crab, the Jonah crab, *Cancer irroratus*, the rock crab, *Cancer borealis*, and the American lobster, *Homarus americanus*, we designed specific quantitative PCR primers and probes for green crabs. We then set up a filtration system to separate isolate eDNA from the plankton tows using the Qiagen DNeasy kit. We are correlating FlowCam and eDNA analyses to test which method allows for a reliable and economically viable monitoring program for marine invasive species. Supported by NSF grants MRI-1624984 and IUSE-1431955 to M.F.

P2-220 DAVIS, JS*; GANNON, JL; High Point University; *jdavis0@highpoint.edu*
Is There Osteological Evidence of a Prominent Zygomaticomandibularis in Hypocarnivorous Mammals?
Several studies have shown a relationship between fusion of the mandibular symphysis and late unilateral activity of the balancing-side zygomaticomandibularis muscle, thought to facilitate the production of transversely-oriented grinding movements during mastication, particularly among species that specialize on plant-based diets. The recurrence of this pattern across mammalia is compelling evidence of convergent adaptation in the masticatory apparatus. Given the importance of the zygomaticomandibularis in this pattern, we hypothesize that this muscle may differ not only in the timing of its activity, but also in its morphology and prevalence among the jaw adductors in species with a fused mandibular symphysis and plant-based diet, when compared to related species with omnivorous or animalivorous diets and patent symphyses. To investigate this relationship, three parallel 3D geometric morphometric analyses are used to characterize the shape of the mandibular ramus in three separate mammalian lineages that include species that are representative of the ecomorphological groups of interest: musteloid carnivorans, xenarthrans, and phyllostomid bats. We focus on the mandibular ramus because its shape is influenced by attachment sites for the major jaw adductors, including the zygomaticomandibularis, and we investigate whether there are convergent trends in its shape among species with plant-based diets.

P1-218 DAVIS-BERG, EC*; ROCK, MO; RAMIREZ, I; ALMARIO-KOPP, D; WILSON, BA; Columbia College Chicago, Chicago IL, University of Illinois at Chicago and Garfield Park Conservatory, Liberty Public Schools; *edavisberg@colum.edu*
Fitch Natural History Reservation, a study in molluscan succession in a re-established forest ecosystem
The Fitch Natural History Reservation was founded in 1948 and is located in Douglas County, Kansas. Prior to the foundation of the reserve, the non-forested areas were heavily cultivated or grazed. Since the late 1940s, the reserve has been allowed to undergo natural succession, returning to a primarily forested ecosystem. In some areas of the reserve, succession has caused a rapid increase in foliage, resulting in a dense underbrush. Molluscan surveys were conducted in the late 1940s through the 1950s, which often included a species list, specific locality information within the reserve, and information on the vegetation growth at the time. We have periodic molluscan collections at three terrestrial sites and one aquatic site from 2004 through 2017. By comparing the more recent collections with the older data, we demonstrate how the molluscan fauna has responded to succession on this reservation over the last 50 years. We have found almost all species documented in the original surveys while conducting our own surveys. We have found an increase in the forest species found at the Reservation as well as a decrease in the grassland species, providing evidence that the molluscan fauna change with the vegetation.

P3-85 DAWSON, KR*; LIGHTSEY, J; DOUGLAS, K; DZIKUNU, G; SOUSA, J; SHORT, Z; ALLEN, L; DZIKUNU, Georgi; Winston Salem State University; *kdawson115@rams.wssu.edu*
Assessing Ecological Water Quality Along a Creek: Preliminary Data
Streams and rivers are some of the most biodiverse freshwater ecosystems, and yet they face many threats. They are often subjected to various forms of pollution, habitat degradation and resource exploitation. This study aims to use macroinvertebrates as an indicator of ecological water quality at various sites along a single creek (Salem Creek) in Winston Salem, North Carolina. We predicted that as the stream approached the urban area, we would observe a reduction in macroinvertebrate diversity and abundance. We collected samples at 5 locations along the creek spanning the entire 9+ miles of the creek's length and used sampling locations that were approximately 2 miles apart. We used two sampling methods at each site. We used a kick net and a standard aquatic net to sample macroinvertebrates. Following field collection, we separated the macroinvertebrates from any debris, preserved them in 70% ethanol and later identified them to order/sub-order. If we observe that the diversity of the macroinvertebrates decreased the farther downstream, it would indicate that pollutants may be entering the water at multiple points thus lowering the quality of the water. We have also collected water samples to share with collaborators in Chemistry and Biology to measure chemical compounds and bacterial strains present at these sites. We plan on utilizing these same sampling methods to test the quality of additional waterways throughout Winston Salem. After we analyzed the types and number of species collected at each site, we concluded that 4 out of the 5 sites were fair in quality. However, one site was not, and we plan to further investigate the reason why.

P2-22 DEBIASSE, M; COLGAN, W; RODRIGUES, D*; RYAN, J; DAVIDSON, B; Whitney Labs, UFL, Swarthmore College; *drodrig2@swarthmore.edu*

Developmental systems drift in tunicate heart gene regulatory networks

Developmental systems drift (DSD) is a form of evolution where a trait or developmental process remains conserved despite changes in the underlying gene regulatory network. Regulatory elements in developmental gene networks often undergo substantial drift, including changes in the order, number or position of transcription factor binding sites. Examining the drift or conservation of regulatory elements across large periods of evolutionary divergence can provide insights into the structure and function of these elements in a network. We compared the heart gene regulatory networks of two tunicate species Ciona robusta and Corella inflata to explore how a long period of DSD, ~ 250my, has altered a functionally conserved gene network. One of the primary nodes in this network is Mesp, an initial cranial-cardiac transcription factor in both tunicates and vertebrates. Here we show that the Mesp enhancer is regulated by conserved upstream transcription factors in both species despite significant changes in sequence. Through serial minimization of a Corella Mesp reporter construct, we found that the location of the enhancer had shifted considerably in comparison to the characterized Ciona enhancer. Cross-species testing of the Ciona and Corella enhancers indicated that conserved upstream transcription factors regulate mesp expression in both species. Mutation of predicted binding sites for these conserved transcription factors revealed that functional important sites had shifted in their spacing within the enhancer while number and order appeared more constrained. These studies indicate that specific structural features of initial regulatory elements in vital development networks are highly constrained, perhaps due to rigorous temporal or spatial expression requirements.

P2-150 DECONINCK, AD*; NIELSEN, ME; HILL, CA; EMANN, W; KINGSOLVER, JG; University of North Carolina--Chapel Hill, Princeton Day School; *aimeed@live.unc.edu*

None Like It Hot: Larvae Move to Avoid Hot but Not Cold Temperatures, Regardless of Rearing Temperatures

Terrestrial ectotherms commonly use both physiological and behavioral strategies to avoid extreme temperatures and to maintain body temperatures within a thermal range that improves growth, development and survival. Developmental temperatures can alter maximum growth rate and optimal body temperatures, and ectotherms may use thermoregulatory behavior to maintain preferred temperatures for their relative optimum. Do developmental temperatures also affect thermoregulatory behaviors? We address this question using the Tobacco Hornworm, *Manduca sexta* . We reared larvae after hatching in either constant or diurnally fluctuating thermal conditions and tested at the 4th (of 5th) larval instar. To determine their preferred temperatures, larvae were placed on a gradient plate and subjected to either increasing or decreasing temperatures for one hour. Initial results suggest that while larvae from both rearing treatments respond behaviorally to escape high temperatures, they do not respond to low temperatures. We are continuing investigations to understand the contribution rearing history may have in modifying these behaviors.

P1-215 DEBIASSE, MB; BUCKENMEYER, A*; BABONIS, LS; BENTLAGE, B; COLLINS, AG; DALY, M; MACRANDER, J; REITZEL, AM; STAMPAR, SN; RYAN, JF; Whitney Lab for Marine Bioscience, University of Guam, National Museum of Natural History, Smithsonian Institution, The Ohio State University, Florida Southern College, University of North Carolina at Charlotte, Universidade Estadual Paulista; *melissa.debiasse@gmail.com*

Placing leaves on the cnidarian tree of life

Cnidarians are a stunning group of animals with diverse ecologies, life histories, and morphologies. Relationships within the cnidarian tree of life have been the subject of controversy for many years and the position of several nodes, especially within the Anthozoa, remain unresolved. This project aims to clarify the relationships among and within cnidarian lineages by combining transcriptome data from 32 newly sequenced taxa in Actinaria, Ceriantharia, and Octocorallia with previously published sequence data from 63 additional taxa. We use an innovative approach that combines a backbone phylogeny estimated from hundreds of loci across 95 taxa with a single-locus 18s phylogeny comprising over 900 taxa. To produce our phylogenomic data set, we assembled RNA sequence data into taxon-specific transcriptomes in Trinity, identified orthogroups across taxa in OrthoFinder, and used a novel pruning approach to remove paraphyletic and monophyletic duplicates from orthogroups. Our resulting data matrix contains 101 genes with 15,286 aligned amino acid sites for 89 cnidarian and 6 outgroup taxa with 78% occupancy. To generate the 18s data set, we mined Genbank for all previously published cnidarian 18s sequences. We use the backbone phylogenomic tree to infer deep nodes and to constrain the 18s sequences, producing the most comprehensive cnidarian phylogeny to date. Deployed together, these data sets will enable the resolution of deep and shallow phylogenetic relationships among cnidarian taxa. These resolved relationships can serve as the foundation for trait-based analyses, and will improve our understanding the evolutionary history of cnidarian innovations.

P2-116 DEES, LH*; HOFFMAN, AJ; WADA, H; Auburn High School, Auburn University; *lesliedees1@gmail.com*

Alteration of eggshell characteristics due to maternal heat stress

In birds, the last step of egg formation is deposition of eggshell which provides a physical barrier for embryos. A match among eggshell characteristics, embryonic demand for gas exchange through pores, loss of water through pores, and environmental condition are critical in proper embryonic development as the metabolic rate of embryos and the demand for greater gas exchange both increase when embryos develop under high temperatures. Recent studies have shown that eggshell characteristics are under natural selection in birds which recently colonized new environments with different temperature and humidity compared to ones in the source population. However, maternal control of eggshell characteristics in response to environmental changes is largely unknown. We hypothesized that eggs whose mothers were exposed to heat while young would have greater pore densities and lower thicknesses to allow for greater gas transfer with the outside air. Towards the end, the goals of this study were to investigate whether thermal environment of mothers as juveniles and/or right before egg laying determined the eggshell thickness and pore density of the eggs they lay. Captive zebra finch females were divided into 4 groups in a fully factorial design where females experienced control (22C) or mild heat (38C) for 28 days during the juvenile period and control (22C) or high heat (42C) for 3 consecutive days as an adult. We found that only the pore density was subject to the thermal environment of the mother, with mothers exposed to heat treatment both as juveniles and adults producing eggs with the greatest pore density, and surviving offspring exhibiting greater pore densities. These results suggest that mothers have the ability to adjust eggshell characteristics so eggs are better adapted to the predicted thermal environment.

P1-84 DEGON, ZD*; NICHOLSON, DJ; CHUNG, A; TAYLOR, Q; CURLIS, JD; LOGAN, M; NEEL, L; DUBOIS, MM; MCMILLAN, WO; COX, CL; Georgia Southern University, Queen Mary University of London, Smithsonian Tropical Research Institute, Arizona Univesity, Northeastern University; *zd00214@georgiasouthern.edu*

Sex-specific relationships between energetics and ectoparasites in a tropical lizard

Tradeoffs among energy allocation to growth, reproduction, and immune function can impact fitness. While both sexes allocate energy to reproduction and immune function, tradeoffs between these functions may be structured in a sex-specific fashion. Specifically, the energetic costs of immunity can differ temporally between the sexes due to behavioral and energetic differences, but this sex-biased energy allocation is not understood for most species. We studied the relationships between ectoparasite (mite) load, organ mass, fat body mass, and total body size in the Panamanian slender anole. We hypothesized that the quantity of mites should increase with the body size and that both sexes would allocate energy away from immune function towards energetic investment in reproductive tissues. We found that larger lizards did have more mites in both sexes. However, only males with greater fat body mass had higher ectoparasite loads. In contrast, the number of mites increases with the size of the ovaries, but not with the size of the testes. We suggest that the number of mites reflected the amount of endogenous fat storage in males, which implies that abundant energetic stores can be channeled in to the immune response to suppress mite infection. In contrast, females that had greater energy invested in reproductive tissues had correspondingly greater mite infections, which implies that investment into reproduction trades off with investment into immune function. Our results suggest that ectoparasites affect energy allocation in ways that are likely to generate sex-specific patterns of fitness in wild ectotherms.

P1-240 DELGADO, AL*; DALY, MA; Portland State University, The Ohio State Univeristy; *delgado7@pdx.edu*

Using DDRAD to infer population distribution of Pederson Cleaner shrimp in the Caribbean Oceans

In this study, we investigated the phylogeographical distribution of a subset of the Caribbean lineage of the Pederson cleaner shrimp, Ancylomenes pedersoni. We focused on the southern range of the Caribbean lineage, which is represented within three sites: Mexico, Honduras, and Panama. The area in which these sites are found was thought to represent one homogenous A. pedersoni population with no genetic structure (Debiases 2015). We employed DDRAD sequencing to obtain a clear resolution of the species distribution. Ipyrad was used to clean data and produce output files. SVDquartets and Maximum Likelihood analysis were used to assess phylogeny and population structure. Adegenet was used to test for a number of populations and relatedness at different levels of structure. Analyses revealed that the three tested sites are indeed panmictic (k=1), but that genetic structuring may be present within two of the sites. This study also shows that gene flow is mostly one-directional—from south to north—and reveals signs of bottlenecking. Further analysis will look at the Caribbean wide lineage of the Pederson Cleaner Shrimp.

P1-52 DELGADO GOMEZ, S*; BATTAGLIOLI, S; HOWELL, M; CIERI, RL; FARMER, CG; University of Utah, University of Utah; Trinity College Dublin; *samurldelgato@gmail.com*

Microfluidics and Gas Exchange in Reptilian Parenchyma

Almost nothing is known about the flow of gases very close to and within the gas exchange parenchyma of any reptile, yet this flow is a crucial determinant of gas-exchange capacity. The parenchyma is diverse, ranging from simple trabecule, where branching structures form a polygonal network along the lung wall, to faveoli, with a honeycomb appearance. Our recent work on gross patterns of airflow within the lungs of a variety of reptiles suggests that much of the flow is unidirectional and laminar, which could increase the thickness of boundary layers and impede gas exchange. To better understand the relative contribution of diffusion and advection to gas exchange at the microscale level, we have: (1) developed physical models of the lung walls; (2) simulated gas exchange. The physical models were created using micro-CT of a green iguana to generate a surface file, which was scaled to maintain dynamic similarity when water flowed over the surface at steady state (Re 8-12), and 3D printed with PLA filament, or laser cured resin. Polyamid seeding particles (50 µm ø) were visualized using Flocoach™ model B1. The gas-exchange simulations were generated for a series of 2D wells, with geometries typical of reptilian respiratory parenchyma, using Fluent and Peclet # <<1. Our results indicate the faveoli are an impediment to convection and suggest thick boundary layers impede gas-exchange with flow at steady state. We found little evidence of vortices developing within the faveoli. These results point to the importance of cardiac pulsations of the vasculature or smooth muscle for improving mass transport. Funded by NSF IOS CAREER-1055080, NSF 1256065, NSF ACI-1238993, and Enterprise Ireland.

P1-114 DESANA, AN*; FARGEVIEILLE, AK; WARNER, DA; Seton Hill University, Greensburg, PA 15601, Auburn University, Auburn, AL 36849; *a.desana3@setonhill.edu*

Lizard Egg Predation by Marsh Crabs: Effects of Microhabitat and Crab Density on Egg Survival

Predation is a key factor in population regulation and evolutionary processes. For oviparous species with no parental care, vulnerability to predation is critical at the egg stage and female nest site choice can reduce egg predation. Based on observations of square-back marsh crabs (*Armases cinereum*) eating brown anole eggs (*Anolis sagrei*), we designed indoor and field experiments to answer three questions: 1) are marsh crabs a major predator of brown anole eggs, 2) does egg predation differ among microhabitat types, and 3) how does crab density affect egg survival? In both experiments, we placed incubating eggs in three different natural and relevant microhabitats: open area, palm frond, and leaf litter. We also manipulated the placement of the eggs as either buried or placed on the surface. Both experiments confirmed square-back marsh crabs as anole egg predators. We also found a difference in egg survival depending on microhabitat type; placement of the egg was crucial for egg survival in the open area microhabitat. Crab density did not affect egg survival in our field experiment. These results suggest that selection of nest site by female brown anoles can affect their offspring survival in the presence of marsh crabs.

P1-137 DESIMONE, JG*; GUTIERREZ RAMIREZ, M; BREUNER, CW; ELOWE, CR; GRIEGO, MS; GERSON, AR; University of Montana, University of Massachusetts Amherst; *joely.desimone@umontana.edu*

Baseline corticosterone and body composition of Gray Catbirds at stopover during spring migration

Each spring, neo-tropical migratory birds traverse the Gulf of Mexico en route to their breeding grounds, often stopping to refuel along the northern Gulf coast. Baseline levels of the metabolic hormone corticosterone (CORT) have been hypothesized to be elevated during migratory flight, reduced during refueling at stopover sites, and increased again prior to departure. During spring migration in 2017, we examined Gray Catbirds (*Dumetella carolinensis*) on St. George Island, a Florida panhandle barrier island and first landfall site for many trans-Gulf migrants. We sought to test the predicted relationships among CORT, refueling rate, and body condition during stopover. We measured baseline CORT, body mass, plasma triglycerides, and precise body composition using a Quantitative Magnetic Resonance analyzer (QMR). We found that birds with low body-, fat-, and lean mass had higher baseline CORT levels. These data are consistent with the hypothesis that baseline CORT declines at stopovers as body condition improves. However, refueling rate (as indicated by plasma triglycerides) was not predicted by CORT. Our data were not able to detect an increase in baseline CORT prior to departure. This may be because Gray Catbirds don't stay long on the island, instead relocating to the mainland to continue their stopover phase. Feather deuterium values will be analyzed to clarify the migration destinations of these individuals and provide context to our findings.

P1-261 DETMERING, S/E*; MCMAHON, T/A; University of Tampa ; *sarahdetmering3@gmail.com*

The Effects of Bd Metabolites on Freshwater Invertebrates

Batrachochytrium dendrobatidis (Bd) is a fungus that is causing extinctions and extirpations of amphibians around the world. Bd is an aquatic fungus that attacks the keratin in the skin of amphibians and the carapace of some freshwater invertebrates, like crayfish. Bd metabolites have been shown to damage the gills of crayfish in the absence of live Bd, but little research is done in this field. Here, we investigated the effects of Bd metabolites, in the absence of Bd, on developing mosquitos and the bioindicator *Daphnia magna* . There is a negative relationship between Bd metabolite concentration (measured as the concentration of Bd removed from the inoculant) and Daphnia survival ($p = <0.01$), but there was no effect of Bd metabolites on mosquito mortality. The presence of Bd metabolites induced molting in *Daphnia* and mosquito larvae, which may have an impact on their development. Our findings indicate exposure to Bd contaminated water, even in the absence of direct contact with Bd may adversely affect some freshwater invertebrates.

P2-111 DEYARMIN, J.S.*; MCCORMLEY, M.C.; CHAMPAGNE, C.D.; STEPHAN, A.P; PUJADE BUSQUETA, L; CROCKER, D.E.; HOUSER, D.S.; KHUDYAKOV, J.I.; Univ. of the Pacific, Univ. of Washington Bothell, Sonoma State Univ., National Marine Mammal Foundation; *j_deyarmin@u.pacific.edu*

Distinct blubber proteome responses to single and repeated ACTH challenges in a marine mammal

Repeated or chronic stress, such as that caused by anthropogenic activity and environmental disturbance, may affect animal health and fitness and contribute to population declines. However, the physiological impacts of repeated stress have not been extensively studied in wild animals, hindering development of stress biomarkers. Baseline endocrine measurements are commonly used for stress diagnosis, but they may be less robust indicators of stress than their downstream molecular mediators. We used proteomics to examine changes in protein expression in the blubber of northern elephant seals *(Mirounga angustirostris)* in response to multiple stress challenges. We simulated chronic stress by administering adrenocorticotropic hormone (ACTH) to juvenile seals once daily for four days and collected blubber before and after the first ("acute") and last ("repeated") administrations. We isolated and sequenced the proteome and identified 8793 proteins in elephant seal blubber. Across the proteome, 46 KEGG pathways were enriched, such as carbon metabolism, glycolysis/gluconeogenesis, fatty acid degradation, and fatty acid metabolism. For differentially expressed proteins, we compared protein abundance across stress states using isobaric labeled tags. Proteins that were differentially in response to ACTH were associated with lipid binding, pentose phosphate pathway, lipid transfer, and other cell maintenance pathways. The stress markers identified in this study may be used to assess stress states in vulnerable marine mammal populations using targeted assays.

P2-30 DHAWANJEWAR, AS*; MEIKLEJOHN, CD; MONTOOTH, KL; University of Nebraska-Lincoln; *abhilesh.dhawanjewar@huskers.unl.edu*

Mitochondrial Diseases and Compensated Pathogenic Deviations

The epistatic effects of amino acid substitutions exert a strong influence on protein evolution trajectories. A substitution that is pathogenic in one genetic background may be neutral or even beneficial in the presence of other substitutions that interact with the pathogenic substitution. Many disease-associated missense mutations or 'Pathogenic Deviations (PDs)' in humans are observed to occur as native, wild-type residues in other non- human species. This particular class of missense mutations is known as 'Compensated Pathogenic Deviations (CPDs)' as in order to become fixed in the non-human species, their pathogenic effects must be compensated by one or more substitutions at other sites in the same protein or in an interacting protein. Defects of the mitochondrial respiratory chain are especially interesting as the respiratory chain is the only metabolic pathway in the cell controlled by both the mitochondrial and the nuclear DNA. To investigate the structural nature of these epistatic compensatory interactions, we identify PDs and CPDs from MITOMAP's database of human mitochondrial disease mutations and map them onto three- dimensional protein structure models. To further understand whether the nature of compensated mutations (CPDs) is different than that of uncompensated mutations (PDs), we examine several structural effects concerning protein stability as well as binding effects. We also compare and contrast the patterns observed in mitochondrial diseases with previous studies that primarily focused on diseases caused by mutations in the nuclear DNA.

P1-48 DIAL, TR*; LAUDER, GV; Harvard University; *terrydial@fas.harvard.edu*

First-feeding prey capture: comparing zebrafish and guppies

Two prominent model fishes, zebrafish and guppies, produce tiny offspring (3.5-5.5 mm in length), yet guppies spend nearly an order of magnitude more time developing *in utero* prior to first feeding. Suction feeding at small size is thought to be constrained by the hydrodynamics of actuating small mouthparts quickly through a viscous medium. By manipulating water viscosity, we control the hydrodynamic regime (measured as Reynolds number, Re) to ask what effect developmental time has on offspring maturation, feeding performance and suction generation between these two species. Ossification rate is used as a measure of morphological maturation and was found to be similar between the two species: each species is 50% ossified at 7.25 mm in length. Despite that first feeding occurs prior to each species reaching even 10% maturity, capture success of suspended prey is significantly higher in guppies (90% vs. 20%). As Re increases, both species are able to capture prey at increasing distances, but at any given Re, guppies successfully feed at greater distances to prey. Both offspring generate negative pressures during a strike, but suction is simultaneously associated with ram feeding. Particle imaging shows that a bow wave leads the approaching zebrafish larvae, which pushes the prey item ahead of the mouth by 0.5 head length. During the suction event, the bow wave temporarily ceases, and the momentum of the larvae allows it to capture the stationary prey. An approaching guppy offspring also produces a bow wave, but due to greater oral jaw protrusion and lateral head expansion, the suction field generated by the guppy extends beyond the horizon of the bow wave. A larger suction field might allow guppy offspring to feed at greater distances and with higher success rates, but maturation of the skeletal system alone does not explain this observation.

P3-120 DILTS, S*; SARAJLIC, D; JUDD, ET; HATLE, JD; PATERSON, C; Univ. of North Florida, Agios Pharmaceuticals, Florida State College at Jacksonville; *jhatle@unf.edu*

Inhibition of hydrogen sulfide production by fat body of lubber grasshoppers

Cellular hydrogen sulfide (H_2S) is a gasotransmitter (like nitric oxide) required for life-extension by dietary restriction in mice. H_2S protects vasculature in mammals. In nematodes, H_2S exposure increases thermotolerance and lifespan. In insects, the production of H_2S by *Drosophila* fed life-extending, low-methionine diets is greater than production on full diets. Together, this suggests increased H_2S production is salubrious for invertebrates. Nonetheless, insects are often said to be 'weak producers'. Here, we provide preliminary evidence for inhibition of H_2S production by lysates of grasshopper fat body. Fat body is analogous to liver, the most strongly producing tissue in mice. We tested production of H_2S using an enzyme activity assay. Lysates were incubated with cysteine and vitamin B6; produced H_2S was detected using lead acetate, which in the presence of H_2S makes the brown precipitate lead sulfide. Surprisingly, higher concentrations (50 ul, median of ~8 mg protein) of fat body lysate consistently produced less H_2S than did lower concentrations (0.69 mg protein). Decreasing the protein amount below 0.69 mg reduced H_2S production in a dose-dependent fashion. We next tested whether fat body lysate would inhibit production of H_2S by homogenates of mouse liver. Indeed, increasing concentrations of fat body lysate tended to decrease H_2S production by mouse liver homogenate (n=19; P=0.075). In contrast to this inhibition by grasshopper fat body, lysates of mealworms did not inhibit production of H_2S by mouse liver homogenate. These data suggest that a component of the lysate of grasshopper fat body, when present at higher concentrations, inhibits enzymatic production of H_2S by liver homogenates.

P3-13 DINGWALL, HL*; GRINSTEIN, M; CAPELLINI, TD; GALLOWAY, JL; Harvard University, Massachusetts General Hospital, Harvard University, Massachusetts General Hospital ; *hdingwall@fas.harvard.edu*

Transcriptomics of postnatal tendon growth

Tendon size can vary widely among closely related taxa, e.g. mice vs. jerboas, suggesting that the tendons of these species may experience different growth regimes. In mice, the period from birth to roughly 1 month of age is characterized by extensive tendon growth. Conventional wisdom states that this growth is driven by expansion of the extracellular matrix with negligible cell proliferation. However, our previous work has shown that tendon cells remain proliferative through postnatal day (P) 14, after matrix production has already begun to increase. Thus, this period is a time of dynamic change within the tendon, but the molecular mechanisms governing these transitions are largely unknown. We performed RNA sequencing on mouse tendons sampled weekly from P0 to P35 to identify transcriptomic signatures associated with the changing cell proliferation dynamics. Approximately 22% of detected genes were found to be differentially expressed (DE) at some point during the time series (adj. $p < 0.01$). To gain a more detailed understanding of temporal gene expression patterns during this period, we subset all DE genes by fitting observed counts to different models of expression over time. Gene Ontology and Gene Set Enrichment Analyses of these subsets suggest that biological processes involved in cell proliferation and differentiation dominate the earlier time points, while cell communication and cytoskeleton organization become more important later. The midpoint of this time series exhibits upregulation of genes involved in the secretion and binding of extracellular matrix, but downregulation of molecules that control cell adhesion. These results suggest that postnatal tendon growth involves three stages: the proliferative phase, matrix secretory phase, and organization phase.

P2-32 DIORIO, R.A.*; HOWEY, C.A.F.; University of Scranton; *raymond.diorio@scranton.edu*

Does Substrate Type Affect Scent-trailing Behavior of Adult and Newborn Timber Rattlesnakes?

Animals can obtain social information from monitoring chemical cues within their environment left behind by conspecifics, competitors, predators, or prey. Whereas many studies have addressed the ability for snakes to trail scents within a laboratory along a homogenous substrate (typically butcher paper), our objective was to determine if the scent-trailing behavior of a snake was affected by changes in substrate type. In our first experiment, we brought 5 gravid timber rattlesnakes (*Crotalus horridus*) into the laboratory where each gave birth to an average 9 neonates. After each neonate shed, we conducted Y-maze trials. For each trial, the Y-maze floor was covered in either paper, sand, leaf litter, or burnt leaf litter. The scent of the mother was applied down one arm of the Y-maze. Prior to each trial, we replaced the substrate and scent. Each neonate was tested on each substrate. Neonates non-randomly chose the arm with the mother's scent 87% of the time when tested on paper ($P < 0.001$) and 73% of the time when tested on sand ($P < 0.011$). When tested on leaf litter and burnt leaf litter, neonates chose the arm with the mother's scent 67% and 53% of the time ($P < 0.068$ and $P < 0.715$ respectively). Substrate affects the ability for neonates to scent trail their mother. In our second experiment, we brought adult male *C. horridus* into the laboratory and repeated Y-maze trials; replacing the mother's scent with the scent of freshly struck and envenomated mouse. We will discuss preliminary results of the second experiment and how they compare to neonate trials. In a natural setting, the mosaic of substrates may facilitate scent-trailing behavior. However, as prescribed fire becomes a more popular forest management tool, care should be taken in where this tool is applied given that it may affect scent-trailing behaviors.

P1-66 DIPAOLO, EC*; MEHTA, RS; COLLAR, DC; Christopher Newport University, Univ. of California, Santa Cruz, Phi Mu; *emma.dipaolo.14@cnu.edu*

Cascading Anatomical Evolution Drives Body Elongation in Clinoid Blennies

Major transformations in body shape punctuate the evolutionary history of ray-finned fishes. Eel-like or torpedo-shaped fishes emerge, sometimes rapidly, from lineages that are otherwise made up of fusiform or shorter-bodied species. These transitions in shape may result from different combinations of changes in anatomical features spread across the body, but it is unknown whether these changes emerge in a correlated manner or if they accrue in series over time. In this study, we measure dimensions of the body, skull, and vertebral regions for species of blenniiform fishes and use phylogenetic methods to identify exceptionally rapid evolution of elongated body shape in a blenniiform subclade that includes the pikeblenny (*Chaenopsis alepidota*) and arrow blenny (*Lucayablennius zingaro*). Major shape transformation began in the shared ancestral lineage of these species (i.e., their stem lineage) as the skull elongated and body depth decreased. After splitting from this ancestor, these species continued to elongate, but they followed different evolutionary trajectories. Transformation in the arrow blenny was achieved by elongating the head, whereas the pikeblenny lengthened the caudal region by greatly increasing vertebral numbers. Overall, our results reveal a major body shape transformation—eel-like blennies—that arose because of cascading anatomical changes spread across multiple ancestral lineages, perhaps as a result of adoption of a novel ambush-style predation followed by divergence in dietary niche.

P1-249 DIXON, G*; KITANO, J; KIRKPATRICK, M; University of Texas, Austin, National Institute of Genetics, Mishima, Shizuoka, Japan; *grovesdixon@gmail.com*

Origin of a new sex chromosome by introgression between sticklebacks

Introgression is increasingly recognized as a source of genetic diversity that fuels adaptation. Its role in the evolution of sex chromosomes, however, is not well known. Here we confirm the hypothesis that the Y chromosome in the ninespine stickleback, *Pungitius pungitius*, was established by introgression from the Amur stickleback, *P. sinensis*. Using whole genome resequencing, we identified a large region of Chr 12 in *P. pungitius* that is diverged between males and females. The region of differentiation falls within an inversion, which appears to prevent recombination between the chromosomes. Population genetic and phylogenetic analyses show that within this inversion, the Y chromosome of *P. pungitius* shares a most recent common ancestor not with the X chromosome, but with the homologous chromosome in *P. sinensis*. Our findings indicate that porous species boundaries can trigger rapid sex chromosome evolution.

P2-4 DOBKOWSKI, KA*; FLANAGAN, KD; CROFTS, SB; DETHIER, MN; Bates College; Friday Harbor Labs, Friday Harbor Labs, University of Illinois, Urbana/Champaign, University of Washington; Friday Harbor Labs; *kdobkows@bates.edu*

Ecology and scaling of juvenile bull kelp (Nereocystis luetkeana)

Bull kelp (*Nereocystis luetkeana*) is the dominant subtidal canopy architect in the Salish Sea, providing important habitat for many species and supplying primary production to food webs within and below the photic zone. Like other kelp, *N. luetkeana* has a complicated life history, alternating between microscopic (zoospore, gametophyte) and macroscopic stages; unlike many other kelps, it is an annual that must complete its lifecycle within a single year. Focusing primarily on juvenile bull kelp (sporophyte, stipe < 30 cm), we investigated the effects of competition and propagule availability on sporophyte appearance in a factorial-design subtidal field experiment. In the lab, we quantified differences of morphological scaling and material properties as well as the effects of temperature on the microscopic zoospore, gametophyte, and sporophyte stages. Our results indicate that bull kelp are probably not propagule-limited at our study sites and competition from understory species is the most important factor determining where juvenile bull kelp sporophytes grow and persist, with some variability in initiation of growth between plots established in different seasons. We also calculate a "breakpoint" between juvenile and adult morphological scaling. Additionally, we show that increasing temperatures may limit zoospore settlement and transitions between microscopic life stages, which has important implications for the fate of this foundation species, and the communities it structures, as global ocean conditions change. Our findings also highlight the importance of studying organisms with complex life histories across multiple stages because of the different factors that dictate their success across ontogeny.

P3-149 DODSON, AN*; OUTOMURO, D; WIATR, A; MOREHOUSE, NI; University of Cincinnati, Purdue University; *dodsonas@mail.uc.edu*

Motley views: Investigating the importance of receiver vantage point in shaping the appearance of a myrmecomorph spider

Animals must manage complex audiences comprised of predators, prey, and conspecifics, each with distinct sensory capabilities. Imperfect mimicry may result from compromises to maximize deception or detection among these multiple viewers. But how do mimics avoid predators while still capturing the attention of potential conspecific mates? One possibility is that morphology perceived by different viewers is dependent on their vantage points, allowing individuals to tailor their appearance to different audiences based on viewer perspective. We tested this idea in *Synemosyna formica*, a jumping spider ant mimic that must manage the responses of conspecifics, ants, and predators such as mantids, birds, wasps, and other spiders. Using high resolution images and elliptical Fourier analysis, we compared dorsal and lateral shapes of *S. formica*, other co-occurring spiders, and two co-occurring ants. We found that *S. formica* is closest in morphospace to ants, while sympatric spiders share less morphological similarity with ants. We also found the degree of similarity between *S. formica* and ant models varied between dorsal and lateral perspectives. Spectral data was collected from corresponding points on the bodies of *S. formica*, co-occurring spiders, and ants. Data were compared through visual models of sympatric predators and ants. We found that *S. formica* and ant spectra overlap in color and brightness while other spiders have less similarity to the ant models. The differences in morphology based on perspective and the similarities in *S. formica* and ant coloration indicate that audience perspective may play a role in shaping mimic morphology. Additionally, we found that juvenile and adult *S. formica* differ in which ant model they most closely resemble, indicating a possible shift in models across development.

P1-10 DOMENECH, S*; LAFOND, B; LONG, M; SELIGMAN, C; GILCHRIST, S; New College of Florida; *gilchrist@ncf.edu*

Implementing High Impact Practices in a Study Abroad Program at Cayos Cochinos, Honduras

High Impact Practices (HIPs) are important in encouraging students to pursue STEM careers. Study abroad can be used as an intensive time for students to learn practices of science including experimental design, field etiquette, and scientific communication. In this 5 week program, students spend three weeks on sight at Cayos Cochinos where they learn field skills to implement with their own mini projects. A student who participated the previous year acts as a teaching assistant to help with reef surveys and with implementing projects. Students are required to submit a series of essays along with the final project. In addition, students maintain a science blog to document their activities. The final presentation is a powerpoint with a voice component. Prior to completing the project, students make presentations to get feedback from the instructor and peers.

P2-279 DOURA, N. M*; CHANDLER, C.; Suny Oswego ; *ndoura@oswego.edu*

Sexually Dimorphic Gene Expression in Terrestrial Isopods

SEXUALLY DIMORPHIC GENE EXPRESSION IN TERRESTRIAL ISOPODS Nora Doura, Christopher Chandler Department of Biological Sciences 392 Shineman Center SUNY Oswego 30 Centennial Dr. Oswego, NY 13126 Males and females of many species differ in characteristics like size or color, and these characteristics may be adaptive. These differences are often the result of different genes being expressed from the genome. Many species of terrestrial isopods show sexual dimorphism, but can also undergo sex reversal because of infection by Wolbachia or experimental manipulations in the lab, making them an interesting system to study the genetic basis of sexual dimorphism. In this study, genes showing sexually dimorphic expression are identified in two species of terrestrial isopods, Trachelipus rathkei and Porcellio laevis. This study will help identify the genetic underpinnings of sexual dimorphism in these species and will help inform future studies on how Wolbachia affects sexual phenotypes. Studying the effects of Wolbachia on gene expression can also lead to further experimentation involving the loss or gain of certain characteristics in the terrestrial species.

P3-34 DOWNS, AM*; KOLPAS, A; BLOCK, BA; FISH, FE; West Chester Univ., Stanford Univ.; *ad846650@wcupa.edu*

Turning Performance by Bluefin Tuna: Novel Mechanism for Rapid Maneuvers with a Rigid Body

Tunas are considered to be energetic swimmers that are capable of exceptional migrations across ocean basins. Their aquatic performance is due to the thunniform, lift-based propulsion, stiff fusiform body shape, and large muscle mass. Rigid bodies present a limitation to the turning performance of aquatic organisms. To examine turning capabilities in a captive setting, Pacific bluefin tuna (*Thunnus orientalis*) were video recorded from a dorsal view as the tuna routinely swam around a large tank or when being fed. Three different types of turning behaviors were observed. Tuna would glide through the turn using the caudal fin as a rudder. Tuna would continually power through the turn using symmetrical strokes of the caudal fin. Lastly, the tuna used a ratchet turn where the global turn was accomplished by a sequence of rapid, short turns by asymmetrical strokes of the tail. Each short turn rotated the tuna about its center of mass changing the trajectory of the rigid-bodied tuna to collectively turn the fish. The angular velocity of the ratcheting action was over 2.7 times that of the global turn. This previously undescribed maneuver provides a mechanism to turn rigid-bodied aquatic organisms and underwater vehicles.

P3-63 DRAMM, CL*; ORSBON, CP; VARGEESE, JJ; ROSS, CF; GIDMARK, NJ; Knox College, University of Chicago; *cdramm@knox.edu*

The impact of gape on biting force of the masseter muscle in male and female macaque monkeys.

The force-length relationship of skeletal muscle constrains the relationship between biting force and gape in jaw systems. If muscle forces and bite force are highest at minimum gape (occlusion), then forces should decrease at larger gape angles, as the mouth is opened. Male macaques have wider maximum gapes than female macaques to provide clearance to their longer canines, but how that impacts jaw muscle force production is unknown. Here, we present data on the impact of masseter muscle force-length relationships on biting force in male (N = 3) and female (N = 2) Rhesus Macaque (*Macaca mulatta*) monkeys. We electrically stimulated the masseter muscle bilaterally at the full range of possible gapes while measuring bite force at the incisors with a force transducer. Surgically implanted markers in the cranium, mandible, and masseter muscle, combined with X-ray videos allowed the use of XROMM to reconstruct 3D jaw/skull position. Both males and females in our study utilized the ascending, plateau, and descending limbs of the force-length curve, and did not differ significantly in the gape angle that correlates with optimal muscle force. The males' jaws could be depressed to a wider gape angle and distance than the females' and their masseters utilized a greater portion of the descending (= long) end of the force-length curve. Male macaques have larger canines than females, creating a difference in the relationship of muscle length with gape, depending on how gape is measured - i.e., from incisors versus canines. The correlation of canine gape with biting force is nearly identical across both sexes (which is not true of incisor gape), suggesting that macaque jaw musculoskeletal biomechanics are more aligned to canine gape than molar gape, incisor gape, or gape angle.

P1-81 DRAUD, TE*; CHAPPLE, TK; HAHN, TP; WIKELSKI, M; CORNELIUS, JM; Eastern Michigan University, Stanford University, UC Davis, Max Planck Institute; *tdraud@emich.edu*
Impact of severe winter conditions and reproductive status on heart rate in the opportunistically breeding red crossbill, Loxia curvirostra
Energy is the currency of life, where a surplus allows for survival and reproduction and a long-standing debt leads to sickness or death. Real-time monitoring of energy expenditures in free-living animals has been relatively limited by available technology. Continuous tone radio transmitters that have been specially modified to detect heart rate, however, allow for real-time estimation of energy expense in free-living, behaving animals, as well as for close monitoring of behavior. Red crossbills live at northern latitudes and/or high elevations year-round and can breed opportunistically throughout much of the year. They therefore offer a unique opportunity to examine the eco-physiology of different life cycle stages under drastically variable seasonal conditions. Here we present heart rate data from free-living breeding and non-breeding red crossbills in the summer and winter. We discuss these variables in the context of red crossbills' unique opportunistic and nomadic annual schedules and the highly seasonal conditions of our field site in Grand Teton National Park.

P2-157 DROLET, J; LE POGAM, A; LOVE, OP; VÉZINA, F*; Université du Québec à Rimouski, University of Windsor; *francois_vezina@uqar.ca*
Very Low Heat Tolerance in an Arctic Cold-Specialized Passerine
The snow bunting (Plectrophenax nivalis) is an Arctic-breeding passerine that experience relatively harsh wintery conditions throughout the year. Although the species is well adapted for these environments, our recent work suggest that the species tolerance to moderate summer heat, especially when actively flying, might be low. Since the Arctic is warming faster than the rest of the globe, it is expected that summer temperatures at the time of chick provisioning might limit the birds' scope for physical activity. Heat stress could therefore affect individual performance and reproductive success. Working at the northern edge of their breeding range (Alert, 82°N, Nunavut), we aimed at determining the limits of thermal tolerance in snow buntings and predicting the ambient temperature at which sustained locomotor activity (e.g. flight or chick provisioning) could lead to hyperthermia in chick-rearing birds. This required field measurements of basal metabolic rate (BMR), maximal thermogenic capacity (Msum) as well as minimal and maximal conductance (Cmin and Cmax). Our results show that inactive snow buntings have a surprisingly high heat tolerance (ambient temperature of 36°C) and a high cold tolerance (< -90°C) in standardized conditions. However, our data also show that for a sustainable activity level representative of the chicks provisioning period (4 X BMR), the additive effect of heat and activity could push the birds above their heat tolerance limit at a much lower temperature (12°C in summer), potentially forcing them to reduce provisioning efforts. Since buntings already experience this temperature during the Arctic summer, our data suggest that the species might be very limited in its capacity to cope with the predicted increase in Arctic temperatures in the nearby future.

P2-232 DROWN, R. M.*; ANDERSON, C. V.; University of South Dakota, Vermillion; *rachel.drown@coyotes.usd.edu*
The functional basis for variable antipredator behavioral strategies in Chamaeleo calyptratus
Selective pressures such as predation, resource availability, and disease influence all animals. To counterbalance these often conflicting demands, many species possess unique morphological, physiological, and behavioral adaptations that increase survival in their environment. Predation, an ever-present selection pressure, is well-suited for studying the relationship between behavior, morphology, and physiology, as the effectiveness of antipredator behaviors may vary depending on a variety of environmental and functional characteristics. Chameleons are a particularly adept model to study the relationship between these adaptations as previous work suggests that antipredator strategies vary significantly with body size and habitat type. Further, their unique morphological and physiological traits, which have adapted in response to their largely arboreal lifestyle, produce relatively slow locomotion, which is poorly suited for fleeing. While fleeing is still a viable strategy, chameleons may also undergo cryptic color changes or behave aggressively to avoid predation. We have examined the functional basis for variation in antipredator behavioral decisions in veiled chameleons (*Chamaeleo calyptratus*) of three different size classes. To do so, we categorized observed antipredator behaviors during mock predation trials and then quantified the performance capacities underlying each potential strategy (e.g., sprint speed and acceleration for fleeing, degree of color change for crypsis, and bite force for aggression) in every individual. Our results indicate that individual differences in performance capacities underlying each behavior influence which response is performed during mock predation trials. The relevance of functional capacities in behavioral decisions provides further insight into the relationship between behavior, environment, and physiology.

P1-171 DUGGAN, BS*; GEORGE, EM; ROSVALL, KA; Indiana University, Bloomington; *bendugga@iu.edu*
A low-cost, open-source system to wirelessly collect and manage RFID data
Cost-effective radio frequency identification (RFID) technology allows biologists to track the movement of tagged animals using short range antennas. Current reader designs generally record data to memory cards, to be manually uploaded and analyzed on a computer. While this approach may be sufficient for some projects, it does not lend itself to the deployment of large numbers of readers over large geographical areas, without significant logistical drawbacks. Here, we have created a system that wirelessly collects data from readers, stores data on a central server, and transmits data over a locally-generated Wi-Fi network to allow for real-time viewing and basic analysis on a computer or mobile device. This system uses a Raspberry Pi mini-computer, an Arduino board, and a transceiver radio module on every device in the RFID network. We will present the results of simulated and real-world tests of this system to validate radio range, ensure reliability of data transfer, and measure effects on battery life. Furthermore, we elaborate on additional features, such as networking radios together to increase range and integrating mobile hotspots to allow remote data access. This system can facilitate new, ambitious experiments that further extend the scope of behavioral questions that can be answered using RFID technology.

P3-72 DULSKIY, AB*; ORSELLI, K; VON DASSOW, G; College of the Holy Cross, California State University, Northridge, Oregon Institute of Marine Biology; *abduls19@g.holycross.edu*

Effect of Simulated Egg Size Reduction on Larval Performance in Dendraster excentricus

Echinoderm eggs vary in volume over several orders of magnitude, but most that develop into planktotrophic larvae cluster in the nanoliter range (0.3-4 nl). Egg size is an important aspect of maternal investment, and the correlation with developmental mode implies an influence of egg size on developmental mechanisms and larval performance. From the starting material provided by the egg, planktotrophic larvae must build certain essential structures to survive to metamorphosis. These include the ciliary band, which is the primary larval feeding and swimming organ; an alimentary tract; and, for echinoids and ophiuroids, a larval skeleton. We therefore wondered whether scaling constraints preclude echinoderms from making even smaller eggs, and hence more propagules. We simulated egg size reduction in the sand dollar *Dendraster excentricus*, which has an egg size (1 nl) that is nearly modal for obligately planktotrophic echinoids, and observed the effect on larval development. To create half- and quarter-sized "eggs," we separated blastomeres at the two- and four-cell stages. It is well known that echinoid larvae can "regulate", creating complete larvae from each of four blastomeres, but we asked: can these partial larvae effectively move water and capture particles? Can they successfully reach metamorphosis? Do essential structures like the ciliary band scale locally, or with overall embryo size? All three sizes - full, half, and quarter - were able to move water and capture particles successfully, and we successfully raised all three sizes of larvae to metamorphosis, although quarters suffered a substantial burden of defects and asymmetry. We found that the proportion of cells in the ciliary band and the number of nerve cells along the band appears to scale with embryo size. This suggests that although developmental regulation might guarantee partial larvae a complete anatomy, further reduction might erode essential body organs to the point of disfunction, thereby conferring a constraint on egg size.

P2-89 DUNCAN, CM*; CHRISTIAN, HC; CHMURA, HE; BUCK, CL; BRIAN, BM; LOUDON, ASI; WILLIAMS, CT; Univ. of Alaska Fairbanks, Univ. of Oxford, Northern Arizona Univ., Univ. of Manchester; *cmduncan3@alaska.edu*

Ultrastructural Changes Within the Pituitary Associated with Reproductive Timing in a Hibernating Mammal

Reproductive timing strongly influences the fitness of the individual. While most vertebrates rely on photoperiodic changes to induce seasonal puberty, the arctic ground squirrel (AGS) naturally undergoes reproductive maturation in a photoperiod-independent manner. In addition, males spontaneously activate their reproductive axis during hibernation, but the timing of puberty is sensitive to external cues. We are using electron microscopy to examine, define, and measure ultrastructural remodeling in pars tuberalis (PT) thyrotroph cells and anterior pituitary (AP) gonadotroph cells, as the AGS transitions from hibernation to the reproductive season. We are also quantifying how the morphology of endocrine cells corresponds with measures of reproductive axis outputs, including changes in steroidogenic gene expression in gonads and plasma sex steroid concentrations. Finally, we are examining the mechanisms that underly plasticity in hibernation phenology and examining whether AP activity can become dissociated from the PT signaling pathway by assessing cellular remodeling in males placed in a 30°C room during mid-hibernation, which induced early puberty onset. We hypothesize that changes in PT morphology underlie initiation of puberty and the timing of the end of hibernation in a photoperiod-independent manner. This basic system-level investigation of reproductive control mechanisms in the AGS could provide insight into non-photic mechanisms that induce puberty onset and underlie plasticity in pubertal timing.

P3-119 DUNCHEON, E/J*; MCCRARY, M/B; O'KEEFE, J/M; CHAMPAGNE, A/M; Univ. of Southern Indiana, Indiana State Univ.; *ejduncheon@eagles.usi.edu*

Lipid Composition in Bat Skin Reflects the Demands of Flight

Flight in vertebrates places physical stress on many areas of the body, including the skin. The stratum corneum (SC) comprises the outermost 10-20 μm of the skin, and is composed of corneocytes embedded in a matrix of lipids, which contribute to the hydration and strength of the SC. Among mammals, bats have a unique SC lipid composition that includes cerebrosides, ceramides with a sugar moiety attached to the headgroup. Cerebrosides interact with water more strongly than other lipid molecules in the SC, and thus may play a large role in hydrating the SC. Furthermore, cerebrosides are prominent in avian SC, suggesting convergent evolution in SC lipid composition between birds and bats to provide the skin with the necessary moisture and strength for flight. We use thin layer chromatography to quantify lipid composition in four regions of the SC in the big brown bat (*Eptesicus fuscus*). In each region, we identified cholesterol esters, free fatty acids, cholesterol, ceramides, and cerebrosides, representing a more complex lipid composition than other mammals. Additionally, we correlate lipid composition with the stress each skin region experiences during flight. Our results indicate that the lipid composition of bat SC reflects their unique lifestyle.

P1-74 DUNN, PO*; HENSCHEN, AE; WHITTINGHAM, LA; Univ of Wisconsin-Milwaukee; *pdunn@uwm.edu*

Gene expression in a sexually selected plumage ornament

One of the grand challenges in animal biology is to understand the influence of genes on the development of phenotypic traits. The plumage of birds encompasses a spectacular array of ornaments long appreciated for their beauty, yet we know little about how the color of plumage patches is influenced by genes. In this study we constructed a de novo transcriptome to examine gene expression in developing feathers of a warbler, the common yellowthroat (*Geothlypis trichas*). This warbler is one of a few species of birds in which a plumage trait, the size of the black facial mask, is known to be sexually selected through female choice. Preliminary analyses indicate that genes related to immunity and oxidative stress (among others) are differentially expressed in the mask of males, compared with feathers from areas of the plumage that are not sexually selected.

P3-147 DZIALO, M*; BRYLA, A; DEMORANVILLE, K; SADOWSKA, ET; TROST, L; PIERCE, BJ; MCWILLIAMS, SR; BAUCHINGER, U; Jagiellonian University, University of Rhode Island, Max Planck Institute for Ornithology, Sacred Heart University, University of Rhode Island; *maciej.dzialo@doctoral.uj.edu.pl*

Dietary Antioxidants Modulate Metabolism And Organ Sizes In Migratory Birds

Increased oxidative stress associated with avian migratory flights could have a strong impact on energy stores (primarily fats) and in consequence, metabolism during and/or after migration. Migration-related adjustments and the strategies of energy usage could differ between seasons, but may also depend on the different possibilities and limitations of antioxidant capacity in autumn and spring. We used a dietary antioxidant manipulation (AO-low or AO-high) and wind-tunnel flight training over autumn and spring to examine its consequences for basal metabolic rate (BMR) and organ sizes. Female European starlings were flown over a period of 15 days, a total of about 600 km. We found an interactive effect between diet and season that resulted in about ~20% higher BMR in AO-high diet birds in autumn, but with no difference in spring. A similar pattern was observed for the pooled mass of heart and flight muscles (~5% higher in AO-high). Pooled mass of kidney, liver and gut differed only between seasons (~9% lower mass in spring). This indicates that dietary antioxidants can modulate the avian energetics through changes in organs capable to generate a high workload, however, this effect is season-dependent. Improved flight machinery may allow faster migration, but with higher energetic costs. The need for greater energetic reserves upon the arrival at breeding grounds may constrain physiological adjustments during spring migration, although birds may still profit from a high antioxidant capacity and refuel or recover faster after migratory flights. Supported by NSF (IOS-0748349 to S.R.M. and B.J.P.) and NSC Poland (2015/19/B/NZ8/01394 to U.B.)

P3-126 EARLS, KN*; PORTER, MS; RINEHART, JP; GREENLEE, KJ; North Dakota State University, Fargo, ND, Pennsylvania State University, University Park, PA, USDA-ARS, Fargo, ND; *kayla.earls@ndsu.edu*

Effects of Cold Stress on Reproductive Fitness in the alfalfa leafcutting bee, Megachile rotundata

The alfalfa leafcutting bee, *Megachile rotundata*, is an extensively managed solitary bee that may experience low temperature stress during metamorphosis. After diapause, pupae can be exposed to cold stress through spring cold snaps and agricultural practices that postpone development until crop conditions are favorable. Cold stress has been found to cause abnormalities in adult bees. However, the effects of low temperature stress on their reproductive fitness is unknown. The purpose of this study was to test the hypothesis that cold stress reduces fitness. Pupae were exposed to either constant or fluctuating cold stress for one week during metamorphosis, released into an alfalfa field after adult emergence, and compared to bees that were not interrupted. Twenty females and 10 males were released in 9 field tents (6.1m x 6.1m x 2.4m) placed in an alfalfa field and monitored for 3 weeks. Fitness and offspring characteristics were measured by the number of offspring, sex ratio, and diapause incidence. Bees exposed to constant cold stress had fewer offspring compared to controls or bees exposed to fluctuating temperatures. While the fluctuating treatment did not cause a reduction in fitness, offspring were more likely to enter diapause, suggesting mothers interpreted environmental conditions differently. This study is the first to show how field performance, fitness, and offspring characteristics, are affected by a stressor experienced before adult emergence in *M. rotundata*.

P1-100 EDMONDS, KE; Indiana University Southeast; *kedmonds@ius.edu*

Regulation of Gastrointestinal Development and Reproduction in the Marsh Rice Rat (Oryzomys palustris)

Environmental factors and hormones can regulate the development of various physiological systems. Photoperiod, melatonin, and thyroid status are known to affect significantly the reproductive system in seasonal breeders, but effects on the GI tract have not been as well studied. The present studies examined whether constant light (which inhibits melatonin release), oral melatonin administration, and hypothyroidism affect gastrointestinal (GI) development and reproduction in juvenile male rice rats. Rice rats were subjected, in separate experiments, to 14L:10D or constant light (24L:0D) photoperiods, the administration of oral melatonin, or the administration of oral propylthiouracil (PTU; 0.06%) to induce hypothyroidism from 21-56 days of age. The following masses were examined: body, testes, seminal vesicles (SV), Harderian glands (HG), spleen, and wet (W) and dry (D) masses of the stomach (St), small intestine (SI), cecum (Ce), and colon (Co). In addition, small intestine and colon lengths were measured. Constant light significantly reduced only SV and HG masses; there was no effect on any other variable examined. Oral melatonin administration reduced body, testes, SV, HG, WSt, WCo, DCo masses and the SI and Co lengths. Hypothyroidism reduced masses of the body, testes, SV, and HG, while causing decreases in only the WCe and DCe masses. These data show that melatonin most dramatically affects growth, reproduction, and GI development in males, but that constant light and hypothyroidism were without effect on most GI endpoints. It was hypothesized that changes in the GI tract may be a necessary mechanism for coping with likely seasonal changes in metabolic requirements. We are currently examining the effects of daily food restriction on these same variables in males.

P1-78 EDWARDS, KM*; REZNICK, DN; University of California, Riverside; *kedwa007@ucr.edu*

Specialization for Two Feeding Modes in High and Low Predation Guppies (Poecilia reticulata)

Guppies from the mountains of Trinidad co-occur with a diversity of predators in the lower portions of all rivers. Waterfalls limit the upstream distribution of predators, so guppies from these upstream localities live in communities with far lower risk of predation. This lowered risk allows them to grow to large population sizes with high densities. This high density creates strong competition between individuals for food resources, which forces a diet shift in the population from a preference for invertebrates in high predation communities towards the consumption of more algae and detritus in low predation communities. Guppies are a part of the Cyprinodontiform group, the most basal members of which are generalized suction feeders. The clade also contains more recently diverged specialized "pickers," some of which have in turn evolved a scraping feeding mode. I compared the jaw bones and head shape of guppies from three pairs of high predation and low predation streams from three different Trinidadian drainages to see if differences in diet are associated with differences in jaw and head shape. The dietary shift in the low predation guppies is expected to be accompanied by a shift from the more gracile jaw morphology of a picker towards the more robust and asymmetrical morphology of a scraper. Specimens were cleared and stained, photographed through a microscope from various angles, landmarked and analyzed using canonical variate analysis and discriminant function analysis. Jaw shape was largely influenced by drainage of origin, with low predation populations showing a varied evolutionary response that was consistently significantly different from their high predation counterparts.

P1-89 EDWARDS, KM*; CAINE, PB; LACEY, LM; HATCH, SA; BENOWITZ-FREDERICKS, Z M; Bucknell Univ., Inst. Seabird Research & Cons.; *kme012@bucknell.edu*

Chick Triglyceride Levels May Reflect Parental Provisioning Decisions in Response to Experimental Food Reduction

Seabirds live in variable environments where food availability is unpredictable and its abundance can fluctuate quickly. During food shortages, parents must balance tradeoffs between their current and future reproductive attempts by adjusting their chick provisioning behavior. Offspring hatching order and sex can influence the costs and benefits of parental investment. We tested the hypothesis that hatching hierarchy and chick sex affect parental provisioning in response to a sudden food reduction. Throughout the breeding season, we supplemented the diets of wild, nesting black-legged kittiwakes (*Rissa tridactyla*) daily. During early chick rearing, we withdrew the food supplementation from some ("withdraw") nests but continued feeding control nests. We weighed chicks immediately before and 3 days after food withdrawal and weighed age-matched control chicks on the same dates. Blood samples were taken concurrent with weighings for quantification of plasma triglycerides, a lipid substrate indicative of avian nutritional state and change in body mass. The effects of food withdrawal primarily manifested themselves in first-hatched (A) chicks, with no significant differences between control and withdraw groups in second-hatched (B) chicks. Overall, withdraw A chicks gained less mass and showed decreases in triglyceride levels, resulting in significantly lower post-withdrawal body masses and plasma triglyceride concentrations compared to controls. Female A chicks exhibited the same pattern, but male A chicks did not. This variation in chick response may reflect either an increased vulnerability of female A chicks to food reduction or a parental decision to preferentially buffer male A chicks from the effects of food shortages.

P3-145 EGAN, JP*; BLOOM, DD; SIMONS, AM; Conservation Sciences Graduate Program, University of Minnesota, Department of Biological Sciences, Western Michigan University, Department of Fisheries, Wildlife and Conservation Biology, University of Minnesota; *eganx149@umn.edu*

Phylogenetic Analysis of Trophic Niche Evolution and Spatial Patterns of Herbivory in Clupeoidei (Herrings, Anchovies, and Allies)

Biotic and abiotic forces govern the evolution of trophic niches, which profoundly impact ecological and evolutionary processes and species biology. Herbivory is an interesting niche because there are theorized trade-offs associated with diets comprised of low quality food that might prevent the evolution of herbivory in certain environments. For this study we investigated trophic niche evolution in Clupeoidei (herrings, anchovies, and allies) and tested the hypotheses that herbivory is negatively correlated with salinity and latitude using a novel, time-calibrated molecular phylogeny, trophic guilds delimited using diet data and cluster analysis, and standard and phylogenetically-informed statistical methods. Phylogenetic comparative analyses did not identify significant negative correlations between latitude and herbivory or salinity and herbivory. In clupeoids there were five evolutionary transitions from non-herbivore to herbivore trophic guilds and no transitions from herbivore to non-herbivore trophic guilds. There were no transitions to zooplanktivore, the most common guild, but it gave rise to all trophic guilds, except algivore, at least once. Transitions to herbivory comprised a significantly greater proportion of trophic guild transitions in tropical/subtropical relative to temperate areas. These findings suggest that cold temperatures may constrain the evolution of herbivory and that herbivory might act as an evolutionary "dead-end" that hinders subsequent trophic diversification and zooplanktivory an evolutionary "cradle" that facilitates trophic diversification.

P3-38 EISINGER, M*; OUFIERO, C; Towson University; *meisin1@students.towson.edu*

Does the Reappearance of a Dorsal Fin in the Black Ghost Knife Fish Apteronotus albifrons Affect Swimming Kinematics?

Apteronotus albifrons, or the gymnotiform black ghost knifefish, is known for its ribbon-like motion of the anal fin during swimming. This anal fin contains approximately 150 individual fin rays that allow for full movement of the fin. While these fish possess an elongate anal fin for locomotion, they completely lack a dorsal fin. However, due to inbreeding or relaxed selection, a mutant strain of A. *albifrons* exhibits an elongate dorsal fin. The presence of the dorsal fin mutation allows for the opportunity to study the effects of the dorsal fin on gymnotiform swimming. This dorsal fin is unique because it does not seem to function like a normal fin; it does not seem that the fish can control the fin. Preliminary internal morphology of the regained dorsal fin suggest that the mutant knifefish regained both the individual fin rays and fin ray supports as seen in the fully functional anal fin. While the swimming kinematics of normal A. *albifrons* have been previously described, the goal of this project was to determine the effect of a regained dorsal fin in the mutant knifefish on routine swimming kinematics and abilities. Using 5 mutant and 4 normal knifefish of similar size, we compared the swimming kinematics of the anal fin (e.g., amplitude and wavelength) during routine forward, backward and hover swimming. Fish were filmed at 250 Hz and fin kinematics were analyzed in ImageJ. Preliminary results suggest that the reappearance of the dorsal fin does not alter routine swimming kinematics. We discuss these results in the context of knifefish locomotion and dorsal fin function.

P2-166.5 EL SAADI, M; MACMILLAN, HA*; Carleton University; *heath.macmillan@carleton.ca*

Recovery Time, Survival, and Hyperkalemia During Fluctuating Thermal Regimes in Drosophila melanogaster

Insects exposed to low temperatures typically enter a state of paralysis known as chill coma, and individuals that do not die from the cold can recover from this state after an amount of time known as Chill Coma Recovery Time (CCRT). Both low temperature injury and prolonged CCRT have been causally associated with progressive hyperkalemia in the cold. In a Fluctuating Thermal Regime (FTR), warm recovery periods interrupt periods of low temperature exposure and enhance low temperature survival. In this study, we examine whether longer recovery periods improve survival and speed up CCRT of female *D. melanogaster*, and if so, whether this effect can be attributed to superior restoration of K^+ balance during these warm periods. Flies subjected to a single prolonged cold stress, as well as flies that experienced multiple cold exposures with shorter warm periods, had higher mortalities and higher CCRTs than flies that stayed warm for longer between cold bouts. Thus, a FTR with longer warm periods enhances survival and reduces CCRT, but whether this is directly or indirectly a result of an improved ability to restore extracellular K^+ balance during warm periods is unknown. We thus tested this hypothesis by measuring hemolymph K^+ concentrations in female flies under the same conditions.

P1-113 ELDERBROCK, EK*; SMALL, TW; SCHOECH, SJ; College of Wooster, University of Memphis; *eelderbrock@wooster.edu*

Nestling Corticosterone Levels are Increased After Adult Provisioning in Florida Scrub-Jays

Nutritional deficiency often results in increased corticosterone levels in nestling birds and corticosterone, a metabolic and stress-related steroid hormone, is hypothesized to play a role in mediating begging behavior. Further, previous studies have found that corticosterone levels of nestlings are negatively correlated with parental nest attendance and provisioning rates. In this study we examined the relationship between adult provisioning and nestling glucocorticoid levels in a free-living species, the Florida scrub-jay (*Aphelocoma coerulescens*). We monitored parental activity at the nest immediately prior to blood sampling and found that nestling corticosterone levels varied as a function of parental provisioning rate and the time since their last feed. Counter to our predictions, higher provisioning rates and more recent feedings were associated with higher corticosterone levels in nestlings. These results suggest that either the act of feeding by parents, the process of digestion, sibling interactions, or some combination of the preceding resulted in increased baseline corticosterone levels in nestling Florida scrub-jays. These results indicate that some caution should be taken in interpreting elevated nestling baseline corticosterone levels as indicating "nutritional stress" or other distressed states in the absence of knowledge of the individual's recent behavioral history.

P2-226 ENGLER, HI*; ASSIS, BA; OWEN, DAS; LANGKILDE, T; The Pennsylvania State University; *hie1@psu.edu*

Are post-anal scales a secondary sex characteristic in eastern fence lizards?

Secondary sex characteristics differentiate males from females but are not directly involved in reproduction. The sexually dimorphic fence lizard, *Sceloporus undulatus*, has several secondary sex characteristics, such as color badges and body size, which appear in adulthood. In addition, post-anal scales - enlarged scales above where the hemipenes evert from the cloaca - distinguish males (who have these scales) from females (who do not) even at hatching. However, beyond being ubiquitously used as an easy, noninvasive way to sex many species of lizard immediately after hatching, little is known about this sexually-dimorphic trait. We tested for relationships between the size of post-anal scales and both testosterone levels and brightness of throat badge coloration in males from hatching to adulthood. We found that males with larger post-anal scales had higher testosterone levels and brighter throat badges. These results suggest that post-anal scales may function as a secondary sex trait in this and possibly other species. Further research should examine the mechanisms controlling the development and growth of post-anal scales, and their potential function (e.g. possibly in supporting the hemipenis during mating).

P2-235 ENTZIAN, RP*; EMBERTS, Z; ST. MARY, CM; MILLER, CW; Univ. of Florida; *rentzian@ufl.edu*

Multiple Weapon Morphs in Leaf-Footed Bugs

When sexually selected weapons are polymorphic, it is often the case that one of the morphs has a large weapon, while the other is unarmed. However, recent studies in both harvestman and beetles have found the presence of multiple, distinct, weapon morphs. The maintenance of such variation suggests more complicated alternative mating strategies are at play. Here, we investigated weapon polymorphism in two leaf-footed bug (Insecta: Hemiptera: Coreidae) species. Many species of leaf-footed bugs have enlarged, sexually dimorphic, hind legs, which they use to compete with other males over access to mates and resources. These hind legs come in a diversity of forms, even within species, making them ideal for investigating the presence of weapon polymorphisms. Using linear measurements, we found evidence to suggest the presence of weapon polymorphism in at least one species of leaf-footed bug. Body size was a poor predictor of weapon morph, which suggests that this may be a genetic polymorphism. To our knowledge, this is the first species to show evidence of weapon polymorphism without also recovering an unarmed, minor, morph.

P1-71 ERB, AJ*; TURNER, AH; Stony Brook University; *arthur.erb@stonybrook.edu*

Braincase anatomy of the Paleocene crocodyliform Rhabdognathus.

Dyrosaurids, specialized marine relatives of crocodylians, are one of few archosaur lineages to survive the K-Pg extinction and present a unique combination of morphology and ecology absent in living crocodylians. Little is known about their endocranial anatomy, leaving questions about their neurosensory adaptations unaddressed. We CT scanned a well-preserved skull of *Rhabdognathus*, a Paleocene dyrosaurid from Mali. We focused on three specific internal structures: the cranial endocast; inner ear; and paratympanic sinuses. The *Rhabdognathus* endocast showed novel features including a dorsal venous system that appears to communicate with the external skull table, enlarged tympanic bullae that meet at the endocranial midline, and elongate olfactory tracts forming half the total endocast length. The tracts end in paired olfactory bulbs with complex bony projections—a unique morphology perhaps serving to increase surface area for olfaction. *Rhabdognathus* has a novel conformation of its paratympanic system. The anterior and posterior divisions of the lateral Eustachian canal meet outside the skull and a unique duct was discovered connecting the pharynx to the adductor chamber. These findings require a reinterpretation of the associated external foramina in dyrosaurids and potentially their close relatives pholidosaurids. The inner ear exhibits aspects of both *Pelagosaurus* and *Gavialis*. The common crus is spherical, as in *Gavialis*, but significantly expanded. The cochlear duct is shifted anteriorly as in *Gavialis*. The semicircular canals appear pyramidal as in *Pelagosaurus* unlike the spherical shape of crocodylians. This is the first time dyrosaurid braincase and neurosensory features have been examined using CT scans. Our work reveals novel morphologies in the ear, paratympanic sinuses, and olfactory bulb that may relate to dyrosaurid adaptation to a marine habitat.

P1-186 ERICKSON, I; VOLLMER, AC; MARCKEL, MC; MOODY, SP; HIEBERT, SM*; Swarthmore College, USA; *shieber1@swarthmore.edu*

Gut Microbiota of Sympatric Migratory and Resident Hummingbirds

The mammalian gut microbiome is important to food utilization, nutrient recycling, fattening, and overall host health in addition to being implicated in stress-responsiveness and anxiety-like behavior. The bird microbiome has been understudied, and hummingbirds have been cited as an important study system because of their rapid metabolism, nectarivory, and high sucrase activity. Additionally, some fatten seasonally for annual long-distance migration (e.g., rufous hummingbird, *Selasphorus rufus*) whereas others (e.g., Anna's hummingbird, *Calypte anna,*) are year-round residents undergoing much smaller annual changes in fat stores. Rufous and Anna's hummingbirds were captured in the San Juan Islands (WA, USA) from May through August, weighed and scored for fat accumulation; cloacal fluid (CF) and feces were collected opportunistically (at known times post-capture) in microcentrifuge tubes. OTUs were identified from the V3-V5 region of 16s rDNA to approximately species level. Core microbiota (phyla present in > 95% of samples) included Actinobacteria, Proteobacteria, Cyanobacteria, and Firmicutes, but not Bacteroidetes. The relative abundance of 6 bacterial phyla varied with fat score, but the ratio of Bacteroidetes to Firmicutes, commonly found to vary with obesity in mammals, did not, perhaps because of rapid cycling of fat score within the migratory phase. Despite compositional differences, however, the predicted functional profiles of hummingbird gut microbiomes were largely conserved, indicating that compositionally distinct microbiomes can maintain similar functions. Further analyses will examine relationships among species, annual phase, fat score, fecal microbiota structure, CF corticosterone, and tonic immobility, a potential behavioral correlate of stress responsiveness.

P1-134 ESHLEMAN, M. A.*; KLUG, P. E.; GREIVES, T. J.; North Dakota State University, USDA-APHIS-WS, NWRC; *michelle.angelucci@ndsu.edu*

Costly Competing Investments: Does Spring Migration Distance Influence the Reproductive Hormones at Arrival to the Breeding Site in a Polygynous Species?

Early breeding individuals are often able to produce the most offspring; however, birds are unable to invest the energy to be fully prepared to breed when they are migrating long distances in the spring. Individuals wait until they arrive at the breeding ground to enter the final stages of reproductive preparation, but migration distance may be an important factor in determining when birds begin activating their reproductive systems. Previous studies have focused on males and monogamous species to investigate the relationship between migratory distance and reproduction. We propose that red-winged blackbirds (*Agelaius phoeniceus*), a polygynous species, are an ideal subject to study this relationship because it is advantageous to be the first female breeding on a territory. The first female typically gets the best nesting location and more parental investment from the male. We captured individuals upon arrival to the breeding ground and obtained a blood and claw sample from both males and females. Females were injected with GnRH to measure their maximum production of the sex steroid hormone testosterone as an estimate of the pituitary and ovarian status. Stable isotopes of hydrogen obtained from the claw samples provide an estimate of each bird's overwinter location. Our study will explore whether migration distance, estimated using stable isotopes, plays a role in the activity or responsiveness of the reproductive endocrine axis upon arrival to the breeding ground.

P1-239 ESPINOSA, AJ*; SPAGNA, JC; William Paterson University; *espinosaa6@student.wpunj.edu*

Phylogenetics of Holarctic Agelenine spiders using an augmented barcode strategy

Spiders in the family Agelenidae, and particularly the Agelenine subfamily, is common in Holarctic faunas, with 1287 species described in 80 genera. The growth of DNA barcoding allowed us to gather a broad dataset of Agelenine taxa, representing 20 genera in the subfamily, and covering nearly the geographic range of the group, including North America, Europe, and Asia. We developed a core taxon set (30 individuals from 9 genera representing North America, Europe, and Asia) with data from between 3 and 6 mitochondrial and nuclear loci, combining lab data, previously published data, and newly generated sequences. We subsequently added databased barcode sequences from 83 additional individuals. We performed Bayesian MCMC analysis, using a GTR+I+G model for 50,000,000 generations, to estimate a phylogeny for the Ageleninae and Tegeneriinae, with an orb-weaver as outgroup. The North American taxa split into two groups, a clade including the Western and Central American genera, and one including the widespread and Gulf Coast genera, and thus the continental assemblage of Agelenines appears diphyletic, but neither of these groups' affinities with European taxa were resolved with statistical support in the Bayesian analysis. Subsequent tree-searches using alternate criteria showed little improvement in resolving the polytomy of these three major groups.

P2-139 ESTES, SK*; AUSTIN, MC; MANDELARE, PE; PAIG-TRAN, EWM; LOESGEN, S; STROTHER, JA; Oregon State University, California State University, Fullerton; *estess@oregonstate.edu*

The Microbiota of Marine Fishes Produce Neuroactive Secondary Metabolites

Most vertebrate animals have complex interactions with their gut and surface microbiota. In marine fishes, mucus samples have been found to have potent antibacterial, antifungal, and anti-proliferative properties. Some of this activity has been attributed to chemical defenses from the host, but recent exploration of fish microbiota has shown that they also produce numerous bioactive secondary metabolites, small organic compounds that are not directly involved in primary metabolism. The resulting mixture of bioactive compounds within the microbiota environment is believed to have an important role in providing for host defense as well as shaping the composition of the microbial community. However, relatively few studies have examined whether the microbiota in marine fishes also produce neuroactive compounds. To address this question, we sampled surface mucus from dozens of marine fishes, isolated 47 unique bacterial strains, cultured these strains, extracted secondary metabolites from the cultures, and then tested extracts for neuroactivity using a zebrafish based behavioral assay and for cytotoxicity using a cell-based assay. We identified numerous microbial strains from several marine fish species that produce compounds with potent pro-nociceptive and cytotoxic properties. Such compounds may alter the behavior of the host organism or potentially have a role in preventing predation.

P1-127 ESTRADA, AD*; WILSTERMAN, K; COMIZZOLI, P; BENTLEY, GE; UC Berkeley , UC Berkeley, Smithsonian Conservation Biology Institute; *allegradestrada@gmail.com*

Sex steroids alter 3D growth of feline endometrial cells in vitro

Endometrial cells lining the uterus are critical for pregnancy success. These cells support implantation and early placental development. In humans, the sex steroids estradiol(E_2) and progesterone(P_4) modulate endometrial cells by stimulating proliferation, altering cell function, and directing cells to form glands in the uterine lining in preparation for blastocyst implantation. However, the pattern of sex steroid production across the reproductive cycle varies in other animals. For example, in humans estradiol remains elevated above baseline after ovulation, whereas estradiol in the domestic cat drops to baseline (<20 pg/mL). We are interested in whether sex steroids regulate feline endometrial cell growth and organization. We cultured isolated endometrial cells in a 3D in vitro system and treated them with E_2 and P_4 at concentrations corresponding to different periods in the estrous cycle. We also treated cells with E_2 or P_4 alone to determine whether these steroid hormones act independently. From images of the treated cells, we quantified morphological changes in cell growth. Steroid hormone treatment decreased the size of 3D structures formed in vitro (AOV, $P < 0.001$; Tukey's HSD: $P < 1.6e-5$). However, progesterone alone increased the number of 3D structures relative to the estradiol treatment (AOV, $P < 0.05$; Tukey's HSD: $P < 0.003$). Analysis of mixed steroid treatments are on-going; however, our findings thus far suggest that feline endometrial cells respond to sex steroids in similar ways to humans. We are using quantitative PCR to measure the expression of genes related to endometrial tissue function, which will further validate that cell organizational changes reflect functional shifts that occur in response to steroids.

P3-3 ETZEL, R*; KHORIATY, J; ELLERS, O; JOHNSON, AS; Bowdoin College; *retzel@bowdoin.edu*

The contribution of morphological characteristics on the bouncing gait of sea stars: A cross-species comparison

While sea stars are known to exhibit a crawling gait, they also exhibit a bouncing gait, observed in at least five species of sea stars. This bouncing gait (periodic vertical motion with associated horizontal variation in speed) is characterized by coordinated movement of a sea star's podia, or tube feet, and an overall increase in speed from the crawl. Here we focus on how the locomotion-relevant geometric scaling of individuals changes with size, and how various morphological differences (such as arm length, ambulacral area, animal density, and height) can inform differences in bouncing behavior between species. To study this, three species of sea star (*Protoreaster nodosus, Asterias forbesi, Luidia clathrata*) were filmed in recirculating seawater flow tanks using two cameras to provide paired views from the bottom and side. Tracker software was used to gather raw position and time data, which were processed using Mathematica to determine parameters such as maximum speed and bouncing frequency. We found *P. nodosus* and *L. clathrata* to be relatively dense sea stars with the ambulacral area from which podia emerge composing about 20% of their ventral surfaces, while *A. forbesi* is less dense, with an ambulacral area around 40%. *P. nodosus* is a tall sea star, while *L. clathrata* is flat and long-armed. With respect to locomotion, *L. clathrata* bounced at a higher frequency and attained speeds more than five times that of *P. nodosus*, while *A. forbesi* bounced at intermediate speeds and frequencies. Further, we found a positive correlation between maximum velocity and size for *A. forbesi* and *P. nodosus*, while *L. clathrata*'s velocity decreased with size. *P. nodosus* and *L. clathrata* both have scaling coefficients consistent with the inverted pendulum model, while *A. forbesi* does not.

P2-35 FABIAN, JM*; MAEDA, M; SIWANOWICZ , I; WALKER, S; BOMPHREY, R; LIN, HT; Imperial College London, Royal Veterinary College, HHMI Janelia Research Campus, University of Leeds; *j.fabian@imperial.ac.uk*

Toward the Neural Representation of Aeroelasticity in Insect Wings

Dragonflies are acrobatic insects that perform critical tasks in flight, such as hunting, mating and navigation. Their wings undergo large, periodic, deformation on each flapping cycle. This aeroelastic response is determined by the interaction of inertial and aerodynamic loads as well as the detailed architectural and material characteristics of the wings. Flying insects detect mechanical strains within the wing via sensory structures called campaniform sensilla embedded within the cuticle of the veins. Information encoded by the campaniform sensilla can be used to monitor instantaneous wing loads and control wing stroke kinematics. Here we combine several microscopy techniques to describe the distribution of campaniform sensilla on the dragonfly wing. The sensory information perceived by each sensillum is largely dependent on its position on the wing, and its own mechanical structure. By identifying the position of campaniform sensilla across the dragonfly wing we can predict how aeroelastic loads are monitored during flight. Additionally, to understand natural loading conditions during free flight we have reconstructed 3D moving and deforming wing geometries based on high-speed recordings subjected to voxel carving. These data are informative for electrophysiological and modelling studies of dragonfly flight.

P1-227 FAHEY, C*; FARADY, S; FREDERICH, M; University of New England, Biddeford, ME; *cfahey2@une.edu*

Vulnerability of coupled Social-Ecological System (SES) revealed in case study of local management of softshell clam industry

A coupled Social-Ecological System (SES) approach can be used to manage the interactions between people and their environment and is the standard for Maine's Fisheries management programs. This allows coastal communities to exert direct management of resources with a focus on responsible use of the coastline, ensuring its future viability. Management and conservation goals for the soft shell clam *Mya arenaria* industry are linked to economic needs. State law requires municipalities with commercial shellfish operations to develop a management program, approved by the Department of Marine Resources. These plans specify conservation work required for license holders to maintain their licensure. Some state-recommended conservation work include population surveys, seeding, spat collection, and predation deterrents, as currently implemented by most municipal shellfish committees. We investigate and evaluate one shellfish conservation program and its impacts on management implications. Using surveys, engaging local clammers, and conducting field work, we found that local interpretation of these mandates fall short of their intended goals, despite adhering to state requirements. Specifically, despite clammers and shellfish managers investing significant time and money in their conservation program, no reliable clam population data is produced, leading to a lack of solid data to inform sustainable resource management. This illustrates that a coupled SES approach for shellfish management can produce large vulnerability in resource management that could result in mismanagement and deterioration of the respective resource.

P1-196 FAIR, T*; GARDNER, M; INGRUM, I; NOONAN, K; CHILDRESS, M; Clemson University; *tfair@g.clemson.edu*
Effects of Hurricane Irma on reef community structure in the Florida Keys National Marine Sanctuary
Coral reefs provide structurally complex habitats for thousands of species of marine organisms. The increased energy of hurricanes has the potential to impact reef fish density, richness or behaviors by altering physical structure or substrate composition. In September, a category 4 hurricane (Hurricane Irma) made landfall in the Florida Keys causing widespread impacts on the Florida reef tract. In this study, we compared pre and post surveys of substrate composition (photo quadrants) and reef fish densities (video transects) on three reefs that varied in proximity to the point of impact. Substrate cover after the hurricane was marked by noticeable decreases in algal cover, particularly turf algae, and increases in sand and coral cover. The impact on abundance within fish feeding groups was inconsistent over the three sites. The initial effects of the hurricane impacted substrate on a varied scale across the reefs, leaving them open to differing coral-algal dynamics as the area is resettled.

P1-130 FALSO, MJS*; SHIDEMANTLE, GI; PASQUALE, VE; CAMPBELL, ZI; GUSTAFSON, KL; MARSHALL, LV; FALSO, PG; Slippery Rock University; *miranda.falso@sru.edu*
Photographic Examination of Nuptial Pads in Xenopus laevis Exposed to the Pesticide Imidacloprid
Amphibians are extremely sensitive to environmental conditions and populations are experiencing widespread and rapid declines in recent years. Numerous studies suggest that chemical contaminants and disease present immediate threats to amphibian populations worldwide. In addition to directly killing amphibians, contamination of aquatic environments with chemicals has been linked to sublethal disruptions of the endocrine and immune systems. This study examined the impact of chronic exposure to a neonicotinoid pesticide on amphibian development and secondary sex characteristics. Neonicotinoids are widely used to kill insect pests by mimicking nicotine and disrupting function of the nervous system. *Xenopus laevis* were chronically exposed to environmentally relevant concentrations of the neonicotinoid, imidacloprid. Following sexual maturity photographs were obtained of the forelimb area containing the nuptial pad. The nuptial pad contains keratinized hooks and breeding glands sensitive to androgens. Methodology is currently being developed to evaluate intensity and size of nuptial pads following treatment. Imidacloprid has been indicated to impact male reproduction in other species, therefore valuable data may be obtained to aid in understanding the impact of imidacloprid on amphibian reproduction.

P3-182 FAMUYIWA, T; Florida Atlantic University; *tfamuyiwa2014@fau.edu*
ABC Transporter Mediated Multidrug Resistance in Prostate Cancer
Background: Prostate cancer (PCa) is the second most diagnosed cancer in men. The high incidence of prostate cancer has been attributed to failures in conventional chemotherapy. Studies suggest that energized ATP Binding Cassette proteins cause 50% of the failure in chemotherapy. This study focuses on the inhibition of ATP Binding Cassette (ABC) protein mediated drug resistance in prostate cancer treatment. Specifically, Poly Lactic-co-Glycolic Acid (PLGA) nanoparticle will be utilized as carrier to deliver SC-514 and 3-Bromopyruvate (3-BPA) in various PCa cell lines. Objective of study: This study aims to: (i) investigate the potential interaction between 3-BPA and SC-514 Method: The bioassays used in this study include: trypan blue exclusion, MTT tetrazolium, NBT, LDH cytotoxicity, cell titer glow, multidrug resistance efflux Results: ROS level of LNCaP cells treated with 3-BPA ($r = -0.5$, $p = 0.11$), SC-514 ($r = -0.72$ $p = 0.04$,) and 3-BPA + SC-514 ($r = -0.58$, $p = 0.04$) showed no significant difference in ROS modulation ($p = 0.54$). Results also, suggested a weak ($r = -0.29$) to moderate ($r = -0.42$) negative correlation between ROS released and cell death. In addition, there was a weak correlation ($r = 0.19$) between percentage ROS induced and percentage apoptotic death. There was a positive correlation between the concentration of drug and cell death. Results based on cell titer glow assay suggested that 3-BPA and/or SC-514 depleted intracellular ATP in DU-145 cells and PC-3 cells. SC-514 and/or 3-BPA are substrates for MDR1. 3-BPA and/or SC-514 potentially block MDR1. Conclusion: 3-BPA and SC-514 has the potential to inhibit multidrug resistance by reducing the intracellular ATP available to ATP Binding Cassette proteins. Apoptotic induction in DU-145 and PC-3 prostate cancer cells appears to occur via a mechanism other than reactive oxygen species (ROS) induction.

P3-16 FARLEY, GM*; BEDORE, CN; PATEK, SN; Duke University, Georgia Southern University; *gmf7@duke.edu*
Rapid hydrostatic tentacle protrusion in cuttlefish
A diversity of organisms rapidly protrude prehensile appendages to capture prey, including the tongues of lizards, salamanders, and frogs, and the tentacles of squid and cuttlefish. Cephalopods provide an interesting comparison to land-dwelling reptiles and amphibians, because the buoyancy of water can support greater appendage mass, yet drag costs are higher in water than in air. Using high-speed imaging (1000-3000 frames/s), we analyzed the strike behavior and kinematics of two species of cuttlefish, *Sepia bandensis* (n=6 individuals) and *Metasepia pfefferi* (n=3 individuals). Although both species have similar body sizes, *S. bandensis* have short, wide tentacles that they extend up to 2 times their body lengths, while the longer and slimmer tentacles of *M. pfefferi* can be extended up to 2.5 body lengths. Their tentacle extension exceeds rapid appendage protrusion in other species (maximum reported is 1.5 body lengths in *Chameleo*). In terms of strike kinematics, *S. bandensis* (34 strikes) reached lower maximum velocities (3 m/s) and accelerations (2000 m/s^2) than *M. pfefferi* (4 m/s; 4000 m/s^2; 14 strikes). Both cuttlefish species exceed the maximum velocities and accelerations reported for the squid *Loligo pealei* (2.3 m/s; 250 m/s^2). *M. pfefferi*'s maximum velocities are comparable to the chameleon *Chameleo outstati* (4.9 m/s) and both cuttlefish species exceed the chameleon's 392.8 m/s^2 maximum acceleration. These findings suggest that the physical properties of water allow cuttlefish to achieve impressive velocities while extending soft, minimally-supported appendages much farther than their land-dwelling counterparts.

P2-50 FASICK, JI*; SERBA, KM; The University of Tampa; *jfasick@ut.edu*

Whale Shark (Rhincodon typus) Retinal Pigments and Visual Foraging Ecology

The whale shark (*Rhincodon typus*) is the largest of all extant elasmobranchs (sharks and rays). Similar to the mysticete whales, whale sharks are filter feeders and spend most of their foraging time in surface waters at depths less than 10m. Whale sharks are also capable of diving to depths in excess of 1500m with speculations that these dives are also associated with foraging. Sequence analyses of the recently published *R. typus* genome was used to describe the whale shark retinal opsins. Results show that whale sharks are rod monochromats and lack cone photoreceptors, a trait that is also found in the filter-feeding mysticete whales. The absorbance maximum of the single rod visual pigment is estimated to be 500nm based on conserved amino acids at rhodopsin positions 83, 292 and 299. Thus, whale shark rhodopsin is spectrally tuned and adapted to surface foraging in pelagic waters and is relatively less sensitive to light at depths greater than 200m. Because *R. typus* lacks cone photoreceptors, the retinal pigment melanopsin, expressed in intrinsically photosensitive ganglion cells (ipRGCs), is critical for controlling the pupil light reflex (PLR) in photopic light conditions to protect the rod-only retina from photobleaching. Previous studies have shown that the phosphorylation sites found in melanopsin's carboxyl-tail are responsible for the activation/deactivation kinetics of ipRGCs expressing melanopsin, which control the rate of the PLR and pupil diameter under photopic conditions. Sequence analysis of the carboxyl tail from whale shark melanopsin reveals phosphorylation sites that are typical of a duplex retina (rods and cones) and are unlike other marine rod monochromats. This would result in a relatively fast PLR in whale sharks in stark contrast to the slow PLR described in rod monochromat whales.

P2-84 FASSBINDER-ORTH, C*; HUGHES, S; Creighton University; *sch88437@creighton.edu*

Radio-Frequency Identification as a Tracking System: a study of honey bee behavior

With recent increases in colony losses and abnormal colony syndromes and behaviors (e.g. Colony Collapse Disorder), it has become more important than ever to examine honey bee (*Apis mellifera*) behavior. One challenge of studying honey bee behavior is to track them noninvasively, so the bees do not alter their normal behavior. To address this challenge, we developed an enclosed system that uses radio-frequency identification (RFID) to monitor honey bee behavior. The data gathered from the system can be used to create a spatial analysis model. The spatial analysis can be used as a predictive model to explain colony loss and determine potential outcomes for colonies. Moreover, it can be used to shed light on altruistic suicide which is a key characteristic of Colony Collapse Disorder. Each system had six RFID readers placed at a standardized distance of one another, and each bee was outfitted with a microchip programmed with a unique identification number (ID). Every reader in the system was attached to a small, single-board computer. The computer provided power to the reader and ran a python program that recorded each communication between its respective reader and microchips within threshold of the reader's antenna. Every time the reader detected a microchip, the ID and timestamp were appended to a text file stored on the computer. The text file was then analyzed to develop the statistical spatial analysis. This system has applications far beyond the scope of honey bee colonies. Because it is not invasive, this system can be used to track any animal that can be outfitted with a 2.5 x 2.5 millimeter microchip. Furthermore, animals that can support larger RFID chips can be tracked at a larger distance than the microchip used in this experiment, enabling the study of free-living organisms.

P1-140 FEINGOLD, SR*; ROARK, AM; Furman University; *sarah.feingold@furman.edu*

Using the Yeast Estrogen Screen to Measure the Estrogenicity of Personal Care Products

Many cosmetic and pharmaceutical products manufactured for daily use contain endocrine-disrupting compounds. These compounds can occur naturally (e.g. phytoestrogens) or can be man-made (e.g. UV filters or phthalates). Many bind to estrogen receptors, leading to sex reversal, infertility, menstrual irregularities, miscarriage, and breast cancer. The purpose of this study was to detect and quantify estrogenic compounds in a variety of personal care products, including shampoos, conditioners, lotions, sunscreens, and moisturizers, using the yeast estrogen screen (YES). Two strains of recombinant *Saccharomyces cerevisiae* containing plasmids that resulted in the expression of either the alpha or beta isoforms of human nuclear estrogen receptor (ER) were used to quantify ER agonism in ethanol extracts of 32 personal care products, each of which was measured in triplicate. Estrogenic compounds in a sample bound to the ER alpha or ER beta receptors, resulting in the dose-dependent expression of beta-galactosidase. The yeast cells were then lysed to release the beta-galactosidase, which cleaved a colorimetric substrate and produced a yellow to red product, with the degree of color change correlating to the concentration of estrogenic compounds. Of 32 personal care products tested, over half were positive for the presence of estrogenic compounds. The results of this study indicate that many popular personal care products contain estrogenic endocrine-disrupting chemicals and suggest that caution is warranted when using such products.

P2-61 FEIPEL, CW*; KROHMER, RW; Saint Xavier University; *krohmer@sxu.edu*

Mapping Aromatase Immunoreactive Neurons and Estrogen Receptors During Early Life Stages of Brain Development in Male Red-Sided Garter Snakes.

The Organizational/Activational Hypothesis states, exposure to androgens early in development organizes the male brain so that, as an adult, the same hormone elicits the expression of male reproductive behaviors. However, in the past several decades, studies have indicated that estrogens, aromatized from androgens, and not the direct action of androgens, may be critical for organization of the male brain. The presence of estrogens during prenatal and perinatal brain development has been shown to stimulate cell growth and promote the formation of neuronal and sex-specific pathways. It is believed that the estrogens that influences CNS development is derived from neuronal estrogen synthesis (aromatization) rather than estrogens found in the circulation. In a recent study, we found that estrogens appeared to be the active hormone regulating courtship and mating in the male red-sided garter snake (RSGS). Consequently, if estrogen is the hormone activating courtship and mating in male RSGSs, estrogens should also be responsible for organizing the male RSGS brain. We tested our hypothesis by examining the brains of newborns, 3, 6, and 9 month old RSGSs, raised under natural conditions in our lab, and wild-caught immature and juvenile RSGSs for the presence and distribution of aromatase immunoreactive (ARO-ir) neurons and estrogen receptors (ER) as indicators of brain development. Preliminary results support an age related progression where ARO-ir neurons and ERs, absent in newborns could be found in the brains of juvenile RSGSs.

P2-11 FEIPEL, CURTIS*; TATUM PARKER, TATIAN; Saint Xavier University; *tatum@sxu.edu*

Bisphenol A's impact on the germination and growth rate of Brassica rapa

The use of Bisphenol A (BPA) a synthetic high production volume compound used in plastics and epoxy resins has grown exponentially, while the consequences of this environmental contaminant is vaguely understood. Considering the ability of BPA to leach into its surroundings, along with its increased use, further studies are necessary to understand its comprehensive impact on the global system. Our study is concerned with the acute stress effects of BPA on terrestrial vegetation, by observing germination rate, root length, root behavior, and true leaf appearance in *Brassica rapa* (Wisconsin Fast Plant). Germination and early development were analyzed by continual exposure of seeds to BPA treatments of 0, 0.05, 0.25, 1, 10, 25, and 50 mg/L. Germination rate and success of germination showed no significant difference within or between any concentration. In our 48 hours post-germination measurements, the root lengths showed significant differences in mean length between treatments, with the 25mg/L and the 50mg/L treatments. The root behaviors observed were classified as normal or abnormal in their geotropic response, finding that in a concentration-dependent manner abnormal behavior increases. BPA is possibly interfering with auxin production and distribution in the root cap. The plants true leaf appearance at 96 hours decreased as the concentrations increased. The true leaf appearance provides a measure of plant health suggesting that the overall plant health declines as the concentration of BPA increases. The differences observed at the higher urban BPA concentrations may have significant effects on agriculture as well as wild plants. Further studies should be pursued to better understand the mechanistic and fitness effects of BPA.

P2-268 FENNER, JL*; CONCHA, C; COUNTERMAN, BA; MCMILLAN, W; Mississippi State University, Smithsonian Tropical Research Institute; *Jls1393@msstate.edu*

Does the Wnt pathway Modulate Pigment and Structural Variation on Butterfly Wings?

Animal coloration is an attractive model for studying how conserved developmental toolkit genes influence the form and function of traits. Butterfly wing patterns provide an ideal system for studying how highly conserved developmental genes are responsible for generating a vast array of natural variation. Recently, it was shown that genes in the melanin pathway modulated both scale color and morphology. Here we examine if a gene, *WntA*, which is responsible for pre-patterning of melanic pigment coloration in *Heliconius* butterflies, also controls cyto-structural variation in wing scales. Knockouts of *WntA* across several *Heliconius* species generated the expected pigment changes, with wing regions typically colored black, instead developing red scales. Here, we show that *WntA* knockouts also had changes in scale structures. The mutant scales were structurally intermediate between wild type black and red scales: the scale ultrastructures (width, length, and area) were similar to black wild type scales, but the nanostructures (lamella ridge and crossrib distance) were more similar to wild type red scales. Our results suggests that *WntA* is not only responsible for pre-patterning scale pigmentation, but also involved in patterning of scale nanostructures.

P2-185 FERGUSON, QR; TOGLIA, DS; MCCARTAN, RJ; LEININGER, EC*; New College of Florida; *eleininger@ncf.edu*

Characterization of X. muelleri laryngeal muscle fiber type using ATPase histochemistry: behavioral and evolutionary implications

Xenopus is an excellent system for investigating how structure and function of peripheral effectors can shape behavior outputs in species- and sex- specific fashions. Most *Xenopus* species produce vocalizations that are sexually dimorphic in temporal structure and inter-pulse interval (IPIs); male call IPIs are typically shorter than female call IPIs, or female calls are absent altogether. In most species investigated, laryngeal muscle fiber type is sexually dimorphic and supports vocal sex differences; male laryngeal muscle is composed of fast twitch fibers, while female laryngeal muscle contains both fast and slow twitch fibers. A subset of *Xenopus* species including *X. borealis* and *X. muelleri* have reduced vocal sex differences; IPIs do not differ between sexes, and are longer than those of other species. We have shown previously that *X. borealis* laryngeal muscle contains fast and slow twitch fibers in both sexes, suggesting that the sexually differentiated laryngeal muscle fiber type characteristic of other species has been lost in *X. borealis*. In this study, we asked whether loss of a sexually differentiated fiber type is unique to *X. borealis* or shared with *X. muelleri*, a closely related species with reduced vocal sex differences. General laryngeal features, such as mass, is sexually dimorphic in *X. muelleri*. ATPase histochemistry under acidic preincubation conditions suggest a mixture of acid-sensitive and acid-stable fibers in male and female laryngeal muscle (indicating a mixed twitch type). Our present findings suggest that evolutionary loss of a sexually differentiated fiber type may be common to species closely related to *X. borealis*.

P3-107 FINGER, JW*; HAMILTON, MT; KELLEY, MD; ZHANG, Y; KAVAZIS, A; GLENN, TC; TUBERVILLE, TD; Auburn University, University of Georgia; *johnwilsonfinger@gmail.com*

Selenium exposure and its effects on oxidative status in the American alligator (Alligator mississippiensis)

Selenium (Se) is an essential nutrient, which in excess can cause toxicity. Anthropogenic activities, such as the disposal of coal combustion waste products, are increasing the risk of Se exposure worldwide. However, most research investigating the toxic effects of Se have been limited to organisms of lower trophic status or organisms that are shorter lived. To counteract this, we administered juvenile American alligators (*Alligator mississippiensis*) 1000 or 2000 ppm selenomethionine (SeMet) or control water for 7 weeks. After this 7-week period, all alligators were euthanized and tissues were stored -80°C until analysis. Levels of superoxide-dismutase-1 (SOD1), SOD2, and glutathione peroxidase-1 (GPX-1) were measured in whole blood and tail muscle by Western blotting. Save for blood SOD2 levels ($p < 0.01$), SeMet treatment did not affect any other parameter investigated ($p < 0.05$). As this is the first study to investigate Se exposure and its effects on oxidative status in crocodilians, future studies are warranted.

P2-149 FINKLER, MS; Indiana Univ. Kokomo; *mfinkler@iuk.edu*
Fluctuating temperature during incubation triggers differential embryonic growth and development during the organogenesis phase of embryogenesis in Chelydra serpentina.
Diurnal fluctuations in nest temperature have been shown to affect incubation duration as well as the sex, physiological performance, and size of hatchling turtles. The influence of temperature fluctuation on embryonic growth and development rates at different developmental phases, however, is not well understood. In this experiment, I incubated Snapping Turtle (*Chelydra serpentina*) eggs at either "constant" (25 ± 0.5 °C) or "fluctuating" (12 h at 29 ± 0.5 °C, 12 h at 21 ± 0.5 °C) thermal conditions. I sampled embryos at predicted time intervals for the onset of organogenesis (Yntema stage 10), the onset of early growth (YS 14), and the onset of late growth (YS 19) as well as at hatching. Embryo dry mass and development stage did not differ between the two groups early in the organogenesis phase, but by the onset early growth phase embryos in the fluctuating thermal treatment had significantly higher dry masses (~42% greater) and were more developed (by ~1 Yntema stage) than those in the constant thermal treatment. The proportional size and developmental difference observed at the beginning of the early growth phase persisted into the beginning of the late growth phase. However, there was no significant difference in incubation duration, in hatchling dry mass, or in various linear measurements of hatchling size between the two treatments. These findings suggest that the organogenesis phase of development is particularly sensitive to diurnal fluctuations in temperature with respect to both growth and development. Overall growth during the late growth stage of embryogenesis, however, appears to be largely determined by the overall size of the egg and the resources contained within, resulting in little difference in hatchling size as a result of fluctuating incubation temperature.

P2-55 FJORDBOTTEN, KM*; BRINKMAN, BE; IWANIUK, AN; Univ. of Lethbridge, Alberta; *krista.fjordbotten@uleth.ca*
Sexual Dimorphism in the Morphology of Neurons in the Prefrontal Cortex of Richardson's Ground Squirrels
Sexually dimorphic behavior is often correlated with variation in relative and absolute sizes of brain regions. However, few studies have tested whether this also extends to neuronal morphology within brain regions of wild species. Richardson's ground squirrels (*Urocitellus richardsonii*) exhibit sexually dimorphic social behavior; females being far more tolerant of other individuals and less aggressive than males. Because the prefrontal cortex plays a key role in modulating social behavior, we hypothesized that the neuronal morphology within the prefrontal cortex is sexually dimorphic in Richardson's ground squirrels. We used virtual microscopy to image Golgi stained pyramidal neurons within the medial prefrontal (mPFC) and orbitofrontal (OFC) cortices of wild caught male and female ground squirrels. From these images, we traced over 180 neurons across both regions and quantified 17 different measurements of neuronal morphology. Mixed models revealed that soma and total neuron volumes are significantly larger in males than females within the OFC. Convex hull and basal dendritic volumes are also significantly larger in males than females in the mPFC. Thus, males tend to have larger neurons with broader dendritic trees, despite a female bias in mPFC volume. Males are larger than females, so these sex differences in neuronal morphology likely reflect larger male brains rather than sexually dimorphic behavior. We suggest that other variables might be more closely associated with sexual dimorphism in Richardson's ground squirrel social behavior, such as dendritic spine density or nonapeptide receptor distribution.

P3-26 FLEISSNER, E.R.*; MENSINGER, M.E.; University of Minnesota Duluth, Truman State University; *fleis133@d.umn.edu*
Kinematics of the Flying Carp
In the 1980's, invasive silver carp (Hypophthalmichthys molitrix) escaped from captivity within the United States and spread throughout the Mississippi River Drainage. Silver carp are planktivorous fish that severely disrupt ecosystems by competing with native filter feeders and altering the composition of the lowest trophic levels. They have gained additional notoriety due to their prodigious jumping behavior in response to moving watercraft, which field studies have shown can be induced by both water turbulence and sound. The triggering mechanism and the functional significance of the jumping behavior remain unknown. To better understand the behavior, 5 silver carp were filmed with a high speed camera mounted below an aquarium and stimulus latency, tail amplitude, tail frequency and swim velocity were monitored during jumping following a mechanical stimulus. The jumping behavior consistently followed a startle response, in which the peak amplitude of tail beats increased from roughly 1.28 cm during normal swimming to 1.60 cm and tail beat frequency increased threefold to 10 - 20 beats/second. Since results suggest jumping is initiated after the startle response, Mauthner neurons may be mediating the response.

P3-163 FLOCK, TM*; KRAMER, AM; LAJEUNESSE, MJ; University of South Florida; *tflock@mail.usf.edu*
The Cost of Trait-Mediated Interactions and Indirect Effects within Predator-Prey Dynamics
Predators shape food-web dynamics and ecosystem interactions in two ways. First by consuming prey, which removes individuals from populations and has positive effects on predator birth and survival. This is known as the density-mediated effect of predators on prey. Secondly, predators affect biotic interactions and food-web dynamics via nonconsumptive, trait-mediated effects. This occurs when predators and the risk they pose change the behavior, morphology, or physiology of prey. Trait-mediated interactions (TMIs) have been reported for a broad group of taxa, and early meta-analyses of these studies concluded that TMIs affect prey population dynamics as strongly as density-mediated interactions (DMIs). However, there has since been considerable growth in research on TMIs and DMIs, as well as new research synthesis standards and practices that can help provide new insight on the impact of direct and indirect effects of predators. Here we describe a phylogenetic meta-analysis that first tests whether DMIs are more or less influential at shaping prey populations than TMIs, and then examine the TMIs caused by invasive species. Invasive species are projected to increase over time and a better understanding of key trait-mediated interactions of invasive species is needed. Our synthesis contained mostly papers published after 2005 (532/664 papers that were relevant to the literature search were published after 2005), and we hypothesized that TMIs have similar effects as DMIs on shaping prey populations due to the cost of the tradeoffs imposed on prey species under nonlethal predator exposure. This meta-analysis updates and strengthens our understanding of biotic interactions and consumer-resource dynamics, and helps predict which invasive species traits are most detrimental to native species via TMIs and indirect effects.

P1-9 FLORES, DV; STRICKLAND, JT; BODENSTEINER, BL; JANZEN, FJ*; Iowa State University, U.S. Fish and Wildlife Service, Virginia Tech University; *fjanzen@iastate.edu*

Planting an Outreach TREE: Exposing Diverse Students to Ecological Research with Reptiles

Women and minorities are seriously underrepresented across the sciences. To help create positive change in ecology, we developed a program called TREE (Turtle Camp Research and Education in Ecology). We seeded the program primarily with an economically and racially diverse group of high school students from rural and urban areas, along with undergraduate and graduate student mentors from across the United States. Participants converged at a field site in northwest Illinois on the Upper Mississippi River National Wildlife and Fish Refuge and the Army Corps of Engineers Thomson Causeway Recreation Area during June of 2007-2012 and 2014-2018 (totaling 59 different high school students, 28 undergraduate students, 17 graduate students, and 4 post-doctorates over the 11 program years). All individuals worked toward four main goals at the site: research experience, education, local outreach, and mentoring. The program capitalized on the extensive diversity of reptiles at the site, giving the students hands-on experience with research and related activities. Anonymous surveys of the high school participants - the vast majority of whom were women and/or racial minorities - revealed that TREE provided an excellent environment for advancing interest in, and knowledge of, science and for influencing career plans of the participants. Many alums have since pursued science-related degrees at universities. This program is a successful model of the importance of outreach, and near-peer mentoring in diversifying the STEM workforce. We thus hope that TREE inspires other research groups to develop programs to expose students from diverse backgrounds to ecological research, education, outreach, and mentoring

P3-73 FOLEY, KJ*; MCALISTER, JS; College of the Holy Cross; *kjfole19@g.holycross.edu*

Egg Size, Composition, and Energy in Suspected Hybrid Asterias Seastars

Egg size and composition vary both within and across marine invertebrate taxa. Generally, smaller eggs contain fewer maternally provisioned biochemical constituents for developing larvae, whereas larger eggs may provide more of these materials and energy. Of these constituents, proteins are used primarily for morphogenesis, whereas lipids are used for both metabolism and morphogenesis. Larger eggs do not always correlate with increased maternal provisioning, however. In fact, how egg size, composition, and energy co-vary is not entirely understood. In some cases, larger eggs may have similar constituent amounts as smaller eggs, but greater volumes of seawater or energy-poor carbohydrates. Hybridized individuals of the sea star *Asterias* have been observed to produce two size classes of eggs. Hybrids may show more variation in egg size across reproductive females than within populations of purebred females, but whether this variation is due to differing amounts of biochemical constituents or seawater is unknown. We assayed the eggs of 12 suspected hybrid *Asterias* females collected from within a hybrid zone for protein composition. While none of the females we spawned produced two different size classes of eggs simultaneously, we did find that across females, the eggs we obtained fell into two different size classes: smaller eggs (egg volume <1.1 nL) and larger eggs (egg volume >1.1 nL). Colorimetric assays indicate that the protein amount of smaller eggs was not significantly less than in larger eggs and that protein density decreased as egg size increased. We are conducting additional assays for lipid and carbohydrate composition, which will provide a more complete understanding of maternal investment in the eggs of *Asterias rubens* and *Asterias forbesi* collected from within a hybrid zone.

P2-278 FONTANA, RM*; CHANDLER, CH; SUNY Oswego; *rfontana@oswego.edu*

Identification of transposable elements in the genome of the terrestrial isopod Trachelipus rathkei

Transposable elements are sequences of DNA which appear multiple times throughout a genome. This is because the transposons are able to jump around the genome, often bringing with them sections of surrounding DNA. Many crustaceans, including terrestrial isopods, have large genomes which include ample amounts of transposons within them. In our current research, we aim to identify and characterize the transposable elements in the genome of the terrestrial isopod Trachelipus rathkei. Using RepeatModeler, we are annotating the different types of transposable elements in this species's genome. We are also testing a novel and hopefully high-efficiency approach, using high-frequency kmers identified directly from raw Illumina sequencing data to identify families of repetitive elements. This will provide a foundation for future genomic studies in terrestrial isopods.

P2-264 FORD, NT*; FORD, MP; SAMAEE, M; SANTHANAKRISHNAN, A; Oklahoma State University; *askrish@okstate.edu*

Effects of varying inter-pleopod spacing to pleopod length ratio in metachronal swimming of crustaceans

Long-tailed crustaceans such as krill and mysids use drag-based metachronal swimming for aquatic locomotion. Pleopod pairs are rhythmically paddled starting from the animal tail to head, such that each pleopod pair is delayed in time relative to the neighboring pair. The ratio of inter-pleopod spacing (G) to pleopod length (L) has been observed to lie within a fairly narrow range of 0.2 to 0.7 in a variety of freely-swimming crustaceans (Murphy et al., Mar Biol 158, 2011). In this study, we examined how varying this G/L ratio from 0.4 to 0.6 impacts metachronal swimming performance. A dynamically scaled robotic model capable of self-propulsion was developed for this study. Physical models of idealized paddle-like pleopods were fabricated from acrylic (four pairs) and outfitted onto the robotic platform. The paddles were programmed to oscillate in tail-to-head metachronal motion with 25% inter-limb phase difference. Thrust generated was measured near the leading edge of the robotic model assembly using strain gauges. Our results showed that time-averaged thrust was slightly augmented with decreasing G/L, but peak thrust increased with increasing G/L ratio. The distance advanced by the self-propelling models under varying G/L will be presented.

P2-255 FULBRIGHT, MC*; MOON, BR; University of Louisiana at Lafayette; *fulbrightmc@gmail.com*

Bite Performance in Map Turtles (Graptemys species)

Bite force is an important measure of performance that directly relates to an organism's fitness. The forces produced by the jaw muscles limit the types of prey that can be consumed by an individual, and therefore the nutrition and energy available to the individual. Bite forces have been recorded in diverse taxa, yet many interesting examples, such as some profoundly dimorphic species, remain to be studied. We are studying bite performance in map turtles (*Graptemys* species) that vary dramatically in head size. Map turtles exhibit three different trophic morphologies: The males of all species are considered microcephalic (i.e., have small heads), whereas females may be microcephalic, mesocephalic, or megacephalic (having profoundly large heads). The differences in head size are thought to relate to dietary differences, with megacephalic females being capable of durophagy, and microcephalic individuals being limited to feeding on softer prey items such as aquatic insect larvae. We are measuring bite forces in microcephalic map turtles *Graptemys sabinensis* and megacephalic ones *Graptemys pearlensis*. Our preliminary results show that microcephalic individuals generate forces comparable to many turtles that are dietary generalists, whereas megacephalic individuals are capable of producing much higher bite forces, commensurate with those of similarly sized snapping turtles (*Chelydra serpentina*). These results support the hypothesis that megacephalic map turtles can exploit hard prey that most other species of turtles cannot consume. In future research, we plan to quantify the muscle morphology and maximum tetanic bite forces elicited by direct muscle stimulation.

P2-125 FULLER, RG*; GORMALLY, BM; ROMERO, LM; Tufts University; *rory.fuller@tufts.edu*

An attention-occupying feeding mechanism does not affect glucocorticoid secretion in captive house sparrows (Passer domesticus)

Bringing wild animals into captivity is a crucial aspect of studying stress physiology, as many experiments which are impractical in the wild can be easily performed in a lab environment. However, the mere act of capturing and housing these animals in an unnatural environment substantially alters their stress physiology, potentially in ways that may alter the outcomes of experiments. While most labs therefore employ habituation periods to allow the animals to become used to their new state, it is often the case that animals never fully return to their pre-captivity baseline glucocorticoid secretion patterns. Here we explored whether giving captive house sparrows (*Passer domesticus*) their feed by hiding it deep within a simulated artificial lawn would help to mitigate this early stressful period by giving the birds a task with which to occupy their time, one which mimics their normal feeding patterns in the environment from which they were captured. We observed no significant differences between the experimental and control groups in terms of glucocorticoid secretion patterns. We speculate that either the task is insufficiently diverting to reduce stress from captivity, or that the primary sources of captivity stress for this species arise from other environmental sources.

P1-6 FURIMSKY, MM*; BALCZON, JM; Westminster College, Pennsylvania; *furimsmm@westminster.edu*

Designing an International Travel Course for Both Biology and Non-Biology Majors

International travel courses have enriched research and learning experiences for many undergraduate students as they develop an appreciation for the natural world. As part of the curriculum at a small private liberal arts college, courses involving travel to destinations characterized by a rich and unique biodiversity are regularly offered. These courses are open to the entire student body, so the typical knowledge base varies from students with introductory high school biology to those senior biology and environmental science majors months away from entering graduate or professional programs. The challenge to designing this course is to ensure a balanced and engaging experience for all involved. The curriculum for a recent lecture course and travel experience to Ecuador, including Amazonia, the Andes and the Galapagos Islands, will be described.

P1-291 FURR, D.*; KETCHUM, R. N.; REITZEL, A.; IVANINA, A. V.; Univ. of North Carolina, Charlotte; *denise.furr@uncc.edu*

Genetic and Environmental Determinants of Stress Tolerance Among the Eastern Oyster Population

The Eastern oyster *Crassostrea virginica* is an abundant benthic bivalve found throughout the Atlantic coast, including North Carolina. It is a remarkably resilient species found in intertidal and near-shore estuarine ecosystems. The environmental variation between estuarine, intertidal, and subtidal zones are ideal for studying ecological factors that can affect within species variation at local geographic scales. No data are currently available on combined genetic and physiological comparisons of oysters from geographically-close locations or from different habitats within locations to determine how genetic and environmental factors determine resilience in location-specific patterns. We investigated the contribution of genetic and environmental factors in stress tolerance among *C.virginica* subpopulations from 4 different sites: two estuarine, one subtidal, and intertidal. All studied populations were closely related and differ by less than 1% nucleotide diversity at COI. Basal expression of pattern recognition genes in oysters' hemocytes (HCs) (TLR2,TLR3,TLR4 and Mannose Rec 2), as well as humoral and inflammation-related genes (Big defensin, Lysozyme, Complement system protein Cq3, and Tumor Necrosis Factor) showed a high level of divergence among all studied populations. Exposure to environmental hypoxia led to decrease in expression of all studied genes in HCs of oysters, where oysters from estuaries showed significantly elevated expression of TLR2, TLR4, and C3q. Expression of TLR3, TLR4, and Cq3 were elevated in HCs of oysters from intertidal zones under hypoxic conditions. Our results indicate that closely-related NC oysters have different mechanisms of acclimation to their specific habitats and response hypoxia.

P3-37 GANLEY, AM*; JASTREBSKY, RA; BARTOL, IK; Old Dominion University, Norfolk, VA, Holderness School, Plymouth, NH; *aganl001@odu.edu*

Maneuvering Performance of Squid: Coupling Kinematics with 3D Velocimetry

Maneuvering is an important component of routine swimming, playing important roles in predator avoidance, prey capture, and navigation. In many squid, multiple propulsive systems and control surfaces are used independently or in concert to perform impressive unsteady maneuvers, such as rapidly changing swimming direction and quickly adjusting trajectory or orientation according to predator or prey behavior. Despite its ecological significance, little is known quantitatively about turning performance in squid, especially metrics like angular velocity and turning radius and the linkage between propulsor/control surface movements and hydrodynamics. To better understand maneuvering in squid, we studied brief squid *Lolliguncula brevis* and longfin squid *Doryteuthis pealeii* as they performed turns in an observation tank using high-speed videography and volumetric (3D) velocimetry. A range of turning categories were identified, ranging from tight rotational (short turning radius) maneuvers with prominent vortex ring flows to broader translational (large turning radius) turns associated with longer, often less-defined regions of concentrated vorticity. Both the fins and pulsed jet were integral for turning, but their relative contributions to rotational torque changed with turning category. Differences in propulsor and control surface usage between the two species correlated with performance metrics, such as angular turning velocity and length-specific turning radii. Our results suggest that the fins and jet work in tandem to achieve a wide diversity of turns and interspecific differences in propulsive/stabilizing systems can affect turning performance.

P2-244 GANNON, JL*; DAVIS, JS; High Point University; *jkrisfal@highpoint.edu*

3D Geometric Morphometric Analysis of Xenarthran Masticatory Morphology

Members of the superorder Xenarthra (sloths, anteaters, and armadillos) have an evolutionary history of insectivory and an associated reduction in dentition, including decreased tooth count, simplified occlusal topography, and loss of enamel. As folivores, sloths specialize on a dietary niche not shared by their closest living relatives. Most mammalian herbivores have highly complex cheek teeth for mechanically processing plant materials, thus, the reduced dentition found among xenarthrans (sloths; Pilosa: Folivora) appears incompatible with their diet. However, in other morphological characteristics, the sloth masticatory apparatus exhibits similarities to non-xenarthran mammalian herbivores. The aim of this study is to characterize the masticatory apparatus of sloths in order to identify the morphological characteristics that correlate with and are likely to mechanically facilitate their folivorous diet. Digital scans of xenarthran skulls and jaw bones, representing 17 different species, were examined via 3D geometric mephometric analysis and the masticatory morphology of sloths was contrasted with that of their relatives.

P2-260 GARCIA RAMIREZ, J*; ROBERTSON, JC; Westminster College, PA; *robertjc@westminster.edu*

Growth and Structure of Gill Rakers in Paddlefish (Polyodon spathula)

Shortly after hatching, larval/early-juvenile stage paddlefish go through a profound series of morphological, behavioral and physiological changes - including changes in pigmentation, growth of a rostrum, and shifts in feeding. Another major transformation occurring during this dynamic period is the growth of large numbers of long, fine gill rakers; these structures are critical for the filter-feeding lifestyle of juvenile and adult paddlefish. Using histology and image analysis, this report details the development and growth of gill rakers in larval and juvenile paddlefish. Numbers of rakers, their lengths and inter-raker spacing are quantified for young fish of various sizes. Cell and tissue features associated with the growing gill rakers are also characterized. Understanding gill raker development and characteristics can lead to a more integrated understanding of the dramatic changes occurring during the critical larval-juvenile period in this species. For example, the ram ventilation filter-feeding of larger paddlefish requires anatomical accommodation (optimized gill rakers) as well as behavioral correlates. We also report comparative results of gill raker analysis for related Acipenseriformes - Atlantic sturgeon (*Acipenser oxyrinchus*) and lake sturgeon (*Acipenser fulvescens*). Comparison of these species allows consideration of the relationships between gill raker structure and diet and feeding behavior in this order of basal ray-finned fishes. Greater understanding of feeding mechanisms and behaviors throughout development in paddlefish may have application in conservation efforts.

P2-236 GARDNER, S*; ASSIS, VR; HORNE, M; MENDONÇA, MT; Auburn University, University of Sao Paulo; *stg0015@tigermail.auburn.edu*

Evaluating toxicity of Florida cane toads: gland sizes and poison secretion

Invasive species can harm native fauna through competition and predation, and toxic invaders can poison native predators. Cane toads, introduced to several locations around the world, have been reported with larger parotoid (poison) glands near the invading front in Australia, indicating higher risk to naïve predators. To assess relative toxicity of Florida cane toads in terms of gland sizes and likelihood of secreting poison, approximately 20 toads per population were captured and placed into plastic bags from 9 Florida populations. Following one hour of capture, toads were removed from the bags and mass, sex, and snout-vent-length (SVL) were recorded. Toads were placed next to a ruler and images were obtained to measure gland sizes, with images also showing if a toad was secreting poison following this handling period. Measurements of total length, width, and area of glands were performed using Image J software. An ANCOVA using the first component of a principal component analysis ("small gland size") of Log-transformed gland length, width, and area, was used to explain morphological differences among Florida toads. Gland sizes increased with increasing body mass ($p = 0.019$), although they were not significantly affected by latitude. Using a generalized linear model to assess likelihood of poison secretion, toads were twice as likely to secrete following capture and handling with every degree of increasing latitude ($p = 0.038$). Although gland sizes of Florida toads didn't significantly change with latitude, the likelihood of toads secreting poison as distance from the introduction point increases in Florida is similar to Australian cane toads, and may indicate relative toxicity increases with increased dispersal.

P3-9 GARNER, AM; PAMFILIE, AM*; DHINOJWALA, A; NIEWIAROWSKI, PH; The University of Akron; *amp183@zips.uakron.edu*

Relationships between Adhesive Performance and Substrate Preference Behavior in Tokay Geckos (Gekko gecko)

The past several decades of research into gecko adhesive system performance, morphology, and ecology have uncovered a stunning array of results. The gecko adhesive system is apparently able to adhere to a wide variety of surfaces, including those that are rough. However, some recent work suggests that the contact setae are capable of generating may be greatly diminished on rough surfaces. A handful of laboratory studies have investigated gecko adhesive performance on rough surfaces, but it is still unclear how surface roughness at a variety of length scales impacts gecko adhesion. Here, we attempt to determine if gecko adhesive capacity is reduced on a rough surface of interest and whether geckos, if, when given a choice, will avoid using this surface.The results of this study will provide additional data detailing how surface roughness impacts gecko adhesion, and also give a starting place for future studies investigating how adhesive performance may be related to substrate preference and habitat use in free-ranging geckos.

P3-10 GARNER, AM*; WILSON, MC; RUSSELL, AP; NIEWIAROWSKI, PH; DHINOJWALA, A; University of Akron, University of Calgary; *amg149@zips.uakron.edu*

Morphometrics and Patterning of the Adhesive Setal Fields of an Anolis Lizard in Comparison to those of its Gekkotan Counterparts

The remarkable ability of geckos to adhere to surfaces has served as inspiration for hundreds of studies spanning the disciplines of biomechanics, chemistry, ecology, evolution, functional morphology, material science, and physics. Fibrillar adhesive systems have independently evolved in two other lineages of lizards (anoles and skinks), but comparatively little is known about the fibrillar characteristics of these convergent adhesive arrays. This is particularly surprising for *Anolis* lizards, because anoles have been the subject of intensive ecological and evolutionary study for several decades. The morphology and patterning of the adhesive setae of several species of geckos has been comprehensively examined, with patterns of variation in setal length, diameter, density, and other morphological characters being revealed along the proximodistal axis of the subdigital adhesive pads. In contrast, such potential variation in the configuration of setal fields in *Anolis* lizards remains largely unexplored. Indeed, the only data that are currently available relate to single gross setal dimensions of a few species. Here we describe preliminary setal morphometrics and patterning data for an *Anolis* lizard and compare this to the patterns reported for gekkotan setae. Our results not only add to the diversity of existing morphometric data for lizard fibrillar adhesive systems, but also stand to serve as additional sources of inspiration for biomimetic fibrillar synthetic adhesives.

P1-55 GARROTT, M.*; LAUN, A.; United States Naval Academy; *m191986@usna.edu*

Biomimetic Caudal Fin for an Unmanned Underwater Vehicle (UUV)

A typical propulsion system for an unmanned underwater vehicle (UUV) features a rotating shaft and a propeller to forcefully push the hull through the water. While efficient, such a vehicle design can result in reduced maneuverability and agility. The caudal fins of many fish suggest potential designs that could provide reasonable efficiency, as well as improved maneuverability. For example, the heterocercal caudal fins of many sharks, such as *Triakis semifasciata*, *Galeocerdo cuvier*, and *Isurus oxyrinchus* appear to be effective shapes that balance propulsive efficiency and maneuverability. Key aspects of such fins are their shape, flexibility, and the tail-angle between the fin's lobes and the fish's body. This presentation discusses efforts to design and optimize an undulating, neutrally-buoyant caudal fin attachment for a common UUV hull-form. Specifically, optimizing the geometric shape and tail-angle for improved flow behavior and maneuverability results in a design similar to actual sharks, such as *Triakis semifasciata*, *Galeocerdo cuvier*, and *Isurus oxyrinchus*. Integration of the biomimetic caudal fin into an existing UUV propulsion system is anticipated to provide superior hydrodynamic performance, efficiency, and maneuverability.

P1-235 GASS, J.T.*; NISHIGUCHI, M.K.; New Mexico State University; *jtgass@nmsu.edu*

Zombie bacteria: using natural transformation to study bioluminescence in the Vibrio fischeri-Euprymna scolopes symbiosis

The beneficial bioluminescent marine bacterium *Vibrio fischeri* has been used to study mechanisms of symbiont specificity, host recognition, and evolutionarily driven trade-offs in environmentally transmitted associations with animal hosts (Cephalopoda: Sepiolidae). *V. fischeri* bacteria colonize the squid light organ where bacterial bioluminescence is produced in order to provide the squid with the ability to counterilluminate. Given that many of the regulatory elements in *V. fischeri* are controlled by the host environment, understanding how such cross talk occurs *in vivo* will shed light on bacterial-host interactions. Therefore, we investigated the feasibility of using chitin induced natural transformation in *V. fischeri* to introduce linear ds DNA expression cassettes, which are designed to integrate at targeted sequences within the *V. fischeri* genome via homologous recombination. This technique is ideally suited to determining host specificity and other aspects of symbiosis. We initially targeted the *luxA* gene within the *lux* operon, which is responsible for generating the luciferase-based bioluminescence produced by *V. fischeri*. Using a targeted insertional knock-out of the *luxA* gene along with an insertional complement of *luxA*, we can study the regulation and modulation of bioluminescence production in the dialog between host and symbiont, which allows for a stable, beneficial association. The on-going development of efficient genetic modification techniques are a vital link in understanding the interdependent connections between host species and their symbionts.

P3-56 GASSLER, TR*; FLAMMANG, BE; New Jersey Institute of Technology; *trg22@njit.edu*

3-D MODELING OF WALKING AND PUNTING IN THE LITTLE SKATE, Leucoraja erinacea

Skates are known to locomote using the anterior lobe, or crura, of their pelvic fins to push off the substrate. Skates have two non-swimming locomotor modes: "walking" via alternating pelvic fins, and "punting", which uses simultaneous bilateral movements of their pelvic fins. It has recently been shown that the Hox genes responsible for limb development in the little skate, *Leucoraja erinacea*, are the same as those found in terrestrial vertebrates (i.e. mice). Previous studies showed the morphology of the pelvic girdle and the kinematics of walking resemble that of a sprawled-gait terrestrial tetrapod (i.e. salamanders). The next step to understanding the locomotion employed by skates is to investigate neuromotor control of the muscles. The pelvic area of *L. erinacea* (puboischiadic bar, fins, and spinal column) was μCT scanned to observe the skeletal elements. The area was then stained with phosphotungstic acid (PTA) and rescanned to visualize the musculature. These scans were reconstructed with Mimics software and used to create and animate a morphologically-based 3-D digital model in the program Maya. The physiological cross-sectional area (PCSA) of the muscles was calculated and the maximum force generation of each muscle involved in locomotion was estimated to use as parameters in the model. This model allowed us to simulate different aspects of muscle stimulation/timing and to investigate the kinematics, biomechanics, and motor modulation of both walking and punting. These data will be used in future projects to compare the model to electromyography (EMG) of *in vivo* little skate muscles.

P1-45 GELLMAN, ED*; TANDLER, T; DE LA CRUZ, DB; ELLERBY, DJ; Wellesley College; *dellerby@wellesley.edu*

Drag Coefficient Estimates from Coasting Bluegill Sunfish (Lepomis macrochirus)

Bluegill sunfish (*Lepomis macrochirus*) coast frequently during volitional swimming powered by body and caudal fin undulations, and maintain a straight body-axis during labriform propulsion with the pectoral fins. Inertial drag is therefore functionally important for this species. The drag coefficient estimated from coasting deceleration was 0.015 ± 0.007 at a Reynolds number of 41000 ± 14000 (± 1sd). This was within the coasting range in other species, and lower than values obtained from ‘dead drag' measurements in this species and others. Low momentum losses during coasting may allow its use during intermittent propulsion to modulate power output or maximize energy economy.

P2-231 GIAMMONA, FF*; MINICOZZI, MR; GIBB, AC; ASHLEY-ROSS, MA; Wake Forest University , Northern Arizona University , Northern Arizona University, Wake Forest University; *giamff17@wfu.edu*

Plastic changes in mass distributions in Kryptolebias marmoratus with air acclimation lead to increased performance in a terrestrial environment

Emersion from an aquatic to a terrestrial environment is a tactic used by many fish species for a variety of reasons. With *Kryptolebias marmoratus*, emersion occurs due to stranding, to escape predators, and to capture prey. Once on land, *K. marmoratus* can employ a tail-flip behavior in order to move across the substrate. The performance of this tail-flip behavior can depend on a variety of factors such as age, size, and time spent acclimating to air. In this experiment, forty *K. marmoratus* individuals were exposed to one of four different fasted acclimation treatments: 28 days in water, 14 days in air followed by 14 days in water, 14 days in air, and 14 days in water. Fish were then put on moist paper and prompted to jump. Number of jumps and distance moved during jumps were analyzed. Preliminary results show that the individuals who acclimated in air only jumped more frequently and moved further with each jump, indicating that plastic changes may occur during air acclimation that improve locomotor performance on land. To test if one of these plastic changes could be a change in mass distribution from the anterior to the posterior, where most of the force needed to jump is generated, lateral and dorsal photos were taken of fish before and after treatment. These photos were then analyzed to track changes in mass along the body. Preliminary results indicate that while most individuals lost weight, mass distribution of individuals in the 14 days in air treatment shifted towards the posterior, while mass distribution did not appear to change appreciably in the other treatment groups. Plastic shifts in mass may thus be the mechanism that allows *K. marmoratus* to perform better when jumping in a terrestrial environment after air exposure.

P1-151 GIGLIO, EM*; PHELPS, SM; GIGLIO, Erin; University of Texas at Austin; *eringiglio@gmail.com*

Context in courtship: the role of leptin in social investment decisions in singing mice

The ability of animals to adapt to context is one of the most important challenges facing any individual. This is particularly important when it comes to sexual signalling and courtship, when the choice to signal or not signal may determine whether or not a given animal gets to live--or whether it gets to reproduce. Signals often impose costs on individuals, including energetic, predatory, and social costs, and individuals must integrate the cost/benefit analysis of signaling before making the decision to signal or remain hidden. Leptin is an exciting potential overall signal for male animals to self-monitor because it responds to many contexual cues about body state, including energetics, immune challenge, and sleep. Here we explore the effect of leptin manipulations on investment in male advertisement song on neotropical singing mice. We administered intraperitoneal injections of mouse leptin (Mus) to male singing mice immediately before a playback protocol designed to evoke song, a social advertisement behavior. Mice injected with leptin sing back more frequently than mice injected with saline, and they have a shorter average latency to respond to playback than saline-injected mice. Interestingly, we find that these results appear regardless of fasting state prior to testing: all animals in this experiment were fed ad libitum, suggesting that variations in endogenous leptin are monitored by individuals even when leptin levels are too high to significantly alter feeding behavior.

P2-170 GILBERT, MC*; AKAMA, A; COX FERNANDES, C; ALBERTSON, RC; Univ. Massachusetts, Amherst , Museu Paraense Emílio Goeldi, Belém, PA, Brazil, Instituto Nacional de Pesquisas da Amazônia, Manaus, AM, Brazil; Univ. Massachusetts, Amherst ; *chaise.gilbert@live.com*

Rapid Morphological Shifts in Native New World Cichlids in Response to an Anthropogenic Alteration to a Major Clearwater River in the Amazon River System

The Tocantins River serves as the major drainage for the Tocantins and Araguaia watershed and was once a large (2,450km), contiguous system. The construction, and subsequent closure, of the Tucuruí Hydroelectric Dam (the major dam in the system) in 1984 established a large (~2,850km2) 'permanent' reservoir, eliminating the once historic streams, floodplains, and rapids that once occupied this length of the Tocantins river. Such dramatic anthropogenic change can either lead to the extirpation of local flora and fauna, or species may be able to adapt to local environmental changes. To explore the latter possibility, we used geometric morphometrics to evaluate changes in native cichlids, incorporating both museum specimens collected prior to the closure of the hydroelectric dam (≤ 1984) and specimens collected during 2017-18. A total of six species, distributed over four genera, were included, representing distinct ecomorphs, varying from large piscivorous fishes to relatively small opportunistic omnivores. While some lineages expressed subtle changes, more drastic morphological shifts were documented in others. Moreover, the morphological changes that we observed tended to be associated with functional aspects of anatomy, ranging from head shape and organization, to the body length to depth ratio. These data suggest that native cichlid populations have undergone rapid (≤ 50 years), and in some instances dramatic, morphological changes since the closure of the dam, and provide insights as to the ways that different fish ecotypes may respond to sudden, large scale hydrological alterations.

P3-161 GILCHRIST, SL*; RODRIGUEZ, L; GILCHRIST, Sandra; New College of Florida, Sarasota; *gilchrist@ncf.edu*

Trash or Treasure: Land Hermit Crab Use of Found Objects at Cayos Cochinos, Honduras

Hermit crabs are well known for their use of found objects such as shells. Some use other natural objects such as bamboo or other plant materials. The largest of the land hermit crabs (eg *Birgus latro*) abandon found objects as they become more terrestrialized. At Cayos Cochinos, we have recorded more use of plastics such as bottle tops, shot gun shells, lotion bottles, and similar objects over the past three years. As humans discard more of these materials, crabs of all sizes have incorporated the objects into their resource pool. We have enriched the area with a variety of shells over the past 14 years, also observing that the novel shells are readily used by the land crabs. The plasticity of use for the found objects poses an interesting question concerning resource acquisition and use, warranting further exploration on future expeditions.

P2-203 GILLIGAN, AM*; DILLON, JG; PERNET, B; ZIEGLER, A; California State Univ., Long Beach, Institut für Evolutionsbiologie und Ökologie, Rheinische Friedrich-Wilhelms-Universität; *ariel.gilligan@student.csulb.edu*

Characterization of the Microbial Community in a Recently Discovered Digestive Organ in the Heart Urchin Brisaster townsendi

Heart urchins (Echinoidea: Spatangoida) of the genus *Brisaster* are often abundant in deep water soft-sediment marine communities. They are deposit feeders and important bioturbators, but little is known of how these mud-dwellers process and digest food. Recently, a novel organ, the intestinal caecum, has been found in several spatangoid genera, but its physiological role is presently unknown. In *B. townsendi* (Agassiz, 1898), a heart urchin common in southern California, this organ is distinct from the rest of the gut in that it contains no sediment, but instead is filled with a dense microbial mass. We used next-generation sequencing to compare microbial communities in the stomach, intestine, intestinal caecum, and rectum of *B. townsendi* with the goal of understanding the caecum's role in the echinoid's biology. We collected *B. townsendi* from ~300 m depth off Long Beach, CA, and sampled the contents of each of the four gut regions from two specimens; in addition, the contents of the caecum were analyzed from an additional eight specimens. We extracted genomic DNA and amplified 16S rRNA genes using Illumina MiSeq. The results show that the caecum harbors a diverse community of anaerobic bacteria with large contributions from sulfate-reducing bacteria of Desulfobacterales averaging approximately 15.97% of the microbial community, as well as Spirochaetales (9.17%) and Bacteroidales (34.64%); this community is distinct from that of the rest of the gut. Using the relative abundance of microbial taxa within the different gut regions as well as additional data, a model for the role of the intestinal caecum in the digestive process of *B. townsendi* is presented.

P2-47 GINGRAS, MA*; EASTER, JH; RAMIREZ, MD; GOODHEART, JA; NEWCOMB, JM; New England College, University of Massachusetts, Amherst, University of California, Santa Barbara; *mgingras_ug@nec.edu*

R-opsin Localization in Dermal Extraocular Photoreceptors of Hermissenda opalescens and Berghia stephanieae

The nudibranch mollusk, *Hermissenda opalescens*, has been shown in previous experiments to have extraocular photoreceptors because of the presence of light-sensitive neurons located in the pedal ganglia. *Berghia stephanieae* is another nudibranch that is a promising organism for future studies of circadian rhythms and extraocular photoreception. The goals of this study were to: 1) identify the rhabodmeric opsin (r-opsin) sequence for *Hermissenda* and 2) to determine whether r-opsin is located in dermal and/or neural tissue in both *Hermissenda* and *Berghia*. Using bioinformatics, the *Hermissenda* r-opsin sequence was identified and alignment with orthologues in other species indicated that it contains the highly-conserved lysine residue involved in photopigment binding. This r-opsin sequence was used to develop complementary RNA probes for fluorescent *in situ* hybridization in *Hermissenda*. We also used a commercially available antibody raised again r-opsin in octopus, for immunohistochemistry in both nudibranchs. Regardless of the histological technique, r-opsin was localized in all of the integumentary structures investigated in both species, including the cerata, dorsal skin, oral tentacles, and the rhinophores. This dermal r-opsin localization was diffuse, as would be expected of extraocular photoreceptors. R-opsin was not present in the brain of either species. This evidence suggests that r-opsin may be used for dermal extraocular photoreception in both *Hermissenda* and *Berghia*.

P2-247 GLASGOW, S.; TROELSEN, P. V.; FALKINGHAM, P. L.*; MAREK, R. D.; Liverpool John Moores University, University of Liverpool; *p.l.falkingham@ljmu.ac.uk*

Stretching Evolution: Regionalisation and Neck Elongation in Plesiosaurs

Plesiosaurs are an extinct and iconic group of long necked marine reptiles from the Mesozoic. Neck elongation in plesiosaurs is almost unrivalled by both extinct and extant vertebrates, yet the mechanisms and selection pressures that underpin this elongation are poorly understood. Hox genes regulate axial regionalisation in vertebrates and the number of cervical regions is generally fixed within major groups of vertebrates. Recent work on cervical regionalisation in extant tetrapods has used 3D geometric morphometrics (GMM) as a proxy to delineate these regions governed by Hox gene suites, and has found that neck elongation in archosaurs occurs with the addition of regions beyond the basal number for amniotes; 3. We used 3D GMM and anatomical descriptions of plesiosaur cervical vertebrae in one species (*Muraenosauus leedsii*, R2863 BMNH) alongside comparisons to regionalisation within an extant phylogenetic bracket (archosaurs and squamates). Results from the GMM and comparative anatomical descriptions suggest that *M. leedsii* had 4 cervical regions. These regions consist of 1) the atlas-axis, 2) C3-C6, 3) C7-C37 and 4) C38-C42. These results suggest that *M. leedsii* had a derived regionalisation formula with the addition of a 4th cervical region, similar to modern archosaurs. Whilst our study so far entails only a single species of plesiosaur, our results suggest that plesiosaurs achieved such elongated necks predominantly by adding cervical vertebrae to region 3, rather than by changing Hox gene regulation to add more, novel, regions. A combination of further species included in this work flow, alongside a detailed examination of plesiosaur neck kinematics will allow for a more complete understanding of the role cervical regionalisation played in plesiosaur neck elongation.

P3-86 GLYNN, KJ*; ZAHOR, DL; CHIPARUS, CL; CORNELIUS, JM; Eastern Michigan University, Eastern Michigan University ; *kglynn2@emich.edu*

Body Condition and Feather Coloration of Urban Vs. Rural American Goldfinches (Spinus tristis) and American Robins (Turdus migratorius)

Many avian species live in both urban and rural environments, which can be beneficial or detrimental to the overall fitness of the residing population. Rural environments may offer a more natural setting with resources historically familiar to most species, whereas the urban environment may offer greater food predictability, protected nesting sites, and safety from some types of predators. Life in the urban environment may be detrimental to species or individuals that are not well adapted to living in close proximity to humans and infrastructure. Our study examined the health of urban and rural American Goldfinches, (*Spinus tristis*), and American Robins, (*Turdus migratorius*), by examining body condition and feather color. Both species obtain carotenoids to color their bright mating plumage from the environment and carotenoids also participate in anti-oxidant defense mechanisms. Brighter plumage may therefore reflect both environmental availability to carotenoids and/or higher individual condition or exposure to metabolic stress. Through this study we hope to better understand how these different habitats, and the potential trade-offs they offer, are impacting the health and overall fitness of these two species.

P1-155 GODFREY, E*; MULLIN, S; LEESE, J; DeSales University; *eg8506@desales.edu*

The role of sexual selection in monogamy: exploring behavioral and hormonal mechanisms in a cichlid fish

In many monogamous species, both sexes compete for mates and demonstrate a preferential mate choice. However, the degree to which intrasexual competition limits the choice of the other sex is not well understood. Here, we explored how male-male competition influences female mate preference using a monogamous fish, the convict cichlid, *Amatitlania siquia*. Females observed a contest between two size-matched males until a winner and loser could be determined. Females were then given a choice between one of the individuals (winner or loser) and a novel individual that she had not previously interacted with. We hypothesized that females would prefer males that won contests and reject males that lost contests. In addition to exploring female preference after intrasexual competition, we investigated what role, if any, androgens might play in this process. Specifically, we measured 11-ketotestosterone (11-KT) before and after the male-male contest, as well as the female preference test using water-borne collection methods. Our results were unexpected; we found females showed no preference between winners or losers and novel males. We did find, however, that males preferred by females showed a drop in 11-KT levels. Taken together, these results suggest that females might not reject males that lose contests, and that androgen levels are more affected by female choice than male-male competition.

P3-166 GOESSLING, JM*; WARD, C; MENDONCA, MT; GOESSLING, Jeffre; Eckerd College, Auburn University Montgomery, Auburn University; *jeff.goessling@gmail.com*

Tradeoffs Between Acute and Chronic Thermal and Immune Acclimation in Common Musk Turtles Sternotherus odoratus

Understanding the role that thermal variability has in affecting immunity is key to understanding the causes and consequences of disease in ectothermic vertebrates. As turtles are exceptionally vulnerable to negative effects of global change, understanding the role of thermal environmental change is of specific importance to the group. Recent experimental studies have demonstrated that seasonal variability can directly account for changes in turtle immunity that may render populations more susceptible to disease. Further, studies have demonstrated that rapid temperature change may exacerbate the effects of seasonal change on turtle immunity. Herein, we performed several thermal and immune manipulations in common musk turtles (*Sternotherus odoratus*) to identify effects of both acute and chronic stimulation of the immune response, and how temperature affects this response. In acute temperature change experiments, we found that rapidly cooled turtles increased phagocytosis rate ($P = 0.039$) and bactericidal ability ($P = 0.023$) as compensatory acclimation for the reduced temperature. Similar compensatory acclimation was seen in turtles that were warmed, in which immune rates of production were slowed. In chronic experiments of immune stimulation (via lipopolysaccharide, LPS) and across two temperatures (25 and 30C), patterns were much less clear after 6 weeks of LPS administration, although warmer turtles generally followed the compensatory acclimation, similar to acutely stimulated turtles. Results from this study help shed light on the role of temperature in affecting immunity in ectotherms and the diversity of responses present within ectothermic groups.

P2-130.5 GOETZ, SM; PICCOLOMINI, S; HOFFMAN, M; BOGAN, J; HOLDING, ML; MENDONCA, MT*; STEEN, DA; Auburn Univ., Central Florida Zoo & Botanical Gardens, Central Florida Zoo & Botanical Gardens, Florida State University, Georgia Sea Turtle Center, Jekyll Island Authority; *mendonca@auburn.edu*

Serum-based Inhibition of Pitviper Venom by Eastern Indigo Snakes

When organisms possess chemical defenses, their predators may eventually evolve resistance to their toxins. Eastern Indigo Snakes (*Drymarchon couperi*; EIS) subdue and consume a variety of pitviper species and it has been suggested EIS possess a physiological resistance to their venom. In this study, we formally investigated this hypothesis by using microassays that measured the ability of EIS blood sera to inhibit A) hemolytic and B) snake venom metalloproteinase (SVMP) activity of Copperhead (*Agkistrodon contortrix*) venom. To serve as controls, we also tested the inhibitory ability of sera from inbred House Mice (*Mus musculus*) and from a snake that does not feed on pitvipers, the Checkered Gartersnake (*Thamnophis marcianus*). As expected, mouse sera exhibited little effect on the activity of either class of toxins tested. However, sera from both EIS and gartersnakes inhibited over 60% of SVMP activity. EIS sera also inhibited 78% of venom hemolytic activity, while gartersnake sera failed to inhibit these toxins. Our results demonstrate that EIS serum is indeed capable of inhibiting two of the primary classes of toxins found in Copperhead venom, suggesting that EIS may possess physiological resistance to venom upon injection. Because we documented resistance to hemolytic components of pitviper venom within EIS but not gartersnakes, we speculate this resistance may be driven by antagonistic interaction while resistance to SVMP may be relatively widespread among snakes and not necessarily related to the diet and ecology of extant species.

P1-107 GOGEL, CA*; MULLIN, SM; LEESE, JM; DeSales University; *cg3612@desales.edu*

House Hunters: Cichlid Edition - Females in a monogamous pair determine nest site location

For territorial animals, one of the most important decisions faced during their lifetime is determining where to establish a territory. This is especially true when a territory includes a breeding substrate or nest site. For many taxa, decisions about territory sites are made individually, but for monogamous species, a pair-bond may form prior to a territory and nest site being selected. Here, we explored which sex might be more likely to choose a nest site using a monogamous fish, the convict cichlid, Amatitlania siquia. In nature, little is known regarding how and when convict cichlids choose nest sites, but studies suggest a combination of strategies in which either the male selects the nest site before courting females or the pair selects a site together. Based on this, we hypothesized that males are more likely to determine a nest site, even after a pair-bond has formed. We tested this hypothesis by observing pair-bond formation, then after a pair-bond formed, we placed males and females in separate compartments of a divided aquarium with their own nest site. After 24 hours, the divider was removed, and the location of both individuals in the aquarium was observed for several days. Overall, females seemed to stay with the nest site they were acclimated to and the males showed less preference, in many cases moving to the female side. These results suggest that the female, rather than the male, may be more likely to choose both territory and nest site after pair-bond formation in this system. While unexpected, this result could indicate that females have been selected to be more discerning of nest sites as they require smooth surfaces to deposit their eggs.

P1-36 GONG, Z*; JAFFE, NH; BLAND, R; COHEN, CS; EOS, SFSU; Univ. of California, Berkeley, EOS, SFSU; *lauragong@berkeley.edu*

Who is Stronger: Attachment Strength of Leptasterias spp. in Relation to Microhabitats and Clades

Intertidal areas are highly variable environments imposing selective forces unevenly on organisms, potentially leading to divergence in behavior and morphology in closely related taxa. *Leptasterias* is a species complex of small, direct-developing sea stars living across intertidal habitats and experiencing different degrees of abiotic stresses, including wave impacts. We compared attachment strength and mobility in *Leptasterias* spp. from microhabitats inferred to be more or less wave-impacted. Attachment strength, the force required to dislodge a star from its substrate, was quantified by a direct pulling test in field and laboratory using a flexible, piano-wire clamp connected to a spring scale. Additionally, resistance to dislodgement by controlled water surge was measured in field and lab environments. And, righting time of sea stars placed oral side up ("flip time") was recorded as a measure of mobility, in the field and lab. We analyzed results of these tests using Mann-Whitney U tests and showed that the attachment strength of *Leptasterias* spp. in more wave-impacted microhabitats is greater than in less wave-impacted microhabitats, whereas the mobility of more wave-impacted sea stars was lower than that of less wave-impacted sea stars. The difference in attachment strength and mobility of *Leptasterias* spp. may be a local adaptation to wave-stressed environments and is being further explored using genetic methods.

P3-111 GONZALEZ, A*; OCHRIETOR, J; AHEARN, G; University of North Florida; *gahearn@unf.edu*

Molecular Characterization of a Novel Disaccharide Transport Protein in Homarus americanus

Essential sugar absorption in animals has been demonstrated to occur by cleavage of polysaccharides into their monomeric form for transport across epithelial cells of the gastrointestinal tract. Recently, it has been suggested that the hepatopancreas of the American lobster, *Homarus americanus*, transports intact disaccharides across their epithelial cells. The purpose of the present study is to better assess the genetic characteristics of this novel transport mechanism by cloning the cDNA encoding the transport protein and determining its location of expression. To accomplish this goal, cDNA generated from adult male lobster hepatopancreas RNA and cDNA from a constructed library was used for PCR cloning. Additionally, *in situ* hybridization and quantitative RT-PCR were performed to localize the expression of transporter cDNA in the hepatopancreas and other tissues thought to utilize this transport mechanism. The partial DNA sequence that was obtained is homologous to a disaccharide transporter in *Drosophila melanogaster*. The analyses from *in situ* hybridization and q-RT-PCR suggest the expression of the transporter in various tissues, especially those related to digestion and absorption (hepatopancreas and intestine). These tentative results provide a foundation upon which the complete molecular characterization and organ distribution of this novel disaccharide transporter will be described.

P3-183 GONZALEZ, P*; CHRYSOSTOMOU , E; FLICI , H; GAHAN , JM; SCHNITZLER, CE; FRANK , U; BAXEVANIS , AD; NHGRI/NIH, NUI Galway, U. Florida; *paul.gonzalez@nih.gov*

From Stem Cell to Neuron: Transcriptional Profiling of Differentiating Neurons in the Cnidarian Hydractinia

Hydractinia symbiolongicarpus, a colonial hydrozoan cnidarian, is a proven and tractable model for studying regeneration and stem cell biology. Its adult tissues contain stem cells called interstitial cells (or i-cells) that are responsible for their ability to regenerate after injury and to continuously renew somatic cells during normal homeostasis. Depending on their cellular context, i-cells have the ability to differentiate into several types of epithelial, neural, or germ line cells. However, the molecular mechanisms that regulate these developmental decisions and the transcriptional changes experienced by i-cells as they commit to different fates are largely unknown. In this study, we characterized the transcriptional profiles of i-cells at different stages of neurogenesis in adult feeding polyps. We performed fluorescence-activated cell sorting (FACS) using transgenic animals expressing reporters for key markers of specific stages in the neurogenic pathway, followed by RNA-seq differential expression analysis. We report full transcriptomes for *Piwi1*-expressing i-cells, *SoxB2*-expressing neural progenitors, and two subtypes of differentiated *RFamide*-expressing neurons. Current work is focused on identifying new cell type-specific markers, as well as candidate genes and signaling pathways involved in cell fate determination. These data provide the first characterization of the transcriptional repertoire of *Hydractinia* i-cells and their progeny, identifying specific targets for future functional studies. Understanding the mechanisms underlying the choice of i-cell trajectory may ultimately allow us to harness these mechanisms to identify new targets for therapies in regenerative medicine.

P3-62 GORVET, MA; AVEY-ARROYO, JA; BUTCHER, MT*; Youngstown State University, The Sloth Sanctuary of Costa Rica; *mtbutcher@ysu.edu*

Keep Calm and Hang On: EMG Activation Intensity in the Forelimb of Three-toed Sloths

Sloths exhibit below branch locomotion and postures whereby fore- and hindlimb pairs equally support their body weight. Suspensory habits require both strength and fatigue resistance of the limb flexors, yet muscle mass is reduced in sloths. It is then possible that sloths minimize muscle activation during tensile loading of muscle-tendon units to maintain support, thus indicating potential neuromuscular specializations for conserving energy. Electromyography (EMG) was evaluated in three-toed sloths (*Bradypus variegatus*: *N*=6) to test this hypothesis. EMG was recorded (2000Hz) via fire-wire electrodes implanted into 8 forelimb muscles while sloths performed suspensory hanging and walking, and vertical climbing. Video recordings (100Hz) were synchronized with EMG to mark footfalls for a total of 227 strides analyzed. EMG activation for each muscle was normalized to peak activation recorded across behaviors. *B. variegatus* demonstrates that flexor/extensor muscles are minimally activated during hanging. Compared to hanging, EMG activation in the forelimb flexors doubles during suspensory walking and increases by a factor of 1.3 during vertical climbing. Overall, the elbow flexors mm. biceps brachii and brachioradialis show the greatest EMG activation, and these large bursts occurred during suspensory walking, while burst intensity was more similar (within 5-15%) between walking and climbing for the m. pectoralis superficialis, biarticular m. triceps brachii long head, and the digital extensors. Activation of the elbow flexors, in particular, may be critical for stabilizing forces acting on the forelimbs during suspension. Further evaluations will include assessment of recruitment frequencies of slow and fast motor units using wavelet analysis.

P1-292 GORDON, KE*; MCCOY, MW; East Carolina University; *gordonka17@students.ecu.edu*

How Temperature, Resource Input, and Standing Genetic Variation Affect Predator Responses of Physa acuta

Changes in the environment influence ecosystems by reducing the suitability of habitats for species and by altering the strength of interspecific interactions. Both pathways change ecosystems via top-down and bottom-up processes. Temperature and external nutrients in aquatic systems effect primary production rates, and thus the growth rates of primary consumers, as well as the vulnerability of consumers to predation. Genetic variation of individuals influences such processes. In this study, we test how temperature, nutrient availability and standing genetic variation of *Physa acuta* affects the snail's growth and vulnerability to predation by *Procambarus clarkii*. We reared snails from inbred or outcrossed lineages at high or low temperatures, with high or low resource inputs and with or without chemical cues of crayfish predation. We assessed how these treatments affected predator avoidance behavior, antipredator morphological responses, reproductive output and survival. While we found little difference in the behavioral response between treatments, we found differences in growth rates in response to resource input, standing genetic variation and temperature. Snails from outcrossed lineages were larger than inbred snails across treatments and snails only produced eggs at the lowest temperatures with the highest resource input. More eggs were laid by snails exposed to predator cues. At high temperatures, survival was reduced across treatments. We found that combined effects of resource input and temperature on growth rates influences rates of predation by crayfish, due to size dependent vulnerability. These results indicate that changes in the environment have effects on species interactions in ways that cascade through food webs and potentially change ecosystem functions.

P2-169 GRAHAM, AM*; BARRETO, FS; Oregon State University; *grahaall@oregonstate.edu*

Interpopulation Variation of Hypoxia Tolerance in an Intertidal Copepod, Tigriopus californicus

Environmental variation along a species' geographic range often imposes strong selection on isolated populations. In the absence of gene flow, populations may become locally adapted, which facilitates population divergence, and potentially speciation. Natural systems in which genetically divergent populations have adapted to different levels of environmental stress allow us to examine the relevance of genetic variation for adaptive evolution of gene networks. Most intertidal organisms experience short-term changes in abiotic factors including temperature, salinity, and dissolved oxygen (DO) in their marine or estuarine habitats. Previous work has shown that *T. californicus* can withstand prolonged exposure to extreme oxygen deprivation with very little mortality; however, this was assessed in only one population, and it is unknown to what degree allopatric populations along a wide latitudinal range are similarly tolerant. Here, we assess both juvenile and adult response to extreme hypoxia in multiple populations of *T. californicus* from California to Oregon. Ultimately, we show evidence for population-level variation in tolerance to low DO levels with regards to survival, as well as growth and development.

P2-109 GRANT, AR*; MALISCH, JL; KIMBALL, MG; OUYANG, JQ; University of Nevada, Reno, St. Mary's College of Maryland; *averygrant@nevada.unr.edu*

Glucocorticoid physiology, territory size, and number of chicks fledged: Untangling the relationship between corticosterone and reproductive success

Breeding is an energetically expensive life history stage, particularly for short-lived organisms inhabiting highly variable environments. Corticosterone (cort), a glucocorticoid hormone, is released in response to noxious and unpredictable stimuli but also acts to increase metabolism at baseline levels. Successful individuals need to balance energy expenditure and costs to maximize fitness. However, evidence for a clear relationship between cort and fitness is lacking, complicated by the fact that this relationship can change within and between life-history stages. We collected repeated within-individual baseline and stress-induced plasma and feather cort levels using free-living mountain white-crowned sparrows (*Zonotrichia leucophrys oriantha*) from pre-breeding to post-breeding during variable environments. Additionally, we mapped territory size for breeding pairs using telemetry and collected data on reproductive success. Using nest cameras during incubation through fledging, we also measured reproductive effort. We discuss the link between the cort phenotype, territory size, and reproduction. These repeated measures data add to the growing research on understanding how flexible cort phenotypes act in changing environments.

P1-167 GRAY, CS*; PHILSON, CS; FOLTZ, SL; DAVIS, JE; Radford University; *cgray34@radford.edu*

PASSER: Utilizing Neural Networks during Data Collection for Real-time Bird Identification

Field-based research projects utilizing automated image capture devices often rely on humans to identify images. This method of analysis is limited in that data can only be retroactively parsed by an observer looking to identify patterns in behavior. If birds could be identified in real-time by an automated process integrated into the camera device, not only would there be hours of time saved identifying animals, it would also enable the possibility of a varied response to different subjects at the time of data collection. We accomplished exactly this as part of the PASSER program by use of Tensor Flow, a neural networking package for the programming language Python that allows users to create a neural network for image classification. A neural network requires a large repository of photos when being used for image classification so that it can provide more accurate identification of the images it will be given. The PASSER project has collected hundreds of thousands of photos of various bird species to be fed into the neural network so that it can fine tune its "neurons" for identification of various species and sexes. The smart feeder can then be updated to use the neural network on its own so that the system sustains itself without human interaction other than necessary hardware maintenance. The neural network, with enough collected data, could potentially even be used to identify individual birds if that specific individual bird frequents the feeder sufficiently often. The uses for this data are abundant as patterns could be easily localized and analyzed without the necessity of countless man hours spent identifying birds. Processes like these may enable a shift of focus from simple species identification, into broad-based environmental-ethological analysis.

P3-92 GRIESBACK, K*; HARTMAN, R; TOBE, S; SCOTT, K; LANDBERG, T; Arcadia University; *kgriesback@arcadia.edu*

Heavy Metal Contaminants in Snapping Turtle Soup from the Philadelphia Area

Snapping turtle soup is a historic dish that remains a menu item in restaurants and taverns in the Philadelphia area. Unfortunately, heavy metals such as iron, lead, mercury and zinc are common in the aquatic environments where these turtles live, and these metals accumulate in turtle tissues through the food web. Though heavy metals negatively affect their reproduction and recruitment, snapping turtles can survive in polluted environments. We examined snapping turtle meat as a food source due to its high potential to transfer acquired heavy metals to the humans that consume it. Samples of snapper soup were acquired from restaurants throughout the lower Delaware River watershed in Pennsylvania (n=40). Meat, fish, and poultry typically contain a level of zinc around 29 ppm, while in vegetables it can be up to 2 ppm. Initial chemical analysis shows that several turtle meat samples contain a level of zinc greater than these values, and greater than the recommended daily intake value (8 mg per day or 0.11 mg/kg for females and 11 mg per day or 0.14 mg/kg for males). The zinc levels in the samples are not high enough to cause toxicity independently, but combined with other zinc-containing foods consumed in the daily diet, turtle meat can contribute to greater overall zinc levels in the body. High zinc content can cause harmful physiological effects. While our other heavy metal analyses are ongoing, snappers may contain nearly all toxic metals- for which there are no safe levels of consumption. This, combined with ecological data showing that continued harvests of turtle populations for consumption is unsustainable, suggests that snapper soup may be detrimental to both humans and turtles.

P2-267 GRIFFIN, C*; BOTELHO, J; HANSON, M; FABBRI, M; BHULLAR, A; Virginia Tech, Yale University; *ctgriff@vt.edu*

The Avian Pelvis Possesses Ancestral Dinosaurian Character StatesEearly in Development

The avian body plan is unique among all other vertebrate groups and was assembled in stages over millions of years. The avian pelvis in particular is conspicuously different from the ancestral reptilian condition, providing adaptations suited to the biomechanical demands of flight (e.g. anteroposteriorly expanded ilium and sacrum, backward-facing pubis, shifts in hindlimb muscle sizes and uses), and so the evolution of this region is key to the origin of Aves. However, whereas the evolution of this region is recorded by extinct forms, how development has influenced the formation of the avian body plan is poorly constrained, leaving a major knowledge gap that precludes an integrated understanding of avian evolution. The avian pelvis could be constructed in one of two ways: 1) the derived avian condition could be present at the outset of morphogenesis, as in the avian beak; 2) the beginning of morphogenesis could resemble the ancestral condition, with derived character states accumulating during prenatal development. Here, we use a new method of imaging embryonic tissues in three dimensions—immunostaining cleared embryos and stacking the resulting confocal microscope images in computed tomography software—to demonstrate that the avian pelvis possesses ancestral archosaurian and dinosaurian conditions (e.g., forward-facing pubis, short ilium, anteriorly directed obturator muscle, shorter abdominals), progressively gaining the derived avian character states during development. Therefore, unlike some portions of the avian body, the beginning of pelvic morphogenesis resembles the ancestral condition of many key characters. In addition to the fossil record, the means of transitioning from typically ‘dinosaurian' to avian locomotion can be studied through development.

P2-132 GROSSKOPF, SM*; MCALISTER, JS; College of the Holy Cross; *smgros20@g.holycross.edu*

Investigating Potential Macroalgal Diets for Larvae of the Sea Urchin Arbacia punctulata

Sea urchin adults have relatively diverse diets of benthic macroalgae, whereas larvae are thought to feed primarily on unicellular phytoplankton. Although recent research demonstrates that kelp detritus can serve as a high-quality food source, it is not entirely understood what role various other macroalgae may play in the diets of larvae. Our goal in this study was to determine if other benthic seaweeds found in adult urchin habitats could provide for similar larval growth, as does kelp. In a pilot study, we determined that larvae of the sea urchin, *Arbacia punctulata*, would consume lab-made detritus of the common intertidal seaweeds *Ulva intestinalis* and *U. lactuca*, *Laminaria agardhii* (kelp), *Fucus* sp., and *Chondrus crispus*, but preferred kelp and *Fucus*. Next, we reared *A. punctulata* larvae under four replicated food treatments: high and low concentrations of the unicellular microalga *Isochrysis galbana* (a standard proxy for phytoplankton), and separate seaweed slurries made from kelp and *Fucus*. We found that *A. punctulata* larvae can grow while consuming kelp and *Fucus* detritus. However, the larvae reared under the *Fucus* and kelp diets did not grow as extensively within 10 days as larvae provided with a high, satiation diet of *Isochrysis*. Larvae consuming *Isochrysis* grew to the 8-arm stage within 10 days whereas the majority of the larvae fed *Fucus* and kelp were still at the 4-arm stage. We are continuing data analysis of this experiment as well as a second experiment that replicated the conditions of the first and will present comprehensive results from both at the SICB Annual Meeting. This project provides an avenue for further research into the diets of sea urchin larvae. Future related studies might examine the effects on larval growth of mixed macro- and microalgae food treatments.

P1-159 GUINDRE-PARKER, S*; RUBENSTEIN, DR; University of Guelph, Columbia University; *slg2154@columbia.edu*

The physiological costs and fitness benefits of group living trade-off in an unpredictable environment

The fitness consequences of group living have been difficult to study in cooperatively breeding species, where it remains challenging to disentangle the benefits of living in a social group from those of alloparental care behavior. Both group living and alloparental care may increase the ability of organisms to cope with harsh environments, though the former remains poorly studied. We use a long-term dataset collected in cooperatively breeding superb starlings (*Lamprotornis superbus*) to determine the fitness consequences of group living, as social groups are significantly larger than, and uncorrelated to, the number of alloparents present in each group. We examined (i) whether social group size increased adult survival, (ii) whether group size served to buffer against harsh environmental conditions, and (iii) whether survival benefits of social group size were mediated by physiological traits (i.e. glucocorticoid hormones, oxidative stress, and immune function). Survival models showed that group size was positively correlated to adult survival, though differently between the sexes: female survival increased with group size similarly across all environmental conditions, whereas male survival increased with group size in periods of average or above average pre-breeding rainfall (though there was no benefit to living in the largest group under harsh conditions for males). We also found that physiological state did vary according to social group size, though individuals in the smallest and largest social groups paid the greatest physiological cost. Our results suggest that while individuals in the largest social groups gain the largest fitness benefits, they simultaneously experience the greatest physiological costs. Harsh environmental conditions may increase social conflict, particularly in males, leading to reduced benefits of group living under harsh dry years.

P2-82 GUO, Y.; CLARK, E.C.*; RENN, S.C.P.; Reed College, Portland State University; *mifguo@reed.edu*

Hunger in the Operant Conditioned Cichlid A. burtoni. Quantified in Velocity by an Arduino based Robotic System

Female *Astatotilapia burtoni*, a species of mouthbrooding cichlid fish, voluntarily starve themselves for two weeks while their young develop. Little is known about the physiological mechanisms that have evolved to allow them to accomplish this. *A. burtoni* therefore represent an excellent animal model in which to study the mechanisms that integrate the regulation of feeding and reproduction. Females with broods in their mouths suppress feeding behavior, even if the brood is removed from the buccal cavity. This suppression of appetite, termed brood care motivation (BM), has previously been measured as the reduction in the quantity of food a female will consume. Here we develop an Arduino-based robotic system to automate the quantification of hunger or feeding motivation in *A. burtoni* using the speed to approach a food-conditioned stimulus. They are conditioned to approach the feeder sensor through the gate sensors upon stimulus of a signaling light, they then subsequently trigger the feeder sensor to release food when they are sufficiently close. Once the fishes are conditioned and brooding, they are tested with a program that doesn't dispense food. This eliminates the consummatory act of feeding in the process of quantifying brood care motivation and will allow us to investigate the underlying neural and physiological mechanisms. Arduino systems are routinely used in robotics education at a high school level and lower, so these experiments offer the opportunity for outreach and collaboration.

P2-242 GURGIS, GP*; DAZA, JD; BRENNAN, IG; HUTCHINSON, M; BAUER, AM; OLORI, JC; SUNY Oswego, NY, Sam Houston State University, TX, Australian National University, Canberra, South Australian Museum, Adelaide, Villanova University, PA; *jennifer.olori@oswego.edu*

3D Geometric Morphometric Analysis of Pygopodid Gecko Skull Morphology and Relationship to Habitat

Pygopodids are an enigmatic group of limb-reduced geckos that live in a variety of habitats within Australia and New Guinea. Despite low taxonomic diversity, pygopodids exhibit a wide array of skull morphologies, sometimes within a single genus. For example, *Aprasia* from Western Australia differ from Eastern and Central species by elongating the parabasisphenoid rostrum and reducing the epipterygoid. To investigate differences in skull shape across pygopodids and assess potential ecological associations, CT scans of 12 specimens from six genera were used for 3D geometric morphometrics. We recorded 29 landmarks in Landmark Editor, and used Geomorph to perform Generalized Procrustes Alignment, Principal Components Analysis, and MANOVA to test for associations with habitat (fossorial, ground, low-shrub, high-shrub). Habitat correlated significantly with shape differences. PC1 (skull depth, orbit shape) explained 46% of the variation whereas PC2 (snout elongation, occipital shape) explained 15%. Fossorial taxa (all *Aprasia* we included) were widely separated from other habitat types along PC1, and the highly elongate *Lialis* was isolated in shape space. Within *Aprasia*, taxa separated along PC2 into Western and Central/Eastern clusters, and MANOVA of *Aprasia* species confirmed geography to be a significant factor. We suggest that the two *Aprasia* morphotypes, and a second genus *Ophidiocephalus*, took different evolutionary paths to achieve head shapes conducive to fossoriality. However, less is known about the locomotor and feeding patterns of pygopodid species, which also may influence morphology and could drive the separation within habitat types.

P1-67 GUTHERZ, SB*; O'CONNOR, PM; Ohio University; *sgutherz0819@gmail.com*

Postcranial Skeletal Pneumaticity in Cuculidae

Birds possess unique modifications of the tetrapod *Bauplan*, including pneumatization of the postcranial skeleton that results from invasion of bone by respiratory epithelium. The degree of pneumaticity in living birds varies greatly among taxa. Previous research has characterized the degree of pneumaticity in selected Avian groups and proposed evolutionary hypotheses, frequently related to body size and/or ecological drivers, in which this variability is framed. This study focuses on Cuculidae, a heretofore unsampled clade that occupies an early branching position in Neognathae and exhibits a broad distribution of body sizes, geographic ranges and types of habitat occupied. Sixteen species were sampled, capturing much of the aforementioned diversity and representing all major cuclid subclades. Skeletal specimens from museum collections were examined for osteological correlates of pneumaticity, with anatomical regions for each specimen scored based on the presence/absence of pneumatic features. This survey reveals both phylogenetic and ecological signals. In both Crotophaginae and Neomorphinae, the basic pneumaticity condition includes aeration of the sternum, humerus, femur, pelvic girdle, dorsal ribs and entire vertebral column except C1. In Cuculinae, Couinae and Centropodinae, the same patterns exist with the exception of the femur. The femur has the greatest variability across Cuculidae, with slightly more than half the specimens sampled exhibiting a pneumatic femur. Other variable regions include bones of the pectoral girdle and the tibiotarsus. In addition to a phylogenetic signal, there appears to be a relationship between relative pneumaticity and both body size and preferred habitat (e.g. terrestrial vs. arboreal).

P1-90 GUTIERREZ-PINTO, N*; LONDOñO, GA; CHAPPELL, MA; STORZ, JF; University of Nebraska-Lincoln, Universidad ICESI, University of California Riverside; *nguti@huskers.unl.edu*

The effect of elevation on the aerobic scope of Andean birds

The aerobic scope (VO_{2max}/BMR) defines an animal's endurance during energy-demanding behaviors necessary for survival. Additionally, the maximal rate of aerobic activity in vertebrates is determined by an individual's ability to obtain, transport, and utilize oxygen (O_2), which is in limited supply at high-elevations (i.e. hypoxia). Hypoxia is especially acute for small, active endotherms like passerine birds that cannot use metabolic suppression as a means of reducing O_2 requirements. Consequently, it can be expected that there are compensatory physiological mechanisms in place to maintain VO_{2max} and BMR at high elevations. Nevertheless, efforts to evaluate the causes of variation in maximal energy use across bird species have not been explicitly developed in the context of elevation. In this study, we compare five pairs of closely-related bird species with contrasting elevational ranges in the Colombian Andes to test for associations between native elevation range and aerobic scope. Preliminary results suggest that high- and low- altitude species have similar VO_{2max}, BMR, and aerobic scopes, which should reflect changes in the underlying architecture and mechanisms (e.g. size of relevant organs or Hemoglobin-O_2 affinity) that allow high-elevation individuals to maintain the same rate of basal and maximal O_2 utilization in spite of low O_2 availability.

P1-264.5 HAFFNER, C*; FOSTER, P; ANDERSON, SJ; COWLES, DL; Walla Walla University; *carston.haffner@wallawalla.edu*

Are Pentidotea resecata Isopods Biting the Hand that Feeds Them? A Study on the Spatial Correlation of Isopod Bite Marks and Wasting Disease on Eelgrass, Zostera marina

As a vital component of many coastal marine ecosystems worldwide, seagrass beds serve as a habitat, food source, and nursery for many species and provide a buffer against the erosive nature of waves and currents. In temperate North America and Europe the main seagrass is eelgrass, *Zostera marina*. In the past a protist pathogen, *Labyrinthula zosterae*, has at times devastated eelgrass beds by causing eelgrass wasting disease. Although wasting disease has not recently spread epidemically in the eelgrass beds in Washington State, *L. zosterae* is commonly present at low concentrations. Understanding the mechanism by which it spreads is important for understanding the potential for future outbreaks. The large green eelgrass isopod *Pentidotea resecata* lives within and feeds upon eelgrass blades. It is an accomplished swimmer and frequently moves from blade to blade, and so could potentially serve as a vector for spreading the disease. In this study we examined the correlation in the laboratory between isopod bite marks and the location of new wasting disease lesions on eelgrass blades collected from Padilla Bay, WA. New *L. zosterae* lesions were significantly more likely to occur on blades that had bite marks than on those which had not been fed on. Additionally, on blades with both bite marks and lesions, the lesions appeared significantly closer to the bite marks than would be expected from a random distribution. These results imply that the feeding and movement of *P. resecata* between eelgrass blades may enhance the spread of the disease.

P2-238 HAGER, ER*; HOEKSTRA, HE; Harvard University; *ehager@fas.harvard.edu*

Functional Significance of Differences in Tail Morphology in Deer Mice

Adaptation to novel habitat often involves changes in both morphology and behavior, which can interact to influence performance. Deer mice (*Peromyscus maniculatus*) in forested habitats have repeatedly evolved longer tails and feet than those from neighboring non-forested habitat. Previous work showed that the presence of the tail is likely critical for balance in deer mice. However, the functional significance of natural variation in tail length has not been tested, and covariance among morphological traits in wild populations makes it challenging to quantify the functional significance of each aspect of morphology independently. In addition, behavioral differences between forest and non-forest populations may interact with morphological variation to produce performance differences among populations. Here we show that forest mice from eastern and western North America have not only evolved convergent tail and foot morphologies, including increases in both the length and number of caudal vertebrae, but also exhibit convergent behavioral traits in a standard climbing assay. Even in laboratory-born, naïve mice, we observe consistent behavioral differences in both climbing preference and climbing performance between forest and non-forest populations, suggesting these differences are genetic. We then use a large, laboratory intercross between forest and prairie ecomorphs to generate mice with novel trait combinations. By quantifying climbing performance in this large recombinant population, we measure the relative importance of the various aspects of the forest morphology for climbing performance, and thus directly test the long-standing hypothesis that long tails have evolved in forest deer mice as an adaptation for arboreal locomotion.

P3-7 HAGEY, TJ*; PHILLIPS, J; GERING, E; Mississippi University for Women, University of Idaho, Michigan State University; *thagey@muw.edu*

Microhabitat Texture of Invasive Hawai'ian Arborael Lizards

The adhesive toes of geckos and some other lizards have the remarkable capability to generate strong adhesion and friction on rough and smooth surfaces, allowing these animals to move through their environments unlike many other animals. The adhesive toe pads of lizards are extremely diverse, nearly as diverse as the habitats these species live in. Pad bearing lizards can be found living in rocky, arboreal, and terrestrial microhabitats in arid, temperate, and topical environments. How the adhesive toe pads of these species may be adapted to their particular microhabitats is an open question. The extensive work on pad bearing Caribbean and South American anole lizards have highlighted some adaptive patterns correlating toe pad morphology with habitat use, as well as how microhabitat adaptation can facilitate habitat partitioning and ecomorphological diversification. We investigated habitat partitioning in relation to perch texture. Perch texture remains a greatly understudied area with expected mechanical interactions with toe pad performance. Conducting fieldwork in Hawai'i, we quantified the texture of perches used by three invasive arboreal diurnal lizards species to investigate if perch texture is acting as an axis of habitat partitioning.

P2-87 HAHN, TP*; CUSSEN, VA; DINGLE, H; ROBART, AR; WATTS, HE; CORNELIUS, JM; Univ. of California, Davis, Washington State Univ., Eastern Michigan Univ.; *tphahn@ucdavis.edu*

The omnivore's opportunity: Importance of alternate foods for movement, molt and reproduction in diet specialist, nomadic songbirds

Diet specialists are particularly susceptible to fluctuations in food supply. A high degree of mobility allows some to use a Rich Patch Exploiter strategy, moving from one pulse of high food availability to another. Although this may allow them to spend most of their time in locations with abundant food, it may also require them to move long distances through regions where their specialized diet is not available. Two tactics for coping with this challenge are: (1) prepare for the move by laying down fuel reserves to be used during the movement, and (2) exploit other food sources besides their typical specialized diet while moving. Crossbills (*Loxia* spp.), and to a lesser extent pine siskins (*Spinus pinus*), are diet specialists, depending heavily on seeds of coniferous trees. As Rich Patch Exploiters, they annually move long distances through regions of few or no seeds in search of abundant conifer seeds. Both prepare for annual (spring/early summer) nomadic migration by depositing fat reserves to fuel long distance flight (tactic 1). However, since distance moved and destination vary from year to year, it seems likely that they may also need to employ tactic 2. Here we demonstrate that they rely heavily on insect foods (e.g., aphids, lepidoptera larvae) that are abundant on coniferous and other trees during the spring/early summer movement period. We also discuss importance of these insects to other components of their annual cycles (reproduction, plumage molt). Periodic reliance on alternative dietary components may be widely important in Rich Patch Exploiting diet specialists such as these finches.

P1-257 HALE, E*; ZOHDY, S; SCHWARTZ, T; Auburn University, Auburn; *ech0025@auburn.edu*

Detection and Quantification of West Nile, Rift Valley Fever, and Dengue Fever Viruses from Dried Blood Spots to Identify Zoonotic Potential

Wildlife, non-human primates (NHPs) in particular, can serve as reservoirs for arboviruses such as Dengue (DF), West Nile (WNV), and Rift Valley (RVF) fever viruses, which can all be found in human populations in Madagascar. To better understand the zoonotic potential of Malagasy wildlife species to act as reservoirs of these viruses, methods for rapid, minimally invasive sample collection and preservation are necessary. With this study we aim to (1) develop a qPCR protocol for detection and quantification of DF, WNV, and RVF viruses, (2) validate the use of dried blood spots on TropBio cards as a method for detecting RNA viruses, (3) to determine the prevalence of these viruses in wild NHP species (lemurs of Madagascar). To validate the protocol, we apply the viral RNA genomes, or house mouse (*Mus musculus*) blood spiked with inactivated viral particles to TropBio cards. RNA was isolated from the cards and the target viral RNA was detected by qPCR. Mouse lemur blood samples were collected from intact forest and deforested regions of Madagascar. Ongoing work will test mouse lemur blood spots for these viruses using this protocol.

P3-115 HALL, A.M.*; ZARDUS, J.D.; BOWDEN, J.B.; MCFEE, W.E.; NAPOLITANO, M.N.; College of Charleston, Charleston SC, The Citadel, Charleston SC, University of Florida Veterinary School, Gainesville FL, NOAA, Charleston SC, NOAA/NIST, Charleston, SC; *hallam@g.cofc.edu*

A Lipidomic Approach to identifying Immune Response in Cetacean Skin to the Attachment of the Tassel Barnacle Xenobalanus globicipitis

The pseudo-stalked tassel barnacle, *Xenobalanus globicipitis*, is an obligate commensal of cetaceans predominantly attaching to the fins and flippers of dolphins and other small whales in tropical and subtropical waters around the world. The life cycle and natural history of this species is little known as it occurs only sporadically across cetacean hosts making it difficult to study. This research explores the potential immune response of cetacean skin and plasma that may be induced by settlement of this barnacle. Plasma and non-invasive skin stripping discs collected from live dolphins during a health assessment in Sarasota, FL were extracted using traditional and novel lipid extraction techniques, respectively. The extracted samples were processed using an untargeted LC-MS/MS approach in positive, negative, and full scan modes and a list of lipids present was compiled for each sample using LipidMatch software. These lipid profiles will be assembled and compared between groups of dolphins with and without *X. globicipitis* attached during health screenings. lipid profiles will be analyzed using a PCA and significant lipids associated with an immune response will be identified. Any significant differences in lipid profiles of animals with and without barnacles attached would be indicative of a potential new health risk for dolphin populations and could open the door for further cetacean immunology studies.

P2-6 HALL, MR*; BERG, O; MüLLER, UK; California State University Fresno; *umuller@csufresno.edu*

Bladderwort as a model organism to study predator-prey interactions in an ambush predator

Bladderworts are a carnivorous plant genus (*Utricularia*) containing several aquatic species; the latter form hundreds of millimeter-sized underwater traps to capture zooplankton prey. The large number of very small traps makes these plants ideal model organisms to study predator-prey interactions in a batch mode (mesocosm). In a laboratory microcosm we pit dozens to hundreds of prey against dozens to hundreds of predators in a small volume (mason jars) for a brief period (hours to days). We monitor the progress and outcome in terms of prey size and type, as well as trap age, size, capture rate, and capture efficiency. To this end, we have developed assays involving machine vision, fluorescence imaging, and sound recording. We can now address such questions as 'how energetically expensive are active traps?' and 'how do prey size or predator size affect capture rate and capture success?'. An individual trap becomes active at the growing end of the plant, then captures and digests dozens of prey items before dying at the senescing end of the plant. We found that young traps have high rates of unsuccessful or spontaneous fires and that the majority of prey items are caught by mature, large traps. Using the volume of water inspired as a measure of the energy expended by traps, we found that small traps spend the most energy despite catching the fewest prey. This finding is contrary to the expectation that energy expenditure should correspond to capture success. The volume of water pumped is furthermore a proxy for the oxidative stress of respiration, which is believed to be a central factor in bladderworts' extremely small genome and high rate of molecular evolution.

P3-25 HALL, J; ABEYESINGHE, S; DALEY, MA*; Royal Veterinary College; *mdaley@rvc.ac.uk*

Interactions between personality expression and locomotor dynamics in helmeted guinea fowl (Numida meleagris)

Helmeted guinea fowl (*Numida meleagris*) have served as a useful animal model for bipedal locomotion, with well-studied features of gait dynamics, musculoskeletal function, energetics, and muscle-tendon dynamics. Yet, wider aspects of behavior have been sparsely studied in guinea fowl. Literature on other vertebrates suggests that individuals within species vary in behavior along a bold/shy personality axis, and these differences are stable across contexts. Bold individuals readily explore novel environments and exhibit higher levels of locomotor activity and lower frequency of observable stress behaviors. We have measured bold/shy personality expression and locomotor dynamics in a flock of guinea fowl in a longitudinal study. Exploratory behavior and activity levels in various environments were used to quantify bold/shy personality expression. We find evidence that, like other species, guinea fowl do exhibit stable variation among individuals consistent with bold/shy personality. In separate experiments, we also measured locomotor dynamics of the same flock of birds while executing turning maneuvers on terrains of different friction. We found that running speed during turns varied significantly among individuals, and the random effect coefficients for individuals from a mixed-model ANOVA showed a positive correlation with independently measured bold/shy personality scores ($r = 0.61$). We also see evidence that 'bold' individuals exhibit a greater learning effect across repeated trials than 'shy' individuals. These preliminary findings suggest interesting interactions between personality and locomotor dynamics, which warrants further consideration for how biomechanics studies can be designed to adequately capture behavioral variation among individuals within a species.

P1-230 HALSEY, MK*; STUHLER, JD; BRADLEY, RD; STEVENS, RD; RAY, DA; Texas Tech University; *michaela.halsey@ttu.edu*

Opportunistic sampling, model-based clustering and least-cost path analysis aid in identification of connectivity corridors in the Texas Rolling Plains

At a time when biodiversity is declining at an alarming rate, it is encouraging that the technology and data afforded to conservation biologists continues to increase. Assessment of fine scale shifts in species distributions and the processes of dispersal and gene flow are made possible by the availability of multilocus molecular markers. Herein, genetic variation was assessed in two species of kangaroo rats (*Dipodomys ordii* and *D. elator*) to identify such patterns. Of the two kangaroo rat species we examined, *D. elator* is endemic to Texas, and is a soil specialist whose population is likely declining due to land use change. Demographic differences influenced by population size are expected to be reflected in the genome of each species. We compared the genetic variability of 59 individuals from eight counties in Texas using a variant of restriction-site associated DNA marker sequencing (RAD-Seq). Individuals were assigned to population clusters using STRUCTURE. Landscape complexity was characterized using a series of models to identify potential barriers to gene flow. Our results suggest that despite differences in ecology, behavior and evolutionary history between these two species, their gene flow response to the complex landscape of the Texas Rolling Plains is similar. Furthermore, we propose that we can evaluate barriers to connectivity in a threatened kangaroo rat species using a more widespread surrogate. Such an approach will provide biologists the unique opportunity to test hypotheses that otherwise may be unfeasible with small, threatened populations and can enable the development of conservation strategies and investigative frameworks that better manage and conserve imperiled species, such as the Texas kangaroo rat.

P2-271 HAMM, AR*; RILEY, AG; MULLIN, MM; ECKERLE, BM; LEHTINEN, RM; CARLSON, BM; The College of Wooster, Ohio; *ahamm20@wooster.edu*

To Delete or Not to Delete: Examining the Role of Mc1r Deletions in Squirrel Melanism

Polymorphism has long interested evolutionary biologists as important variation from the standpoint of selection as well as a possible route to speciation. Color polymorphism, in particular, is widespread in many taxa and is important in conspecific interactions, predator avoidance, thermoregulation, and other important functions. Different color variants (such as melanism) may present both costs and benefits to individuals displaying variant phenotypes. While melanistic individuals remain a rarity in some populations, other populations harbor melanism at a relatively high frequency in the absence of an obvious selective benefit. In order to better understand the evolutionary significance of these phenotypes, especially where they persist at high levels, it is important to identify the genetic basis of this variability. Previous work in the gray squirrel, *Sciurus carolinensis*, identified a 24 base-pair deletion in the *melanocortin I receptor* gene (*Mc1r*) that showed a strong association with melanism in introduced populations in the United Kingdom, as well as a small number of individuals from Massachusetts, Virginia, and British Columbia. In this study, we sampled *S. carolinensis* in Wooster, OH, where melanistic individuals account for ~70% of the local population. Our results confirm that the same *Mc1r* deletion observed elsewhere is indeed present in the Wooster population. However, our results also suggest that the relationship between the presence of this deletion and the development of melanism may not be as simple as previously thought. Further investigation is necessary to fully understand the genetic basis of this phenotypic variation.

P1-56 HAMMOND, L; CERRA, K*; CURET, O; PORTER, M; MEREDITH, T; Florida Atlantic University; *tmeredi1@fau.edu*

Follow that smell: Fluid dynamics through the shark olfactory organ

Elasmobranchs (sharks, skates, and rays) are known for their acute olfactory sense. Olfactory system morphology is diverse and varies interspecifically, but the links between morphology and function are unclear. We hypothesize that variations in morphology impact the fluid flow through the olfactory organ and in turn have consequences for olfactory sensitivity. The shark olfactory system consists of an incurrent channel, an excurrent channel, and the organ itself, which is comprised of two rows of lamellae, which are overlain with olfactory epithelium. The shape of the organ and number of lamellae vary dramatically among species. Our goal was to use bioinspired models to examine the impacts of varying organ shape and lamellar number on flow through the olfactory organ. We based bioinspired models on varying meristics for the organ (length, width, and depth) and for the lamellae (number, width, and interlamellar distances). Particle Image Velocimetry was used to quantify the effects of meristic variation on flow patterns and rates through the model. We found that vortices are generated in each interlamellar space. In addition, we observed that flow distribution between lamella changes along the length of the organ. These flow characteristics likely have implications for odorant biding. However, these flow structures still need to be corroborated at lower Reynolds number. These data suggest that the variations in olfactory morphology may be important for distributing fluid through the system to the sensory epithelia and information processing.

P1-35 HANDY , SH*; ARNETTE, JP; CEJA , M; POFF , MA; OWERKOWICZ, T; California State University, San Bernardino; *towerkow@csusb.edu*

Heat Exchange Through the Skin of the American Alligator: Do Osteoderms Play a Role?

Osteoderms in crocodilians are known to function in mechanical protection, locomotor support, and acid-base regulation. With a rich vascular supply, osteoderms are also thought to play an active role in crocodilian thermoregulation, allowing the animal to absorb or dissipate heat faster than has non-ossified dermis. We tested this hypothesis by monitoring superficial and deep temperatures of juveniles of the American alligator (body mass 0.3-30 kg) during warming and cooling between 15 and 30°C. We recorded skin surface temperatures with an infrared camera, and core temperature with a cloacal thermocouple. We controlled for cutaneous perfusion by running the experiments first on live animals and then on their carcasses. We found, unsurprisingly, that animal size has a significant negative effect on rate of heat exchange. Further, warming (to 30°C) occurred significantly faster in live animals than carcasses, but differences in cooling (to 15°C) were not appreciable. Scales with osteoderms (in the cervical and dorsal regions) showed small (<2°C) differences in temperature profile from neighbouring scales without dermal bone. These temperature differences were most pronounced at the start of each experiment, and disappeared with each experiment duration. Notably, these temperature differences were not consistent between anatomic regions within an animal, or between animals (i.e., scales with osteoderms sometimes showed higher, sometimes lower surface temperature). Importantly, these temperature differences were similar in carcasses. This suggests that heat exchange through the crocodilian skin is dependent more on thermal characteristics of individual scales, and their anatomic location, than on vascular perfusion of underlying tissue, with or without osteoderms.

P1-61 HARDY, AR*; HALE, ME; Univ. of Chicago; *arhardy7@uchicago.edu*

Mechanoreceptor distribution in fish pectoral fins: Clues for optimal sensor placement

The fins of fishes are innervated with sensory nerves and specialized endings capable of providing proprioceptive and tactile feedback. Across ray-finned fish studied, the sensory nerves extend distally within each ray following fin ray branching patterns. Nerve fibers exit the rays to innervate the inter-ray membrane, synapsing with mechanoreceptors. Mechanoreceptors respond to deformation of the fin and as the key link to the environment their location, number, and distribution may reflect adaptations to a particular habitat or fin function. To explore this further, we examined mechanoreceptor distributions in round goby (*Neogobius melanostomus*) pectoral fins, which frequently interact with the bottom substrate. Immunolabeling revealed a non-homogenous distribution of mechanoreceptors across the fin with fin rays located closest to the substrate exhibiting the highest concentrations. We found the highest density of endings within a ray in locations of fin ray branching. As these fin regions spread and deform during contact we suggest fin ray branching points may be particularly informative locations from which to sense contact and changes in fin ray position. These results lead to many questions regarding sensor placement, redundancy of the sensory system, and function of fin ray branching patterns. In an effort to tackle these questions, we compare our data in round goby to that of other species that vary in their frequency of substrate contact, pectoral fin function, and morphology and develop phylogenetically framed analyses in order to better elucidate the structure-function relationship of fin ray sensation.

P2-158 HARO, D*; BURKE, RL; PAULY, GB; LIWANAG, HEM; California Polytechnic State University, Hofstra University, Natural History Museum of Los Angeles; *daharo@calpoly.edu*

Cold tolerance plasticity and cold acclimation of non-native Italian wall lizard (Podarcis siculus) populations from New York and California

Thermal tolerance data are collected to increase our understanding of how closely an organism's physiology reflects adaptation to its environment. Unfortunately, because thermal tolerance can be highly plastic, sensitive to prior housing conditions, and sensitive to methods of measurement, comparisons between and within studies can be complicated. Though we know that thermal tolerance is plastic, to understand how it relates to adaptation to the thermal environment, it is important to study how plastic it can be. To do this, we measured cold tolerance of two non-native populations of *Podarcis siculus* once weekly during a cold acclimation treatment. Heat tolerance, thermal preference, evaporative water loss, and standard metabolic rate were also measured before and after the cold acclimation treatment. We found that the population of *P. siculus* from the more variable climate (Long Island, NY) was able to shift its cold tolerance relatively quickly, whereas the population from the milder climate (San Pedro, CA) did not shift its cold tolerance. NY lizards also decreased thermal preference while CA lizards did not. Temperature coefficients (Q_{10}) of water loss and metabolism were greater in CA lizards. Overall, results suggest that NY lizards are more adapted to a varying thermal climate compared to CA lizards. This underlying difference in plasticity, a potentially adaptive trait, would not have been detected if lizards had only been tested once prior to the cold acclimation treatment. These findings highlight the need to incorporate plasticity into theory and experiments investigating potentially adaptive traits.

P1-59 HARRIS, MD*; DEORA, T; ROTH, E; Univ. of Washington, Indiana Univ.; *monicah555@gmail.com*

Spatial Content of Visual Scenes Mediates Different Strategies for Gaze Fixation in Hawkmoths

As they navigate their environments, insects must parse the moving visual scene and respond to different features appropriately. In particular, they must distinguish between visual motion arising from their own movements relative to the environment (ego-motion) and those arising externally. Ego-motion creates optic flow across the entire visual field, called wide-field motion. In contrast, an external agent moving in the visual field (e.g. a wavering flower or an approaching predator) stimulates only a small patch that travels coherently across the retina, hence called small-field motion. To fixate a moving scene, the hawkmoth, *Manduca sexta*, can either reorient its entire body or change the angle of its head to redirect gaze. For pitch stabilization, moths respond predominately to wide-field motion, modulating both body posture and head orientation to follow expansive visual stimuli. Our recent experiments also show that for some visual scenes, moths exhibit head movements strongly correlated to the small-field visual motion, suggesting that head motion and body posture reorientation are separable strategies for visual fixation. To identify these parallel strategies, we investigate which aspects of the visual scene elicit head motion by changing the relative salience of the wide- and small-field stimuli. Moths are tethered at the center of a cylindrical visual arena and presented an image of a flower against mottled backgrounds of varying contrast and spatial frequency. The flower and background oscillate vertically at different temporal frequencies. A Fourier analysis reveals the extent to which the moth nods its head in response to each stimulus. Our data suggests that moths use the head-motion strategy to follow the small-field target provided the background has sufficiently low spatial frequency (blurry and lacking prominent edges).

P2-252 HARRISON, JS*; PORTER, ML; MCHENRY, MJ; ROBINSON, HE; PATEK, SN; Duke University, Univ. of Hawaii, Manoa, Univ. of California, Irvine, Humboldt State University; *jacob.harrison@duke.edu*

Scaling of elastic mechanisms: the tiny strikes of larval mantis shrimp

Mantis shrimp (Stomatopoda) strike prey using an elastic mechanism in their raptorial appendages. Across species, adult mantis shrimp use appendages that range up to 4 cm in length, while their larvae strike using raptorial appendages that are only 1 mm in length. Making use of this impressive size range, we examined the scaling of morphology and kinematics of the elastic mechanism in adult and larval mantis shrimp raptorial appendages. We filmed raptorial appendage strikes in larval Philippine mantis shrimp (*Gonodactylaceus falcatus*; 2 animals, 6 strikes) and found that they accelerate at an average of $1.6x10^5$ rad/s^2 with a maximum angular velocity of 308 rad/s, similar to adult strikes. However, the speed of larval strikes (0.33 m/s) is slower than adult mantis shrimp (2.1-20.2 m/s). We also examined the morphology of larval raptorial appendages using microCT scans and compared them to adults. Adult mantis shrimp use muscles to store elastic energy in the merus exoskeleton, while internal latches release the strike. We found that larvae possess similar muscle and latch arrangements as adults, which suggests that larvae also store and release elastic energy using a spring and latch mechanism. By establishing strike kinematics and morphology of larval mantis shrimp, we offer insights into the scaling of the mantis shrimp elastic energy storage mechanism.

P1-106 HARTLEY, JG*; GOMES AVERSA, MD; LEESE, JM; DeSales University; *jh6817@desales.edu*

Female mate preference influenced by intrasexual competition and differences in male quality

Sexual selection, the ultimate mechanism driving the evolution of sexual dimorphism in plants and animals, includes both intra and inter-sexual components. Exploring the interaction of these forces is difficult and most experimental studies tend to focus on one aspect or the other. Here, we set out to explore the interaction between intra- and inter-sexual selection pressures on mate preference in a monogamous model system. Two female convict cichlids, *Amatitlania siquia*, were placed into an experimental aquarium containing two compartments with a potential male mate and nest site in each, and a central neutral compartment. The females could freely move between compartments and interact with potential male mates, as well as each other, for a three-day observation period. This design allowed for simultaneous intrasexual competition between females as well as the formation of a preference between two males of similar quality. In a second experiment, the same design was used, but the two males differed in quality. We found that females demonstrated a time-based preference for males in both experiments, but that in the first experiment (size-matched males), there was no difference in preference between the two males; each female seemed to prefer one of the males. In the second experiment (size difference males), however, both females demonstrated a preference for the large male. This was evidenced by females spending significantly less time with the smaller male by the end of the experiment. This suggests that in the presence of intrasexual female competition, females may adjust their threshold for potential mates, even to the extreme level of foregoing reproduction with a low-quality male when a higher quality male is unavailable. Future work will explore how levels of female aggression may be affected by differences in male quality in this experimental paradigm.

P3-89 HARTMAN, R. A.*; GRIESBACK, K.; SCOTT, K. S.; TOBE, S.; LANDBERG, T.; Arcadia University; *ryan.hartman007@gmail.com*

Heavy metal contamination of common snapping turtles in the Lower Delaware River watershed

The common snapping turtle (Chelydra serpentina) is a long lived reptile that tolerates tremendous amounts of pollution. Because of this, they have been used as indicators to monitor toxicity of their environment. The industrial history of the Philadelphia area as a manufacturer of steel and paper milling led to highly polluted waterways which suggests that the snapping turtles of the region are contaminated with heavy metal pollutants such as zinc, mercury and lead. While zinc is an essential element for humans, there are no known safe levels of lead consumption. This poses a potential health risk as snapper soup is a Philadelphia regional delicacy served in restaurants for hundreds of years and trapping turtles for consumption is legal. We examined the heavy metal content of tissue samples of C. serpentina (n= 47 claw clippings from living and additional muscle samples from road-killed turtles) collected in a ~900 square mile area around Philadelphia. Atomic absorption spectroscopy showed detectable heavy metal concentrations in all the samples. As expected, claw tissues of C. serpentina varied dramatically in zinc concentration across sites indicating that local conditions and historical pollution determine metal content. Keratin tissue (AVG= 1351.66µg/g, SD=2292.39µg/g, n=20) showed significantly higher zinc content than muscle (AVG=57.32µg/g, SD=14.59µg/g, n=2). Analysis for lead and mercury are still being investigated. Since turtles throughout the lower Delaware River watershed may have extreme metal concentrations in their tissues, eating turtle flesh from this area may be dangerous to humans in addition to being detrimental to turtle populations already potentially stressed by habitat degradation.

P2-237 HARTWICK, MN*; REICHMUTH, C; THOMETZ, NM; University of San Francisco, University of California, Santa Cruz; *mnhartwick@dons.usfca.edu*

Evaluating Seasonal Changes in Body Condition for Spotted, Ringed, and Bearded Seals

Arctic seals must manage considerable seasonal changes in sea ice coverage, air and water temperatures, photoperiod, and prey availability. These species utilize blubber for onboard energy storage, thermoregulation, streamlining, and buoyancy, and this insulating layer changes in thickness and composition throughout the year. Specifically, seals rely on blubber as a critical energy reserve during physiologically taxing life-history stages such as breeding, lactation, and molt. Blubber thickness, along with complementary morphometric measures, can be used to assess overall body condition in seals. We used a modified truncated cones method to track within-individual, fine-scale changes in the body condition of three species of Arctic seal. Our study animals included 4 spotted seals (*Phoca largha*), 3 ringed seals (*Pusa hispida*), and 1 bearded seal (*Erignathus barbatus*) trained to participate in research procedures at two facilities in California and Alaska. We used a portable ultrasound machine to measure blubber thickness at 12 sites along the length of each animal. We used photogrammetric methods to measure standard length, curvilinear length, and body heights using scaled photographs. In addition, we collected direct measures of body length, girth, and mass. Ultrasound, photogrammetric, and direct morphometric data were collected weekly for a minimum of one year. Using a modified truncated cones method, seals were modeled as a series of consecutive cones in which the inner core represented lean mass, and the outer layer represented blubber mass. Separating lean mass and growth from dynamic changes in overall body condition enabled assessment of critical periods when seals are most reliant on blubber energy reserves.

P2-49 HASSERT, JC*; STAHL, A; BUSCHBECK, EK; University of Cincinnati, Scripps Florida Society of Research Fellows; *Hasserjc@mail.uc.edu*

Gaining Focus: Using RNAi to Understand How T. marmoratus Larval Eyes Maintain Focus

Visual systems are complex and require that all pieces work together to form clear images. The refractive power of the lens is fundamentally important for any eye to maintain correct focusing. During growth, all parts of the eye need to coordinate to maintain focus. Previous studies have thoroughly examined how vertebrates can preserve this property during their growth, but there are few studies which attempt to answer the question in invertebrates. Unlike vertebrates which grow gradually, insects must undergo ecdysis—shed their outer layer, including their lenses. This presents a unique evolutionary challenge to overcome: how do you maintain correct focus with rapid eye growth? An excellent model for eye development are Thermonectus marmoratus larvae which have exceptional eyes that use a bifocal lens to focus images on two retinas. These larvae undergo rapid growth between their 2nd and 3rd larval stages and substantially reform their lenses to accommodate this growth. The cuticular protein Lens3 is a major contributor to the lens. In this project we use RNAi to knock down Lens3 expression and to investigate if reduction of this major lens protein leads to refractive errors, or if T. marmoratus eye development contains compensatory mechanisms that allow correct focus to be maintained. Knockdowns can be measured using a customized ophthalmoscope to determine focusing abilities. This study will provide insights towards the question of whether invertebrates use active or passive regulation to maintain focus.

P2-46 HAVENS, LT*; KINGSTON, ACN; SPEISER, DI; UNC Chapel Hill, USC Columbia; *lukethavens@gmail.com*

A novel, automated approach to electroretinography

Understanding the physiological limits of an animal's visual system is an important part of studying its visual ecology. Without first determining what an animal is physiologically capable of sensing, it is difficult to ascertain what visual information in its environment could have behavioral significance. An effective way to assess the physiology of visual systems is via direct recording of the electrical activity of photoreceptors using a technique known as electroretinography (ERG). But accurate ERG can be time and labor intensive, often involving manual adjustment of the wavelength and intensity of light stimuli and real-time comparison of physiological responses to inform those adjustments. Furthermore, because stimulus adjustment often involves its own skillset, ERG can require expertise beyond that necessary for the electrophysiological preparation itself. To improve both the efficiency and accessibility of ERG, we designed a highly automated system for both stimulus presentation and data acquisition. Rather than relying on manual adjustment of stimuli and real-time comparison of response, our system automatically adjusts the intensity of all light stimuli to specified photon flux. In addition, light control can be achieved through a series of prompts, allowing users to set up and run automated trials after answering a set of basic questions about the experiment. Here we test this novel system's ability to accurately assess spectral sensitivity in the well characterized visual system of the crayfish using both existing magnitude of response and novel temporal acuity based techniques, where higher magnitude of response and temporal acuity denote greater sensitivity. Using this system, we find that we are able to acquire highly accurate, reproducible results in ERG experiments quickly and with minimal training beyond introduction to electrophysiology.

P2-243 HAWKINS, RK*; BELL, CJ; STOCKER, MR; Virginia Tech, University of Texas at Austin; *rehawk@vt.edu*

Intraspecific Variation in the Cranial Osteology of Diplometopon zarudnyi

A snake-like body plan and burrowing lifestyle characterize countless vertebrate groups through convergent evolution. One such group is the amphisbaenians, a limbless clade of lizards that are primarily fossorial and exhibit head-first burrowing behavior. Correlated with this behavior, amphisbaenian skulls are recognized as more rigid and coossified than those of non-burrowing lizards. However, due to their elusive lifestyle, amphisbaenian skulls are not yet well understood, including how cranial osteology may vary among individuals of the same species and what that reveals about constraints on skull morphology of head-first burrowing taxa. We investigated intraspecific variation in the cranial osteology of amphisbaenians using *Diplometopon zarudnyi*. Variation among skull and skull element morphology was analyzed qualitatively and by performing 3D landmark-based geometric morphometrics on 3D models created from microCT data. Significant differences were observed in the length of dorsal contact between the parietal and occipital complex, the interdigitation of the frontals and parietal, and the degree of coossification between the occipital complex, fused basioccipital and parabasisphenoid, and Elements X. These results reveal significant variation in suture interdigitation and morphology of the occipital region in *D. zarudnyi*, indicating that the variation may be the result of different stages of ontogenetic development or that these regions may have less strict morphological constraints in head-first burrowing taxa. Examination of this variation across other head-first burrowing taxa will help determine if this is clade-specific or part of a broader macroevolutionary pattern.

P1-38 HAWKINS, O. *; TACK, N. ; DU CLOS, K. ; GEMMELL, B. J. ; University of South Florida; *hawkinso@mail.usf.edu*

Does the wing-like shape of an oceanic plankton predator provide hydrodynamic camouflage?

Ctenophores or comb jellies are known to be important marine predators that can alter plankton community dynamics in coastal ecosystems. Open ocean ctenophores are ubiquitous but poorly understood due to their delicate, gelatinous nature. *Cestum veneris*, or the venus girdle, is a very unusual ctenophore that exhibits a compressed, wing-like morphology, differing greatly from other gelatinous zooplankton. This animal continuously glides through the water propelled by ciliary ctene rows at the rear of the wing. *C. veneris* primarily preys on hydrodynamically sensitive copepods capable of responding to minute fluid disturbances with powerful escapes. However, there is currently little information on *C. veneris* feeding ecology. In order to determine if the unique wing-like morphology of *C. veneris* is capable of masking the hydrodynamic signal given off to copepod prey, we recorded the interaction of the copepod *Acartia tonsa* as they approached a 3D analog of the wing in a laminar flow water channel. We found that at low simulated swimming speeds copepods always detected and avoided contact with the wing. However, as speed increased, the reaction distance of the copepods relative to the wing decreases. At naturally observed swimming speeds, direct copepod contact with the wing could be observed. Quantification of fluid deformation rates around the wing and comparison of copepod response locations suggest that at natural swimming speeds, the wing-like morphology of *C. veneris* provides hydrodynamic stealth to aid in capturing sensitive prey.

P2-167 HAWTHORNE-MADELL, J; LIVINGSTON, K; AARON, E; LONG, JH*; Vassar College, Colby College; *jolong@vassar.edu*

Developmental Error Increases Genetic Variation in Evolving Robots

Because genetic variation is required for adaptive evolution, it is essential to understand the mechanisms that maintain it in the face of selection. Although genetic errors such as mutation are primary, here we demonstrate another independent mechanism for maintaining genetic variation in populations: random epigenetic errors in development. We simulated populations of mobile, autonomous robots in which genomes encode morphological and neural structures, spatial relations, and regulatory elements; the interactions of structures and regulatory elements unfold in an explicitly modeled developmental process. Our system also explicitly models random genetic errors and random developmental errors. We simulated 11 levels of genetic error rate, 11 levels of developmental error rate, and their interactions in 10 populations of 60 simulated robots over 100 generations, with fitness determined by a simple movement task. In the presence of directional selection, genetic variation was proportional to the rate of random developmental error. Moreover, random developmental error and random genetic error are separate and independent mechanisms, as demonstrated by their statistical independence over evolutionary time. In addition, at all levels of developmental error, the mean individual fitness increased over generational time. This model therefore is consistent with the prediction that random developmental error is an evolutionary mechanism that maintains genetic variation, which, in turn, enables sustained adaptive evolution. This work was funded by the U.S. National Science Foundation (grant no. 1344227, INSPIRE, Special Projects).

P2-180 HEFELE, KR*; CELEC, S; JORGENSEN, DD; Roanoke College, Roanoke College ; *krhefele@mail.roanoke.edu*

Cardiac Function in the American lobster: How Does Pericardial Sinus Pressure Relate to Pressure Inside the Heart?

The American lobster (like other decapod crustaceans) employs a single pumping chamber, the ventricle, to push hemolymph into an arterial tube network. The ventricle (V) is suspended in a space, the pericardial sinus (PS), by an array of suspensory ligaments. Hemolymph returning from the tissues passes through the gill circulation, is collected in the PS, and moves from the PS into the V during ventricular relaxation through three pairs of openings (called ostia) located in its dorsal, lateral, and ventral walls. However, the exact mechanism of ventricular filling is not well understood. In this study we investigated hydrostatic pressure distribution in the PS in relation to ventricular lumen pressure over the cardiac cycle. Hemolymph pressure was measured continuously in the ventricular lumen and in different locations in the PS in quiescent animals. The digitized pressures were overlaid electronically and the integrated difference between V and PS pressures was expressed as the cardiac filling index (Pa·sec). We also investigated how the cardiac filling index (CFI) changes during periods of higher metabolic demand (while the animals walked on a submerged treadmill) when heart rate (HR) is elevated. We found a significant difference between CFI when comparing rest and exercise conditions (34.3 Pa·sec and 21.5 Pa·sec respectively; n=5). CFI decreased with increased HR during exercise. We found that hemolymph pressure is not homogeneous throughout the PS, and therefore CFI varies within these different regions of the PS. These observed differences likely owe to the complex geometry of the PS. We suggest that some ostia may be more important in the ventricular filling process because PS pressure is not homogeneous in this space.

P2-207 HERBST, HD*; PORTER, ME; Florida Atlantic University; *hherbst2015@fau.edu*

Impacts of denticle density: Quantitative analyses of marine fouling on shark skin

Marine fouling is the settlement of microorganisms on wet surfaces. Many studies have designed structures that mimic the microscopic patterns of dermal denticles on shark skin to prevent marine fouling. For example, industrial surfaces inspired by shark denticles reduced marine fouling and decrease bacterial growth by up to 87%. However, we found no quantitative evidence to justify the claim that shark skin is antifouling. This study quantifies marine fouling on shark skin from the blacktip shark (*Carcharhinus limbatus*) along dorsal and ventral surfaces, which provided a range of denticle densities and varying morphology. We hypothesized that significant growth would occur on control and shark skin surfaces during the 120 hour experimental period. We also expected to find increased percent cover where denticle density was lowest. Shark skin and control samples, sterile petri dishes, were exposed to agitated flow-through seawater and daylight cycles for 120 hours (five days). We quantified fouling every 24 hours by removing the surface from water flow, photographing, and then using NIH ImageJ to quantify percent cover. When control surfaces were exposed to seawater conditions, significant growth (more than 30% cover) was present after a 24 hour time period. At 24 hours of exposure, shark skin showed less than 0.01% growth and on average there was only 1.7% cover at the end of the 120 hour experimental period. We showed that percent cover over time increased as denticle density increased. These data suggests that denticle density plays a key role in preventing fouling, as denticle presence led to significantly less microorganism settlement over time when compared to a control. Future research will be conducted to determine if shark skin prevents bacterial growth and if denticle morphology impacts fouling.

P2-265 HERBST, K*; SCOTT, K; LANDBERG, T; Arcadia University; *kherbst@arcadia.edu*

Effects of Drug and Rat Body Part on the Growth of Necrophagous Beetle Dermestes maculatus

Observing arthropod colonization on bodies can provide investigators with valuable information on post mortem interval (PMI). Blow flies colonize bodies rapidly and are forensically useful on relatively fresh remains however necrophagous beetles with slower development may be more useful in cases with longer PMI. However, diet affects growth and in cases of drug related deaths, insects may experience second hand drug effects. Based on blow fly research we expected a depressive effect of both ketamine and xylazine on growth and development. Further, higher fat content in meat types was predicted to increase growth rate and decrease time to metamorphosis. We tested the effects of these drugs in different doses and combinations on beetle development over 9 weeks in 6 body regions (arms, legs, 2 trunk segments) of 18 lab rats. Rats were skinned, dried and assigned to 108 replicate tanks (~5x5x1"), each containing ten 1st instar skin beetle larvae (*D. maculatus*). Larvae were photographed weekly and measured (mm) using Image J. Emerging adults were weighed (g) and removed from tubbies as found. As expected, body region affected growth rate (ANOVA; $p<0.0001$ for both weeks), with the anterior trunk producing the largest larvae. Growth during weeks 1 and 2 showed dramatic effects (ANOVA; $p<0.0112$ week 1, $p<0.0385$ week 2), with the highest ketamine dose in combination with xylazine produced the largest larvae over both weeks. While increasingly larger doses of ketamine produced larger larvae, xylazine may buffer its effects, as combination treatments of lower ketamine dosages did not significantly differ from control groups. These results suggest that forensic investigations using beetles to determine PMI require understanding the fat content of the meat and the drug combination/dose present in the body.

P2-93 HERNANDEZ , E.*; VáSQUEZ, O./A.; TORUCCO, A.; RAHMAN, MD./S.; University of Texas Rio Grande Valley; *eleazar.hernandez02@utrgv.edu*

Annual and Lunar Reproductive Rhythms of the Atlantic Sea Urchin in the Southern Gulf of Mexico

The Atlantic sea urchin, *Arbacia punctulata*, is a unique invertebrate and a primeval species of the phylum Echinodermata. Natural phenomena such as water temperature and moonlight act as external cues that stimulate the reproductive activity of aquatic organisms. In order to acquire a better understanding of the correlation between gonadal maturity, lunar reproductive rhythm and spawning season in the economically and environmentally important marine species, the focused objective of our study was to determine the annual and lunar reproductive rhythms of the Atlantic sea urchin in the southern waters of Texas in the Gulf of Mexico. Sea urchins were collected monthly from July 2016 to June 2017 and sampled weekly in accordance with the lunar cycle from May to July in 2017 in South Padre Island, Texas. The gonadosomatic index (GSI, a biological indicator of isometric growth in gonads) of each sea urchin was calculated as the percentage of gonad weight/total body weight measurements. Gonadal tissues were sectioned and stained with hematoxylin-eosin. Subsequent histological examination of ovaries and testes was performed: maturity levels and spawning phases were determined quantitatively by calculating the percentage of oocytes (immature egg) and ova (mature egg) for each female and the production of sperm for each male. Collectively, our histological analysis suggests that Atlantic sea urchin spawns synchronously according to the lunar cycle and could spawn several times for the following summer months in the southern Gulf of Mexico.

P1-63 HERNANDEZ, AV*; COHEN, KE; GIBB, AC; PORTER, ME; Florida Atlantic Univ., Univ. of Washington, Northern Arizona Univ.; *ahernandez2013@fau.edu*

Why So Cirrihous? Functional morphology of cirri in Cottoidea species

Some teleosts species have elongate and projecting structures on their heads that have been called barbels or cirri. Barbels have been well studied and are described as sensory structures in Siluriformes and Acipenseriformes. Cirri functions are characterized differently among teleost fish groups. In the current study, we investigate the functional morphology of the cirri on five species within Cottoidae (Blepsias cirrhousis, Clinocottus globiceps, Jordania zonope, Nautichthys oculofasciatus, Oligocottus rimensis). Cirri in these species represent morphological diversity, ranging from few to numerous and simple to ornate. This study addresses the following questions: (1) What are the morphological and histological components of cirri? and (2) What functions do cirri serve? Examination of cleared and stained specimens suggest that the cirri in three of these five species are supported by cartilaginous rods. Using scanning electron microscopy, we observed structures on the cirri and nasal pores of these species with morphology similar to that of the taste buds documented in the barbles of Siluriformes and Acipenseriformes. Interestingly, taste bud morphology varied among the five species studied here and warrants further histological investigation. Differences in structure and function of cirri found across the five species may be due to variable ecology and habitat — where they may serve lesser or more significant roles. Because cirri are often used to describe and differentiate among species in Cottoidae as well as in other groups with similar structures, elucidating the functional morphology of cirri in this group will help determine their value as characteristics for morphometric and systematic studies.

P2-194 HERNANDEZ, J*; HUCUL, CE; BELDEN, LK; MOORE, IT; Virginia Tech; *jess228@vt.edu*

The influence of extra-pair paternity on the cloacal microbiome of a free-living bird

Socially monogamous females that engage in extra-pair copulations face potential fitness trade-offs including, but not limited to, good genes and increased genetic diversity in offspring, but also loss of paternal care and increased harassment by their social partner. Sexually transmitted pathogenic microbes have been suggested to be a cost of extra-pair copulations for female birds for nearly five decades, but this hypothesis has not yet been adequately tested. To determine how extra-pair copulations are related to the composition of the cloacal microbiome, we performed an observational study of free-living female tree swallows (*Tachycineta bicolor*) during the breeding season in southwestern Virginia. Tree swallows are a socially monogamous box-nesting species that exhibit high rates of extra-pair activity that vary both within and between populations. First, we characterized the cloacal microbiome of females by collecting cloacal swabs and determining the taxonomic composition of cloacal bacteria using 16s rRNA gene amplicon sequencing. Then, we used nestling paternity as a conservative proxy to estimate the frequency of extra-pair copulations and to determine the minimum number of sexual partners per female. This study increases our understanding of how sexual activity, specifically extra-pair copulations, influences the cloacal microbial communities of wild birds. Additionally, this study broadens our understanding of the potential costs of common life-history tradeoffs faced by free-living animals.

P1-252.5 HERNANDEZ, A. M.*; RYAN, J. F.; Whitney Laboratory for Marine Bioscience, University of Florida; *ahernandez6@ufl.edu*
A comprehensive assessment of 6-state recoding in phylogenetics
Dayhoff, JTT, and LG matrices are 20-state amino acid replacement models used to score amino acid substitutions in phylogenetic analyses. Recently, recoding amino acid matrices into six groups based on substitution frequency in these models has been proposed as a solution to problems associated with substitution saturation and compositional heterogeneity in phylogenetic analyses. While these strategies have some appeal from a theoretical perspective, they have never been empirically tested. To test the performance of Dayhoff-6 and S&R-6 recoding, we used simulations to determine if recoding is truly appropriate to address saturation and compositional heterogeneity. If recoding is appropriate, the expectation is that as saturation or compositional heterogeneity levels increase, recoded matrices should outperform non-recoded datasets. On two separate trees that include a wide range of animals and a few closely related outgroups, we simulate 1,000 datasets of 1,000 amino-acids under the Dayhoff and JTT models and increase branch lengths from 1 to 20 in increments of 1. We show that this increase in branch lengths corresponds with saturation. For each dataset, we reconstruct trees using both recoded and non-recoded models. In both cases, trees produced under recoding strategies were consistently suboptimal to those produced under non-recoded matrices when comparing Robinson-Foulds distances. Similar simulations to test compositional heterogeneity are ongoing. Our preliminary results suggest that these flavors of recoding do not improve the accuracy of phylogenetic reconstruction and that results based on these schemes should be reevaluated.

P1-111 HEUERMANN, T M*; CURRY, R L; Villanova University; *theuerma@villanova.edu*
Inter- and intra-specific variance in boldness behavior of hybridizing Black-capped and Carolina chickadees
Animal personality, behavior consistent within but variable among individuals, influences evolution in both predictable and changing environments. Our research program focuses on interactions between black-capped and Carolina chickadees in southeastern Pennsylvania where their ranges overlap in a hybrid zone. As climate change drives the hybrid zone northward, understanding the species' response mechanisms to change becomes increasingly important. In this study, we investigated boldness behavior in pure and mixed populations of Black-capped and Carolina chickadees. To measure boldness response, we used a motorized woodpecker decoy as a simulated threat at active nests. Most assays elicited a pair response, while video recordings provided individual-level behavioral measures. Preliminary analysis indicates that in terms of latency to make the first ‘chick a dee' alarm call and total call rate, pairs in all populations behaved similarly; however, black-capped chickadees gave fewer dee notes (less intense response) than chickadees from Carolina or hybrid-zone populations. A secondary focus of this study is how variation in a personality-related gene, DRD4, contributes to these differences in boldness response. Prior work in our lab indicates that a single nucleotide polymorphism in DRD4 exists in different frequencies between Carolina and Black-capped populations. Work in progress aims to determine whether a relationship exists between boldness response and DRD4 genotype.

P1-181 HERRMANN, M/A*; ROMERO-DIAZ, C; CAMPOS, S/M; MITER, G/A; WILLIAMS, D/R; SOINI, H/A; NOVOTNY , M/V; HEWS, D/K; MARTINS , E/P; School of Life Sciences, Arizona State University, Tempe AZ, USA, Department of Biology and Center for the Integrative Study of Animal Behavior, Indiana University, Bloomington IN, USA, Department of Chemistry, Indiana University Bloomington, IN, USA, Institute for Pheromone Research and Department of Chemistry, Indiana University Bloomington, IN, USA, Institute for Pheromone Research and Department of Chemistry, Indiana University Bloomington, IN, USA, Department of Biology, Indiana State University, Terre Haute IN, USA; *morgan.herrmann@asu.edu*
The Effects of Chemical Signal Content in Social Communication of Lizards
Odor signals are involved in feeding, territorial, social and reproductive behavior of animals. Most chemical scents are complex blends of multiple compounds, yet varying proportions of different chemical combinations may lead to different levels of signal response. We conducted a series of chemical playbacks, in a controlled environment, with lizards of the genus *Sceloporus*, to assess behavioral responses to two volatile heterocyclic compounds, identified from femoral pore secretions and a demonstrated role in communication in other taxa. These compounds were presented alone or in combination with each other and in different proportions. We found evidence supporting the hypothesis that varying either the number or the proportion of the compounds significantly alters individual responses to chemical scents. Interestingly, the relationship between the two compounds was interactive rather than purely additive. These results provide deeper insight into the effect of chemical signal content in communication and behavior.

P3-98 HEWINS, B; RIDEOUT, A; HARDING, W; MACDONALD, E; FERGUSON, L; GIBSON, G*; Acadia University; *glenys.gibson@acadiau.ca*
Effects of Environmentally-Relevant Levels of Microplastics on Tissue Structure in Mytilus edulis (Blue Mussels)
A major environmental stressor facing marine organisms is the near-ubiquitous glut of microplastics in ocean ecosystems. We investigated the effects of microplastics on the histology of the bivalve mollusc *Mytilus edulis*, filter feeders that are highly abundant in coastal ecosystems. Our objective was to determine if microplastics are taken up into tissues at high risk of exposure (e.g., gills, hepatopancreas) and to use histochemistry to look for tissue-level effects. We exposed mussels to polystyrene particles (5 micrometer diameter) at a low concentration that is typical of water samples of the mid-Atlantic Ocean (1-2 particles/ m3) and at a higher concentration characteristic of some coastal areas (100x low). Controls included field-sampled mussels and mussels cultured in the lab but without polystyrene exposure. After a six-week exposure, we compared the histology of the gills and hepatopancreas in paraffin section using histochemistry. We examined potential changes in basic tissue structure (Hematoxylin and Eosin, Gomori trichrome), mucin production and distribution of hemocytes (periodic-acid Schiff-Alcian Blue), as well as classic indicators of immune responses including lipofuscin production and melanisation (Nile Blue). Preliminary results suggest that polystyrene exposure, even at these low concentrations, was associated with several stress-related responses in both organ systems.

P3-83 HITT, LG*; BLANCHETTE, A; KHALIL, S; FINKELSTEIN, ME; RIBEIRO, RD; IVERSON, ENK; MCCLELLAND, SC; KARUBIAN, J; Tulane Univ, Univ of California, Santa Cruz, Royal Holloway Univ of London; *lhitt1@tulane.edu*

Effects of Lead Exposure on Reproductive Success and Extra-Pair Paternity in the Northern Mockingbird

Chronic, sublethal exposure to lead, a common urban contaminant, causes behavioral and physiological problems in humans living in cities, but little is known about the effects of lead exposure on urban wildlife. Our previous work on the northern mockingbird (*Mimus polyglottos*) in New Orleans suggests that birds in high-lead neighborhoods have higher concentrations of lead in their blood and feathers and are more aggressive. Here, we examine how the reproductive output and cuckoldry rates of mockingbirds may be impacted by lead exposure. On the one hand, more aggressive, high lead males may obtain higher quality territories and resources and mate guard more effectively, leading to high reproductive output and reduced cuckoldry rates within their nests. Conversely, high lead birds may experience reduced reproductive output via direct impacts of lead exposure on the survival of eggs and nestlings, and increased cuckoldry through infertility or excessive aggressive behavior. Our findings provide insights into how lead exposure may mediate fitness via tradeoffs between aggressive behavior, cuckoldry rates, and offspring survival.

P3-58 HITTLE, KA*; KWON, ES; COUGHLIN, DJ; Widener University, Chester, PA; *kahittle@widener.edu*

Climate Change and Anadromous Fish: How Does Thermal Acclimation Affect the Mechanics of Myotomal Muscle of Atlantic Salmon, Salmo salar?

Climate change is leading to rapid changes to ecosystems worldwide. In response to accelerated temperature shifts, to survive many species must acclimate to their shifting thermal environment. We were interested in how climate change will impact a commercially and recreationally important species of fish, Atlantic salmon (*Salmo salar*). Native to the North Atlantic, these anadromous fish live their first few years in small streams and rivers before migrating to the ocean where they grow to adult size. As climate change alters the thermal environment of their natal streams, we asked how their muscle function will be altered by extended exposure to both warm and cold temperatures. We performed a thermal acclimation study of salmon swimming performance (U_{crit}) and muscle function for groups of fish acclimated to 4, 12 and 20º. After swimming performance experiments, muscle mechanics of both fast-twitch or white and slow-twitch or red myotomal muscle bundles were investigated across a range of experimental temperatures. U_{crit} did not vary with thermal acclimation when tested at a common experimental temperature (10ºC). White muscle displayed modest shifts in function with thermal acclimation, while red muscle showed very little variation. Typically, the fastest contractile properties were observed in the muscle from the 12ºC acclimation group. Fish from both coldest and warmest acclimation groups displayed slower kinetics when tests across a range of common experimental temperatures. Overall, Atlantic salmon appear to have limited ability to acclimate across a range of physiologically relevant temperatures, suggesting that climate change will pose of challenge to this already threatened species.

P3-78 HOEKSTRA, LH*; JUDSON, JM; JANZEN, FJ; BRONIKOWSKI, AM; Iowa State University; *lhoek@iastate.edu*

Quantitative Genetics of Life History in a Population of Long-Lived Reptiles

Comparative studies of the evolutionary genetics of complex traits remain limited by sparse taxonomic sampling of natural populations, particularly for life-history traits, such as lifespan and lifetime reproductive fitness, that require sampling the full life course of individuals. Not surprisingly, most existing estimates of the inheritance of such life-history traits come from model organisms in laboratory settings (e.g., flies, mice) or from species of particular interest to humans (e.g., humans, horses, dogs, birds). However, recent advancements in genomic sequencing and new methods for inferring wild pedigrees allow the development of non-traditional model systems. The Western painted turtle, *Chrysemys picta*, is an excellent candidate for studying the quantitative genetics and life-history evolution of a long-lived ectothermic vertebrate. As with many turtles, painted turtles lack sex chromosomes, yet still exhibit a suite of sexually-dimorphic traits throughout their lifetime. Extensive mark-recapture and census efforts of a wild population of painted turtles along the Mississippi River in Thomson, Illinois have provided sound estimates of demographic parameters, including sex ratio, vital rates, and heritability of nesting behavior. We leveraged 25 years of tissue samples collected during this longitudinal field study to genotype a large fraction of the population (N=900). We used the resulting genome-wide SNP panel to associate phenotypic variation in life-history traits (e.g., size-at-maturity, reproductive effort, lifespan) with population-genetic variation, addressing key questions about the sex-specific heritability of life history.

P3-45 HOFFMANN, KA*; CHANG, E; LENTINK, D; Stanford University; *khffmnn@stanford.edu*

Towards Highly Maneuverable and Efficient Avian-Inspired Bio-Hybrid Flying Robots with Morphing Wings

The mystery of understanding how birds fly also has significant benefits in a major area of micro air vehicle (MAV) and general unmanned aerial vehicle research: improving maneuverability and efficiency to allow for flying highly dynamic, longer missions. A bird's ability to morph its wings enables highly dynamic and efficient flight. This results in greatly improved performance compared to fixed wing aircraft of comparable size and weight, which are optimized for limited sequences of flight. We developed a feathered bio-hybrid flying robot to better understand how birds use their feathers to control flight. Closely mimicking pigeon wings enables us to understand the possible maneuvers enabled through wing morphing, and how to perform them in a repeatable, controlled manner. We adapt well understood equations of motion from traditional fixed wing aircraft to simulate our morphing wing bio-hybrid robot. By building our understanding of the maneuvers possible with morphing wings, we will be able to use this information to fly difficult missions autonomously, for example through a set of defined waypoints or to track another flying object using morphing for primary flight control. Better understanding the dynamics of the bio-hybrid wing are also essential for the development of disturbance rejection, such as stabilizing in gusty turbulent conditions. All of these developments lead towards a fully autonomous bio-hybrid aerial robotic platform. Finally, the robot and mathematical models offer deeper insight into how birds may control their flight.

P3-19 HOFFMANN, SL; PORTER, ME*; Florida Atlantic University, 1992; *me.porter@fau.edu*

Three-dimensional fin kinematics of submerged walking in the epaulette shark

Epaulette sharks (Hemiscyllium ocellatum) use tetrapod-like walking with a variety of gaits that involve sequential fin movements to advance the animal forward. During walking, the fins rotate about the proximal insertion and undergo conformational changes to contact the substrate. The goal of this study was to quantify the three-dimensional (3D) kinematics of the pelvic and pectoral fins during steady walking. Three juvenile epaulette sharks were outfitted with markers along the fins and body and filmed submerged walking in a 50 L aquarium. We calibrated two GoPro Hero 5 Black cameras with overlapping views for 3D analysis and tracked marker movement in XMALab. We placed four markers at the proximal pectoral fin insertion and four markers along the pectoral girdle that were used to model pseudo-rigid bodies to quantify fin rotation in relation to the body axis using Autodesk Maya 2017. We used additional markers distributed throughout the distal and trailing fin edge to quantify the conformational changes of the fins. Fin rotation and conformation were compared to the velocity, duty factor, and stride frequency of the trials to determine the role of fins in walking performance. Our data show that both pelvic and pectoral fins rotate in three axes during walking, and that both fins undergo substantial conformational changes during walking. The fin rotation quantified in this study greatly exceeds that observed during yaw maneuvering in other shark species. The pelvic and pectoral fins and girdles, and associate musculature, of epaulette sharks are previously described as highly specialized to facilitate walking along the substrate. We suggest that this increased musculature and high degree fin rotation and flexibility allows this species a greater degree of control needed for more complex walking movements.

P2-205 HOLMES, IA*; RABOSKY, DL; DAVIS RABOSKY, AR; University of Michigan; *iholmes@umich.edu*

Snake and lizard gut microbiome metacommunities across host communities with variable diversity

Gut microbiomes are an ideal system for testing hypotheses about ecological community assembly, especially regarding the importance of diversity dependence in structuring communities. We compare gut microbiome richness across three communities that vary in host species richness to determine the effects of host community richness on microbiome richness. We sequence the hind-gut microbiomes from largely complete lizard and snake (squamate) communities across three latitudes (42 degrees north, 32 degrees north, and 12 degrees south) in the Western Hemisphere. The communities range from five host species, to 24, to 69, and the number of host higher taxa represented follows a similar increase towards the equator. Given the host gradient in species and phylogenetic diversity, gut microbiome lineage diversity might be expected to increase as well. However, we find no such increase either within or between hosts, at any level of microbial taxonomic structure. We explore the causes and consequences of this anti-gradient by examining the phylogenetic histories and ecological diversity of the hosts.

P1-152 HORR, DM*; IVANOV, BM; PAYNE, AA; ROUZBEHANI, M; VEGA, J; WANG, H; JOHNSON, MA; Trinity University, San Antonio; *dhorr@trinity.edu*

Behavioral Repeatability in the Bark Anole, Anolis distichus, Across Social Contexts

Many species express variation in behavioral types, such that individuals within a population may consistently express a type of behavior that differs from others. Yet often behavior is context-driven, where individual responses may differ when individuals are presented with a potential competitor versus a potential mate. Behavioral syndromes occur when individuals who fall within one behavioral type continuously present this behavior type across a number of different situations, regardless of context. Here, we studied the repeatability of male *Anolis distichus* lizard behavior to examine whether social display or locomotor behaviors are consistent across multiple social contexts. Additionally, we analyzed whether physiological or morphological variation across males is associated with the repeatability of these behaviors. In this study we performed two replicates of each of three trials (male-female, male-male, and nonsocial Open Field Tests) to record social behaviors (dewlap and push-up displays), and general movements. We then measured the mass, head size, dewlap area, and SVL (snout-vent-length) of each lizard, and collected physiological measures of liver mass, fat pad mass, and hematocrit levels. We found that individual *A. distichus* behaviors were generally consistent within each type of trial, and their average movement and display behaviors were consistent across the different tests. We did not find support for associations between physiological or morphological traits and behavior. In sum, these lizards exhibited behavioral consistency both within and across social contexts, raising the possibility that these traits may be associated with a behavioral syndrome.

P2-199 HOUTZ, JL*; RECEVEUR, JE; PECHAL, JL; BENBOW, ME; HORTON, BM; WALLACE, JR; Millersville University, Michigan State University; *jlh498@cornell.edu*

Starling Gut Microbial Community Changes Through Decomposition: A New Approach for Wildlife Forensics

In the context of wildlife forensics, knowing the time interval from the moment of death to discovery or the postmortem interval (PMI) range can reduce the number of potential suspects to those without a viable alibi for the time of the crime. A PMI range can be determined by tracking the temporal succession of the microbial communities associated with a decomposing body. We characterized temporal shifts in the taxonomic and *in silico* predicted functional composition of the postmortem microbiome associated with the gut tracts of European Starling (*Sturnus vulgaris*) carcasses over three days. The objectives for this study were to: 1) characterize the gut microbiomes of starlings antemortem and postmortem; 2) compare microbial taxonomic and functional composition among different gut tract regions including the small and large intestines, ceca, and cloaca; and 3) determine if and how avian gut microbial taxonomic and functional composition changed in a repeatable and predictive pattern during decomposition. We detected significant differences between antemortem and postmortem samples in both taxonomic and functional composition after 24 hours, but the microbiome remained stable between 24 and 72 hours postmortem. There were significant differences between gut tract regions in both taxonomic and *in silico* predicted functional composition antemortem, but sample location microbiomes converged after death. Our findings are the first to describe the postmortem microbiome in an avian model, and provide preliminary data for the potential forensic utility of the avian gut postmortem microbiome in estimating time of death.

P2-3 HOWARD, CC*; CELLINESE, N; University of Florida; *cchoward@ufl.edu*

Breaking Ground on Bulb Evolution in the Monocots

Plant bulbs are underground organs with resting buds located on a reduced stem surrounded by layers of leaves and/or scales. This trait has evolved at least eight independent times within the monocots. Iconic examples include tulips, hyacinths and onions. Although all bulbs are thought to be a common structure, there exists a diversity of bulb scale morphologies. Bulbs can be comprised of leaf bases, swollen scales, swollen leaf bases, or both leaf bases and scales. Additionally, external bulb morphology varies across taxa. Some are covered with a paper-like outer covering (i.e. tunicate bulbs [e.g., onions, tulips]) and others lack this trait (i.e. imbricate bulbs [e.g., lilies]). Furthermore, bulb size (i.e. diameter) varies greatly both within and among clades, with the Amaryllidaceae housing some of the largest bulbs and the Poaceae the smallest. The multiple independent origins of this trait provide researchers with an excellent opportunity to study the evolutionary and developmental processes that have promoted the evolution of these seemingly similar, yet morphologically diverse, structures. To generate evolutionary hypotheses of bulb evolution, in this study, we quantified bulb size variation across the monocots, and investigated potential underlying causes of size evolution.

P3-48 HSU, S.J.*; WANG, J.; DONG, H.; CHENG, B.; Pennsylvania State University, University of Virginia; *buc10@psu.edu*

Effects of Wing Flexibility on the Aerodynamic Performance of Blue Bottle Flies Flying in a Magnetic-Levitated Flight Mill

Insect wings can deform substantially during flight, exhibiting patterns of camber and twist that vary throughout a wingbeat cycle. Such deformations have profound implications on the aerodynamics and flight performance of insect flight, which, however, are difficult to quantify, especially for free flying insects. In this study, we measured the flight performance and kinematics of blue bottle flies (Calliphora vomitoria) flying steadily in a magnetic-levitated (MAGLEV) flight mill, including the flight speed, forward thrust, and wing surface deformations via combined high-speed videography and marker-less surface reconstruction. We then analyzed the underlying aerodynamics by simulating the flight kinematics using a high-fidelity, three-dimensional, computational fluid dynamics simulation, and compared the aerodynamic performance of the deformed wings and the undeformed wings. During steady flight, the flies' wings had positive camber during downstroke and negative camber during upstroke, i.e., creating a pocket with an opening towards the stroke direction in both half strokes. The wings also exhibited continuous spanwise twists, leading to decreasing angle of attack from wing root to tip. Mean thrust generation in deformed wings increased by 26% on average compared with that of undeformed wings, as the deformation reduced the drag during downstroke and increased the thrust during upstroke, primarily due to the forward force-vectoring. Wing deformation also significantly enhanced the thrust-generation efficiency by 32%. Our results revealed the indispensable role of wing flexibility in the insect flight performance and also could have critical implications on the design of flapping-wing micro-air-vehicles.

P1-46 HUBER, D.*; CUNNINGHAM, T.; CASARETO, S.; AMPLO, H.; FORD, J.; DECKER, S.; MARA, K.; The University of Tampa, New Jersey Institute of Technology, University of South Florida, University of Southern Indiana; *dhuber@ut.edu*

Fluid Dynamics of Hammerhead Shark Locomotion

The hammerhead sharks are characterized by an extremely unusual head morphology, the cephalofoil, the function of which has long been debated. While advantages have been identified for sensory systems, the role of this structure in locomotion is poorly understood. Therefore, we sought to quantify the effect of cephalofoil shape on fluid drag. The heads of six hammerhead species of varying cephalofoil morphologies were CT scanned, digitally reconstructed, and 3D printed. Fluid drag was then experimentally measured on each head model while varying angle of attack (i.e., pitch, yaw, roll from 0-35 degrees) in a recirculating flume. Drag coefficient, a measure of the effect of shape on drag, was derived from these measurements. Preliminary results indicate that fluid drag is affected by cephalofoil shape. The largest mean drag coefficient for pitch was associated with the largest, most ancestral cephalofoil of the winghead shark *Eusphyrna blochii*, whereas the smallest mean drag coefficient for pitch was associated with the smallest, most derived cephalofoil of the bonnethead shark *Sphyrna tiburo*. Mean drag coefficients were linearly related to cephalofoil width, indicating that drag reduction may be a selective pressure in the reduction of cephalofoil size. All species also demonstrated a reduction in drag force and drag coefficient at positive pitch angles, which supports the observation that sharks maintain positive angles of attack during swimming to generate lift with the ventral body surface.

P1-26 HUBER, D.*; TRAVIS, K.; GRACE, M.; FORD, J.; DECKER, S.; The University of Tampa, California State University Long Beach, National Oceanic and Atmospheric Administration, University of South Florida; *dhuber@ut.edu*

Structural Mechanics of Cookie Cutter Shark Jaws

Sharks exhibit a wide array of feeding mechanisms, behaviors, and ecologies, among which the cookie cutter sharks (Isistius spp.) are rather unique. Their semi-circular, scoop-shaped lower jaw bears teeth fused into a saw blade, which is used to excise circular flesh plugs from large fishes and marine mammals via longitudinal rotation of the body. To identify the extent to which these unique anatomical attributes facilitate their unique feeding niche, Finite Element (FE) models of the jaws of the large tooth cookie cutter shark *Isistius plutodus* and spiny dogfish *Squalus acanthias* were developed from CT scans; the spiny dogfish represents a generalized shark feeding mechanism for comparison. Models for both species were then virtually manipulated to represent all possible character states, resulting in 7 models per species (jaws, jaws + fused/unfused functional teeth, jaws + fused/unfused replacement teeth, jaws + fused/unfused functional teeth + fused/unfused replacement teeth). FE simulations were run to determine jaw performance during normal biting (i.e., forces applied perpendicular to the jaw surface) and rotational biting (i.e., forces applied parallel to the jaw surface), and jaw stress and strain energy were determined. Preliminary analyses for the cookie cutter shark indicate that jaw stress and strain energy are 1) lower during rotational biting than during normal biting, and 2) lower when fused functional and replacement teeth are present, suggesting structural adaptation for the unique feeding niche occupied by this shark.

P1-276 HUIE, JM*; SUMMERS, AP; KOLMANN, MA; University of Washington, George Washington University; *jmhuie@uw.edu*
Body shape and feeding morphology explain ecological differences in riverine herbivorous fishes
Herbivorous fishes may feed on any combination of stems, leaves, flowers, seeds, fruits, and nuts of diverse aquatic plants, as well as algae. In the Neotropics, most pacus, the herbivorous cousins of piranhas, eat a combination of these plant constituents, which vary in their accessibility, material, and nutritional quality. Additionally, pacu diets fluctuate across ontogeny, and with seasonality and flowering demography of their prey. Several species of pacus are phytophagous, a curious kind of herbivore that feeds almost exclusively on Podostemaceae, or riverweed plants, which only occur in rapids, a challenging environment for fishes to live in. The degree to which pacus feed on riverweed varies from obligate year-round consumption to strictly seasonal and facultative feeding. Obligate phytophages feed heavily on riverweed and occur in the rapids, while facultative phytophages only consume riverweed during seasons with low flow. Does ecological specialization (diet) beget morphological specialization in the feeding apparatus of phytophages? We used micro-computed tomography (μCT) scanning to compare functional feeding traits among 24 species of serrasalmids, 3 of them obligate phytophages. We also compared body shape between pacus using geometric morphometrics to identify potential locomotor adaptations for rheophily. Obligate phytophages don't have distinct jaw mechanics from more generalized herbivores, but they do have the dentition and slicing jaw action more suited to shearing fleshy plant material than other pacus, which have jaws built for crushing seeds. Unrelated obligate phytophages are also converging on similar body shapes that are distinct from sympatric herbivores. Phytophagy involves more drastic changes to body shape than to feeding morphology, suggesting that body shape has equally important ties to diet as feeding morphology.

P1-178 HUMFELD, SC*; GERHARDT, HC; SARAH, Humfel; University of Missouri; *humfelds@missouri.edu*
Perceptual biases and the evolution of acoustic signals with multiple elements
The acoustic advertisement signals of many animals comprise a single sound repeated in a monotonous fashion. Multi-element signals, in which sounds with different acoustic parameters are produced closely together in time, are observed in a wide diversity of species across taxonomic groups. While increasing signal complexity may communicate greater information content, it is unclear what factors might effect the evolution of increasing signal complexity. In this study, we tested the hypothesis that acoustic preferences exhibited by females during mate-choice might constrain the evolution of increased call complexity. In a species where males produce only simple trilled calls (*Hyla versicolor*), we presented females with a choice between a natural, single-element call and an artificial, two-element signal. Artificial signals were generated by appending a computer-synthesized tone-burst to a normal trill. We were specifically interested in the main and interaction effects of: 1) the position of the artificial appendage relative to the trill; 2) the duration of the trill; 3) the duration of the appendage; 4) and the silent interval (SI) between the two call elements on preferences. The results of this study confirm that two-element signals with following appendages were generally attractive, but especially so when the duration of the trill is short. We observed interaction effects between the appendage position and both the SI and the duration of the appendage. In a leading position, longer appendages and appendages with a longer SI resulted in particularly unattractive multi-element calls. We conclude that receiver psychology is likely to be an important constraint on the evolution of increasing signal complexity. The generality of our results requires additional comparative studies of species with single-element signals.

P1-33 HUNG, Y-T; LIN, T-Y; SHIH, M-C; CHI, K-J*; National Chung-Hsing University, Taiwan; *kjchi@phys.nchu.edu.tw*
Functioning Mechanism and Detachment Process of the Tentacular Suckers in Cuttlefish Sepia pharaonis
Octopus and cuttlefish use muscular suckers to capture the preys; while octopus are known to generate suction force by muscle contraction, the functioning mechanism of cuttlefish suckers remains unexplored. Here we examined the suction performance and detachment process of tentacular suckers of cuttlefish *Sepia pharaonis*. Suction without muscle contraction implies a passive mechanism; pressure difference might be created by pulling the stalk. To examine the role of sucker ring, we compared suction performance with ring intact, removed, and replaced. Results suggest that the ring is critical presumably in distributing the pulling stress for better contact. However, insertion of a stiffer ring could not enhance its performance. Although intermittent leakages were observed, pressure difference still generated, implying self-sealing even with imperfect contact. On substrates of varying roughness, suction performance remains similar. Synchronous recordings of suction force, sucker deformation, and internal bubble formation during attachment-detachment process reveal that bubbles could change the force-deformation curve; because gas deforms more easily than the liquid, bubble expansion could retard pressure increase hence to prolong attachment duration. This study demonstrates the functioning mechanisms of tentacular suckers of cuttlefish. The identified mechanical features fit their predation strategy for capturing fast-moving preys. Unlike artificial suckers, cuttlefish suckers perform well on rough, curved, or even soft surfaces, which provide insights for future bio-inspired design of underwater attachment devices.

P2-213 HUNG, A*; KENALEY, CP; Boston College; *hunga@bc.edu*
Vertebral Stiffness in Ray-finned Fishes: Contrasting Material Properties Between Swimming Modes and Body Region
The axial skeleton of fishes plays an important role in developing thrust during undulatory swimming. A considerable number of studies have focused on the established role of axial stiffness in modulating undulatory dynamics, including propulsive wavelength. Few studies, however, have addressed whether axial skeletal stiffness varies across species with different swimming styles defined by a spectrum of propulsive wavelengths. In addition, recent work in our lab indicates that propulsive wavelength increases as it passes through the fish body. In this study, we set out to (1) evaluate whether vertebral stiffness varies between species of different swimming modes including classically defined anguilliform, subcarangiform, and carangiform locomotor styles; and (2) whether vertebral stiffness contributes to the lengthening of the propulsive wave by a rostrocaudal gradient of increased stiffness. To this end, we measured the compressive stiffness of vertebrae using custom-built material-testing units along the vertebral columns of six species of teleost fishes: American eel (*Anguilla rostrate*), brook char (*Salvelinus fontinalis*), Florida pompano (*Trachinotus carolinus*), yellow perch (*Perca flavescens*), Chain Pickerel (*Esox niger*), and lookdown (*Selene vomer*). We found that the stiffness of the vertebral column increases rostrocaudally in all species and that overall vertebral stiffness is lowest is anguilliform swimmers and highest in carangiform swimmers. Taken together, these results indicate the importance of passive tissues in modulating swimming dynamics in fishes.

P3-143 HUSAK, JF*; LAILVAUX, SP; Univ of St. Thomas, Univ of New Orleans; *jerry.husak@stthomas.edu*
Is the exercise response adaptive?
Superior locomotor performance is associated with advantages in terms of male combat success, survival, and fitness in a variety of organisms. In humans, investment in increased performance via the exercise response is also associated with numerous health benefits, such as decreased incidences of metabolic syndrome, cardiovascular disease, obesity, and diabetes, and aerobic capacity is considered to be an important predictor of longevity. One of the most striking aspects of exercise physiology is how similar the response to exercise is across vertebrate animals, suggesting that the response to exercise is both ancient and adaptive. However, no studies have tested whether non-human animals that invest in increased athletic performance through exercise realize a fitness advantage in nature. Previous work with green anole lizards showed that they respond to different forms of exercise training, and that enhanced performance results in tradeoffs in other systems, such as reproduction and immnuocompetence. We released sprint-trained, endurance-trained, and untrained-control male and female green anole lizards into isolated, urban islands in New Orleans, LA, USA and monitored their survival. We predicted that training would enhance survival during the active season, but that the associated maintenance costs of training would decrease survival overwinter compared to controls. We found that sedentary controls realized a significant survivorship advantage over all time periods compared to trained lizards. Our results suggest that locomotor capacity is currently optimized to maximize survival in green anoles, and that forcing additional investment in performance moves them into a suboptimal phenotypic space relative to their current environmental demands.

P3-138 IBRAHIM, AS*; HUND, AK; STEPHENS, JQ; WICKER, VV; TSUNEKAGE, T; SAFRAN, RJ; LEVIN, II; Agnes Scott College, University of Colorado - Boulder; *aibrahim@agnesscott.edu*
The effects of sex and growth rate on variation in nestling telomere length
Offspring growth rate and sex-specific development are key components of the natal life history stage. Nestling traits and stressors during this period can have long term fitness consequences. Telomeres, which are protective non-coding caps on the ends of eukaryotic chromosomes, shorten rapidly during development due to high rates of cell division and oxidative stress. Longer telomeres have been found associated with higher survival rates and better organismal performance. We examined the effects of nestling sex and growth rate on relative telomere length in North American barn swallow (*Hirundo rustica erythrogaster*) nestlings. Our study used a cross-foster design, where half of the eggs in experimental nests were switched with synchronously-laid eggs from other nests at the start of incubation. Nine days after hatching, nestlings were measured for body size and mass, and blood samples were taken for molecular sexing, quantification of relative telomere length, and for parentage analysis using microsatellite markers. At day twelve, morphological measurements were repeated to calculate growth rate. We used quantitative PCR to estimate relative telomere length in nestlings and found that male nestlings had relatively longer telomeres compared to female nestlings. Growth rate was not related to relative telomere length in either sex.

P1-296 IDEC, JH*; FISHER, BL; Hendrix College, Conway , California Academy of Sciences, San Francisco; *idecjj@hendrix.edu*
Characterizing Color Diversity in Ants Using Databases and Image Analysis
Ants (Order Hymenoptera, Family Formicidae) are a widespread and diverse group of insects. Despite many years of research in ant ecology and evolution, the diversity of color in ants as a group has not yet been closely examined or explained. In doing so we used a dataset consisting of ~50k images from the ant specimen database AntWeb. Images of ant heads were first segmented from their backgrounds using an active contour algorithm. The RGB colors of pixels in the segmented region were averaged and assigned to that specimen. We then tested for the effects of phylogeny, caste, microhabitat, and environment on these colors. Color metrics included HSL lightness and proxies for pigment saturation devised from Euclidean distance in the HSV color space. We hypothesized that darker and more heavily pigmented ants would be found in habitats prone to higher UV exposures or colder temperatures due to the UV-shielding and heat-absorbing properties of melanin. We found that genera, primary ant castes, and ants living in different microhabitats showed statistically significant differences in lightness and pigment saturation. Despite a strong signal for color at the genus level, ants as a group showed on average decreased lightness and greater pigmentation under conditions where they would be more likely to be exposed to sunlight. Queens and males, which often mate in sun-exposed locations, were darker on average than workers. Ants collected from trees were also darker than those from the litter or underground. Caste and microhabitat effects compared between genera and possible global effects of UV and temperature are still under investigation at the time of writing.

P1-148 IRWIN, SJ*; SANGER, TJ; JOHNSON, MA; Trinity University, San Antonio, Loyola University, Chicago, Trinity University, San Antonio ; *sirwin@trinity.edu*
Social and Exploratory Behaviors Of Thermally-Stressed Lizard Hatchlings
The temperature at which vertebrate eggs are incubated can significantly alter the phenotype and behavior of the juveniles. More specifically, increases in incubation temperature as small as a few degrees can result in malformations of the skull and changes in brain morphology. This pattern has been observed in multiple vertebrate species. While previous studies have shown that aspects of cognition are altered by differences in incubation temperature, especially in ectotherms, we do not yet know how temperature-related changes in morphology may be associated with animal social behavior. In this study, we performed a series of behavioral trials on *Anolis sagrei* (the Cuban brown anole) hatchlings from eggs incubated at standard (27° C) and elevated (34° C) temperatures to determine how incubation temperature affects interactions with conspecifics, predators, and prey. We also measured the extent to which these lizards explore novel objects and novel environments. Our data suggest that hatchlings exposed to embryonic heat stress are both less exploratory and less aggressive than hatchlings from eggs incubated at standard temperatures. By quantifying how changes in the thermal environment of embryos are associated with post-hatching behaviors, we contribute to a growing understanding of how embryonic heat stress may impact the ecology of animals in a warming world.

P1-86 IVANINA, AV*; SOKOLOVA, IM; University of North Carolina at Charlotte, Charlotte, NC, USA , Department of Marine Biology, University of Rostock, Rostock, Germany; *aivanina@uncc.edu*

Effects of salinity on cellular energy budget of biomineralizing tissues of marine bivalves

Shell provides mechanical support and protection from predators and environmental stressors. The mantle edge (ME) and hemocytes (HCs) play a major role in molluscan shell formation, and this process is an energetically demanding. The aim of this study was to determine whether energy costs of biomineralization increase under the conditions unfavorable for $CaCO_3$ deposition and if so, which cellular functions might be responsible for that. Two species with different shell mineralogy (*Crassostrea gigas* and *Mercenaria mercenaria*) were exposed for 2 weeks to 3 salinities (30, 18 or 10) and cellular energy demand for protein synthesis, bicarbonate turnover, Ca^{2+} transport, and H^+ transport was measured in ME cells and HCs. In clams' ME, the energy demand was similar for the 4 studied cellular processes. Acclimation of clams to 10 PSU led to allocation of energy into the protein synthesis and bicarbonate production. The energy allocation of the oysters' ME and HCs into the 4 studied cellular processes was balanced at salinity 30 PSU, whereas at 18 PSU an energy flux was diverted to the protein synthesis and H^+ transport. Acclimation to 10 PSU led to major decrease of energy demand for all 4 cellular processes in oyster HCs. In the oysters' ME energy allocation into the studied cellular processes at 10 PSU was similar to that at 30 PSU. Our data indicate that energy cost of biomineralization in M. mercenaria and C.gigas have different sensitivity to low salinity. In oysters, the energy costs of biomineralization-related functions of HCs and ME cells were highly affected by lowest salinity, where in clams the energy costs for biomineralization were robust to all tested experimental conditions.

P3-153 IYENGAR, EV; Muhlenberg College; *iyengar@muhlenberg.edu*

As the world warms: Hydration status of a native (Ariolimax columbianus) and invasive (Arion rufus) slug in the temperate rainforest

The recent pattern of replacement of populations of the native banana slug (*Ariolimax columbianus*) by the invasive terrestrial slug *Arion rufus* on San Juan Island, Washington state, USA, may be due to differences in susceptibility to desiccation rather than direct competition. While both species are poikilotherms, the native species is endemic, so it is likely even more sensitive to environmental changes. Recent years have been aberrantly hot and less humid. Field collections examining the level of hydration of different subpopulations of these two species indicated some small differences. However, in general both the hydration levels and the evaporation response of the two species of slugs to maintenance at different temperatures was surprisingly similar, and elevating maintenance temperature by 10oC did not necessarily increase the amount of evaporation. Therefore, it appears unlikely that physiological differences in susceptibility to desiccation are the main factors driving the recent differences in population dynamics. Alternative hypotheses, such as competition for food or shelter, should be investigated.

P1-213 JACKSON, JL*; SLOAT, SA; ROCKMAN, MV; New York University; *mrockman@nyu.edu*

Caenorhabditis nematode diversity in a neotropical rainforest

Caenorhabditis nematodes are abundant, globally distributed animals. Although *C. elegans* is one of the best studied organisms in biology, basic features of *Caenorhabditis* biodiversity and biogeography are poorly characterized. We isolated nematodes from more than 300 substrates (rotting fruit and flowers) collected on Barro Colorado Island, Panama, to discover the baseline characteristics of the local *Caenorhabditis* fauna. We identified *Caenorhabditis* worms morphologically and performed experimental mating tests with known strains in the laboratory to determine species identities. The majority of isolates were *C. briggsae* and *C. tropicalis,* two species with androdioecious mating systems (males and hermaphrodites). These two species are globally distributed. The remaining isolates belong to three species of *Caenorhabditis* with gonochoristic mating systems (males and females). Two of these, *C. becei* and *C. panamensis,* are known only from Panama. Species were not restricted to particular substrate types. Our results are consistent with emerging patterns in *Caenorhabditis* biogeography, which show that androdioecious species are cosmopolitan while gonochoristic species often have narrow geographic distributions.

P2-245 JACQUEMETTON, CP*; BIRD, DJ; VAN VALKENBURGH, B; University of California, Los Angeles; *cjacquem@ucla.edu*

Cribriform plate shape in domestic dogs is heavily influenced by cranial shape

The relationship between humans and domestic dogs has dramatically changed in the ~20,000 years since their domestication. In the past 500 years, domestic dogs have increasingly become the focus of intense artificial selection, leading to extreme variation in skull shape. Selection for snout length has been particularly intense, with some dogs having long slender snouts (many sighthounds), and others having almost no snout at all (pugs). This likely has impacts on structures within the snout, such as those related to olfactory ability including the cribriform plate. Using CT scans from over 40 dog breeds, we reconstructed the cribriform plate using Materialise 3-D rendering software and then applied geometric morphometrics to quantify how cribriform plate shape varies among breeds. The overall shape of the cribriform plate across domestic dogs varies greatly, and closely maps the overall shape of the snout. In dog breeds with thin elongate snouts, the cribriform plate is long and narrow, much like a vase, whereas in dogs with shortened snouts, the cribriform plate resembles more of a shallow, broad dish. While dog breeders have not selected for alterations to the shape of the cribriform plate, the intense selection for extreme skull shapes in a relatively short period of time has greatly modified the shape of the cribriform plate.

P3-156 JAMAL, FA*; KOWALEWSKI , MJ; PAULAY, G; University of Florida; *fjamal@ufl.edu*

Pinnotherid Crabs and Their Sand Dollar Hosts, Eastern Gulf of Mexico

The genera *Dissodactylus* and *Clypeasterophilus* (Family: Pinnotheridae, Phylum Arthropoda) are commensal or parasitic crabs that live in association with irregular sea urchins (Class Echinoidea, Phylum Echinodermata). The association of pinnotherid crabs on sand dollars was studied off of Steinhatchee, FL, in the eastern part of Gulf of Mexico during 2017 and 2018. A total of 18 sites were sampled by scuba, including repeated sampling of 2 sites. Each sand dollar along with its crabs was collected in a separate Ziploc bag while scuba diving. Sand dollars were identified to species level and body size was estimated in terms of maximum body length and body width. Morphological and molecular approaches were employed to identify species of crabs. The number of crabs found on each sand dollar, maximum carapace width, maximum carapace length and sex were also noted. A total of 606 echinoids hosting 1322 crabs were collected. The analytical results indicate that three molecularly distinct pinnotherid crab species (*Clypeasterophilus stebbingi*, *Dissodactylus latus*, *Dissodactylus mellitae*) were associated with five species of sand dollars. Distribution of crabs suggests host species preference. In contrast, pea crabs infested echinoid hosts across a wide range of size classes. Collectively, the mean burden (number of crabs per sand dollar) was 2.18 (including uninfested hosts), with individual burden varying from zero to sixteen crabs per host specimen. Male to female sex ratio was 1.16:1. Some sand dollars were heavily infested (59.74%-96.6%) and *Mellita tenuis* being the least infested host (37.3%).

P2-5 JARAMILLO, AM*; KOVAL, MK; RODRIGUEZ, KM; SANCHEZ, AM; DUNN, SR; DER, JP; BURNAFORD, JL; California State University Fullerton; *andrewjayyyy@csu.fullerton.edu*

Stayin' Alive? Assessing the ability of an intertidal seaweed to recover from repeated exposure to desiccation and high temperatures during low tide

Silvetia compressa, a canopy-forming alga, plays a vital role in rocky intertidal ecosystems as a primary producer and habitat for animals. Intertidal organisms are under seawater at high tide and exposed to terrestrial conditions at low tide. Stressors such as wind and heat during low tide can negatively affect algal physiology and subsequently biomass and canopy cover. We manipulated hydration level (values down to 17% wet mass) and body temperature (low mean = 22.79ºC, high mean = 30.49ºC) over two simulated low light low tides, and monitored the effect on biomass and maximum quantum yield (MQY: a measure of photosynthetic potential) over three days of recovery in simulated high tide conditions. At the end of the second low tide, hydration status was positively correlated with MQY in both low (r = 0.92) and high (r = 0.94) temperature treatments. Following 84 hours of recovery, biomass loss was minimal and not strongly associated with low tide temperature or desiccation and negative effects of desiccation on MQY disappeared, but on average, MQY in high temperature treatments was only 91.6% of that in low temperature treatments. Temporary MQY decreases following low tide desiccation indicate a reduced ability to produce sugar which could affect growth. Repeated exposure to warm low tides could slowly lower an individual's maximum attainable photosynthetic potential. The combination of dry and warm days could ultimately lead to a decrease in canopy cover, exposing understory organisms to harsh low tide conditions with long term effects on community structure and function.

P1-73 JASINSKI, SE; State Museum of Pennsylvania; *sejasinski@gmail.com*

Emydid turtles from the Miocene-Pliocene of the southern Appalachian Mountains and their implications for the evolution of the Emydidae

Emydid turtles (Testudines: Emydidae) are the most diverse and widespread family of turtles in the New World today. The fossil record of emydids is made up mostly of fragmentary remains from several main fossil regions, including Florida, Nebraska, and Kansas. Today the family consists of 10 to 12 extant genera and over 50 species. While the fossil record has a relatively high amount of disparity, many of the fossil taxa are fragmentary and have later been synonymized with other taxa, reinterpreted as being members of other families, or considered nomina dubia. The Gray Fossil Site, in eastern Tennessee, is a fossil locality interpreted as an ancient pond-like sinkhole from the latest Miocene-early Pliocene. The site has at least four fossil emydids including representatives of *Trachemys*, *Chrysemys*, *Terrapene*, and *Emydoidea*/*Emys*. All these turtles represent distinct species. Based on phylogenetic analyses, they show similarities with species from various geographic regions, suggesting these represent a non-analog turtle fauna. *Trachemys haugrudi* from the site is found to be closely related to fossil species from Florida. The new species of *Chrysemys* is most closely related to fossil *Chrysemys* from Nebraska, although the latter is Pleistocene in age. A new species of *Terrapene* lies outside crown *Terrapene* and near the base of the *Terrapene* clade while also being most closely related to species from the midwestern United States. The fourth, enigmatic emydid shows affinities with *Emydoidea* and *Emys*. If a member of the former genus, it would represent the southern-most extent of *Emydoidea*, modern or fossil, whose modern biogeographic range extends to central Indiana. The distinct turtle fauna at the Gray Fossil Site provides significant new information in our understanding the evolution of the emydids.

P1-44 JAVIER, JP*; PAIG-TRAN, EWM; California State University, Fullerton; *jpjavier@csu.fullerton.edu*

Filtration Along a Reticulated Mesh, Anatomy Predicts Feeding Ecology in Neonatal Whale Sharks, Rhincodon typus

The largest fish in the ocean, *Rhincodon typus* (Whale Shark), is one of three filter-feeding sharks. While a few studies have predicted the filtration mechanism used by *R. typus*, none of these studies have successfully verified this mechanism in either a live or model animal. In addition, no studies have predicted the prey selectivity in a neonatal whale shark. The objective of this study was to explore how the morphology of the filter pad separates food particles from the water. We documented the filter anatomy in neonatal whale shark specimens and calculated the freestream and transverse flow through the buccal cavity and filter pores respectively. We then created anatomically correct, scaled 3D physical models of the filter pad reticulated mesh and inserted the printed filters into a physical model of a whale shark buccal cavity. We ran a series of filtration experiments using microspheres (60 µm - 340 µm) that represent the full-size range of potential zooplankton prey. Modeling the neonatal specimen allows us the rare opportunity to study feeding mechanisms in an animal that is CITES protected and rare in aquaria. Understanding the mechanism of filtration and prey selectivity in neonatal whale sharks helps to predict their ecology and likely habitat usage in the wild.

P2-27 JAYASUNDARA, N*; KOZAL, J; MASSARSKY, A; TREVISAN, R; BLUE, M; BONE, A.J.; LINDBERG , C.D.; DI GIULIO , R.T.; Univ. of Maine, ME, Duke University, NC, Univ. of North Carolina Chapel Hill, NC; *nishad.jayasundara@maine.edu*

Later-life persistent bioenergetic effects of exposure to multiple mitochondrial stressors during development in zebrafish Danio rerio

Emerging evidence suggest that mitochondrial processes and structures are reprogrammed during vertebrate development. Developmental exposure to such stressors may alter this reprogramming process leading to persistent effects on metabolism through life. We focused on zebrafish *Danio rerio* to examine synergistic later life effects of developmental exposure to a chemical (polycyclic aromatic hydrocarbons -PAHs) and physical (temperature) stressor. We focused on temperature and PAHs since thermal fluctuations are common in many aquatic habitats and PAHs are ubiquitously present at low-levels in aquatic sediments. We evaluated effects of early-life exposures to PAH mixtures on embryonic mitochondrial integrity and function at 28ºC and 32ºC, the persistent bioenergetic effects later in life at tissue and organismal level, and the role of the aryl hydrocarbon receptor (AHR) in mediating these effects. Embryo mitochondrial function was characterized using the XFe24 Extracellular Flux Analyzer. To evaluate persistent effects, mitochondrial function in whole hearts and brains of the adult zebrafish and whole organismal swimming performance and aerobic respiration were examined. Data suggest that early-life exposure to PAH mixtures results in embryonic mtDNA damage, as well as AHR-dependent changes in mitochondrial function. Interestingly, thermal exposure had no effect on embryonic mitochondrial function, but showed altered tissue bioenergetics later in life. Overall, results indicate that low-levels of developmental exposure to multiple abiotic stressors can have persistent whole organismal metabolic effects.

P2-21 JEAN, G.H.Q.*; STEINWORTH, B; MARTINDALE, M. Q.; University of Miami, University of Florida, University of Florida ; *gxj52@miami.edu*

Oral-Aboral Axis Specification in "Upside Down Jellyfish" Cassiopea xamachana

Many decisions about the generation of the animal body plan, including axial patterning, are made in early development. However, many animals, such as the diverse group cnidarians, are capable of post-embryonic patterning (e.g. regeneration and asexual reproduction). Genetic networks coordinating embryonic axis specification are well-characterized in the sea anemone, *Nematostella vectensis*. In another cnidarian, *Cassiopea xamachana*, buds develop the oral-aboral axis at an angle to that of the parent polyp, presenting an interesting question of how this axis is established during asexual reproduction. Here we show a preliminary morphological and molecular analysis of *Cassiopea* embryonic development with the goal of characterizing the molecular basis of axis specification in sexual and asexual reproduction. Our results indicate that expression of certain genes with known involvement in *Nematostella* axial patterning are spatially restricted during the embryonic development, consistent with involvement of these genes in *Cassiopea* axial patterning. Differences in expression patterns between *Cassiopea* and *Nematostella* also suggest diverging roles for some of these genes. This study has progressed our understanding of embryonic axis specification and helps lay the groundwork for functional studies comparing embryonic development and asexual budding in *Cassiopea*.

P2-188 JEBB, KE*; YOUNG, CM; MORAN, CJ; GERRY, SP; Fairfield University, The Citadel; *kamryn.jebb@student.fairfield.edu*

Effects of Temperature on Muscle Physiology of Tautog

Understanding the impacts of temperature on ectotherm muscle is important for understanding thermal effects on whole organism performance. Much of the work to this point has been predicated on thermal acclimation of muscle via myosin isoform regulation. The duration of acclimation, however, has varied greatly in the literature. As a result, we aimed to address the effects of acclimation on fish locomotor muscle. By comparing thermally acclimated fish to fish taken and tested immediately from the wild we addressed the effects of acclimating fish to a specific thermal environment in the lab. Our study species was tautog (*Tautoga onitis*), a labrid fish found along the eastern coast of North America in waters that range from 5°C to 20°C. Locomotor muscle fiber kinetics and power output of the abductor superficialis muscle were measured in a group of tautog acclimated at 20°C and a group of tautog collected once water temperatures reached 20°C in the wild. Muscles were tested at 5°C, 10°C and 20°C. 20°C acclimated tautog locomotor muscle produced more power when tested at 5°C than the power produced by natural 20°C tautog when tested at 5°C. This finding suggests that increased exposure time to warmer waters allows tautog abductor superficialis muscles to perform better at colder temperatures. At colder temperatures, both 20°C acclimated and 20°C natural tautog showed a longer time to maximum twitch and time to relax when compared to that of warmer temperatures. This suggests that duration of acclimation did not impact muscle performance, rather, performance was effected by exposure to cold temperatures.

P1-34 JEFFRIES, L*; MATLOFF, L; FEO, T; LENTINK, D; Stanford Univeristy, Stanford University, Smithsonian Institution of Birds; *lindsiej@stanford.edu*

Overlapping Feathers Maintain Contact through Interlocking Microstructures during Wing Morphing

Flight feathers maintain a continuous aerodynamic surface during flight despite major wing shape changes. We have discovered that feather microstructures interact between two adjacent feathers when acted on by aerodynamic and wing extension forces. First, aerodynamic forces acting dorsal ventrally press overlapping feathers together. Then, as the bird extends its wings, a lateral extension force pulls the feathers apart. Feather separation is prevented by interlocking microstructures. To understand this microstructure interaction, we studied three pairs of overlapping pigeon, *Columba livia*, feathers. The rachises of each pair were attached to a 3D printed base with an anatomically accurate spacing. Feathers were interlocked by hand and 3D tomographic images of the interlocked regions were acquired using a Zeiss Xradia 520 Versa X-ray CT machine. Examination of the images revealed that the structures responsible for interlocking overlapping feathers appear to be hooked rami tips on the ventral side of the proximal feather's leading edge and friction barbules on the dorsal side of the distal feather's trailing edge. Comparison with SEM images of the same regions revealed that lobate cilia stick up and out of the barbule plane and may be the primary structures that interlock with the hooked rami tips. Further examination of this mechanism could be used to develop bioinspired fasteners.

P3-112 JIMENEZ, A.G. *; ELLIOTT, K.H.; Colgate University, McGill University; *ajimenez@colgate.edu*

Measures of oxidative stress do not vary with age in thick-billed murres (Uria lomvia)

While there is growing evidence that demographic senescence is an important feature of wild populations, there remains little consensus about any physiological mechanisms that contribute to senescence in wild animals. In birds, many systems appear to remain constant with increasing age, showing no deterioration until 'catastrophic' mortality sets in. Oxidative stress may be an important contributor to physiological senescence in wild birds because of their inherently high whole-organism metabolic rate. As a by-product of aerobic respiration, ROS (reactive oxygen species) are produced and can cause structural damage to proteins, lipids and DNA. The anti-oxidant system exists in animals to deter from rapid rates of ROS-related damage to macromolecules. As individuals age, they may accumulate oxidative damage that leads to tissue deterioration. Oxidative stress has been a debated mechanism for aging by gerontologists, ecologists and physiologists. We examined oxidative stress measurements in thick-billed murres by assessing levels of catalase (CAT), glutathione peroxidase (GPx) and superoxide dismutase (SOD) activities, and total antioxidant capacity with respect to peroxyl and hydroxyl scavenging capacity. Additionally, we measured lipid peroxidation (LPO) damage in pectoralis muscle biopsies from wild thick-billed murres aged 8 to 37 years of age (N = 41). When considered in a general linear model with body mass, body size and sex, no parameter varied with age. CAT activity increased with body size while SOD activity was higher in females. Hydroxyl scavenging capacity increased with body mass and decreased with body size. LPO damage, GPx activity and peroxyl scavenging capacity were independent of all parameters. We concluded that muscle oxidative stress levels do not vary with age in thick-billed murres, supporting the catastrophic mortality hypothesis.

P1-41 JIMINEZ, M*; MURTAGH, N; WALDROP, LD; New Mexico Institute of Mining and Technology; *magdalena.jiminez@student.nmt.edu*

Micro Particle Image and Tracking Velocimetry for Assessing Flow in the Circulatory System of Tunicates

A key process in the development of closed circulatory vasculature is flow produced by the heart, which often begins as open circulatory flow. However, flow in open circulatory systems and microvasculature is often difficult to quantify. In the past, the movements of blood cells have been used as a proxy for fluid speed inside small vessels, but recent works have demonstrated that blood-cell speeds result in underestimating flow by up to 50%. In this study, we used micro particle image velocimetry (micro PIV) and particle tracking velocimetry (PTV) to quantify fluid flow speeds in the circulatory system of the tunicate, *Ciona savignyi*. Micro PIV is a technique that uses computational algorithms to reconstruct fluid flow velocity fields based on the bulk movement of illuminated tracer particles, and PTV tracks individual particles and reconstructs velocities from their displacements. We present a comparison between two artificial tracer particles (fluorescent microspheres and fluorescent liposomes) introduced by injection and two flow reconstruction techniques with the movements of blood cells at four points within the circulatory system, including the heart.

P1-222 JOHNSON, C*; GEORGE, SB; Georgia Southern University, Statesboro, GA; *georges@georgiasouthern.edu*

Factors Affecting the Facilitative Interaction Between Cordgrass Spartina alterniflora and Ribbed Mussels Geukensia demissa in Georgia's Salt Marshes

The ribbed mussel *Geukensia demissa*, can filter the total volume of water in a salt marsh twice a day. Making the salt marsh the most invaluable natural water purification system in the world. Ribbed mussels are found on raised portions of the marsh sediment called mounds. Mounds store water, reduce soil salinity stress, have a high organic content and promote cordgrass (*Spartina alterniflora*) growth. However, salt marshes are threatened by a variety of natural and anthropogenic factors. Rising temperatures may be altering the positive effect ribbed mussels and cordgrass have on each other. The purpose of this study was to examine the relationship between these two species in a saltmarsh at Tybee Island, Georgia. At this site, cordgrass height and density vary with distance from a winding tributary off of Tybee Creek. In addition, a road cuts through the high marsh. Four mounds located in the high marsh close to the tributary and four located in the mid marsh further away from the tributary were surveyed from spring through fall 2018. *Spartina* height and density and ribbed mussel abundance were determined on each mound. Temperature was monitored by placing one temperature logger in the high marsh and another in the mid marsh. Data from loggers indicate that the number of days when temperatures were above 110°F was higher in the high marsh than the mid marsh. Despite higher temperatures and proximity to the road, cordgrass density and height, and ribbed mussel abundance in the high marsh increased significantly over time. Mean mussel abundance in the high marsh was 39 ± 2 and in the mid marsh was 27± 2. The proximity to the tidal creek may have a positive effect on cordgrass growth which in turn lowered the temperatures and provided suitable shelter for ribbed mussels.

P2-187 JOHNSON, N.J.*; BROWN, J.M.; DEAROLF, J.L.; AVERY, J.P.; Hendrix College, Conway, AR, Univ. of Alaska Fairbanks; *johnsonnj@hendrix.edu*

Effect of multi-course prenatal steroids on fiber-type profile and enzyme activity in the guinea pig rectus thoracis

When a mother is set to give birth prematurely, she is often given glucocorticoids to accelerate the development of her fetus' lungs. Despite the steroids' known effect on lung development, little is known about the effects on ventilatory muscles. We hypothesize that exposure to prenatal steroids accelerates the development of these muscles. Thus, the breathing muscles of fetuses exposed to these steroids will have fiber-type profiles and enzyme activities more similar to those of 1-day-old neonatal muscles than the muscles of control fetuses. Pregnant guinea pigs were injected with either betamethasone (0.5 mg/kg body weight - treated) or sterile water (control) at 65%, 75%, and 85% gestation, and samples of the fetal rectus thoracis (RT) muscle were collected. Sections of the treated and control RTs were cut with a cryostat and stained for their reaction to myosin heavy chain antibodies. The antibody A4951 was used to stain for type I, slow-twitch fibers, and the antibody 2F7 was used to stain for type IIA, fast-twitch oxidative glycolytic fibers. Using ImageJ software, the diameter and density of staining for 2F7 was measured for the fast-twitch fibers. To determine the glycolytic and oxidative capacities of fetal, neonatal (1-day-old), and adult RT, lactate dehydrogenase (LDH) and citrate synthase (CS) activities were measured. The LDH and CS data will hopefully allow us to draw a conclusion about enzyme activity throughout development. If the treated fetal and neonatal data are similar, it would support the hypothesis that prenatal steroids accelerate fetal breathing muscle development. Thus, premature infants exposed to prenatal steroids will be able to ventilate their lungs just as well as full term infants.

P2-41 JONES, AE*; WEBB, JF; Univ. of Rhode Island; *aubree_jones@my.uri.edu*

The Lateral Line System of Larval Brook Trout, Salvelinus fontinalis: Early Indications of Life in Flowing Water

The ecomorphology of the mechanosensory lateral line (LL) system of teleost fishes with reference to the flow regimes that they inhabit is not well understood. The canal neuromasts (CN) and superficial neuromasts (SN) of the LL system occur in varying proportions among species. Several authors have documented relatively high numbers of CNs and low numbers of SNs in adult salmonids (Order Salmoniformes), which is unusual among teleosts. Brook trout (*Salvelinus fontinalis*), a commercially important species, is routinely raised in hatcheries and are available for study. Here we describe the morphology and distribution of the cranial CNs and SNs in alevin and fry to determine when the relative numbers of CNs and SNs observed in adults are established. An ontogenetic series (0-52 days post-hatch, dph; n=13 spec.; from wild-caught parents) were prepared for SEM. Length, width, and area of presumptive CNs (PCNs) and SNs were determined. By 14 dph (yolk sac still present), PCN and SN morphologies have diverged, with larger, oval PCNs and smaller, round SNs. By 45 dph (after feeding has begun), preopercular PCNs have begun to sink into a canal groove. Multiple PCNs are also found in each of the other canal series: supraorbital (n=12), infraorbital (n=10), preopercular (n=6), and mandibular (n=8). However, only 5 lines of SNs are present on the head; SN number is relatively low, especially when compared to that in stomiiforms (another group of basal euteleosts), and otophysans (e.g., zebrafish, tetras, goldfish), which have 100's of SNs and tend to live under low flow conditions. The high number of cranial CNs may be related to their life in flowing water and the functional significance of this will be discussed.

P3-144 JULICK, C*; TENGER-TROLANDER, A; GREEN, A; KRONFORST, M; MONTOOTH, K; Univ. of Nebraska-Lincoln, Univ. of Chicago, Univ. of Michigan; *cjulick@unl.edu*

Divergence in metabolic plasticity in response to seasonal rearing conditions among migratory and non-migratory populations of monarch butterflies (Danaus plexippus)

My current research explores the divergence in metabolic plasticity in response to seasonal rearing conditions among migratory and non-migratory populations of monarch butterflies. The long migration that returns individuals to overwintering sites in Mexico is four generations removed from the individuals that migrated north during the spring and summer. This natural history predicts developmental plasticity for many aspects of flight physiology and energy allocation to enable long-distance migration in the context of a life-history strategy that requires conservation of energy to invest in reproduction after overwintering. Furthermore, not all populations migrate, allowing for population divergence in migration-associated traits. Using migratory (North American) and non-migratory (Costa Rican) populations of monarchs reared for two seasons under both non-migratory (summer) and migratory (fall) conditions, we tested the prediction that migratory populations have greater plasticity in metabolic performance in response to rearing conditions than do non-migratory populations. We find that Costa Rican populations have elevated resting metabolic rates in response to fall migratory rearing conditions. Under these same conditions, the Costa Rican population also has higher resting metabolic rates relative to the North American population. Together, these patterns indicate that North American, but not Costa Rican, populations can maintain metabolic homeostasis across seasonal rearing environments. We also find that the two populations have different metabolic scaling coefficients for their flight metabolic rate in response to fall migratory rearing conditions.

P1-32 KACZMAREK, EB*; KOLMANN, MA; GREAR, ME; SUMMERS, AP; Brown University, George Washington University, Pacific Northwest National Laboratory, University of Washington; *elskabette@gmail.com*

Thorn on my side? Form, function, and evolution of defensive weaponry in doradid catfishes

Doradid catfishes are weaponized with pectoral and dorsal fin spines with lateral rows of thorn-like barbs. These spines often reach 30% of body length and can be abducted and locked into place. The pectoral girdle, which supports the pectoral spines, has a broad ventral surface with an interdigitating median suture, in contrast to the slender ventral arms of the pectoral girdle in other teleosts. We used micro-CT scans, finite element analysis, mechanical testing, and phylogenetic comparative methods to study the morphology, function, and evolution of these defensive adaptations in doradids. The median suture is formed by a zipper-like series of projections, which differ in three-dimensional morphology from the well-documented interdigitating sutures of cranial bones. We predict this suture permits flexion under mediolateral compression. This is supported by the results of both static compression of a finite element model of a pectoral girdle and spines and by compression of the pectoral girdle using a mechanical testing system. We also tested for evolutionary integration between barb and girdle morphologies and found a strong phylogenetic signal in the morphometrics of the pectoral spines, girdle, and median suture. A phylogenetic partial least-squares regression indicated strong integration between barb and girdle morphologies overall; however, phylogenetic generalized least squares (PGLS) regressions on paired traits did not find strong relationships between suture interdigitation and either pectoral girdle or spine morphometrics. PGLS results did find strong integration between girdle width and barb cross-sectional area, suggesting that as spines get stiffer, the pectoral girdle gets broader.

P3-150 KAHN, AS*; LORD, JP; KATIJA, K; BARRY, JP; Monterey Bay Aquarium Research Institute, Moss Landing, CA, Moravian College, Bethlehem, PA, Monterey Bay Aquarium Research Institute. Moss Landing, CA; *akahn@mbari.org*

Respiration and Water Processing by Glass Sponges in Sur Ridge, a Dense, Deep-water Coral and Sponge Habitat

Benthic communities beneath the ocean's photic zone cannot rely on locally produced food as light cannot penetrate to fuel photosynthesis. Deep benthic communities thus rely mainly on imported nutrients, either as material sinking from the photic zone or arriving via lateral currents. The food that arrives is often limiting, yet in some locations, dense communities manage to persist and even flourish. Sur Ridge off the coast of Big Sur, California is such a community. This deep submarine ridge (800-1700 m) has diverse and dense communities supported in part by habitat-forming, deep-sea corals and sponges. The impact of corals and sponges as foundation species is clear, but what affects their distributions is not fully resolved. To investigate this, we focused on sponges to understand 1) their own energetic needs via metabolic rate, and 2) the effects of pumping activity on the surrounding water. We measured *in situ* respiration and activity levels, as pumping rates, using optical oxygen sensors and a novel deep particle imaging velocimetry system (DeepPIV) deployed by remotely operated vehicle. Respiration was variable between species, with some having very constant oxygen removal rates and other species with removal rates that varied even over a 5 minute span. DeepPIV revealed that the glass sponges of Sur Ridge pump many times their own body volume of water each day, with pumping rates dependent on osculum size. Given the efficient particle capture of other glass sponge species, this may indicate that dense patches of sponges at Sur Ridge can affect the overlying water column and create different microenvironments for other benthic fauna.

P3-47 KASSNER, Z*; MUIJRES, F.T; RIBAK, G; Tel Aviv university, Israel, Wageningen University & Research, The Netherlands; *zivkassner@gmail.com*

Wing kinematics during sideslip maneuvers in damselflies

Blue-tailed damselflies (*Ischnura elegans*) tend to navigate through dense vegetation and catch flying prey while aloft. To track an oscillating target, they tend to fix their body orientation in space and fly sideways. The ability to separate heading and flight direction may aid for gaze stabilization and visual tracking of objects that move over a stationary panorama. Here, we analyzed the wing kinematics during sideways flight to unveil how four-winged damselflies coordinate wing motions to achieve controlled sideslip. Free-flying damselflies were filmed chasing an artificial target that oscillated laterally 6 cm, at 2 Hz. During the sideslip maneuver (e.g., flying sideways to the left and then to the right with little changes in body yaw), the left forewing consistently reached a more mediocaudal and a higher position above the body's horizontal plane. It also had a higher flapping amplitude, compared to the contralateral forewing. Maneuvering sideways in the opposite direction resulted in a mirror-image of the above asymmetry. No significant differences were observed in wing pitch, stroke plane angle and wingbeat frequency between the four wings throughout the maneuver. We suggest that other than enhancing maneuverability, controlling the fore- and hind wing separately improves objects tracking by improving gaze stability. Our kinematic analysis shows a mechanism that damselflies use to execute a complex maneuver that we believe, enhances the ability to track moving objects. Revealing the mechanism that allows four-winged insects to produce the sideslip maneuver provides a better understanding of the evolution of insect flight apparatus. It can also aid in the design of biomimetic drones that can execute complex maneuvers without compromising visual information.

P1-245 KAWAHARA, AY*; PLOTKIN, D; MEUSEMANN, K; TOUSSAINT, EFA; ESPELAND, M; DONATH, A; FRANCE, G; FRANDSEN, P; ZWICK, A; BARBER, JR; MISOF, B; BREINHOLT, J; University of Florida, University of Freiburg, Zoologisches Forschungsmuseum Alexander Koenig, Brigham Young University, Australian National Insect Collection, Boise State University, RAPiD Genomics; *kawahara@flmnh.ufl.edu*

Evolutionary history of butterflies and moths

Butterflies and moths (Lepidoptera) are a mega-diverse order of insects with nearly 160,000 described species. They are ecologically important as pollinators, are often pests to agriculture, serve as models for many different scientific disciplines, and are key indicators of environmental change, but a robust phylogenetic framework for the order is lacking. Here we present the first comprehensive, dated evolutionary tree of butterflies and moths, which was constructed based on a dataset of 2380 orthologous loci and 25 non-redundant, carefully assessed fossils. Our results show that the origin of Lepidoptera is ~295.6 ± 17.3 Ma, considerably older than previously believed. We analyzed the dataset using different datasets and dating schemes, our results conclusively show that the majority of lepidopteran lineages diversified in the Cretaceous. We test correlations to two central co-evolutionary hypotheses, the postulated synchronized timing of Lepidoptera with angiosperms and the postulate that moth ultrasonic hearing organs originated in response to bats, in the early Paleogene. Our results reveal that angiosperm-feeding lepidopteran lineages may have originated largely in synchrony with the earliest flowering plants, but the evolution of hearing organs in Lepidoptera predates the origin of insectivorous bats. The early rise in hearing organs suggest that these morphological structures had a different function in the Cretaceous and were only later co-opted as an anti-bat strategy during the Paleogene.

P2-161 KAWARASAKI, Y*; TEETS, NM; PHILIP, BN; POTTS, LJ; GANTZ, JD; DENLINGER, DL; LEE, RE; Gustavus Adolphus College, University of Kentucky, Miami University, Hendrix College, The Ohio State University, Miami University; *ykawaras@gustavus.edu*

Characterization of Drought-Induced Rapid Cold-Hardening in the Antarctic Midge, Belgica antarctica

Survival of the Antarctic midge, *Belgica antarctica*, on the terrestrial habitats of the Antarctic Peninsula is promoted, not only by the adaptation to tolerate prolonged exposures, but also by their ability to respond to unpredictable changes in their environments. Rapid cold-hardening (RCH) describes the extremely swift acclimatory response of insect that occurs within minutes to hours. Most traditionally, the RCH response is induced by a brief exposure to mildly-low temperatures. However, a similar rapid acclimatory response can also be elicited by an exposure to drought. In this study, we characterized this drought-induced RCH response in larval *B. antarctica*. Compared to fully hydrated larvae, those desiccated at various relative humidity (R.H.) conditions for 2 h had a significantly greater survival to freezing at -14 °C by ~50%. Although the amount of water larvae lost varied between 4%-16%, all treatments were equally effective in eliciting the protective response against freezing stress, and its induction was evident within 30 min of desiccation at 85 or 0% R.H. conditions. Interestingly, the RCH protection induced by desiccation persisted after larvae were allowed to recover a significant portion of the lost water. Our results indicate that larval *B. antarctica* are highly sensitive to desiccation stress, capable of swiftly initiating physiological changes in response to a small reduction in their body water content. Supported by NSF grants PLP-1341385 and PLP-1341393.

P1-250 KAY, DI*; GIGNAC, PM; ERICKSON, GM; O'BRIEN, HD; Oklahoma State University Center for health Sciences, Florida State Univeristy; *david.kay@okstate.edu*

Using Simulation Studies to Determine Phylogenetic Effect on the Evolution of Dental Material Properties in Gnathostomes

Sample size and phylogenetic signal are important and related factors in phylogenetic comparative evolutionary analyses; however, methods for assessing minimum taxonomic resolution are currently lacking. Previously, we have measured hardness and elastic modulus values in enamel and orthodentine from a broad sample of Gnathostomata. The distribution of these values demonstrated a lack of phylogenetic signal, potentially due to small sample size given the longevity of the clade. Here we tested whether low phylogenetic signal is robust to increased sampling using paired (non-randomized and randomized) simulation studies. In the first simulation, genus-rank sister taxa of represented species were added to the phylogenetic tree and assigned simulated material properties derived from the previously measured values of their congeners. In the second simulation, added taxa were instead assigned material properties randomly from a distribution of the entire materials dataset with bootstrap resampling. Both simulations were performed for 200 iterations, from which phylogenetic signal was estimated. Analysis of the simulations identified an increase in phylogenetic signal for both hardness and elastic modulus of dental tissues at higher levels of taxonomic representation, suggesting that additional sampling is necessary to elucidate underlying evolutionary processes. Further analyses should consider the needs of robust sampling to ensure that the relationships between evolutionary relatedness, dental materials, and diets can be meaningfully addressed.

P1-120 KEER, SA*; PRADO, M; MAY, C; MCMENAMIN, S; HERNANDEZ, LP; KEER, Stepha; The George Washington University, Boston College, Boston College; *skeer@gwu.edu*

Developing a zebrafish model to investigate the role of thyroid hormone in proper mineralization of ear ossicles

Thyroid hormone plays an important role in mineralization of the skeleton throughout development and maintenance of mineralization into adulthood. Hypo- and hyperthyroidism lead to lack of mineralization and hypermineralization respectively, both of which can lead to long-term issues such as increased fracture risk and impaired functionality of bones. Indeed, hypothyroidism has been associated with anatomical defects within the middle ear of mammals, although the functional implications of these skeletal abnormalities have not been investigated. Here we use the zebrafish as a model to investigate the role of thyroid hormone in proper mineralization of several cranial features. Middle ear ossicles in mammals are derived from the hyomandibula and quadrate that support the jaws within fishes. In contrast, Weberian ossicles that characterize Ostariophysan fishes (rendering them hearing specialists) are derived from ribs and vertebral elements. Here, we investigate patterns of mineralization in both the hyomandibula and quadrate as well as the tripus, a key Weberian ossicle. These data are used in the development of a model system to evaluate morphological patterns of mineralization in both homologues of mammalian middle ear ossicles as well as ostariophysan Weberian ossicles. Functional hearing tests on these thyroid-disrupted zebrafish will ultimately be performed to determine the specific functional consequences of these improperly mineralized bones. The fact that Weberian ossicles are functionally analogous to the ossicles of the mammalian middle ear will allow us to hypothesize how mineralization defects may affect human hearing.

P2-37 KELLEY, MD; CAGLIANONE, J*; MENDONCA, MT; Auburn University; *mdk0014@auburn.edu*

Gopher tortoises behaviorally utilize UV signals in their external environment

Most chelonians are slow-moving, herbivorous vertebrates that rely on brightly colored plants to obtain their nutritious requirements. As a result, coevolution with their plant foods has been suggested as a potential cause for a trade-off between visual and olfactory acuity (i.e. influencing the ability to find food items at close vs. long range by using both color and smell). While recent studies have emphasized the chemosensory abilities of reptiles, some studies have also shown that in addition to specialized chemosensation through large olfactory bulbs & the vomeronasal organ, many reptiles may also have a 4th cone in their retina to be able to see in the ultraviolet spectrum of color as well (e.g., red-eared sliders) and behaviorally prefer UV signals. In this study, we assessed UV behavioral preference in gopher tortoises (*Gopherus polyphemus*) through the use of cardboard discs in a paired choice experiment [Treatment 1: orange disc with spectra peak between 700-850 nanometers (nm) and Treatment 2: orange disc with spectra peak between 700-850 nm and UV peak between 200-300 nm]. Because visual recognition is immediate, initial contest analysis via chi-squared analysis indicated a significant effect of first choice for the UV disc ($p=0.004$), regardless of randomized presentation to either sex. Additionally, a Poisson distribution of raw numbers of different behaviors also indicated a preference for the UV treatment ($p=0.011$). Finally, after performing a principal component analysis, principal component 1, including behaviors of sniffing, head extension, and biting/rubbing the disc, significantly differed in preference for the UV treatment ($p=0.02$), regardless of sex ($p=0.1$). This is the first study to indicate a behavioral preference for visual signals in the UV for gopher tortoises.

P2-38 KELLEY, MD*; KA, C; MENDONCA, MT; Auburn Univerisity; *mdk0014@auburn.edu*

Gopherus polyphemus behaviorally discriminate conspecific chemical cues from other environmental chemical cues

Gopher tortoises are social and have been shown to behaviorally respond to intraspecific chemical cues in their environment, discriminating potential mate-choice cues from other scents. Studies have shown that certain chemicals from chin gland secretions can elicit combat behaviors in male tortoises when placed on inanimate objects. Likewise, other studies of tortoises have shown that olfactory investigation is increased when chin gland secretions are present at burrows and that tortoises are able to recognize familiar from unfamiliar conspecifics. Yet, no study has examined social behaviors, such as head-bobbing, in gopher tortoises towards only a chemical presentation of chin gland secretions. In this study, using a paired design presenting cotton swabs of pooled male gopher tortoise chin gland secretions vs. controls (acetone & strawberry, in two separate experiments), we found that tortoises of both sexes ($p=0.68$) were 9 times more likely to sniff chin gland secretions than acetone ($p=0.0004$), and also, performed grouped behaviors (i.e., sniffing, eating, biting, & head bobbing) preferentially towards the chin gland swab ($p=0.0003$). In the second experiment using chin gland secretions vs. strawberry, we found that tortoises also discriminate between chemical cues through different head bobbing vs. nodding behavior. For example, towards the chin gland treatment, only dominant head bob displays (>10 seconds) were observed similar to courtship ($p=0.056$), whereas towards the strawberry treatment, only brief (~2 seconds) olfactory nods or head extensions ($p=0.03$) were observed. Differential head movements suggest discrimination of olfactory signals, in which chin gland cues elicit social awareness but strawberry cues only elicit olfactory awareness.

P3-39 KELSAY, TS*; SEIN, IH; DEBAN, SM; University of South Florida; *tkelsay@mail.usf.edu*

Thermal Sensitivity of Burst Swimming in Salamanders

In many biological systems, escape response affects the predator/prey dynamic. For animals in which burst speed is essential for survival, time to peak velocity is paramount. However, environmental temperature affects performance of many organismal movements. Muscle-powered movement is especially thermally sensitive in ectothermic tetrapods; therefore, acceleration of salamanders to peak velocity is expected to be significantly affected by temperature changes. Previous studies have shown, however, that some salamander species show surprisingly low thermal dependence of swimming velocity (Q_{10} ~ 1.0-1.6). We imaged several genera of salamanders swimming in a temperature-controlled basin at 7 and 17°C (±1°C) and measured time to peak velocity, peak velocity, average acceleration, as well as the frequency and amplitude of the traveling body wave. In general, thermal sensitivity of swimming acceleration and velocity were lower than that of limbed locomotion in ectothermic tetrapods that have been examined, confirming earlier studies. Frequency and amplitude of the traveling wave were significantly different across temperatures. Investigating the energetics, fluid flow and motor control of swimming would yield insight into the interestingly low temperature sensitivity that salamanders exhibit while swimming.

P1-220 KENNEDY, J/GC*; LEARY, C/J; Univ. of Mississippi; *jgkenned@go.olemiss.edu*

The role of reproductive interference and endocrine stress in the decline of native green treefrogs following Cuban treefrog invasions

Invasive species are a leading cause of global amphibian declines. In many cases, how invasive species negatively impact native amphibians is well established, but in other cases these processes remain enigmatic. For example, the introduction of Cuban treefrogs, *Osteopilus septentrionalis*, in the southeastern United States is linked to the decline of native green treefrogs, *Hyla cinerea*, but there is little evidence that predation, competitive exclusion, or transmission of pathogens are contributing factors. Here we examine how reproductive interference and endocrine stress potentially contribute to the negative impacts of invasive Cuban treefrogs on native green treefrogs. We hypothesize that reproductive interference plays a central role in the decline of native green treefrogs following Cuban treefrog invasions because the acoustic communication systems of these species overlap in a way that is predicted to stimulate chronic elevations in circulating glucocorticoids in green treefrogs. For example, male Cuban treefrogs produce advertisement calls possessing similar spectral and temporal features as the aggressive calls of male green treefrogs. Male green treefrogs produce aggressive calls during intraspecific vocal contests and hearing these calls stimulates the production of corticosterone (CORT) in vocal contest losers, which suppresses reproductive behavior. We will present preliminary data from vocal playback experiments examining how the acoustic courtship signals of Cuban treefrogs affect the endocrine physiology of native green treefrogs.

P2-281 KENNY, NJ*; RIESGO, A; The Natural History Museum, London; *n.kenny@nhm.ac.uk*

Evolution on Ice: 'Omic insights into Molecular Adaptation in Antarctic Sponges

Animals in the Antarctic seas have adapted to some of the most challenging conditions found anywhere on Earth. Temperatures ranging between 0 and -1.8°C and a food supply which fluctuates widely render their survival difficult. Nevertheless, species have found the means to thrive in such conditions. Sponges are particularly important members of Antarctic ecosystems, but to date our knowledge of how they endure these temperatures is limited at best, especially at a molecular level. We aim to identify the mechanisms by which sponges have adapted to such extreme environments by contrasting congeneric species pairs adapted to vastly differing thermal environments. These aims are being accomplished using transcriptomic and genomic sequences from genera within the Demospongiae. The chosen genera are abundant in the Antarctic, Caribbean and Mediterranean, and play essential roles in the benthic ecosystems in which they are found. Particularly, we have sequenced multiple transcriptomes from 10 target species, as well as the genomes of *Mycale acerata* and *Mycale laevis*, and are supplementing our "omic" work with targeted in situ and functional experiments. Using this data, we have performed a number of tests for selection (particularly in Hyphy/CODEML) and identified genes with multiple lines of evidence for positive selection, including a number of phylogenetically well-conserved "housekeeping" genes. We have also analyzed differential gene expression and content. With this data, we can state which genes are vital in cold conditions, and when adaptive molecular mechanisms have been used broadly, convergently, or in vastly varying ways across sponge and animal phylogeny.

P3-171 KEPAS , ME*; VIRGIN , EE; HUDSON , SB; WEBB, AC ; FRENCH , SS; Utah State University ; *megenkepas@gmail.com*

Sex Differences in the Metabolic Rates of Uta stansburiana in Relation to Oxidative Stress

The regulation of metabolism in response to environmental stressors is a crucial adaptation. Increased metabolic rate leads to mitochondrial production of reactive oxygen species. Here, we investigate the impact of metabolic rate on oxidative stress in the Common side-blotched lizard (*Uta stansburiana*) and compare sex differences in standard metabolic rate relative to oxidative stress. The metabolic rates of males and females may also differ significantly due to both differential energetic requirements and levels of metabolically active hormones. In this study, we measured resting metabolic rate and oxidative capacity in 53 male and 39 female wild-caught side-blotched lizards from St. George, UT. Oxidative capacity of individuals was calculated by combining measures of blood antioxidants (OXY) and reactive oxygen metabolites (d-ROMS). The oxidative index data were compared with standard metabolic measures of O2 intake and CO2 output in a climate-controlled environmental chamber. We also assessed the effect of reproductive investment (e.g., clutch size and stage) on oxidative capacity in females. From these comparisons we can better understand the sex-dependent role of physical stress on metabolism, as well as the oxidative costs of both reproductive investment and metabolic activity.

P2-90 KERNBACH, M.E.*; CASSONE, V.; MARTIN, L.B.; University of South Florida, University of Kentucky; *Kernbach@mail.usf.edu*

The Impact of Light Pollution on Melatonin Secretion in House Sparrows

Light pollution, or the presence of unnatural light at night, is a widespread yet understudied anthropogenic stressor. Although impacts of light pollution on wildlife have become apparent over the years, the mechanisms by which artificial light at night affects their physiology and behavior are not well understood. For example, avian reservoir species exposed to dim light at night exhibit decreased resistance to West Nile virus. The hormone melatonin (i.e. the "chemical expression of darkness") is secreted in darkness and suppressed in the presence of light. This indolamine coordinates daily rhythms within the body including metabolism and immune functions. Because melatonin plays such an integral role in coordinating these physiological functions, it remains a possibility that light pollution induced suppression of melatonin leads to maladies in wildlife. To investigate whether melatonin is suppressed by dim light at night, we exposed wild-caught house sparrows (*Passer domesticus) to ~6 lux light at night in captivity for 3 weeks and measured melatonin at 5 points throughout the night. This study emphasizes that light pollution can influence hormonal regulation and potentially mediate downstream circadian incoordination or physiological functions that lead to detrimental outcomes in wildlife.*

P1-198 KIM, GE*; ALBRIGHT, R; RITSON-WILLIAMS, R; Tufts Univserity, California Academy of Sciences, California Academy of Sceinces; *grace_e.kim@tufts.edu*

Foundational studies of Caribbean crustose coralline algae

Many coral reef restoration efforts fail to address the natural ecosystem processes necessary for the long-term persistence of reefs. Crustose coralline algae (CCA) have been shown to play many essential ecological roles on reefs including facilitating coral recruitment and contributing to reef calcification. Despite their demonstrated significance, little is known about the diversity of these algae on reefs. Understanding the systematics of CCA has largely been limited by their cryptic taxonomy which relies on specialized morphological features difficult to discern without a microscope. Here we provide an accessible morphological and molecular characterization of the Caribbean CCA, and evaluate hypotheses of CCA relationships through the phylogeny of these Caribbean species. Using the genetic marker *psbA*, we found that despite morphological similarities, *Titanoderma prototypum* is distinct from *Lithoperella atlantica*. Further, the diagnostic significance of secondary pit structures within the family Lithophylloideae (*Lithophyllum* spp. and *Titanoderma* spp.) was verified by scanning electron microscopy. We found that *psbA* was diagnostic for each species, so it can serve as a genetic barcode for Caribbean CCA and will be assembled into a database as a foundation for identifying CCA species. We will also compile these morphological details and live photographs into a guidebook that can be used by researchers to identify CCA species in the field, with the hope of furthering the study and restoration of these critical reef plants.

P2-36 KIM, J*; FUSE, M; San Francisco State University; *jenn_kim@outlook.com*

DNA methylation regulates different nociceptive responses to strong vs. mild stimuli in Manduca sexta

Nociception is the neural process that underlies responses to threatening stimuli, and is seen even in animals with the simplest of sensory systems. In a form of non-associative learning known as nociceptive sensitization, organisms respond to harmful stimuli with defensive behaviors and maintain heightened responses even in the absence of the stimuli. While the molecular mechanisms underlying nociceptive sensitization are increasingly characterized, it is unclear how conserved they are across the animal kingdom. DNA methylation (DNAm) has been shown in different species to regulate learning and memory paradigms, including nociceptive sensitization in some instances. In this study, we hypothesize that DNAm regulates nociceptive responses in the tobacco hornworm, *Manduca sexta*. We have identified putative DNAm genes in the *M. sexta* genome, and have used a behavioral assay to determine changes in the threshold force to elicit a defensive striking behavior before and after either a strong (pinch to the body wall) or mild (injection) stimulus. Vehicle-injected animals typically remain unaffected by the injection, yet become sensitized after a pinch, where subsequent testing results in a strike threshold that is significantly lower than baseline. Injecting DNAm inhibitors, RG108 and Zebularine, not only countered the decrease in threshold typically seen in sensitized animals, but also facilitated a decrease in threshold in response to the injection. These results suggest that DNAm mediates both nociceptive responses to strong stimuli and anti-nociceptive responses to mild stimuli. Methylation and bioinformatics analyses will be done to further assess these findings and identify genes that are differentially methylated in nociceptive responses.

P2-122 KIMBALL, MG*; CHRISLER, AD; GRANT, A; MALISCH, JL; St. Mary's College of Maryland, Univ. of Nevada, Reno; *mgkimball@smcm.edu*

Acute stress and glucose mobilization in Mountain Dark-eyed Juncos (Junco hyemalis)

Resource mobilization and reallocation is a major endpoint of the physiological response to acute stress. In mammals, a hyperglycemic response to acute stress is well characterized, however it is not consistently detectable in non-mammalian vertebrates. A hyperglycemic response to acute handling stress has been shown in some passerines including White-crowned Sparrows and White-throated Sparrows. Here we characterized the glycemic response to acute-handling stress in a breeding, free-living, population of Mountain Dark-eyed Juncos (*Junco hyemalis*) in Mono County, CA. Juncos were trapped in seed-baited potter traps at Tioga Pass Meadow from May 17 to June 20, 2018, coinciding with territory establishment and early nesting period. Blood samples were collected at 0, 15 and 30 min post-capture. We utilized a human blood glucose meter, FreeStyle Lite, to determine real-time glucose levels in the field, after previously validating this novel technique. Consistent with research in other sparrow species listed above, blood glucose levels were higher than baseline (time point zero) at 15 minutes (42.6% increase) and 30 minutes post-capture (66.7% increase). Additionally, predictors of glucose mobilization including: date, scaled body mass, fat score, hematocrit, sex, and bleed delay time were modeled using backward and forward stepwise regression. Analysis showed that Juncos mobilize glucose in response to acute handling stress and response is best modeled when scaled mass, hematocrit, and date are included as predictor variables. These results suggest that glucose mobilization capacity is influenced by measures of body condition including mass and hematocrit, and the response may fluctuate during the breeding season.

P1-165 KINDEL, M*; KöNIG, B; LOPES, PC; Chapman Univ., Univ. Zurich; *kinde108@mail.chapman.edu*

Can Peripheral Immunity of Healthy Animals Affect Social Behavior?

Social interactions are critical for the survival and reproduction of many organisms, but also carry costs, such as exposure to pathogens. Given the role played by the immune system in determining vulnerability to infections, could molecules from this system also serve a role in mediating exposure to pathogens by impacting variation in social behavior? We here test whether immune function in the blood may be associated with the propensity to seek social interactions (sociability). To do this, we studied a population of wild house mice (*Mus domesticus*) where social interactions were tracked remotely and we used these interaction data to categorize animals in terms of sociability. Blood, hair, brain and other tissue samples from animals with extreme sociability phenotypes were collected. We then assessed the levels of three important cytokines (TNF , IFN and IL1) in the serum of these animals and tested whether cytokine levels could be explained by the sociability phenotype and/or sex of the mice. We found main effects of sex and sociability on the levels of TNF , but not on IFN or IL1 . We discuss these findings in light of what is known about how each of these cytokines can impact behavior during illness. Our results indicate that, at baseline (or outside major disease events), certain elements of peripheral immunity may be associated with sociability. While it is known that several pro-inflammatory cytokines can impact behavior during illness, we are only now uncovering the possible effects that these immune mediators have on every day behaviors. Our findings help further our understanding of the multiple observed connections between immunity and social behavior.

P1-188 KING, T/P*; MARUSKA, K/P; Louisiana State Univ.; *tking21@lsu.edu*

Male social rank influences the immune response in an African cichlid fish

For species living in dominance hierarchies, social rank dictates access to resources and often contributes to reproductive success. To ensure survival, individuals constantly evaluate trade-offs between crucial biological systems, like the reproductive and immune systems, depending on their social rank and physiological state. Little is known about how social species balance interactions between immune system function and fluctuations in social status and reproductive fitness, particularly in fishes, the largest and most diverse group of vertebrates. Astatotilapia burtoni is ideally suited to address this question because males reversibly transition between dominant reproductively-active and subordinate reproductively-suppressed phenotypes depending on their social environment. Here, we tested the hypothesis that immune responses differ with male social rank and reproductive state. We injected males with phytohaemagglutinin (PHA), a lectin that stimulates localized inflammation, and quantified differences in the width of the caudal peduncle in response to injection. We demonstrate that subordinate males have a greater difference in the width of their caudal peduncles (pre- vs. post-injection) compared to dominant males, indicative of the recruitment of more leukocytes and a stronger immune response. Sectioned spleens also showed differences in the quantity of macrophage centers between PHA and vehicle-injected males. Using qPCR, we are also comparing expression levels of pro-inflammatory cytokines in spleen and kidney of immune-challenged dominant and subordinate males. Because little is known about how reproductive physiology influences immune responses in fishes, this research provides greater insight into how socially plastic animals balance these trade-offs, with important implications for other taxa that exist in dominance societies.

P1-162 KITTREDGE, MJ*; HAWK, A; MENG, O; LAMPARTER, M; THUL, T; PASK, G; Bucknell University; *mjk041@bucknell.edu*

PiSpy: Affordable Video Rig for Monitoring Animal Behaviors

Observations of animal behavior can be critical for many ethological questions, such as sensory responses to stimuli, locomotor activity, and eating habits. An automated system to monitor animal behaviors is a valuable tool in the field of ethology, but the cost can be prohibitive for many researchers, particularly those from low income countries. We have developed an affordable, customizable, and easy-to-use video monitoring device prototype, the PiSpy. The PiSpy platform is based on a Raspberry Pi computer and 8 megapixel Pi Camera and is designed to be able to record and monitor behaviors at any time in both light and dark conditions. To run this fully automated recording system, we developed a graphical user interface (GUI) to control each aspect of recording, such as frequency, duration, lighting control, etc. As a versatile recording device, PiSpy is able to adapt to the type of species it is monitoring, with the lights, video capture and frequency all adjustable, allowing research questions from many fields to be answered through it. Additionally, PiSpy is affordable at under $100, with many of the parts being home-made or easily attainable. We have piloted PiSpy in a range of studies such as ant tracking, beehive entrance monitoring, rat feeding behavior and locomotor activity in ground squirrels. We hope that our open-source PiSpy video recording platform, with its simplicity, adaptability and affordability, will contribute to many research advances within the biological sciences and beyond.

P1-201 KLEPAC, CN*; BARSHIS, DJ; Old Dominion University; *cklep001@odu.edu*

Physiological Evidence of Local Adaptation in the Massive Corals Porites lobata and Goniastrea retiformis from Ofu Island, American Samoa

Corals native to variable thermal environments often resist bleaching temperatures and survive exposures that typically bleach conspecifics from cooler environments; providing promising evidence for the persistence of reefs under projected global climate change. This bleaching resistance is attributed to acclimatory or adaptive conditioning to frequent sub-lethal water temperatures. Acclimatization plays an important role in modifying thermal thresholds and has been observed within 1 week and up to 2 years in Acropora corals. However, it is not known how many species are capable of thermal acclimatization. From 2015-16, populations of two massive corals, *Porites lobata* and *Goniastrea retiformis*, were transplanted from three contrasting backreefs in Ofu Island, American Samoa, into a highly variable (HV) pool known to elicit increased bleaching tolerance. Following one week, six, and twelve months, transplanted and native coral samples were exposed to a controlled acute thermal stress assay. Physiological bleaching responses - chlorophyll concentration and photosynthetic efficiency - were quantified to characterize heat stress responses. For both species, corals transplanted into the HV pool had reduced photochemistry and pigment. Variation in thermal tolerance was instead driven by native backreef, not acclimatization or genomic differences. Moreover, comparisons of HV coral growth and bleaching response data suggest trade-offs in fitness versus stress tolerance. Summer temperatures of 2016 surpassed regional records, and HV pool variability increased in magnitude, potentially reaching local stress thresholds. This study strongly contrasts previous research conducted in the Ofu pools, indicating that distinct coral species use fundamentally different strategies to respond to and resist thermal stress.

P2-177 KLINE, GE*; TIBBS, LE; JUDSON, JM; JANZEN, FJ; Iowa State University, Iowa State University ; *grkline@iastate.edu*

The Role of CIRBP in Temperature-Dependent Sex Determination in Painted Turtles

The sex of many reptile offspring is determined by the temperature at which the eggs are incubated. Still, how thermal cues are transduced to molecular signals and then to gonadal differentiation is poorly understood in species with this temperature-dependent sex determination (TSD). Recently, researchers found that the Cold-inducible RNA-binding protein (CIRBP) encoding gene is expressed differently at male- and female-inducing temperatures in the common snapping turtle (*Chelydra serpentina*), which has TSD. We examined a key SNP of the CIRBP gene in painted turtle (*Chrysemys picta*) hatchlings to see if differences in genotypes corresponded to differences in gender, as in *C. serpentina*. In the first study, the turtles were derived from eggs collected from one population and then incubated at 28 °C, which on average should yield a 1:1 sex ratio in this species. We extracted DNA from liver and ran PCR using primers designed specifically for the SNP. Of the 116 samples extracted, 84 yielded a high-quality sequence for analysis. We detected no variation in the 501 bp SNP region, although we found variation at other sites along the gene. Despite the absence of within-population variation in this SNP, we further extracted DNA from *C. picta* from distant localities with divergent climates, and still found no notable geographic differences in this SNP. Our findings suggest that the same SNP of CIRBP does not play identical roles in TSD of *C. picta* and *C. serpentina*. Even so, the remainder of the 5437 bp CIRBP gene has yet to be sequenced and analyzed, therefore this gene may still be important in the molecular biology of TSD in *C. picta*.

P1-58 KO, DD*; LIN, H-T; Imperial College London; *dsk13@ic.ac.uk*

The Role of Head Roll during Dragonfly Visual Guidance

Dragonflies are impressive aerial hunters, accurately catching their prey in chases that last less than a second. Their success hinges on not only their excellent vision but also careful positioning of their eyes relative to their bodies and their targets to efficiently extract relevant information for guidance. This general visuomotor technique is a form of active vision. Dragonflies steer their eyes with the head precisely in both conspecific pursuits and prey interceptions. This active head rotation results in a specific projection of the prey image on the retina and therefore shapes the motion statistics the visual system perceives. This project aims to analyse this head motion as the dragonfly transition from cruising flight, to prey interception and then conspecific chases. Specifically, we focus on the head roll axis which ultimately sets the visual reference frame for processing motion information. We will introduce preliminary data and analysis on the head roll with respect to target positioning and velocity in in both free-flight and tethered experiments. Active vision holds multiple advantages over traditional fixed image acquisition techniques, as although visual data holds a great amount of information, this comes at the cost of expensive computation. By tactically shaping the visual input signal, the dragonfly can inspire efficient approach to autonomous visual guidance.

P2-219 KOLMANN, MA*; IRISH, F; HERNANDEZ, LP; George Washington University, Moravian College; *mkolmann@gmail.com*

Muscled Up and Sutured Down: Cranial Musculature & Feeding Mechanics in Piranhas and Pacus

The serrasalmid fishes, pacus and piranhas, exhibit considerable dietary diversity, feeding on fins, scales, and whole fishes to the seeds, fruits, and leaves of aquatic and terrestrial plants. These prey span both an ecological and a biomaterials continuum, from tough plant fibers and silicated matrices to the chitin, muscle, bone, and sinew of animal prey. Serrasalmids feed on such prey using jaws with only a few degrees of freedom; essentially the jaws are constrained to only dorso-ventral abduction/adduction. Compared to other bony fishes, serrasalmids have fused most of their cranial skeleton together, resulting in an akinetic skull with with little obvious proclivity for jaw protrusion. How can such a 'simple' skeletal arrangement result in such dietary diversity? We describe the gross anatomy of the feeding morphology and infer functional themes across the serrasalmid fishes using both manual dissection and contrast-enhanced μCT scanning. We document hidden myological complexity in serrasalmids, stemming in particular from the divergence in lever mechanics between herbivorous pacus and carnivorous piranhas. Piranhas in particular seem constrained in cranial space, jaw adductors appear to have displaced branchial musculature posteriorly. Pacus and piranhas feature different arrangements, fiber architecture, and hypertrophy of select adductor mandibulae divisions, we suspect as a means of augmenting jaw leverage for different occlusal regimes. These occlusal modes presumably relate to gape limitation incurred by different prey: granivorous and frugivorous pacus feed on large, ovoid prey items while piranhas are frequently gouging chunks of flesh, fins, or scales from prey.

P3-79 KOLONIN, AM; CALVILLO, PA*; ASPBURY, AS; GABOR, CR; Texas State University; *a_k282@txstate.edu*

Land Use Conversion Affects Stress and Life-History of Stream Fish

Human-induced habitat alteration from land use conversion is one of the main drivers of decreased biodiversity and health in freshwater ecosystems. Urbanized environments produce run-off that introduces pollutants and alters water temperature, chemistry, and hydrology which can affect the physiological stress response of resident fishes by elevating or dysregulating their primary stress hormone, cortisol. The stress response is an important and energetically costly hormone-mediated mechanism that allows organisms to adjust their behavioral, physiological, and life-history phenotypes in response to environmental disturbances. However, prolonged stress can become maladaptive and lead to long term suppression of growth, reproduction, and immune function, thereby directly influencing population declines. Some species of fish are able to persist despite environmental challenges and stressors while other are not. We explored the consequences of land use conversion on baseline cortisol release rates, stress response (to agitation), and life history plasticity of the common mosquitofish, *Gambusia affinis*, which persist in urbanized habitats while other fish perish. We sampled two urban and two rural streams (defined by % impervious cover) within geographical proximity. We found that *G. affinis*, in urban populations, has significantly elevated baseline and agitation cortisol levels compared to rural populations. Further, urban populations of *G. affinis* had higher reproductive allotment (RA: dry brood mass). There was also a significant positive relationship between RA and cortisol. Our findings suggest that *G. affinis* behave as opportunistic adaptors and are able to modulate their reproductive output in lower quality streams.

P1-280 KOLUCH, MP*; BURTON, K; OHRENBERGER, J; FARINA, S; GIDMARK, NJ; Knox College, Univ. of New Hampshire, Howard University; *mpkoluch@knox.edu*

Biomechanical and histological explorations of bendable tooth attachments in goosefish

Teeth are diverse in their morphology and function among fishes to accommodate a variety of feeding and prey capture strategies. Fully formed teeth typically require rigid attachments to the jaws, but attachments for developing teeth must be mobile to accommodate growth. Therefore teeth are typically non-functional while developing and only become functional once they become fixed ("ankylosed") to the jaw. Goosefish (*Lophius americanus*) have some ankylosed teeth along the labial rim of the jaw but also have a large proportion of half-developed teeth, which are attached only on the lingual side by a ligament. This provides a hinging mechanism that allows the teeth to bend freely to allow prey into the mouth, while the ligament locks the teeth in place labially to prevent prey from leaving the mouth. We used a lever motor and high-speed video to test resistance to bending of both tooth types (ankylosed and hinged) in both lingual and labial directions. The hinged teeth bend more than 90 degrees in the lingual direction with little force (less than 1 Newton), whereas almost no bending (less than 10 degrees) is seen with high forces (above 8 Newtons) in the labial direction. Ankylosed teeth bent little in either direction. We also examined this ligament histologically via paraffin embedding and generalilzed contrast stain. This ligament is composed entirely of collagen (with no elastin), suggesting that the ligament is inelastic. This study demonstrates functional utility during multiple phases of tooth development in goosefish.

P3-96 KOROTASZ, AM*; BRYAN, AL; Savannah River Ecology Lab; *korotasz@mail.usf.edu*
Accumulation of ^{137}Cs by Carnivorous Aquatic Macrophytes (Utricularia spp.) on the Savannah River Site
Plants are an important mode of transfer of contaminants from sediments into food webs. In aquatic ecosystems, contaminant uptake by macrophytes can vary by path of nutrient uptake (roots vs. absorption from water column). Carnivorous plants likely have additional exposure through consumption of small aquatic organisms. This study expanded on previous research suggesting that bladderworts (Genus *Utricularia*) accumulate radiocesium (^{137}Cs) and examined for (1) a potential association between sediment and plant concentrations and (2) differences in ^{137}Cs accumulation among rooted and free floating *Utricularia* species. A strong correlation was found between average ^{137}Cs concentrations in all *Utricularia* species (combined) and sediments ($r_s = 0.9$, $p = 0.0374$). Among three bladderwort species at common sites, *Utricularia floridana*, the only rooted species, had higher mean ^{137}Cs concentrations than *Utricularia purpurea*, and *U. purpurea* had a greater mean ^{137}Cs concentration than *Utricularia inflata*.

P3-77 KOTNOUR, JL*; GLOVER, M; MBUYU, N; MCPEEK, S; WRIGHT, NA; Kenyon College; *kotnourj@kenyon.edu*
Interactions of life history traits and locomotion investment across the avian tree
Across the avian tree, species drastically differ in their locomotion style, particularly the extent to which they invest in flight vs. terrestrial locomotion. Bird species are equally as varied in their life histories. We investigated how this investment impacts a species' life history across five life history traits: rate of development, nest type, flight style, body size, and main method of obtaining food. The diagonal length of the sternal keel and length of the tarsometatarsus were used to quantify the investment in forelimb and hindlimb locomotion, respectively. We measured the long bones and keels of over 2,000 individuals from museum collections, representing the majority of avian families and all major branches of the avian tree. We employed phylogenetic generalized linear models to explore the coevolutionary relationship between flight investment and life history traits. We found the relative investment of forelimbs to hindlimbs was predicted by life history. A species' investment in their locomotion was well predicted with their primary mode of obtaining food; species that obtained food primarily through ground and arboreal foraging tended to have lower flight investment.

P2-186 KRAJNIAK, K.G.*; TEPEN, Z; SWANSON, N; Southern Illinois University Edwardsville; *kkrajni@siue.edu*
The response of the Isolated Earthworm Crop-Gizzard to the Annelid Oxytocin Related Peptide, Lumbricus1
Oxytocin and related peptides are present in animals from most phyla including Annelida. In the earthworm *Eisenia fetida* annetocin excites the isolated crop-gizzard. Our lab showed that this peptide and other oxytocin related peptides also stimulated the crop-gizzard of *Lumbricus terrestris*. Two oxytocin related peptides are predicted in the genes of the earthworm of *Lumbricus rubellus*, Lumbricus 1 and 2. Therefore, we tested Lumbricus 1 on the crop-gizzard of the related species *L. terrestris*. The crop-gizzard was removed from the animal, placed in a tissue bath filled with earthworm saline, and attached to a force transducer, which was connected to a computer using Iworx software to record the contractions. Increasing concentrations of peptide were injected into the tissue bath and the resulting changes in contraction rate and amplitude were used to create log-concentration response curves. Lumbricus 1 may cause an increase in contraction rate and a biphasic response in contraction amplitude. Of the nine trials, five showed an increase in rate with Lumbricus 1, however the variability of the data led to large standard error bars when graphing the average response. The contraction amplitude data exhibited too much variability between each trial to determine any effect. Throughout each of the trials, a biphasic response was observed, but no persistent nature was seen between them. Since oxytocin was excitatory on all preparations tested in the past, we are currently challenging the same crop-gizzard preparations with alternating, increasing doses of oxytocin and Lumbricus 1. This regimen should clarify the effects of Lumbricus 1 on the isolated earthworm crop-gizzard.

P2-196 KRINOS, AI*; MEDINA, DM; HUGHEY, MC; WALKE, JB; GAJEWSKI, Z; SARMENT, LS; BELDEN, LK; Virginia Tech, Virginia Tech / Vassar College, Virginia Tech / Eastern Washington University, Virginia Tech / University of Michigan; *akrinos@vt.edu*
An evaluation of the predictive potential of gene sequences for antifungal capacity of amphibian skin bacterial isolates
Recently, amphibian skin bacteria have been isolated and sequenced as part of an initiative to develop probiotic-based approaches to mitigate infection by the pathogenic fungus Batrachochytrium dendrobatidis (Bd) in wild amphibians. Bioinformatics is increasingly used to infer the inhibitory ability of bacteria based on short-read amplicon data (~250 bp of the 16S rRNA gene) by matching these sequences to a database of Bd-inhibitory isolates. However, anti-fungal predictions made solely via sequence-based similarity are rarely validated. Here, we matched sequences of the bacterial 16S rRNA gene of 22 isolates from the skin of two endangered Atelopus frog species to sequences in the database, and used the database to predict the anti-Bd ability of each isolate. We then performed in vitro challenge assays to determine whether the isolates behaved as predicted. We found that the database only predicted the outcome of the challenge assays for 55% of the isolates, suggesting a fair amount of uncertainty in using sequence matching to assign anti-Bd properties of amphibian skin bacteria without actual challenge assay data.

P2-64 KROHMER, RW; ALCALA, DM*; Saint Xavier University; *krohmer@sxu.edu*

Colocalization of Aromatase and Nitric Oxide Immunoreactive Neurons in the Forebrain of the Male Red-Sided Garter Snake

Nitric oxide (NO) first identified as an endogenous regulator of blood vessel tone, may also serve as a neurotransmitter. With a half-life of less than five seconds, NO has been examined by assessing the presence of enzymes responsible for the formation of NO. The NO producing enzyme, reduced nicotinamide dinucleotide phosphate-diaphorase (NADPH-d) is broadly distributed in the mammalian and avian brain, particularly in steroid-sensitive areas implicated in the control of reproductive behavior. In addition, distribution of NADPH-d corresponds to areas with dense populations of cells containing the aromatase enzyme (ARO). Previously, we found aromatase immunoreactive (ARO-ir) cells to occur at all levels of the male red-sided garter snake (RSGS) brain. However, cells containing the highest concentration of ARO-ir were concentrated in regions classically associated with the control of courtship behavior and mating. In the current study, we examined the anatomical relationship between ARO and NO by labelling ARO-ir and NADPH-d (NO-ir) cells. The distribution of ARO-ir cells was similar to that reported by Krohmer et al (2002) with NO-ir cells significantly overlapping the ARO-ir cells in regions critical for the control of courtship behavior, such as the preoptic area, bed nucleus of the stria terminalis, nucleus sphericus, hypothalamus, and septum. Tissues double labelled for ARO and NADPH-d revealed a possible co-localization of these enzymes within the same cell subset. Based on these data, the close association of ARO-ir and NO-ir cells suggest input from NO-positive neurons may modulate the expression or activity of ARO in the male red-sided garter snake brain.

P3-4 KUKAJ, A.*; ESCALANTE, G.; ELLERS, O.; DICKINSON, P.; JOHNSON, A. S.; Bowdoin College; *akukaj@bowdoin.edu*

Force-velocity relationships in cardiac muscles of the American lobster, Homarus americanus

Crustacean hearts provide a comparatively simple model for understanding the mechanics of heart function. As with all hearts, the work done by the lobster heart creates pressure that circulates blood, or hemolymph, throughout the body. The ability of the heart to do work depends on heartbeat frequency and amplitude. When tissues need more energy, the heart can increase the volume being pumped into and out of the heart by increasing these variables. Such functional changes can alter the stretch imposed on the heart by elastic pulls and pressure changes during contraction and relaxation, which, in effect, alter the length of the intrinsic muscles of the heart. Similarly, increases in frequency will alter the velocity at which the heart changes length. We assessed the characteristic length-tension and force-velocity relationships of the lobster heart and quantified how these relationships change with increased inotropy as induced by SGRNFLRFamide (SGRN), an endogenous neuropeptide in *H. americanus*. We found that (1) the lobster heart length-tension curves fit the general pattern observed for cardiac length-tension curves from other species in that the active force generated by the muscle increases up to a point with increasing muscle length, (2) the lobster heart force-velocity curve resembles the iconic curve in that contractility of the heart increases as lengthening velocity increases and decreases as shortening velocity increases, (3) SGRN shifts the length-tension curve up, thereby increasing heart contractility, and (4) SGRN decreases the effect of velocity on force during both lengthening and shortening of the heart. These relationships among tension, length and velocity and neuromodulators such as SGRN enable flexibility in the heart's response to cardiac demand.

P2-57 KUNSELMAN, LF*; SANCHEZ, N; KINGSTON, AC; SPEISER, DI; Univ. of South Carolina; *lfk@email.sc.edu*

Characterizing the Optic Lobes of the Florida Fighting Conch Strombus alatus

Conch (Gastropoda: Strombidae) possess strikingly large and complex eyes for a gastropod mollusc. The presence of relatively complex eyes suggests that the neural structures associated with visual processing in conch may also be more complex than those observed in other gastropods, which tend to have relatively small eyes or no eyes at all. In this study, the optic lobes of the Florida fighting conch *Strombus alatus* were characterized using ethyl gallate as a neurohistological stain. Brains were harvested and fixed overnight in 2% glutaraldehyde, 1% paraformaldehyde, and 0.16 M cacodylate buffer. Following fixation, the brains were immersed in osmium tetroxide for several hours and transferred to a saturated ethyl gallate solution for two more hours. The conch brains were then sectioned, and photographs of the sections were used to create 3-D reconstructions of the brains. The optic lobes of *S. alatus* appear to be larger and more complex than those of other gastropods. In the future, the tracing of optic nerves with fluorescent lipophilic dyes will be utilized to more fully describe how the photoreceptors in the eyes project to the optic lobes of *S. alatus*.

P2-26 KVISTAD, L*; AMOS, N; AUSTIN, L; FALK, S; GAN, HM; LOW, G; MORALES, H; PAVLOVA, A; STIER, A; WALTERS, J; SUNNUCKS, P; Monash University, Deakin University, University of Gothenburg, University of Glasgow; *lynna.kvistad@monash.edu*

Neo-Sex Chromosomes May Drive Mitonuclear Selection in the Eastern Yellow Robin

Mitonuclear interactions may be drivers of climate adaptation and lineage divergence. The Eastern Yellow Robin (EYR) shows 6.8% mitogenome sequence divergence between inland and coastal populations. This variation correlates with climatic factors, suggesting possible metabolic local adaptation. Differentiation of the nuclear genomes of populations that bear different mitolineages is heterogeneous for markers mapped to a Zebra Finch (ZF) reference genome; it is particularly strong for a 15.4 MB region mapping to ZF autosome 1A that contains an overrepresentation of nuclear genes (32) with mitochondrial functions. In the hybrid zone of the two mitolineage-bearing EYR populations, differentiation in this 15.4 MB region is strong between females and virtually absent in males. To investigate this, 10x whole genome resequencing data for 100 birds were mapped to a draft EYR genome. The 32 mitonuclear genes from the 15.4 MB region were then mapped to two kinds of EYR scaffold: one limited to females, and one seen in both sexes but with half the read-depth in females than males. This supports the hypothesis that 15.4 MB region may be inherited as a neo-W chromosome with corresponding neo-Z. Neo-sex chromosomes may be overlooked by assuming synteny to a reference. The inferred neo-sex chromosome architecture presents a candidate explanation for the female-limited selection previously indicated in EYR. These ideas are being tested by comparative genomics, measurements of mitochondrial and whole-bird respiration, and fitness estimates.

P1-268 LABATCH, NR*; POWELL, CL; LANDBERG, T; Arcadia University ; *nlabatch@arcadia.edu*

Effects of ontogeny and sexual dimorphism on jump performance in the Cave Cricket (Ceuthophilus spp.)

Sexual dimorphism often results in different relationships between morphology and performance for males and females. Increased loads associated with reproductive investment often hinder female locomotor behavior. However, sexual selection could help compensate for increased loads and reduced escape performance by increasing the length and mechanical advantage of limbs. We tested this hypothesis in Cave (aka Camel) Crickets (*Ceuthophilus* spp.) and predicted that cave cricket females would have longer legs than males for a given body size in order to allow for increased load during reproductive cycles without decreased escape performance. We simulated predator attacks and measured average jump distance in 120 individuals. As predicted, females were heavier for a given total length when compared to males and juveniles (ANCOVA; p=0.0339) and have longer legs for a given total length than males and juveniles (ANCOVA; P=0.0048). Females, males, and juveniles all jumped similar distances for their leg length (ANCOVA; p=0.7877). Our results suggest that sexual selection on jump performance in cave crickets has increased female leg length to compensate for reproductive load. This provides support for the differential equilibrium hypothesis which posits that sexually dimorphic life history strategies are caused by unique environmental pressures in male and female Orthoptera. Since female orthopterans are often larger than males, leg length may be under selection in other species with similar morphological constraints on morphology and escape performance.

P1-255 LAFOND, JC*; SAVAGE, AE; University of Central Florida; *lafondj@knights.ucf.edu*

Why won't Bullfrogs Die? A Study of Host Tolerance to Deadly, Fungal Pathogen

The fungal pathogen *Batrachochytrium dendrobatidis* (*Bd*) has caused population declines and extinctions in hundreds of amphibian species globally. The American bullfrog (*Rana catesbeiana*) has been implicated as a vector species responsible for the global spread of *Bd*, however little is known about the genetic mechanism behind pathogen tolerance in this species. Many amphibian species experience natural selection acting on the Major Histocompatibility Complex (MHC) class II gene, a vertebrate immune gene that binds to foreign antigen proteins, facilitating T-cell recognition, and subsequent acquired immune response. Here we compared populations of *R. catesbeiana* with other well-studied populations to determine if MHC class II polymorphism could be responsible for the widespread tolerance to *Bd* expressed by *R. catesbeiana*. We collected genetic samples from three populations of the American bullfrog from across its North American range. We also collected samples of the lowland leopard frog (*Rana yavapaiensis*), a species with intermediate *Bd* susceptibility that varies among populations. *R. yavapaiensis* samples were taken from two populations; one population that had developed tolerance to *Bd* via MHC class II, and another that had not. We amplified, and sequenced MHC class II genes from all populations, and quantified the number of beneficial alleles shared between species. The proportion of MHC class II beneficial alleles was determined in each *R. catesbeiana* population and was compared against the proportions found in the tolerant and non-tolerant populations of *R. yavapaiensis*. Determining if phenotypically divergent species evolve the same way in response to disease remains an important question for amphibian conservation. Our study aims to broaden our understanding of the immunogenetic evolution of species that appear to be ubiquitously tolerant to *Bd*.

P1-262 LAGGAN , N.A.*; JOYCE, L.; MCMAHON, T.A.; The University of Tampa, University of Montana; *Nicholelaggan@gmail.com*

Exploring the infection dynamics of Batrachochytrium dendrobatidis and soil nematodes: A host parasite system

Batrachochytrium dendrobatidis (Bd) has caused the mass decline of hundreds of species globally; posing a serious threat to biodiversity, ecosystem health and stability. Most of the research on this topic has focused on Bd and amphibian interactions because of the severe devastation in frog populations, but Bd has been found in other non-amphibian hosts (e.g. crayfish and soil nematodes) as well. Understanding the host-parasite interaction between Bd and its non-amphibian hosts is essential for understanding the dynamics in the wild, developing applicable epidemiological models, and functional management plans. In this experiment, we examined the interaction between soil nematodes (*Caenorhabditis elegans*) and Bd. We exposed soil nematodes to Bd on agar dishes with no other food resources and maintained these organisms for up to several weeks, photographing each adult nematode daily to document the infection dynamic. Nematodes were exposed to Bd and E. coli in an agar plate and the proportion of nematodes that moved to each food resource was documented. Bd exposure did not alter adult nematode length throughout the infection ($^2_1$= 0.43, p = 0.51), but did increase vulva bulging ($^2_1$= 5.18, p = 0.02). Bd zoosporangia emerged from the nematode body through the vulva and Bd infection reduced nematode movement over time ($^2_1$= 8.95, p = 0.003). We also saw nematodes moved towards Bd as a food resource. These results indicate that Bd impacts both nematode survival and mobility. Bd may impact nematode survival in the wild, but further research is required to understand the full extent of these infection dynamics.

P1-244 LAMON, K. D.*; WILLIAMS, G. C.; Louisiana State University, Baton Rouge, California Academy of Sciences, San Francisco; *klamon3@lsu.edu*

Molecular Phylogenetics of Pacific Basin Octocorals — from Deep-Sea California to Pacific Coral Reefs

Corals are vital to many marine environments that depend on their diversity to sustain other marine organisms. Of the coral classes, Octocorallia is the most diverse, housing over half of all coral species diversity, but little is known of their phylogenetic relationships. Our objective for this study was to build a phylogeny for Pacific Basin octocoral families to understand their evolutionary relations. We sampled octocorals found in the deep-sea California waters and Pacific coral reefs as these regions contain a high abundance of octocoral species. We first surveyed the morphological diversity of sclerites, the skeletal scale-like components of corals, through scanning electron microscopy (SEM). We then used Sanger methods to sequence the ND6, ND2, and msh1 genes of 16 octocorals from a range of different families. Sequences were then aligned and concatenated within Mesquite and then used to build Bayesian and maximum likelihood trees. The topography and bootstrap values of these trees strongly suggest the order Pennatulacea and family Ellisellidae, which is placed in the suborder Calcaxonia, are sister taxa. We conclude that the designation of Pennatulacea as a separate order does not reflect evolutionary history and that the pennatulacean axis was likely derived from a calcaxonian ancestor. Future directions would include the addition of more samples from Ellisellidae and Pennatulacea to determine whether the support for our hypothesis remains strong. Our analysis would also benefit from a thorough comparison of the morphology of Pennatulacea and Ellisellidae. On a broader scale, sampling more species from other octocoral groups (scleraxonians, alcyoniinans, and holaxonians) could result in findings of other paraphyletic taxa within Octocorallia.

P1-109 LANE, S.J.*; LINKOUS, C.R.; BREWER, V.; SEWALL, K.B. ; Virginia Polytechnic Institute and State University, New Mexico State University ; *samjl89@vt.edu*

Female Aggression in Song Sparrows is Higher in Urban Habitats

Urban adapters are animals that are able to live in human-impacted areas, such as suburbs and cities. It has been hypothesized that urban adapters have behavioral phenotypes that permit them to persist in these human-impacted environments. Indeed, song sparrows (*Melospiza melodia*) live and breed in both urban and rural habitats and previous research has shown that urban males of this species show greater territorial aggression. However, little attention has been given to female behavior across urban and rural habitats. To determine if living in human-impacted habitats is associated with elevated aggression in female song sparrows, we simulated the intrusion of a conspecific female onto the social territory of focal females at two rural and two urban study sites in Blacksburg, VA. Specifically, we placed a model bird within 5 to 10 m of the focal bird's nest and played one of 6 exemplars of previously recorded female vocalizations. For 3 minutes without the model and 6 minutes after the model was exposed, we measured the focal female's distance from the speaker and the number of chitters, chets, growls, and buzzes produced by the female as a measure of aggression. We found that female song sparrows nesting in urban habitats were more likely to respond to a simulated female intruder and showed a greater behavioral response to conspecific intrusions than did females in rural habitats. This pattern of greater female aggression in urban habitats parallels previous reports of greater territorial aggression in males and raises the hypothesis that resource competition may be higher in urban environments, driving increased territorial aggression in both sexes of song sparrows.

P2-19 LANZA, AR*; SEAVER, EC; University of Florida, 1989; *alexislanza@gmail.com*

Insights into the role of TGF- superfamily signaling in annelid dorsal-ventral axis formation

TGF- superfamily signaling regulates a variety of developmental processes and has a conserved role in patterning the dorsal-ventral body axis. Within this signaling family, there are two distinct branches: the Activin/Nodal pathway and the BMP pathway. Recent studies in some spiralian species have suggested that BMPs play a crucial role in dorsal-ventral axis patterning. Here, we investigate patterning of the dorsal-ventral axis in annelids. Previous pharmacological inhibition studies in the annelid *Capitella teleta* suggests that signaling via the ALK4/5/7 receptor patterns the dorsal-ventral axis, implicating the Activin/Nodal pathway. In this study, we further determine the mechanism of the Activin/Nodal pathway as it functions in *C. teleta* axis patterning, as well as the role of TGF- superfamily signaling in the more basally branching annelid, *Chaetopterus variopedatus*. In *C. teleta* embryos we utilize antisense Morpholino Oligos that target SMAD2/3, a pathway specific component, and then score larvae for phenotypic analyses. Secondly, early cleavage stage embryos of *Chaetopterus* were exposed to various chemical inhibitors, raised to larval stages, and scored for axial anomalies. Similarities between *Chaetopterus* and *C. teleta* are revealed as chemical interference with the Activin/Nodal pathway but not the BMP pathway results in larvae that lack detectable dorsal-ventral axes. Furthermore, our results suggest TGF- superfamily signaling functions differently in annelids than in their spiralian counterparts, the mollusks. Comparative analysis using *C. teleta* and *Chaetopterus* sheds light on the mechanism of TGF- signaling and the ancestral state of annelid dorsal ventral axis patterning, thus contributing to our understanding of how changes in developmental programs lead to evolution of spiralian body plans.

P2-200 LAROCHE, R. A.*; BENEDICT, C.; TITUS, B. M.; RODRIGUEZ, E.; MEYER, C.; University of Houston, Auburn University, American Museum of Natural History, American Museum of Natural History, National Museum of Natural History; *rasl850148@gmail.com*

First Characterization of the Clownfish-Hosting Sea Anemones Microbiome Across Host and Habitat

The relationship between clownfish and sea anemones is, arguably, the most recognizable example of symbiosis on the planet. The relationship stems from the ability of the clownfish symbionts to live with immunity among the otherwise lethal tentacles of sea anemones. It is broadly understood that this immunity stems from the interplay between the mucus coating covering the clownfish and the mucus coating produced by the sea anemone. These mucus layers, containing important microbial communities and metabolic compounds, serve as the interface of the entire symbiosis. Although the taxonomic and functional diversity of the microbiome within these layers may shed light on the emergence and health of this symbiosis, it remains entirely uncharacterized. Here we use high-throughput 16s amplicon sequencing to characterize the microbiome of host anemones *Entacmaea quadricolor, Heteractis magnifica, Stichodactyla mertensii, Heteractis aurora*, and *Cryptodnedrum adhaesivum* from the Maldives. We further explore the taxonomic and functional diversity of the *H. magnifica* microbiome from anemones sampled on atoll fore reef communities that host clownfish symbionts and those from shallow (1m depth) reef channel anemones that do not host fish. This study provides the first glimpse into the taxonomic and functional diversity of the microbiome of the clownfish sea anemones.

P2-192 LARSON, A M*; KANATOUS, S B; Colorado State University, Fort Collins; *spashley@rams.colostate.edu*

Temporal Examination of Myoglobin and Myosin Heavy Chain Expression Patterns in Skeletal Muscle Cells

Myoglobin is a hemoprotein that is involved in oxygen storage and transport, a nitric oxide and reactive oxygen species scavenger, and has shown interactions suggesting a role in cellular lipid transport. Typically, myoglobin expression follows an established slow muscle fiber type. These slow muscle fibers contain a protein called myosin heavy chain I and are found in endurance muscles. Interestingly, recent evidence has shown a change in myoglobin expression without a change in fiber type. This indicates that myoglobin expression is not always fiber type dependent and could be expressed through alternate mechanisms. Our lab has shown that mixed lipid supplements elevate myoglobin levels in cells from terrestrial and marine mammals, but it is unknown how these supplements affect myoglobin expression relative to the fiber type of the cultured tissue. To investigate, we have cultured and differentiated C2C12 myoblasts in the presence and absence of lipid. Cells were then harvested each day after differentiation initiation. Western blots were conducted to ascertain the expression of myoglobin and myosin heavy chain I and assayed for functional myoglobin content. With these methods, we have found myoglobin expression prior to that of myosin heavy chain I. This could indicate that there are pathways to myoglobin expression independent from fiber type expression. Examination of alternate routes of myoglobin expression that are not reliant on fiber type establishment could yield potential therapeutic benefits to combat ischemic diseases seen in humans.

P2-283 LARTER, M*; DUNBAR-WALLIS, A; BERARDI, A E; SMITH, S D; University of Colorado, Boulder, University of Bern, Switzerland; *maximilien.larter@gmail.com*

Evolution of floral pigmentation and regulation of the anthocyanin pathway in Iochrominae

Anthocyanins are the main class of pigments found in flowers, and are largely responsible for determining floral hue and color intensity. Even over relatively short evolutionary timescales, radical changes in flower pigmentation have occurred in many plant genera. However, the genetic mechanisms underlying these changes at the species level are generally unknown. It is thought that because of pleiotropic effects, the core genes of the pathway are unlikely to suffer deleterious mutations, preserving the vital roles of the pathway products in other tissues. This suggests an important role for regulatory changes in the evolution of floral pigmentation. We use HPLC to identify and quantify floral products of the anthocyanin pathway, and qPCR to measure gene expression of 7 core genes of the pathway, in 28 species (3 individuals per species) of the Iochrominae clade (Solanaceae). We found that complete losses of floral anthocyanins are convergently due to down-expression of three late genes of the pathway. We are currently using transcriptomics to identify the regulatory elements responsible for these changes in a subset of species. Additionally, we aim to further our understanding of the control of metabolic flux through the pathway, i.e. which genes are reducing or increasing the total amount of pathway products, and the ratio of products, for example anthocyanins vs. flavonols.

P2-16 LASLO, M; JUST, J*; ANGELINI, DR; Harvard University, Colby College; *jjust@colby.edu*

Beyond D. melanogaster: Insect Sex Determination in the Large Milkweed Bug

The determination of a sex phenotype is a fundamental process in the development of sexually dimorphic organisms. Despite the ubiquity of sexually dimorphic animals, sex determination pathways vary greatly among them, indicating their subjectivity to evolution. However, little is known about their molecular and genetic details in most organisms other than mammals and *Drosophila melanogaster*. Hence, the heteropteran *Oncopeltus fasciatus* provides a novel model organism to the study of sex determination in insects. *O. fasciatus* has three orthologs of *doublesex (dsx)*, the master regulator of sex determination in *D. melanogaster*, as well as single copies of other genes acting in fruit fly sex determination, such as *intersex (ix)*. In *D. melanogaster* and many other insects, *dsx* regulates sexually dimorphic development via alternative splicing. RNAi of single orthologs in *O. fasciatus* do not alter sex determination, indicating potentially redundant functions of the orthologs. RNAi knockdowns of *ix* produce intersex phenotypes, demonstrating the factor's crucial role in wildtype sex. We are conducting triple- and double-knockdowns of the *dsx* orthologs to further investigate the role of *dsx* in the sex determination of *O. fasciatus* as well as the potential redundant function of the three orthologs. Additionally, we are interested in the role that alternative splicing of *dsx* and *ix* plays in the sex determination of *O. fasciatus* and are conducting qRT-PCR analyses to investigate the presence of sex-, age-, and tissue-specific splicing isoforms. Our results will provide new detailed insights into the sex determination pathway of an under-studied but species-rich group of organisms.

P3-137 LATTANZIO, M; Christopher Newport Univ.; *matthew.lattanzio@cnu.edu*

Parallel Patterns of Climate-Mediated Spatial and Temporal Morph Turnover in a Color Polymorphic Species

The evolution and maintenance of color polymorphisms inferred to represent alternative mating tactics are most often studied within the framework of sexual selection theory. Indeed, morphs typically diverge in key factors tied to reproductive success such as social dominance, mate access, and territory quality. However, this emphasis limits our appreciation of the range of other parameters capable of influencing the evolution of color polymorphic systems. For example, in some lizards, heterogeneous morph spatial dispersion patterns occur that suggest a link between morph occupancy and local climatic regimes occurs as well. I capitalized on a long-term dataset on male ornate tree lizards (*Urosaurus ornatus*) to test the hypothesis that color morphs linked to alternative mating tactics also diverge in environmental tolerances. Males were scored visually as expressing one or two of the three putative color alleles (o, b, y), and climate data were obtained for each locality-year combination. My findings reveal allele-specific patterns of climate-mediated turnover over a seven-year period that are remarkably congruent with allele occupancy patterns across 56 localities spread through a broad portion of the species' geographic range. Specifically, blue alleles were most strongly associated with wetter and cooler years/habitats, and orange alleles were more likely to occur in hotter and drier years/habitats. In contrast, yellow alleles exhibited no clear climate associations in either dataset. Collectively, these findings support that the underlying physiological differences among competing morphs influence their relative survival across an environmental gradient as well as their mating success. In a broader sense, the joint effects of these processes could serve to enhance a polymorphic species' capacity to persist in lieu of environmental change.

P1-128 LAVIN, SR*; WHEATON, CJ; MYLNICZENKO, ND; Disney's Animal Kingdom, Orlando, FL; *shana.lavin@disney.com*

Is a GnRH Vaccine an Effective Contraception Method in Zoo-Managed Mammals?

Effective contraception plays a critical role in collection plans for zoo species. Permanent methods to control reproduction often are not suitable options, and short-term contraceptive efforts (e.g., synthetic progestins) have proved challenging. A promising alternative method for use in both sexes is a gonadotropin-releasing hormone (GnRH) immunocontraceptive vaccine. This vaccine has been used successfully for population control in a variety of wild and domestic mammalian species. We tested the efficacy of the GnRH vaccine GonaCon™: USDA in Nile hippopotamuses, (n=2 , 1) or Improvest®: Zoetis US in red river hogs (n=2), large flying foxes (n=12), Nubian goat (n=1), warthogs (n=2), and reticulated giraffe (n=1). Animals were injected subcutaneously 1-3 times with the vaccine using empirical doses. Serial injections were separated by at least four weeks. Before and after vaccine administration, we measured fecal testosterone and progesterone in males and females, respectively, using enzyme immunoassays. Results were highly variable depending on species and/or course of treatment. For example, treatment was effective in all species tested with the exception of warthogs and giraffe. Bats were suppressed but had negative vaccine reactions following a single injection of the vaccine. All other species required multiple doses to suppress patterns of gonadal steroids. GnRH vaccines have potential for contraceptive treatment in zoo mammals. Health and hormone monitoring, however, is needed in species previously untested to assess safety, efficacy, reversibility, and the need for booster injections.

P3-12 LAVINE, M.D.; HAYES, A.M. *; ZINNA, R.S.; GOTOH, H.; EMLEN, D.J.; LAVINE, L.C.; Washington State University, Mars Hill University, Hokkaido University, University of Montana; *abigail.hayes@wsu.edu*

Uncoupling horn growth from body size in the Asian rhinoceros beetle

The Asian rhinoceros beetle *Trypoxylus dichotomus*) represents one of the best examples of exaggerated trait growth. Males of this species have extraordinarily large head horns with respect to body size, which they use in male-male competition for access to females. These horns grow out of scale to body size so that large males have horns much larger than would be expected based on their overall body size. We have previously found that the insulin receptor mediates the exaggerated growth of these sexually dimorphic, condition-dependent horns but does not account for horn allometry. Here we use RNAi to examine the role of other genes that function in horn growth. We have identified several genes, both from the insulin-signaling and other pathways, that appear to be involved both in overall horn growth, and more specifically in mediating the scaling of horn length to overall body size.

P1-37 LAW, CJ*; DURAN, E; HUNG, N; RICHARDS, E; SANTILLAN, I; MEHTA, R; Univ. of California, Santa Cruz; *cjlaw@ucsc.edu*

Cranial shape differences do not translate to bite force differences between musteloids with distinct dietary ecologies

Size and shape are often considered important variables that lead to variation in performance. In studies of feeding, size-corrected metrics of the skull are often used as proxies of biting performance; however, few studies have examined the relationship between cranial shape in it's entirety and estimated bite force across species and how dietary ecologies may affect these variables differently. Here, we used geometric morphometric and phylogenetic comparative approaches to examine relationships between cranial morphology and estimated bite force in the carnivoran clade Musteloidea. We found a strong relationship between cranial size and estimated bite force but did not find a significant relationship between cranial shape and size-corrected estimated bite force. Many-to-one mapping of form to function may explain this pattern because a variety of evolutionary shape changes rather than a single shape change may have contributed to an increase in relative biting ability. We also found that dietary ecologies influenced cranial shape evolution but did not influence cranial size nor size-corrected bite force evolution. While musteloids with different diets exhibit variation in cranial shapes, they have similar estimated bite forces suggesting that other feeding performance metrics and potentially non-feeding traits are also important contributors to cranial evolution. We postulate that axial and appendicular adaptations and the interesting feeding behaviors reported for species within this group also facilitate different dietary ecologies between species. Future work integrating cranial, axial, and appendicular form and function with behavioral observations will reveal further insights in the evolution of dietary ecologies and other ecological variables.

P2-123 LAZENBY-CHOI, M*; RUBIN, AR; WADA, H; Auburn University; *mpl0011@auburn.edu*

Effects of Incubation Temperatures on Beak Coloration Development in Zebra Finches

Developmental environment can have a strong influence on phenotype of offspring. In birds, embryonic development is a crucial life history stage with incubation temperature playing a large role in determining individual phenotype. Incubating parents will modify their incubation behavior depending on their body condition and ambient temperature by exposing eggs to suboptimal temperatures. Many studies have assessed the effects of constant suboptimal incubation temperatures on phenotype, but little is known about how fluctuating incubation temperatures alter offspring phenotype. Similarly, only few studies have investigated long-term effect of incubation temperature on fitness-related measures. One fitness related trait in birds is beak coloration, a secondary sex characteristic that indicates health condition and influences successful mating for both males and females, which varies with age and sex. Here, we assessed how periodic cooling during embryonic development influences the development of beak coloration as zebra finches (*Taeniopygia guttata*) reach sexual maturity. Embryos were incubated at one of the three temperature regimes; constantly low (36.4°C), periodic temperature (average 36.4°C), and control (37.4°C) temperatures. The hue, intensity, and saturation of the beak color was then recorded every 15 days from post hatch day 45 to 90. In *T. guttata*, juveniles have dark black beaks which become bright red in males or bright orange in females. Differences in the rate of development of this coloration between treatments, and between sexes within a treatment may indicate sex specific responses to suboptimal incubation temperatures.

P2-48 LE, DA*; COOK, TA; BUSCHBECK, EK; University of Cincinnati, Wayne State University School of Medicine, Detroit; *le2da@mail.uc.edu*

Extended electroretinogram (ERG) analysis to probe for genetically induced photoreceptor deficiencies in Drosophila melanogaster

Extracellular electroretinograms (ERGs), which measure the neuronal response of the retina to light stimuli, have been widely used to examine proper functioning of photoreceptors. ERGs have shown deficiencies resulting from the knockdowns of the gliogenic transcription factor *pros* in *Drosophila melanogaster* Semper cells, which are eye-intrinsic glial cells that reside adjacent to the photoreceptors. In contrast, Semper-cell specific knockdown of the transcription factor *dPax2* showed no deficiency, even though histologic analysis revealed highly disrupted eye morphology in such flies. In the preceding study, ERGs were measured in response to individual light pulses. Here, we developed two additional extensive light stimulation protocols: the "flicker fusion frequency" test and the "extended sequence" test. In the former test, flickering light stimuli of different frequencies were presented until we found the "fusion frequency" for which photoreceptors respond to the flickering pulses as if they were one prolonged pulse. In the "extended sequence" protocol, multiple repetitions of short light pulses were presented over several minutes to evaluate if photoreceptors were able to sustain consistent responses. Using these protocols, we revealed that Semper-cell knockdowns of *dPax2* showed a significant weakening of responses to later-presented light stimuli in the extended sequence. Our evidence suggests that photoreceptors in these knockdowns may not be able to maintain efficient energy supply from their associated Semper cells, and hence proper *dPax2* function also appears to play a role in homeostatic support for the photoreceptors. Our findings highlight the importance of characterizing physiological performance under a variety of different stimulus protocols.

P1-88 LEBENZON, JE*; MOHAMMAD, L; MATHERS, KE; TURNBULL, KF; STAPLES, JF; SINCLAIR, BJ; Western University, London, Canada, Univ. of Calgary, Calgary, Canada; *jlebenzo@uwo.ca*

Burning Down the Powerhouse: Does Mitophagy Drive Metabolic Suppression During Diapause in the Colorado Potato Beetle (Leptinotarsa decemlineata)?

Temperate insects spend over half their lives overwintering, during which most enter diapause; a pre-programmed state of developmental arrest. One of the most consistent physiological changes associated with diapause is metabolic suppression. All diapausing insects suppress their metabolic rates, but we have a limited understanding of what drives this metabolic suppression. Some insects degrade their muscles during the winter, however we do not know the extent to which this degradation contributes to metabolic suppression, especially at the mitochondrial level. In this study, we investigated the physiological mechanisms that drive metabolic suppression during diapause in the Colorado potato beetle (CPB), which suppress their metabolic rate by ~88% during diapause. We found that there is a gradual suppression of mitochondrial respiration rate as CPB enter diapause, and those in diapause have virtually undetectable respiration rates. This is, in part, driven by the breakdown of mitochondria in flight muscle, which we confirmed using MitoTracker staining, transmission electron microscopy, and citrate synthase enzyme assays. Furthermore, diapausing CPB show increased expression of *parkin* (a kinase involved in tagging mitochondria for removal), decreased expression of *atg5* (an autophagy-related protein involved in later stages of mitochondrial removal), and no change in mitochondrial biogenesis gene expression. These results suggest that mitochondria are tagged, but not fully disposed of during diapause in CPB, resulting in a decrease in functional mitochondria and suppressed metabolism. This study will help contribute to our understanding of how insects regulate mitochondrial abundance and function, and provide new insights into the mechanisms underlying diapause and metabolic suppression.

P2-91 LEFAUVE, MK*; HERNANDEZ, LP; George Washington University; *mlefauve@gwu.edu*

Invasive Correlated Behavioral Traits in Cypriniform Fish

Behavioral syndrome is a suite of correlated behaviors that are expressed within a given context (or across contexts) as correlations between activity levels and boldness in foraging and anti-predator contexts. Assessments of behavioral syndrome have suggested that some of these correlated behavioral traits such as boldness and activity, allow for comparisons in these traits between species in similar contexts. A species' ability to invade novel habitats could be linked to some of these flexible correlated behaviors. This study looked at behavioral syndrome in fish species considered to be invasive or potentially invasive and species not considered to be invasive to determine if there is indeed a behavioral syndrome which appropriately characterizes "invasiveness". Using validated tasks such as shelter latency and scototaxis, we determined species' boldness in complex environments, exploratory behavior, latency to explore a novel environment, and activity in both a novel and familiar environment. Preliminary data suggests that species that are noninvasive are more active in a familiar environment ($p<0.01$) but seem to be less exploratory when in a novel or fearful environment ($p<0.05$). These results suggest that there are a series of correlated behavioral traits that can aid in invasion of novel ecosystems by fish species. While several studies have investigated morphological and physiological adaptations associated with invasive species, relatively few studies have examined the behavioral syndromes that may characterize these dangerous species.

P2-263 LENARD, A*; PEREZ, A; DIAMOND, SE; Case Western Reserve University; *angie.lenard17@gmail.com*

Urban nighttime-biased warming alters growth and developmental trajectories throughout ontogeny in a cosmopolitan butterfly species

It is well established that mean temperatures are rising; however, rates of warming are not equal spatially or temporally. Cities create "urban heat islands" and the pattern of diel warming is often asymmetrical. Rises in nighttime temperatures contribute more to mean temperature change than rises in daytime temperatures. However, the biological consequences of such nighttime-biased warming are largely unknown. In this study, we examined how nighttime-biased warming affects the growth and development of painted lady caterpillars (*Vanessa cardui*), a widespread butterfly species, throughout ontogeny. We reared animals under one of six diurnally fluctuating temperature treatments: three treatments represented typical diurnal fluctuations in summer temperatures, including an average day, a warm day, and a cool day; the three remaining treatments modified these diurnal fluctuations such that the warming was biased towards the nighttime, but with comparable daytime temperatures. We also compared the effects of these fluctuating temperature treatments against chronic warming treatments with the same mean temperature. We recorded the body mass of caterpillars at each larval instar, at metamorphosis (pupation), and upon eclosion as adults, and we recorded the development time (in days) to each developmental stage. Our results indicate consistent acceleration of development time under nighttime-biased warming regimes; however, the effect of nighttime-biased warming on body mass throughout ontogeny was more idiosyncratic.

P3-141 LENGA, SH*; CIRINO, LA; MILLER, CW; University of Florida; *sarah.h.lenga@ufl.edu*

Effects of Autotomy on Sperm Depletion in Narnia femorata

The classical understanding of male reproductive costs may overestimate male reproductive resource capacity. Understanding the limits of male reproduction helps us understand the selection pressures on male reproductive phenotypes and how these phenotypes may persist in a population. There is evidence to suggest that *Narnia femorata* may suffer from sperm depletion. Furthermore, the loss, or autotomy, of a hind leg weapon during the juvenile stage of an *N. femorata* promotes the growth of larger testes. The objective of this study was to understand the extent to which sperm depletion is occurring in *N. femorata* and if enlargement of the testes through autotomy mitigated this depletion. I addressed these objectives by quantifying hatching success from females mated with virgin and multiply mated males that either had or had not autotomized one of their hind legs during development. Preliminary analyses suggest hatchling number and hatchling success decline as the number of previous matings by males increased. We predict that autotomized males will experience a more subtle decline in hatchling number and hatching success with increased matings when compared to their intact counterparts. This study will resolve whether or not males who have lost a pre-copulatory weapon are better equipped to compete in a post-copulatory context.

P2-97 LEPIANE, K/L*; CLARK, C/J; University of California, Riverside; *klepi001@ucr.edu*

Silent flight and the hunting strategy of the Common Poorwill (Phalenoptilus nuttallii)

Common Poorwills (*Phalaenoptilus nuttallii*) are nocturnal insectivorous birds that have a sit-and-wait predation strategy. They wait for an insect to fly overhead, then fly up and catch it in their beak. *P. nuttallii* have several wing and feather features that are hypothesized to reduce their locomotion-induced sounds, aiding in silent flight. These specialized features include a velvety dorsal surface and vane fringe, both present on flight feathers. There are two hypotheses for the evolution of silent flight: prey detection and stealth. The prey detection hypothesis predicts that silent flight evolved to reduce the sounds generated by locomotion, improving a predator's ability to acoustically locate prey. The stealth hypothesis predicts silent flight evolved to help predators launch surprise attacks. The prey detection hypothesis predicts that the predator relies on auditory cues to hunt. However, *P. nuttallii* is not known to hunt acoustically and their eye morphology and hunting behavior suggest that they may be primarily visual hunters. Therefore, we hypothesize that silent flight evolved in *P. nuttallii* to aid in stealth. Silencing features may reduce ultrasound by dampening the sounds produced when two feathers rub together, allowing *P. nuttallii* to avoid detection by hearing insects while hunting. We assess hypotheses of how flying insects may detect an approaching predator, and how likely it is that silencing features present on *P. nuttallii* wings aid in a stealthy hunting strategy. We recorded *P. nuttallii* hunting in the wild with an infrared camera to quantify their feeding behavior and the behavior of their intended prey during an attack.

P2-45 LESLIE, CE*; ROSENCRANS, RF; BAZAN, NG; FARRIS, HE; Univ. of Texas, Austin, Louisiana State University School of Medicine, New Orleans; *cleslie@utexas.edu*

Hormonal Modulation of Retinal Sensitivity in a Neotropical Frog

Visual cues are often a vital part of animal communication and courtship. While a plethora of studies have focused on the role that hormones play in acoustic communication of anurans, relatively few have explored hormonal modulation of vision in these animals. Much of what we do know comes from behavioral studies, which show that a frog's hormonal state can affect both its visual behavior and mating decisions in significant ways. However, to fully understand how frogs use visual cues to make these mating decisions, we must first understand how their visual system processes these cues, and how hormones affect these processes. To do this, we performed electroretinograms (ERGs) to determine the retinal sensitivity of the túngara frog (*Physalaemus pustulosus*), a neotropical species whose mating behavior includes previously described visual cues. We performed ERGs for both scotopic and photopic conditions. Tested frogs were either non-reproductive or hormone-treated with human chorionic gonadotropin (HCG) prior to testing to determine the effect of hormonal state on visual sensitivity.We found that both sexes display higher visual sensitivity under scotopic conditions compared to photopic conditions. In addition, hormone injections significantly increased visual sensitivity of females under scotopic conditions. These results not only support behavioral findings regarding visually-guided behavior in this species, but also serve as a starting point for elucidating the mechanism of hormonal modulation of visual sensitivity.

P2-44 LEVENDOSKY, MW*; BEDORE, CN; Georgia Southern Univeristy, Georgia Southern University; *ml06458@georgiasouthern.edu*

Bioelectric potentials of shark prey are independent of body size

Elasmobranchs use electroreception to localize prey at short distances. While this sensory system has been well studied, the methods by which prey bioelectric fields are generated and the voltage and frequency characteristics of the bioelectric fields are less studied. Additionally, electroreception literature often states that prey body size is positively correlated with voltage, however, there is a complete lack of empirical evidence supporting this claim. Therefore, the goal of this study is to survey bioelectric potential strength across a range of sizes (length and mass) of invertebrate, teleost, and elasmobranch species. As previously reported teleosts possessed stronger electric potentials (361 ± 83.5 μV) than both elasmobranchs (99.7 ± 1.6 μV) and invertebrates (44.9 ± 8.0 μV), which is likely related to different osmoregulatory strategies used by these groups. Within each of these groups, there was no relationship with length/width or mass. However, among elasmobranchs batoids tended to have larger electric potentials than sharks. This difference may be attributed to the physical flow of water and the ions within it, or as a result of physiological osmoregulation that occurs at the gills. Therefore, future work will examine electric potentials within the context of these physical and morphological features (water volume, flow rate and gill surface area) of the respiratory organs.

P3-151 LEVY, O*; NORONHA, C; TELEMECO, RS; ANGILLETTA, MJ; Tel Aviv University, Tel Aviv, Israel, Federal University of Goias, Jatai, Brazil, California State University, Fresno, CA, Arizona State University, Tempe, AZ; *levyofi@gmail.com*

Metabolic Depression During Winter Could Mitigate Impacts of Climate Change on lizards

The impacts of climate change have been extensively studied in lizards. However, most studies have explored how warming may affect the potential for activity and subsequent growth and reproduction, while climate change may also affect overwintering lizards. In particular, although lizards may be able to begin activity and reproduction earlier under a warming climate, warmer winters will raise energy demands, increasing the risk of starvation and decreasing surplus energy for growth or reproduction. To better understand the energy demands of lizards during winter, we tested whether thermal acclimation of metabolism enables animals to save energy using a widespread group of lizards from the *Sceloporus undulatus* complex. In the lab, lizards from four populations were exposed to either a constant 12°C, a constant 2°C, or a linear decrease in temperature from 12°C to 2°C. After three weeks, we compared the metabolic rates of these when exposed to 2°C and 12°C to their rates prior to acclimation. Interestingly, lizards vary in their acclimation strategies based on their current climate. In particular, lizards from the relatively cooler populations (Colorado) reduced their metabolic rate only at the cooler temperature (2°C), and lizards from relatively warmer population (Arizona) reduced their metabolic rate only at the warmer temperature (12°C). Moreover, lizards from the population from New Jersey, which is characterized by an intermediate climate, reduced their metabolic rate under both 2°C and 12°C. These different levels of acclimation can affect the ability of lizards to mitigate impacts of global warming.

P1-15 LEWIS, AK; University of Florida; *lewis23a@ufl.edu*
Feminization of mouse male external genitalia and digit ratio: Inappropriate applications of gendered terms in sex biology
Biologists studying sexual dimorphisms often impose gendered terms (masculinize, feminize, etc.) onto morphological sex characteristics. Application of gendered descriptions to morphological characters and morphogenetic processes reinforces outdated notions of gender and sex. Genital development is a major focus of the study of sexual differentiation. In our experimental studies, we found that XY mouse embryos exposed to the anti-androgenic chemical vinclozolin at specific embryonic stages have a mislocated urethra. At birth, the urethra of VCZ-treated males is where the XX female urethra typically is. Biologists typically refer to this as "feminization," although urethral position is a morphological sex trait, not a gender trait. Another well-studied sexually dimorphic character is the ratio of second to fourth digit length (2D:4D ratio). In humans, the 2D:4D ratio has been shown to correlate with gender, sexual orientation, health, and behavioral traits. Men typically have 2D < 4D, while women typically have 2D > or = 4D. The same ratios are seen in male and female mice, respectively. It's been suggested that 2D:4D is reflective of fetal androgen exposure, and dimorphism in mouse 2D:4D is due to androgen/estrogen signaling in the 4th digit. Prenatal exposue to vinclozolin induces XY mice to develop XX-typical 2D:4D proportions. Previous work has referred to XY mice with XX-typical 2D:4D as "feminized". While appropriate for correlating gender with digit ratio, this is not an appropriate description of biological sex characters. I examined the frequency of gendered terms in PubMed entries and found that these terms are often inappropriately applied to animal and plant studies of sex. As biologists, it is our responsibility to improve our descriptions and terms.

P1-92 LIEFFRIG, SA; DERRICKSON, EM*; Loyola University Maryland; *ederrickson@loyola.edu*
The Influence of Dietary Protein:Carbohydrate Ratios on Body Composition in Two Species of Growing Mice
Researchers have shown that organisms choose a diet that preferences protein intake and that a misaligned protein:carbohydrate (N:C) ratio impacts body composition. We tested this hypothesis in juvenile mice in studies of *Mus musculus* and *Peromyscus californicus*. Reproductive females and their pups were fed isocaloric diets varying in N:C ratio. *M. musculus* pups were sacrificed at peak lactation (day 16) and *P. californicus* pups were sacrificed from peak lactation (day 20) through 85 days of age. Lean mass (primarily protein) was determined as total mass minus water, fat and ash mass. We predicted that pups on a low N:C diet would have lower lean body mass and greater fat mass. *M. musculus* pups at peak lactation on the low N:C diet had a lower total body mass and greater proportion of fat; contrary to predictions, lean mass was not different across treatments. *P. californicus* pups also exhibited slower growth as N:C ratio decreased and no difference in lean mass. However, in *P. californicus* pups, total fat was not different at 20 days and subsequently diverged between treatments with mice on the high N:C diet depositing greater amounts of fat. These results are generally consistent with the protein leveraging hypothesis. Growth rate is constrained by dietary protein and, for Mus, insufficient dietary protein results in increased fat deposition. Contrary to expectations, *P. californicus* on high N:C diets deposited fat at a higher rate suggesting that post-weaning juvenile mice may be hyperphagic beyond the need for leveraging protein.

P1-168 LIGOCKI, IY*; MILLER, J; JACKSON, L; CUMBIE, J; GIL, M; University of California, Davis, University of Florida, University of California, Santa Cruz, 1984; *ligocki.3@osu.edu*
Alone or in a group? Territory defense in solitary and group-living dusky damselfish, Stegastes adustus.
Animals that form social groups do so for a number of reasons including avoidance of predators, increased efficacy at finding or guarding food or resources, or for greater success at acquiring mates. While each of these explanations of grouping are associated with fitness gains, there are also potential costs associated with grouping depending on the size of the group, the quality of the territory, or competition in the environment. The dusky damselfish, *Stegastes adustus*, is a reef fish found in the Caribbean where it defends a territory on which it "farms" algae turf. These fish protect their territory and turf from heterospecific intruders who move through the reef and attempt to graze on the algae. Some, but not all damselfish territories are occupied by more than one fish who appear to share in territory defense and maintenance duties. We investigated variation in damselfish territory size and quality in Akumal Bay, QR, Mexico to determine i. whether larger groups hold higher quality territories, ii. whether the relative size of group member's influences territory defense, and iii. whether being a part of a group reduces the workload for dominant fish. We found that groups of fish occupied larger territories which contained more rock shelters and algal cover than solitary fish. We also found that the largest fish in groups performed the majority of territory defense behaviors. The amount of defense performed by the largest fish in groups was not significantly different from that performed by solitary fish. Taken together, these results suggest that while grouping may impart benefits on individuals in that they can maintain larger and higher quality territories, individuals do not face a reduced workload by forming a group.

P1-132 LIND, CM*; AGUGLIARO, JA; MOORE, IT; VERNASCO, BJ; FARRELL, TM; Stockton University, Fairleigh Dickinson University, Virginia Tech, Virginia Tech, Stetson University; *craig.lind@stockton.edu*
Integrating Metabolic Costs of Infection with Endocrine Indicators of Current Reproductive Investment in Pygmy Rattlesnakes Afflicted with Snake Fungal Disease
Fungal diseases have emerged as a major conservation concern in recent years. The energetic cost of coping with fungal infections competes seasonally with allocation towards life-history functions directly related to reproductive success. Such trade-offs could be reflected in circulating levels of hormones that mediate energy mobilization and reproduction in males and females. Establishing such relationships can be valuable both in terms of elucidating disease impacts and in establishing the significance of circulating hormones in conservation and management. We used a population of pygmy rattlesnakes afflicted with snake fungal disease (SFD) to examine energetic trade-offs and their endocrine basis. Specifically, we used flow-through respirometry to establish the metabolic cost of coping with SFD. We also monitored seasonal corticosterone, testosterone (males), and estradiol (females) in relation to infection status over the course of two years. Infected snakes had significantly elevated resting metabolic rates compared to uninfected snakes. Additionally, infected snakes had elevated corticosterone and lower testosterone and estradiol compared to uninfected snakes. Relationships between infection and reproductive hormones were only apparent during seasonal periods of significant reproductive investment in males and females. Results are consistent with the hypothesis that coping costs associated with SFD force allocation of resources away from processes directly related to current reproductive success and that trade-offs are mediated by adrenal and gonadal steroids.

P1-5 LINDSAY, SM*; BORGER, EC; University of Maine, Orono; *slindsay@maine.edu*

Developing Scientist Spotlights to Help Marine Science Undergraduates Build Metacognitive Skills and Science Identity

Students who can see themselves in a particular role (i.e., as a scientist) and feel that they belong to a scientific community tend to have greater academic success in STEM disciplines. Thus, how we portray scientists in our classes and textbooks, and the people that students encounter as role models and mentors matter. Students also succeed when they learn to practice metacognitive skills that faculty often take for granted. In this project, we used publicly available data to investigate the diversity of faculty in marine science/marine biology undergraduate programs at eleven institutions in the United States, comparing that to the diversity of undergraduates who completed B.S. degrees in marine science-related majors at the same institutions from 2013-2016. Not surprisingly, we found mismatches between the diversity of students and faculty in these undergraduate programs, including our own. Informed by these mismatches, we began creating "Scientist Spotlight" activities to highlight non-stereotypical marine scientists whose research coincides with key concepts taught in an introductory marine biology course. We modeled our approach on similar activities that have improved student sense of belonging in community college biology programs. In our adaptation of these activities, students reflect on the content of interviews with the spotlight scientists and associated science readings (i.e., metacognitive skills practice), and on the types of people who are scientists. Our pilot results suggest the Scientist Spotlights can provide insight about student understanding of the topic (e.g., bacterial influence on animal development), reinforce students' desire to learn more, and that students took away positive, yet realistic views of the qualities that define people who do science.

P2-215 LINDSEY, LN*; DELISLE, AL; INGLE, DN; PORTER, ME; Florida Atlantic University; *llindsey2016@fau.edu*

Cetacean vertebral trabecular bone mechanical properties vary among swimming modes and diving behaviors

Among cetaceans, species with rigid, torpedo-shaped bodies anterior to the caudal region are considered the most active, high-speed swimmers. Interspecific variation is encoded in the axial skeleton, where vertebral morphology varies among species with different modes of locomotion. Here, we categorized ten species of cetaceans based on functional groups determined by swimming modes (rigid-body vs. undulatory) and diving behavior (shallow vs. deep). The goal of this study was to determine trabecular bone mechanical properties among cetacean functional groups and regions of the vertebral column. We hypothesized that the greatest mechanical properties would be in shallow-dwelling, rigid-bodied swimmers and in the caudal regions of the vertebral column. Dephinid and kogid vertebrae were obtained from necropsies and stored fresh and frozen before testing. Vertebrae were dissected from four regions of the vertebral column (thoracic, lumbar, and two caudal) and were cut into 6 mm3 cubes. Bone cubes were compression tested in the rostro-caudal orientation at 2mm/min using an Instron E1000 material tester. Stiffness, yield strength, and toughness were calculated from stress-strain curves. Preliminary data suggest that rigid-bodied, shallow-diving cetaceans had the greatest material properties compared to undulatory, deep-diving animals, while animals with rigid bodies but habitually dive to deep depths were intermediate between the two. These data may indicate that in addition to whole body rigidity, animals that habitually overcome surface drag and wave turbulence have increased skeletal loading during active swimming than those that incorporate prolonged glides during deep dives.

P2-126 LITTLER, A.S.*; SRIRAM, A; GARCIA, M.J.; TEETS, N.M.; University of Kentucky; *asli226@uky.edu*

Out in the Cold: Genetic Correlation of Cold Tolerance Traits in Drosophila Melanogaster

Cold stress can cause a number of injuries which can lead to reduced fecundity and survival. Thus, cold tolerance is tightly linked to overall fitness and ultimately is a target for selection. Further, the extent to which selection can act on cold tolerance is dictated by the degree of heritable genetic variation. In this experiment, we examined variance in cold tolerance among isogenic lines of *Drosophila melanogaster* to test the hypothesis that commonly used cold tolerance metrics are genetically correlated. We selected 12 isogenic lineages from the *Drosophila* Genetic Reference Panel with previously known variance in lower lethal temperature. For each line we analyzed acute cold shock survival (-2°C for 1 h), tolerance of chronic cold (4°C for 24h), critical thermal minimum (CTmin), chill coma recovery (CCR), and behavioral deficits in climbing performance after cold exposure (4°C for 8h). We observed significant genetic variation for every cold tolerance measure but surprisingly found that cold tolerance measures were not significantly correlated across lines. For example, some lines had high survival after cold shock but exhibited poor CCR time, while others showed the opposite pattern. Our results demonstrate that cold tolerance exhibits significant genotypic variance, but that different metrics of cold tolerance may have distinct underlying mechanisms. Ultimately, understanding patterns of phenotypic variance across various cold tolerance traits is essential for predicting adaptation to changing environmental conditions, including those brought on by climate change.

P1-69 LIU, J; SUNY University at Buffalo; *liujuan@buffalo.edu*

Weberian Apparatus Evolution in Fossil and Living Catostomids (Teleost, Cypriniformes)

Weberian apparatus is an evolutionary functional novelty consisting of a series of modified peri-vertebral elements for sound transmission (specialized hearing) in all Otophysi fishes. It is especially well developed in cypriniforms including members of the family Catostomidae. Complementing a rich history of anatomical study into this group, morphology of the Weberian apparatus has recently become available for study in the earliest members of Catostomidae. To explore possible evolutionary trends for this group of fish, I examined the Weberian apparatus in all the oldest catostomids (Eocene in age) and the majority of extant catostomids. The fossil taxa with preserved Weberian apparatus examined for this study include Amyzon aggregatum, A. gosiutense, A. hunanese, A. kinshenehnicum, "Amyzon" brevipinne, and Plesiomyxocyprinus arratiae. The shape and size of Weberian ossicles are similar across phylogeny and geologic ages of catosotmids, whereas other associated elements are highly diversified. Synapomorphies observed from both fossil and extant taxa are: presence of a large transverse plate between the left and right rib 4; rib 2 being fused into rib 4 and together contributing to the transvers plate; and the os suspensorium emerging from rib 4 instead of the centrum. Evolutionary trajectories across Eocene to present materials were most prominent in the length, width, and projecting direction of rib 4, the size of neural spine 4, and shape and size of the neural complex. These trends coincide with taxonomical diversification and geographical dispersal of catostomids, suggesting that Weberian apparatus evolution is associated with both speciation and niche differentiation of catostomids.

P3-113 LLEWELLYN, HJ*; SMITH, EN; SURMACZ, CA; HRANITZ, JM; Bloomsburg University; *csurmacz@bloomu.edu*

Sublethal Effects of the Neonicotinoid Imidacloprid on Cellular Stress in the Honey Bee Brain

Global declines in honey bees (*Apis mellifera*) have been linked to Colony Collapse Disorder (CCD), a phenomenon that occurs when worker bees disappear from the colony, leaving the brood unattended. While there is no single cause of CCD, sublethal doses of pesticides cause physiological and behavioral changes that adversely affect hive health. This research examined the effects of sublethal doses of the neonicotinoid imidacloprid on biomarkers for cellular stress, Heat Shock Protein 70 (HSP 70) and the oxidative enzyme superoxide dismutase (SOD). Honey bee foragers collected from central PA apiaries were harnessed, fed to satiation, and randomly assigned to control or imidacloprid treatments. Control bees were fed 1.5 M sucrose. Bees in treatment groups were fed 1.5 M sucrose with imidacloprid (Macho® 4.0, AgriStar) at doses of $1/5^{th}$, $1/10^{th}$, $1/20^{th}$, $1/50^{th}$, $1/100^{th}$ and $1/500^{th}$ of the LD_{50} (18 ng/bee). After four hours, bee heads were removed, frozen and homogenized. Bees exposed to high doses (1/5 and 1/10 of the LD_{50}) of imidacloprid had higher SOD activity than low doses (≤0.18 ng/bee). HSP70 levels displayed a hormetic stress response. Positive controls had higher levels of HSP70 than negative controls. The 1/100 and 1/5 treatments were lower than the positive control. Doses of 1/10 and 1/50 showed intermediate stress levels, overlapping both positive and negative controls, with $1/20^{th}$ of the LD_{50} being the median high dose. Future work will examine the effects of imidacloprid on gene expression in honey bee brains following the administration of a conservative dose of $1/20^{th}$ of the LD_{50} of imidacloprod. This research seeks to further our understanding of how neonicotinoids affect the honey bee brain and the role they may play in CCD.

P1-202 LOBERT, GT*; COLLINS, EE; MAHON, AR; Central Michigan University; *lober1gt@cmich.edu*

Phylogeography and biodiversity of Pycnogonida in the Western Antarctic

Sea spiders (Pycnogonida, Chelicerata) form a basal clade within the phylum Arthropoda that includes over 1300 species to date, with over 260 described from the Southern Ocean. Of the 264 species in the Antarctic, 108 are noted to be endemic to the region. Previous studies in the literature have found that Antarctic biodiversity is underrepresented due to sampling logistics and lack of research collections from many regions of the Southern Ocean. Additionally, sea spider identification based on morphology alone is in many cases unreliable and many cryptic species lineages have been discovered. This study aims to add to the current inventory of Antarctic sea spiders through the use of molecular barcode data and includes samples collected from throughout the Western Antarctic (Antarctic Peninsula, the Amundson, Bellingshausen and Ross Seas). With the molecular barcodes generated by this study, we will also covariate data for specimens collected to add to the biological knowledge of our species in question (location, depth, and habitat types where available). This study will increase the knowledge of Antarctic sea spiders, including cryptic species and it will improve our overall understanding of Southern Ocean faunal biodiversity and evolutionary relationships

P2-140 LOPEZ, K.E.*; CHAVEZ-DOZAL, A.A.; YU, W.; SALAS, S.S.; RAMI, R.; NISHIGUCHI, M.K.; New Mexico State University, Laboratoire Arago; *klopezla@nmsu.edu*

"You talkin to me?" Interspecies communication fosters collaboration between closely related symbionts in the sepiolid squid-Vibrio mutualism

The beneficial association between squids in the family Sepiolidae (Mollusca: Cephalopoda) and bioluminescent bacteria in the family Vibrionaceae form a unique relationship that provides a model to study the interactions between animals and bacteria. Sepiolid squids from the Mediterranean Sea (genus *Sepiola*) are unique in that these squids serve as hosts for two bioluminescent bacterial species: *Vibrio logei* and *Vibrio fischeri*. *Vibrio* bacteria produce unique communication molecules known as acyl-homoserine lactones (AHLs) that used to modulate light via quorum sensing (QS). Since *V. logei* and *V. fischeri* differ in many of their physiological properties, we examined whether these species produce AHLs that could be "understood" by the other species, and whether the regulatory genes controlling AHL production and subsequently luminescence are genetically distinct. We created a null mutation on the response regulator gene *luxO* to determine whether mutations at this locus affect the ability of bacteria to communicate within and between both species during symbiosis. Additionally, we swapped *luxO* between the two species to measure how luminescence is regulated, and whether it effects the type of AHL being produced in sympatry. Our results demonstrate that *luxO* is required for luminescence production, but additional secondary regulatory genes are responsible for *luxO* regulation even in a different genetic background. By understanding how different species of bacteria communicate inside an animal host will provide insight as to how symbiotic bacteria evolve cooperative mechanisms in complex beneficial associations.

P2-249 LOUIS, LD*; BOWIE, RCK; DUDLEY, R; Univ. of California, Berkeley; *llouis@berkeley.edu*

Skeletal morphology of migratory and resident Dark-Eyed Juncos (Junco hyemalis)

Migratory birds dramatically increase the size of flight muscles in preparation for migration. However, we know very little about how migratory behavior influences bone morphology, even though bone and muscle are known to experience both mechanical and endocrine crosstalk. To determine the effects of migratory behavior on skeletal morphology and biomechanics, we analyzed specimens of both migratory and resident Dark-Eyed Juncos (*Junco hyemalis*) collected during breeding season. We obtained micro-computed tomography scans of the humeri and femora to separate the influence of mechanics (higher number of loads per day) from that of putative systemic changes (hormonal changes impacting bone morphology in preparation for migration). Our preliminary results in males show that migratory birds have a higher humerus width relative to resident birds, resulting in an increase in the ability to withstand the bending and torsional forces applied in flight. There was no difference in bone width of the femur. These results suggest that the humerus is altered to handle migration, but do not discern whether the mechanism is by increased wingbeats per day or by an increased force applied by the larger muscle. We are still performing analyses on trabecular (spongy) bone morphology and bone density. Further, analyses of an altitudinal migrant supspecies of *J. hyemalis* will enable us to tease apart the potentially confounding effects of migration and mass on bone morphology. Increasing our understanding of how migration influences bird bone morphology will clarify the evolution of morphological plasticity and migratory behavior.

P3-159 LOVE, CN*; FLYNN, RW; LANCE, SL; Univ. of Georgia, University of Georgia; *love@srel.uga.edu*

DNA Methylation Patterns in Amphibians Populations with Differing Contaminant Exposure Histories

Environmental contamination is a growing global concern, and amphibian susceptibility to contaminants varies both within and among populations. In previous work we found evidence of amphibian population adaptation to contaminated environments, however we did not explore the mechanisms and associated costs of this tolerance. DNA methylation is an epigenetic mechanism with important gene expression regulatory function in many animals and can vary with contaminant exposure. Additionally, increased global methylation patterns can contribute to accelerated aging rates and may represent a cost of contaminant exposure and/or tolerance. Our objectives were to 1) measure global DNA methylation in amphibians experimentally exposed an environmentally relevant trace element, 2) quantify variation in global DNA methylation across amphibian populations from wetlands differing trace element levels. To accomplish objective one, we exposed larvae of two species, *Anaxyrus terrestris* and *Gastrophryne carolinensis*, from populations with different exposure histories, to copper [Cu] and measured whole body global DNA methylation. *A. terrestris* larvae exhibited a negative relationship between methylation and increasing Cu exposure, regardless of exposure history. *G. carolinensis* larvae with no population history of exposure exhibited a similar pattern. However, larvae from contaminant exposed populations showed hypermethylation with Cu exposure. To accomplish objective two, we collected *Lithobates sphenosephalus* and *A. terrestris* eggs, larvae, and adults from wetlands differing in contamination type and level, and measured global DNA methylation in whole embryos, liver and brain. Broadly, DNA methylation levels increased with age, and patterns differed among species, tissue type, and wetland contamination history.

P2-135 LOWDER, KB*; TAYLOR, JRA; Scripps Institution of Oceanography, UC San Diego; *kblowder@ucsd.edu*

The fountain of youth is chilly: California spiny lobster larvae progress faster in warmer water despite decreases in acidity

The phyllosome larvae of spiny lobsters spend months developing in the open-water environment, potentially leaving them vulnerable to the influence of decreasing pH and increasing temperature. Here, we studied the survival and growth of California spiny lobster (*Panulirus interruptus*) phyllosoma exposed to reduced pH and increased temperature conditions. We hypothesized that warmer temperature alone would accelerate the progression to later larval stages, but reduced pH and combined stressors would increase mortality and slow growth. Two hatches of California spiny lobster phyllosoma (8 replicates/treatment, 20 to 25 larvae/replicate) were exposed to ambient pH and temperature (8.04, 18.5 °C), increased temperature (8.04, 22.2 °C), reduced pH (7.66, 18.4 °C) and combined reduced pH and increased temperature (7.67, 22.4 °C) conditions for 3.5 (hatch 1) or 5 weeks (hatch 2). Larvae were checked for survival every three days, and a subset from each treatment were staged daily starting at 2.5 weeks. By 3.5 weeks of exposure, 33% of hatch 1 and 42% of hatch 2 in both increased temperature treatments reached Stage III of XI, rising to 100% at 5 weeks. In contrast, only 0-4% had reached this stage in the ambient and reduced pH treatments by 5 weeks. After 3.5 weeks, 15% of hatch 1 larvae exposed to increased temperature/reduced pH were alive, significantly more than the 2% of other treatments. At 5 weeks, there was no difference in hatch 2 survival among treatments (p=0.60). These findings indicate that there are no negative effects of early exposure to reduced pH on the growth rate and survival of larval California spiny lobsters, but increased ocean temperature speeds up larval development, potentially reducing larval duration and bolstering settlement.

P2-148 LOWNDS, BI*; TOPPING, NE; JOST, JA; Bradley University ; *blownds@mail.bradley.edu*

Linking Environmental Conditions to Zebra Mussel (Dreissena polymorpha) Growth and Performance in a Central Illinois Population

The invasive zebra mussel, (*Dreissena polymorpha*), has caused significant ecological and economical damage. While their physiology has been examined for a variety of environmental conditions both in the field and the lab, there are gaps within the literature. First, little is known about the cellular processes during environmental fluctuations. Second, there are discrepancies in the reported values for both optimal and lethal temperatures, which may be attributed to localized adaptation or acclimation. However, these differences make it challenging to develop biologically relevant laboratory experiments without knowing the thermal limits for our specific population. Therefore, our objectives were to determine the optimal conditions for a zebra mussel population at Banner Marsh by linking growth (shell size, shell mass, and tissue mass) to environmental parameters (water quality, food quantity, and temperature). Field enclosures were deployed for a period of four weeks in May and again in mid-June. Within each enclosure mussels were either clumped or divided into individual chambers. On average, mussels experienced greater shell growth and lower tissue loss when they were housed individually, suggesting that clumping behavior negatively impacts growth. Also, mussels experienced greater shell growth and lower tissue loss in May than in June. While water quality and food quantity varied over time, conditions remained within optimal limits. Since temperatures regularly exceeded 31°C in June and July, the relatively poorer performance in June and July may be attributed to greater temperature stress. We are currently measuring the levels of two cellular stress markers to determine the role of cellular physiology in this response.

P1-54 LUNA, M*; AMTHOR, A; YAEGER, J; NOEL, A; NADLER, N; Georgia Institute of Technology, Georgia Tech Research Institute; *mluna7@gatech.edu*

Bio-Inspired Fluid Transport of Spanish Moss

The Spanish moss (Tillandsia Usneoides) is an epiphytic, bromeliad that uptakes water and fog from the atmosphere. The outer epidermis surface of the Tillandsia is coated with wing-shaped trichomes that when wet bend downwards, creating a superhydrophilic film of water between the epidermis and the trichome that flows in a single direction. In this study, the Tillandsia Usneoides trichome wing structure was investigated for biologically inspired fluid transport applications. We also preformed relative humidity experiments of the Tillandsia with and without trichomes. These experiments demonstrated that Tillandsia with removed trichomes increased relative humidity 22.7% more than that of the intact Tillandsia. The Tillandsia's trichomes also conserve 19.7% more of its total mass within a 24-hour period, suggesting increased water retention for Tillandsia with trichomes. Through bio-inspiration from the Tillandsia Usneoides' unique trichome structure, a bio-mimicking mechanism using hydrogels is suggested. Biomimicry of the Tillandsia can be valuable for applications requiring fluid spreading and retention, such as systems that require constant lubrication.

P2-107 LYNN, S.E.*; KERN, M.D.; The College of Wooster; *slynn@wooster.edu*

Characterizing the effects of early life cooling on HPA axis development in free-living songbirds

Early life experiences can affect the function of the hypothalamo-pituitary-adrenal (HPA) axis of vertebrates, with potential fitness consequences. We have shown that repeated drops in body temperature during the first week of life of eastern bluebird (*Sialia sialis*) chicks, such as those which occur when females are away from the nest, dampen the chick HPA response to restraint prior to fledging. To explore which aspects of the HPA axis are affected by cooling, we subjected chicks to experimental cooling during the first week of life (Cooled chicks) or maintained chicks at brooding temperatures (Controls). Prior to fledging, we characterized corticosterone (CORT) secretion after (1) 60 min of restraint (to confirm the effects of cooling on HPA activity), (2) injection with adrenocorticotropic hormone (ACTH; to assess adrenal sensitivity), or (3) a dexamethasone (DEX) suppression test (to characterize negative feedback sensitivity of the HPA axis). We confirmed that repeated cooling early in life reduced CORT secretion in response to later restraint. Sensitivity to ACTH challenge did not differ between temperature treatments, but, compared to Controls, Cooled chicks exhibited impaired negative feedback sensitivity. This unexpected result does not, however, explain our consistent finding that Cooled chicks have a lower CORT response to restraint than Controls. Our data suggest that early life cooling alters the HPA axis at multiple levels. We hypothesize that cooling also alters HPA axis function at the level of the hypothalamus or anterior pituitary. Such effects are likely to be strong, with early life cooling producing an overall dampening of CORT secretion in response to novel stressors, despite impairing negative feedback of the HPA axis to glucocorticoids.

P1-129 MACKAY, S.B.; TRAINOR, C.*; WILSON, K.; BERGMAN, D.A.; Grand Valley State University; *trainorc@mail.gvsu.edu*

Effects of Nonylphenol on Crayfish Molting Hormones

Nonylphenol (NP) is a commonly used surfactant in a variety of industries. NP shows an affinity for estrogen receptors, hence its classification as an endocrine disruptor and potential danger to reproductive success. NP accumulates in aquatic environments and several studies have demonstrated reduced olfaction and impaired gonad development and feminization in a variety of species after exposure. Previous research suggests that NP exposure can also lead to reduced molting. As molting is triggered by ecdysone release or inhibited by molt inhibiting hormone (MIH) release, this decrease in molting could be attributed to interference with either aspect of this endocrine controlled system. Increases in MIH or decreases in ecdysone are potential mechanisms for delayed or diminished molting. However, changes in the concentrations of these hormones are not the only possible site of interference as competitive receptor binding inhibition could change molting frequency. We hypothesize that NP will disrupt the molting hormone signaling pathways. To test this hypothesis, we quantified hormone concentrations in the hemolymph and receptor expression in gonad tissue during nonylphenol exposure.

P1-157 MACLEOD, P.F.; O'ROURKE, C.; RENN, S.C.P*; Reed College, Portland OR, Reed College Biology Department; *renns@reed.edu*

Manipulating operational sex ratio to influence female competition and male choice in a lek-like mating system.

Social living, while adaptive in terms of enhanced access to mates and predator avoidance, also comes at a cost in terms of increased competition for resources and limitation regarding an individual's opportunity to mate. As such, competition in social groups often leads to the formation of dominance hierarchies, established and maintained by agonistic interactions. These hierarchies often serve to ameliorate within-group conflict and reduce the costs of fighting conspecifics. The most frequently studies dominance hierarchies are those observed among males under conventional sex-role mating systems in which reproductive success is highly variable for males. In such situations, females are generally considered to play a passive role, selecting from dominant available males. However, potential exists for females to also compete with each other in these arenas. The cichlid fish *Astatotilapia butroni* provides an interesting opportunity to study how female competition and male choice are influenced by the operational sex-ratio. In this maternal mouth-brooding lekking species, the females remove themselves from the available breeding population while brooding young in their buccal cavity. This allows us to manipulate the operational sex-ratio while maintaining consistent encounter rates among females as well as between males and females. We find that as the number of available females per male increases, the rate of female directed aggression by females increases, consistent with an increased competition for male mates. Female directed aggression by males also increases, consistent with male choosiness when the number of available females per male increases. These data support a more nuanced interpretation of conventional sex-role theory.

P2-117 MAENAGA, ML*; FORMICA, VA; NOVARRO, AJ; Swarthmore College; *mikamaenaga@gmail.com*

Eat or Be Eaten: Exploring the Relationship Between Stress Response and Cannibalism in Beetle Larvae

Animal survival depends on an effective and appropriate stress reaction. One immediate reaction to external stressors, such as predators and competitors, is an increased heart rate. Heart rate reactions are linked with the fight-or-flight response and may be especially important for organisms that experience frequent aggressive interactions. As larvae, forked fungus beetles (*Bolitotherus cornutus*) regularly cannibalize one another and can spend up to 3 years living on a shared, limited resource. Thus, individual stress responses may shape the outcome of extreme competitive interactions, and therefore survival. In this study, we explored the relationship between heart rate reactions and cannibalism in *B. cornutus* larvae. We hypothesized that individuals with a greater heart rate response to stress are more likely to survive cannibal interactions with competitors. To test this hypothesis, we measured the stress response of lab-reared larvae as the change in heart rate when exposed to an environmental stimulus (direct light) relative to the baseline heart rate. We then paired larvae of similar sizes in cannibalism arenas to determine which individual would cannibalize their competitor, and latency to do so. Of the 39 pairs we placed in cannibalism arenas, we observed an 85% rate of cannibalism. Given the intense rate of cannibalism, we suspect that physiological traits for evading cannibalism are under strong selection. Our experiment will allow us to determine whether individual stress response is related to survival probability in the face of extreme competition. Understanding the physiological link to aggressive behavior will contribute to the limited knowledge of stress physiology in invertebrates.

P3-2 MAGUIRE, M.C.*; HAMBELTON, G.; ELLERS, O.; DICKINSON, P.; JOHNSON, A.S.; Bowdoin College; *mmaguire@bowdoin.edu*

Contributions of artery and sarcomere length changes to the heart's ability to generate tension in the American lobster, Homarus americanus

With increased activity, the heart's blood volume during diastole increases, which consequently increases the stretch on the walls of the heart. As is typical with striated muscles, the ability of the heart to generate tension increases with increasing stretch up to some maximum. This increase in tension-generating ability may be due to sarcomeres generating greater force at longer lengths on the ascending limb of the length-tension curve. However, lobster hearts are suspended by elastic ligaments and arteries within a pericardial space, thus the tension on the heart is influenced both by changes in sarcomere length during diastole and artery stretch during systole. Furthermore, the heart is anisotropic, with characteristically different active forces along the transverse and longitudinal axes. We examine the effects of both sarcomere and artery length changes on tension generation by the heart at different points in the cardiac cycle as well as the potential contribution of differences in sarcomere length to the observed anisotropy. In terms of anisotropy, no significant differences in sarcomere length were found between longitudinal and transverse fibers. In terms of length-tension curves, we found that tension increased with increasing length of the heart plus artery system, but that the initial portion of the whole-heart length-tension curve occurred at lengths where the arteries were responsible for absorbing the imposed changes in length. Thus, whole-heart length-tension curves for lobster heart suggest potential neural stretch receptors in the arteries that anchor the heart in the pericardium.

P1-125 MAHONEY, A*; FUSE, M; San Francisco State University; *mahoney5@mail.sfsu.edu*

Pupation and Eclosion are Delayed Following Imaginal Disc Damage in Early Instar Larvae in the Hornworm, Manduca sexta

Tissue damage results in developmental delays in many organisms, putatively by delaying key developmental hormones, allowing for tissue repair. This is noted as pubertal delays in humans and metamorphic delays in holometabolous insects like the tobacco hornworm, *Manduca sexta* and the fruit fly, *Drosophila melanogaster*. Understanding how these delays arise can provide insight into how conserved the mechanisms of tissue repair are across animals. The aim of this study was to identify a "critical window" where tissue damage no longer caused delays in development in *M. sexta*. Larvae were irradiated with varying doses of x-rays at the beginning of the 3rd and during their last larval instar (L5), on days 1, 2, 3 or 4 after ecdysis. Timing to wandering behavior, pupation and adult eclosion were monitored. It was hypothesized that irradiation would delay pupal development if presented early in the last larval instar, but not later - after release of developmental hormones - and that larval molts would not be affected given the differences in the roles of developmental hormones at this time. Pupation was delayed after irradiation at the 3rd larval instar or at the beginning of the 5th larval instar within the 1st day after L5 ecdysis. Adult eclosion was significantly delayed irrespective of when the x-rays were administered. Delays in L3 larvae were only noted at higher irradiation levels. These results suggest a delay factor may inhibit key developmental hormones for pupation that are already released in the L5 stage after day 1. These delay factors, even when released at an earlier instar, will delay pupation and adult eclosion, but not larval molts. These data suggest the effects of tissue damage can have profoundly different results depending on the endocrine status of the organism.

P2-262 MAIE, T.*; CHRISTY, R.M.; MAIE, Takash; Univ. of Lynchburg, VA; *maie.t@lynchburg.edu*

Adhesive force and endurance during waterfall climbing in an amphidromous gobiid, Sicyopterus japonicus (Teleostei: Gobiidae): Ontogenetic scaling of novel locomotor performance

An amphidromous sicydiine goby, *Sicyopterus japonicus*, exhibits rock-climbing behavior during upstream migration along rivers and streams. Using the pelvic sucker, formed by fused pelvic fins, *S. japonicus* generates suction for adhesion on the climbing surface. By measuring performance variables that correlate to successful rock-climbing capability, we evaluated scaling relationships of suction force generated by the pelvic sucker and its fatigability during climbing in *S. japonicus* both with respect to body mass. During continuous climbing on the 60°-inclined surface, the pelvic sucker of *S. japonicus* exhibited a strong positive allometry in generating force for adhesion. In addition, during sustained adhesion, time constant as a measure of fatigue time for the pelvic sucker muscles scaled non-linearly with body mass and showed the best fit to a quadratic regression, the peak point of which predicted intermediate-sized individuals (large juveniles to small adults) to be the best in endurance performance during adhesion. Our experimental results indicate that different sizes of waterfall-climbing gobies have different performance capacities for rock climbing, relating to physiological differences in their pelvic muscles. In addition, our data from *S. japonicus* can indicate selection pressures on the locomotor capacities of waterfall-climbing gobiids vary during ontogeny.

P2-81 MALTBY, R; NOURBAKHSH-REY, M *; MARKHAM, MR; University of Oklahoma; *rmaltby@ou.edu*

Metabolism Sensing Mechanisms in the Electric Organ Cells of a Weakly Electric Fish

Weakly electric fish navigate and communicate with electric organ discharges (EODs) produced by the coordinated action potentials of muscle-derived electric organ cells (electrocytes). EOD production incurs significant metabolic costs in the electric fish *Eigenmannia virescens* which reduces signal amplitude during food restriction. This effect is mediated by leptin, a peptide hormone that typically plays multiple central and peripheral roles in energy homeostasis. We hypothesized that, in addition to these functions, leptin is also regulating EOD amplitude in *E. virescens* by directly modulating electrocyte function. We found that electrocytes express a leptin receptor (LepR), and gene phylogeny groups the *E. virescens* LepR with those of freshwater teleost fish. Electrocytes also express an ATP-sensitive K^+ channel (K_{ATP}) complex that couples electrical excitability to metabolic status in a number of cell types including smooth and skeletal muscle. In many cases K_{ATP} is a downstream target of leptin. We cloned electrocyte K_{ATP} subunits and expressed them in *Xenopus* oocytes. Voltage-clamp experiments revealed an inwardly rectifying K^+ conductance that is enhanced by the metabolic inhibitor sodium azide. Gene phylogeny of *E. virescens* K_{ATP} indicates that the functional channel consists of Kir6.2 and SUR2B subunits. Because leptin receptors are known to be coupled to K_{ATP} channels in several other physiological systems, we hypothesize that electrocyte LepR and K_{ATP} channels form a signaling complex that couples metabolic state to signal output in *E. virescens*. Future experiments will test this hypothesis.

P2-83 MARKLAND, S*; ORTIZ ALVARADO, CA; TWOMBLY ELLIS, JF; CORDERO MARTINEZ, CS; SILVA ECHEANDIA, SA; PETANIDOU, TF; TSCHEULIN, T; BARTHELL, JF; GIRAY, T; AGOSTO RIVERA, JL; ABRAMSON, CI; Oklahoma State University, Stillwater, University of Puerto Rico Rio Piedras, Cornell University, Ithaca, New York, University of the Aegean, Mytilene, Lesvos, Greece, University of Central Oklahoma, Edmond; *sarah.markland@okstate.edu*

Honey Bee Shift Work in Comparison to Learning Behavior and Foraging Profiles

Apis mellifera, also known as the European honey bee, sometimes shows a bias toward specific colors of flowers. They can also show preferences for foraging at specific times of the day, i.e. morning or afternoon shifts. The question this research aims to explore is whether or not a bee who was particular in choosing a shift was also particular regarding decision making while foraging. Our hypotheses were that shift work would correlate with foraging behavioral patterns, and that bees would react to a decrease in flower reward by choosing the more reliable color of flower. Moreover, foragers may respond to variability and change flower preference or they may be constant to one type of flower. Bees that forage only at one time may also forage only on one type of flower. We set up two bee hives and taught them to visit feeders of sucrose water. The bees were then marked with different colors specific to hive and time of day to observe the shift work behavior. Then, the marked bees were followed in order to observe their decision making process when the reward of a particular color of flower, that had previously been experienced as consistent, was reduced while the other remained higher. We found that the bees fit in to one of four categories of foraging behavior, which did not correlate with their shift work preference. We also noticed that the number of morning bees and afternoon bees were not evenly distributed.

P3-129 MARROQUIN-FLORES, RA*; MORTIMER, NT; PAITZ, RT; BOWDEN, RM; Illinois St U; *ramarro@ilstu.edu*

Cold-inducible RNA-binding protein may regulate gonadal development in the red-eared slider turtle

Temperature-responsive genes, such as those coding for heat shock proteins, play a vital role in embryogenesis. Cold-inducible RNA-binding protein (Cirp) is a heat shock protein present in the gonadal tissues of multiple taxa with a potential regulatory role in the sex-determining pathway. The red-eared slider turtle (*Trachmeys scripta elegans*) exhibits temperature-dependent sex determination (TSD), where thermal cues trigger gonadal differentiation during development. In *T. s. elegans*, Cirp is up-regulated concurrent with estrogen-inducing transcripts at female-producing temperatures. Intron retention has been proposed as a regulatory mechanism for sex-specific development, and RNA-binding proteins can regulate the retention of introns. As Cirp is an RNA-binding protein localized in developing gonads, we hypothesize that Cirp plays a regulatory role in gonadogenesis by impacting the stability of target transcripts via intron retention. *T. s. elegans* eggs were incubated under fluctuating temperature treatments and either held under conditions that should produce males, or given a simulated heatwave to induce female development. Gonads from embryos were dissected for immunoprecipitation and RNA-seq. Sequenced RNA product will be aligned to an internal transcriptome developed from published raw reads to identify the target transcripts. Target transcripts will be translated and aligned to the painted turtle (*Chrysemys picta*) proteome to identify alignment gaps that correspond to retained introns. Our approach will help us understand how Cirp responds to fluctuating temperature treatments, and how it may regulate the nuclear expression of reproductive genes.

P3-167 MARSHALL, AS; MULLINS, H*; URISTA, CY; DAVIS, JE; Radford University; *amarshall39@radford.edu*

Heterophil/Lymphocyte Ratio as a Measure of Immune Response in Humans Exposed to a Novel Microbiome

Much research has been done on the long-term adaptive consequences of migration; however, less attention has been focused on short-term health effects of human travel. When traveling, individuals may experience new environments and new microbiomes that impact their health. While this travel might be short-lived, there may be longer-term consequences. What happens to an individual's immune response when they are introduced to a new environment? How might this impact immigration patterns and spread of disease across native and immigrant populations? This research examined the physiological changes that a group of 16 North Americans in 2017 and 15 individuals in 2018 experienced while traveling in the Peruvian Amazon for three weeks. Specifically we examined weight, body temperature, and heterophil/lymphocyte ratio. These variables were measured before the expedition, at the end of the expedition, and after their return to the United States. All collected data was analyzed using ANOVA and PCA. Initial results suggest an increase in immune response without any documented illness and potential negative correlations between immune activity and weight loss. This may suggest that the human body will initiate an immune response simply from exposure to a novel microbial environment, not solely in response to illness.

P1-273 MARSHALL, SK*; MOSSOR, AM; SPAINHOWER, KB; DIGGINS, TP; SINN, BT; BUTCHER, MT; YSU, WVU; *ammossor@student.ysu.edu*

Phylogenetic and funtional evaluation of Xenarthran hindlimb structure

Morphological divergence in the forelimbs is often associated with functional habits exhibited by the Xenarthra as a clade, ranging from arboreal-suspension in sloths to terrestrial-digging in armadillos. We hypothesized that quantitative differences in hindlimb form also will be predictive of the lifestyles observed among xenarthrans. A total of 27 functional indices were calculated from 42 measurements of bone length, width, and depth from a sample of N=83 skeletal specimens (total: 19 species). All raw data were initially log-transformed to account for allometry. Index data were evaluated using Principal Component Analysis (PCA) and corrected with phylogenetic PCA to determine the osteological correlates among extant taxa, and were subsequently used to predict substrate preference and substrate use by discriminant function analysis. PCA on index data clearly separated sloths from armadillos in morphospace based on gracility versus robustness, respectively, of hindlimb skeletal elements, whereas these characteristics were intermediate in anteaters. With the exception of hip moment index (HMI) and tibial tuberosity index (TTI) being associated with generalized traits in mammals, separation patterns were largely similar after accounting for phylogenetic relatedness among taxa. The predicted memberships for substrate preferences and uses for each species almost invariably corresponded with their observed lifestyles, with several indices relating to knee articulation stability and ankle/limb mechanical advantage as the significant discriminating features. Overall, our assessments expand interpretations of limb form and functional habits exhibited among xenarthrans, and potentially identify several conserved traits related to fossorialty as well as morphological trade-offs between digging and climbing.

P2-154 MARTINEZ, E*; MENZE, MA; AGOSTA, SJ; EASTERN ILLINOIS UNIVERSITY, UNIVERSITY OF LOUISVILLE, VIRGINIA COMMONWEALTH UNIVERSITY; *emartinez9@eiu.edu*

The Hungry Caterpillar: Linking Mitochondrial Energetics and Life History Traits as a Function of Temperature in Manduca sexta.

The relationship between whole-organism growth and metabolism is generally assumed to be positive and causative; higher metabolic rates support higher growth rates. In *Manduca* sexta, existing data demonstrate a deviation from this simple prediction: at supraoptimal temperatures for larval growth, metabolic rate keeps increasing while growth rate is decreasing. This mismatch presumably reflects the rising "cost of maintenance" with temperature. Precisely what constitutes this cost is not clear, but we suspect the efficiency with which mitochondria harness oxygen and organic substrates into cellular energy (ATP) is key. We tested this by integrating existing data on M. sexta growth and metabolism with new data on mitochondrial bioenergetics across the temperature range 14ºC-42ºC. Across this range, our measure of mitochondrial efficiency closely paralleled larval growth rates. At supraoptimal temperatures for growth, mitochondrial efficiency was reduced, which could explain the mismatch between growth and metabolism observed at the whole-organism level. On a broader scale, this study suggests that the thermal plasticity and thresholds of mitochondrial ATP production are likely a major modulator of growth performance in holometabolous insect larvae.

P2-256 MAYERL, CJ*; BOND, LE; STRICKLEN, BM; GOULD, FH; GERMAN, RZ; Northeast Ohio Medical University; *cmayerl@neomed.edu*

The coordination of respiration and swallowing in preterm mammals

Endothermic animals such as mammals have high functional demands for both feeding and breathing. However, these two behaviors must be temporally separate because food must cross the airway in the pharynx. The ability to coordinate feeding and breathing is therefore critical to survival. Preterm infant mammals typically struggle to coordinate these behaviors, reflecting an immature nervous system. However, increased neuroplasticity in such infants suggests that they may be able to overcome problems coordinating breathing and swallowing as they age. To test this possibility, we compared the coordination of respiration and deglutition in preterm and term infant pigs longitudinally from birth to weaning. We found that term pigs exhibited substantial coordination between breathing and feeding from seven days old through weaning, and that they increased the delay of inspiration following a swallow as they aged, implying increased airway protection. However, preterm infants possessed no stereotyped breathing patterns related to the timing of the swallow when young and failed to develop such coordinated behavior throughout suckling. Our results indicate that some aspects of this immature nervous system are carried through infancy and may be manifest as animals wean and start eating solid food.

P1-290 MCCANN, M*; LATTANZIO, M; Christopher Newport Univ.; *madison.mccann.13@cnu.edu*

Sex Differences in the Response to Recent Climate Change by a Sexually-Dimorphic Species

The growing threat of climate change to biodiversity has led to a surge in studies geared to understanding species' responses, particularly with respect to changes in mean body size. Yet although current theory predicts widespread climate-driven declines in the mean body size of numerous taxa, both size increases and stasis have also been observed, prompting a need for further inquiry into the factors underlying these alternative ecological responses. In particular, the potential for males and females to exhibit divergent responses to long-term climatic shifts has received scant attention. Here we evaluate the impact of recent climate change on adult body size of male and female sage brush lizards (*Sceloporus graciosus*) drawing from eight populations spread throughout the species' range. Historical data (1954-1996, n = 905) supported male-biased sexual size dimorphism (SSD) and a tendency for larger size in warmer as well as more seasonal and rainy habitats. Present-day data (2017, n = 229) however revealed a different pattern: namely, a lack of consistent SSD and a tendency for larger size in cooler as well as wetter habitats. Temporal shifts in size were primarily driven by temperature, followed by precipitation, with the greatest size increases in habitats experiencing greater overall climate shifts over time. Interestingly, the sensitivity of females and males to climate shifts diverged in a way that may explain their lack of present-day SSD. Overall, we conclude that climate change may also favor larger body sizes (particularly when accounting for temperature and precipitation shifts), and that sex-specific climate responses may override expected patterns of SSD and body size evolution in a species.

P3-23 MCCARTY-GLENN, M*; SYED, S; MEHTA, RS; WARD, AB; WARD, Andrea; Adelphi University, Univ. of California, Santa Cruz; *award@adelphi.edu*

How substrate impacts terrestrial locomotion in American eels

American eel (*Anguilla rostrata*) populations have been threatened due to a number of factors including dams which can block the upstream migration. However, like many elongate fishes, American eels can move between bodies of water by either climbing a dam wall or leaving the body of water to circumnavigate the dam. In this research, we tested American eels moving across three different substrates: hard-packed sand, small loose pebbles, and small fixed pebbles where the pebbles were glued to each other and the container. We found significant interactions between substrate and location along the body. On hard-packed sand, American eels had the lowest distance ratios and velocities, especially along the middle of the body. Both the distance ratios and velocities were similar across substrates at the head and tail of the animal. Wave amplitude and frequency were found to differ across the body, but not between substrates. This study will provide additional understanding to how best to open up migratory pathways for American eels through the development of eel passageways.

P2-69 MCCRACKEN, A.R.*; DABE, E.C.; MOROZ, L.L.; Wesleyan University, University of Florida; *amccracken@wesleyan.edu*

Neuronal Cell-type Homologies and Nervous System Innovations in Euthyneuran Molluscs

Euthyneura molluscs provide a unique opportunity to study the homology and evolution of nervous systems on a cellular level because these animals have the largest neurons in the animal kingdom. Since the Cambrian expansion, molluscs have undergone multiple independent nervous system centralization events where clusters of neurons have fused or been lost. In contrast, the serotonergic Metacerebral Cells (MCCs) are functionally and morphologically conserved across 380 million years of evolution, the longest traced single neuron homology in any system! Yet, little is known about the genetic homology shared between Euthyneura. To address this, we compared CNS, ganglia, and single neuron transcriptomic data from *Pleurobranchaea californica* to the genomic and transcriptomic data from the classic Euthyneura neuroscience model *Aplysia californica* and to other close and distant relatives. BUSCO analysis revealed 94% conservation of metazoan single copy orthologs in the *P.californica* hybrid assembly suggesting that we have constructed a reference transcriptome of near genome quality. Neuropeptides are diverse fast-evolving signal molecules that regulate physiological processes and behavior. Manual annotation of neuropeptides revealed that out of the Euthyneura evaluated, *P.californica* had the fewest shared neuropeptides with *A.californica*. Overall, the MCC transcriptome profile was highly conserved across species with orthologs found for transcription factors, ion channels, neuropeptides and the serotonergic biosynthesis genes. We also found numerous innovations in gene expression at the ganglia and single neuron levels, altogether allowing for a better understanding of how brains, novel circuits, and behaviors have evolved.

P3-118 MCCRARY, MB*; DUNCHEON, EJ; ALLEN, HC; O'KEEFE, JM; CHAMPAGNE, AM; University of Southern Indiana, The Ohio State University, Indiana State University; *mbmccrary@eagles.usi.edu*

Molecular interactions in bat skin suggest convergent evolution with birds

The outermost layer of skin, the stratum corneum (SC), protects the body from mechanical abrasion, pathogens, and excessive water loss. The SC is 10-20 μm thick and is composed of corneocytes embedded in a lipid matrix. These lipids help maintain the barrier function of the skin, and in most mammals consist of ceramides, free fatty acids, and cholesterol. However, bat SC contains a more diverse group of lipids including cerebrosides, ceramides with a sugar moiety attached to the headgroup. This lipid composition resembles avian stratum corneum, and may indicate convergent evolution between bats and birds. We used infrared spectroscopy to investigate the conformation of lipid chains in the SC of the big brown bat (*Eptesicus fuscus*) at 5° intervals from 15-50° C. Additionally, we exposed the SC to different vapor pressures and measured changes in hydrogen bonding properties as a function of hydration. We found that lipid chains in bat SC respond to temperature in a manner more similar to lipids in avian SC than lipids in the SC of most mammals. Furthermore, the presence of cerebrosides may affect hydrogen bonding interactions between lipids and water in the SC. The similarities between bird and bat SC may be a result of selection to maintain barrier function while simultaneously meeting the mechanical demands of flight.

P1-95 MCCUE, M.D.*; KLOK, J.; LIGHTON, J.R.B.; Sable Systems International; *mmccue@sablesys.com*

Running mice increase their metabolic rates, but don't increase rates of lipid oxidation

Moderate intensity exercise in humans consistently causes increases in metabolic rates, and thankfully, also increased rates of lipid oxidation. Interestingly, it is not uncommon for a standard laboratory mouse consuming a diet with >5% lipid content to voluntarily run as much as 3 km per day when provided with a running wheel. Changes in RER are often used to infer shifts in oxidative substrates, but such changes are difficult to reliably quantify during short term bursts of activity (e.g., 20-60 seconds) on a running wheel. In order to reliably document changes in oxidative fuels we designed a treadmill respirometry system with reduced time constant to document rapid changes in respiratory gases. Subadult mice were switched from a control diet to one that was supplemented with a stable isotope labeled fatty acid (^{13}C-palmitic acid; 4g/kg chow) for one week in order to enrich their body lipids. Mice were fasted for 1 h prior to experimental trials to minimize the assimilation (and subsequent oxidation) of recently ingested nutrients. We then measured the metabolic rates (VCO_2) as well as the isotopic enrichment ($\delta^{13}C$) of mice for 5 minutes prior to exercise and during a 7-min bout of exercise at a speed of 15 m/min, and found that VCO_2 increased by over 50% during the first minute of exercise and leveled out during continued exercise. Rates of oxidation of endogenous palmitic acid (calculated from the ($\delta^{13}C$ in the exhaled breath) increased by 40% during the first minute of exercise; however, these values rapidly decreased, and during the last minute of exercise they were not statistically different from the resting state. These results suggest that unlike humans, mice do not fuel sustained, short-term locomotor activity using endogenous lipid stores.

P3-165 MCDONALD, JY*; LUSK, E; SAVICI, S; CASTO, JM; Illinois State University; *jmcdona@ilstu.edu*

Ectoparasites, Developmental Trade-offs, and Inflammation

In cavity-nesting songbirds, blood-feeding ectoparasite infestations can induce developmental trade-offs among somatic growth, physiological maturation and immune function. To grow and reproduce, ectoparasites require blood meals, which may be costly to host chicks, yet few studies have assessed which consequences of blood meals might induce developmental trade-offs. Previous research in European starlings (*Sturnus vulgaris*) suggests that Northern fowl mite (*Ornithonyssus sylviarum*) infestations produce effects on nestling phenotypes that are not simply mimicked by experimental blood loss. Perhaps mites also induce energetically costly acute phase responses in host chicks, characterized, in part, by increased proinflammatory cytokine production. We experimentally manipulated Northern fowl mite abundance and experimental blood loss in starling chicks and assessed chick survival, somatic growth, physiological maturation, and plasma concentration of the proinflammatory cytokine interleukin 6 (IL-6), to assess whether inflammation intensity covaries with these other variables. Nests were assigned to one of three treatments: permethrin-induced mite reduction, experimental blood loss, or mite enhancement. We assessed somatic growth of chicks at 5, 10 and 15 days of age. At these ages, blood was also collected to assess hematocrit, hemoglobin concentration, and inflammation via an IL-6 enzyme immunoassay. In chicks from the experimental blood loss group, additional blood was also collected as part of their experimental treatment. Preliminary results suggest that, relative to the other treatments, mite enhancement produced lighter chicks, and slowed physiological development. These data will be presented and discussed along with data on plasma IL-6 concentrations and nestling survival.

P2-54 MCDONALD, MS*; COHEN, JH; PORTER, ML; University of Hawai'i at Mānoa, University of Delaware; *marisam7@hawaii.edu*
Visual physiology of the grass shrimp Palaemonetes vulgaris
Grass shrimp of the genus *Palaemonetes* are visual animals, which use their eyes for predation, defense, and orientation. However, work on their visual physiology is dated and comparative studies on sympatric species are absent. This study aimed to investigate the visual physiology of *Palaemonetes vulgaris* through the use of electroretinogram (ERG) recordings. ERG data was used to model multiple spectral classes in shrimp tested under dark and orange chromatic adaptation and assess irradiance sensitivity with V-logI curves. *P. vulgaris* were found to be dichromatic, consistent with earlier work that described a broad peak at 540 nm and a narrow peak at 390 nm. The primary peak was clearly seen in dark-adapted animals in the green spectrum at 531 nm. Under orange chromatic-adaptation a UV peak emerged at 390 nm. As well as being a narrower peak shape, there was a 10 nm wavelength discrepancy in the peak wavelength of the green visual pigment compared to earlier work. The UV visual pigment was consistent with previous studies. In addition to spectral sensitivity, irradiance sensitivity measurements were taken at 530 nm in *P. vulgaris*, as well as in the closely related species *P. pugio*. These species are found sympatrically, but tend to separate by salinity and substrate in their natural habitats. We found that there is no significant difference between the irradiance sensitivities of the two species when they are maintained in the same conditions. Thus, any differences in habitat do not appear to be reflected in visual physiology.

P1-281 MCGRATH, SC*; GEISINGER, R; CARTY, W; SCOTT, K; MOORE, G; LANDBERG, T; Arcadia University, Arcadia Universtiy, Alfred University, Arcadia University ; *smcgrath_01@arcadia.edu*
Effects of Farming Practices and Animal Husbandry on Bone China Quality
Bone quality varies greatly within and between species for evolutionary, ecological, and developmental reasons. Diet and exercise may also influence the material properties of live bone by affecting the structure and composition of the primary bone minerals, calcium and phosphorus, as well as trace elements such as zinc, potassium, lead, and manganese. We use atomic absorption spectroscopy and scanning electron microscopy and material testing to determine how animal husbandry practices used to raise cows impact the chemical composition of cow femurs. From there, we transform the bone into bone china, a high-quality ceramic material made from 50% bone ash (the inorganic mineral component of bone), kaolin clay, and feldspathic mineral. When bone china is produced from cows that are free-range and grass-fed, the ceramic material is high-quality- white, translucent, and strong. However, when bone china is produced from industrial sources or bones of cows that are raised in small factory farms and primarily grain-fed, the bone china appears of lower quality- tinted yellow or off-white, has greater opacity, is more fragile and melts at lower temperatures. Preliminary results of the factory-farmed animal bone show the presence of whitlockite, a possible indicator of metabolic bone disease. Whitlockite incorporates iron and manganese into the hydroxyapatite structure which may explain the poor quality and low performance of grain-fed bone china. Our preliminary research suggests that bone china has extreme potential to reflect many aspects of biological variation by expressing not just our agricultural practices, but our values. Variation of this historic material has potential application in many forms including in industry, prosthetics, craft, and art.

P2-218 MCINERNEY, MG*; STAAB, KL; McDaniel College, Westminster, MD; *mgm005@mcdaniel.edu*
The Structure and Composition of the Kinethmoid and Attached Ligaments in Cypriniform Fishes
Fishes in the order Cypriniformes are characterized by having a sesamoid bone in the upper jaw called the kinethmoid. The kinethmoid is attached to the maxillae, premaxillae, palatines, and neurocranium by ligaments that are responsible for transmitting muscular forces to protrude and retract the jaw during feeding. Each ligament is composed of differing types of connective tissues, and we examined the morphology and composition of the tissues from a functional perspective. We used histology to describe the morphology of the elements in the upper jaw of four cypriniform species, the goldfish, *Carassius auratus,* zebrafish, *Danio rerio,* rosy minnow, *Pimephales promelas,* and tiger barb, *Puntigrus tetrazona*. Using both quadruple and quintuple staining methods, we were able to identify the structure of the kinethmoid and ligamentous connections in addition to the types of cartilage-like connective tissues present. The premaxillary ligament is composed of hyaline-cell cartilage, a tissue with densely packed cells and little extracellular matrix. Both the palatine and maxillary ligaments resemble mammalian ligaments by having fusiform-shaped cells in a matrix with parallel fibers, but the palatine ligament extends more rostrally during protrusion and contains elastin, which may function to retract the jaws. Additionally, the kinethmoid stains differentially for both high and low tensile collagen where the low tensile region is located towards the interior of the bone while the high tensile region is on the periphery. Through our research, we can work towards a more complete understanding of the biomechanics of kinethmoid-mediated premaxillary protrusion.

P2-276 MCKENNA, A/J*; SMITH, A; GIBBS, A/G; Univ. of Nevada, Las Vegas; *austin.mckenna@unlv.edu*
Rapid Evolution of Starvation Resistance in Drosophila: Physiological and Molecular Mechanisms
We subjected five replicate populations of *Drosophila melanogaster* to selection for starvation resistance and compared them to a founding control population that had been maintained at large population sizes to reduce linkage disequilibrium. After only one generation of selection, all five replicate selected populations survived longer without food than the control population, and starvation survival continued to increase over the next 9 subsequent generations. Previous studies have shown that long-term starvation-selected Drosophila contain more lipid, have lower metabolic rates and develop more slowly than controls. Lipid contents in our selected populations increased within three generations, and development tended to be slower within five. Samples were collected each generation for a genome-wide association study to link changes in SNP allele frequency with evolved phenotypic changes. Preliminary findings of the GWAS will be presented.

P2-223 MCNEMEE, RE*; GREENWAY, R; TOBLER, M; Kansas State University; *remcnemee@ksu.edu*

Genital evolution in livebearing fishes of caves and toxic springs

Populations of *Poecilia mexicana*, a live-bearing fish common in freshwater streams in Southern Mexico, have adapted to life in toxic sulfide streams in and outside of caves. Previous studies have shown that these populations have evolved morphological, physiological, and behavioral adaptations to extreme environments, resulting in ecological speciation. Reproductive isolation between populations in differing habitat types is facilitated by natural and sexual selection against migrants between habitats. However, selection against migrants cannot solely explain the low levels of observed gene flow. We predict genital divergence between populations may contribute to reproductive isolation. The question remains, however, whether and how the genitalia of males (gonopodial tip) and females (urogenital aperture) differ among populations inhabiting contrasting environments. Particularly, the cave populations may have evolved differences in genital traits associated with a sensory role in sexual selection in the absence of light. We quantified genital variation in four populations of *Poecilia mexicana* (sulfide surface, non-sulfide surface, sulfide cave, and non-sulfide cave) with ongoing speciation to test if male and female genitalia diverge in a correlated fashion. We found that there is divergence in genitalia across populations in different habitat types. We also document evidence that male and female genitalia have coevolved within populations. The basic requirements for mechanical isolation are consequently fulfilled in this system, and experimental studies are now needed to understand the functional significance of genital variation.

P3-42 MCPEEK, S. J.*; KOTNOUR, J. L.; GLOVER, M.; MBUYU, N.; WRIGHT, N.; Kenyon College; *mcpeeks@kenyon.edu*

Searching for sexually dimorphic flight in Eastern bluebirds (Sialia sialis)

The presence and extent of sexual dimorphism is an important question in all aspects of the zoology of a species. Birds provide some of the most striking examples of this phenomenon, like the male Eastern bluebird's vibrant blue plumage compared to the female's dull periwinkle. However, investigations of sexual dimorphism are traditionally limited to physiological differences such as body size, color, and secondary sexual traits, with little focus on whether sex differences could affect behavioral traits such as flight performance. We used high speed video footage of flight from 10 breeding pairs of Eastern bluebirds in rural Ohio to ask whether males and females exhibit sexual differences in their flight behaviors during the breeding season. We hypothesized that females have impaired flight performance during the breeding season compared to males due to the higher energetic costs of reproduction on females. Our findings suggest that males and females exhibit sexual differences in their flight behaviors during reproduction. These results imply that sexual dimorphism in birds extends to complex behavioral traits, and further work should address how these differences manifest during the non-breeding season.

P2-60 MCPHERSON, DR; SUNY Geneseo, New York; *mcpherso@geneseo.edu*

Retrograde labeling of neuronal projections to the heart in the pond snail, Lymnaea stagnalis

As in vertebrates, the heart of gastropod mollusks is myogenic with neuromodulation from the central nervous system. In the pond snail Lymnaea stagnalis the primary source of neuromodulation is by way of the intestinal nerve. Earlier explorations of the central nervous system have identified several populations of neurons that have recognizable modulatory effects on heart rate and cardiac muscle contraction, but it is not certain that all of the relevant neurons have been identified. To address this, I have carried out backfills of the intestinal nerve using using biocytin, which yields backfills of superior quality. The results indicate a much larger and more widespread innervation of the heart than has been previously described. A portion of the newly observed neurons may be sensory, while others may have motor effects. The results will be compared to previous results and the identity of possible transmitters will be explored by double-labeling using transmitter-specific antibodies.

P1-87 MCTERNAN, MR*; SEARS, MW; ANDERSON, RA; Clemson University, West. Wash. University; *mmctern@g.clemson.edu*

Higher Food Availability May Offset Energetic Limitations Associated With Less Activity Time

Warming climates are projected to shift the activity patterns of many animals. While animals with longer periods of activity have a higher potential for somatic growth, some locally adapted populations may deviate from this expectation. We studied two populations of *Sceloporus occidentalis* in Washington State, one in a cool climate and one in a warm climate. The cooler climate restricts activity, yet individuals from this population still reach a fatter body condition. Individuals from the cool site also expend more energy daily on maintenance metabolism but have higher food availability. As such, we hypothesize that higher food availability at the cool site may permit greater seasonal maintenance energy expenditure that still results in more residual energy left for storage. To evaluate our hypothesis, we use estimates of activity time and measures of maintenance metabolism to calculate seasonal maintenance energy expenditure. We then subtract these values from seasonal daily energy intake estimates to calculate residual energy supply. While activity patterns of many animals are expected to shift with warming climates, food availability may play a key role in offsetting potential energetic consequences.

P2-155 MECKEL, S; LADNER, R; WILLIAMS, JB*; Southern Illinois University Edwardsville; *jasowil@siue.edu*

Diurnal temperature variation enhances survival and potential fecundity in the overwintering goldenrod gall fly, Eurosta solidaginis

Previous work suggests elevated winter temperature speeds the onset of post-winter development as well as negatively impacting survival and potential fecundity. However, these studies typically used constant exposure temperature with less consideration of the potentially important contribution of diurnal variation. To determine the effect of variable winter temperature on the above parameters, we compared pupation date, survival, and potential fecundity in the goldenrod gall fly, *Eurosta solidaginis*, exposed to constant, average monthly temperature or diurnal cycles that fluctuated between monthly low and high temperature (average-constant or average-variable groups). In addition, to assess the effect of elevated winter temperature we subjected larvae to constant temperature and a diurnally fluctuating regime as predicted by a climate change model (elevated-constant or elevated-variable treatment). Elevated winter temperature sped development as larvae exposed to constant, elevated temperature had a median date of pupation of March 24, which occurred 13, 24, and 36 days before those in the elevated-variable, average-variable, or average-constant treatments respectively. Levels of adults displaying a righting response five days after eclosion was greatest in those subjected to the elevated-variable treatment (54%), while the remaining groups averaged only 30%. Exposure to variable winter temperature preserved potential fecundity as females in the elevated-variable and constant variable treatments produced and average of 148 ± 14 eggs compared to just 104 ± 9 eggs in the constant temperature treatments. In sum, elevated winter temperature sped the onset of spring development, while variable temperature regimes enhanced survival and potential fecundity.

P1-277 MELSTROM, KM*; WISTORT, ZP; University of Utah; *keeganmelstrom@gmail.com*

Quantification conundrum: Just how repeatable are dental complexity measurement methods?

Increases in the availability and affordability of 3D model generation have led to the rapid development of methods that evaluate the morphology of extinct and extant animals. In particular, orientation patch count rotated, a technique that quantifies phenotypic tooth morphology, allows for the direct comparison of dental elements without homologous landmarks. This method has been particularly useful in the ecological reconstructions of extinct taxa. Given the fast pace of technological development, the program that initially developed the method, Surfer Manipulator, is often not used in subsequent studies, replaced by more intuitive, flexible, or freely available programs. Unfortunately, the repeatability of these methods is neglected due to a combination of factors including dissimilar datasets or unavailability of programs. Here, we use a single dataset of saurian teeth to directly test the compatibility of three orientation patch count rotated methods: Surfer Manipulator, the R-package 'molaR', and MorphoTester. We find that the freely available programs, MorphoTester and molaR, consistently produce identical dental complexities, an expected observation as these programs calculate dental complexity in the same fashion. In contrast, these programs do not replicate the measurements generated from Surfer Manipulator, frequently producing higher average dental complexity values. In particular, dentitions belonging to carnivores are especially susceptible to this disparity. We strongly recommend that datasets created from combinations of these methods should not be used, especially for ecological reconstructions. These results emphasize the importance of replicating previous studies with the advent of novel methods. Additionally, in the case of orientation patch count rotated, care needs to be taken when deciding what method to apply to one's dataset.

P2-94 MEYER, SC*; JOHNSON, CA; PINTOR, LM; Georgia Southern Univ., Ohio State Univ., Ohio State Univ; *sm30152@georgiasouthern.edu*

Giving Up Density as an Approach to Identify a Difference in Foraging Behavior Between Native and Invasive Crayfish Species

Orconectes rusticus is a prolific invasive crayfish species that has invaded a broad geographic range and has displaced several crayfish species. Previous studies have investigated the differences in life stages and physical characteristics of *Orconectes sanbornii* and *Orconectes rusticus* but did not include individual foraging behavior in their comparisons. A better understanding of the behavior of *O. rusticus* is needed to understand why it is such a successful invader. In Ohio streams *O. rusticus* has been displacing *O. sanbornii* in a major portion of its natural range. Here we tested whether native *O. sanbornii* were displaced by invasive *O. rusticus* through superior foraging and whether foraging behavior changed in the presence of a model fish predator. We used depletable food patches of chicken liver to compare the foraging behavior of native *O. sanbornii* and invasive and native populations of *O. rusticus* under high, low or no predation risk. We then measured the remaining food concentrations in each patch after a 24-hour period as an indication of giving up density (GUD). We found that there was no significant effect of predation risk on the GUD of either species. However, *O. sanbornii* left significantly lower GUDs on average than either native or invasive populations of *O. rusticus*. Which suggests that *O. sanbornii* is a more active forager than *O. rusticus*. Our research indicates that the invasion mechanism that *O. rusticus* employs to displace *O. sanbornii* is not exploitative foraging but rather an unidentified mechanism. Gaining a better understanding and being able to better identify the mechanisms of species invasions can lead to better and more effective management of invasive species in the future.

P3-61 MICHEL, K B*; WEST, T G; DALEY, M A; ALLEN, V; HUTCHINSON, J R; Royal Vet College, London; *kmichel@rvc.ac.uk*

A comparison of appendicular muscle physiology and biomechanics in Archosauria

Archosaurian reptiles (including living crocodiles and birds) have had an explosion of locomotor variation since the Triassic. Their appendicular muscle physiology and biomechanics are pivotal to our understanding of how their diversity, natural history and evolution relate to this locomotor variation. Information on muscle contraction velocity, force and power in extinct archosaurs such as Pseudosuchia and Ornithodira is of course not available from fossil material, but is needed for biomechanical modelling and simulation. However, an approximation or range of potential parameter values can be obtained by studying extant representatives of the archosaur lineage. Here, we perform a quantitative study of the physiological performance of multiple muscles from several individuals of Nile crocodile (*Crocodylus niloticus*) and Elegant crested tinamou (*Eudromia elegans*). Nile crocodile musculature shows high power and velocity values-- the FTI4, a small "hamstring" hip extensor and knee flexor actively used for terrestrial locomotion, performs particularly well. The Elegant crested tinamou muscles' performance is on par with birds of similar body mass, and shows the same pattern of parameter variation between muscles of a similar function in other birds. These findings demonstrate physiological differences between anatomical muscles, potentially based on their roles during locomotion. By contributing new data from previously unstudied archosaurian species and muscles to existing data, we can now better bracket possible muscle parameter values, and thereby better estimate in computational analyses how extinct archosaurs may have moved.

P2-184 MIDKIFF, B.S.*; DEAROLF, J.L.; THOMETZ, N.M.; Hendrix College, Conway, AR, Univ. of San Francisco, CA; *midkiffbb@hendrix.edu*

Comparison of glycolytic metabolism in bottlenose dolphin and harbor porpoise vocal muscles

Toothed whales use a specialized nasal system to produce vocalizations that they use to navigate and communicate. For example, the Atlantic bottlenose dolphin (*Tursiops truncatus*) uses its primarily slow-twitch left nasal musculature (LNM) to produce whistles, while its right nasal musculature (RNM) produces clicks using fast-twitch fibers. In comparison, the harbor porpoise (*Phocoena phocoena*) only emits clicks, and its LNM and RNM are both primarily fast-twitch. Thus, we hypothesized that the dolphin RNM would have higher glycolytic activity than its LNM and both porpoise musculatures would have similar glycolytic activities. To test these hypotheses, samples of the LNM and RNM of dolphins and porpoises were collected from stranded animals and frozen. The muscle samples were prepared for the lactate dehydrogenase (LDH) assay, and their LDH activities were assayed under the following conditions: 50 mM imidazole, 0.15 mM NADH, 1 mM pyruvate, and pH 7.0 at 37oC. Using a microplate reader, we measured the rate of change in absorbance (340 nm) at Vmax to calculate glycolytic activity. One specimen per muscle of each species was used to determine the optimum dilution factor before running that dilution factor on all specimens. *T. truncatus* RNM glycolytic activity was found to be 207.4 (± 95.2) µmol /min*g, while the LNM activity was 172.9 (± 12.6) µmol /min*g. *P. phocoena* equivalents were 266.9 (± 205.4) and 215.7 (± 105.7) µmol /min*g. Results showed higher glycolytic activity in the RNM than in the LNM for both species and higher glycolytic activity in porpoise muscles compared to the dolphin equivalents. However, all four of the measured glycolytic enzyme activities were low, which fits with the small energy requirements of clicking in these cetaceans.

P1-64 MILLER, AL*; HEARST, LW; University of Tampa; *abraham.miller@ut.edu*

Evolution of Relative Eye Size in Scorpions

The evolution of eye size has been studied across multiple vertebrate and invertebrate taxa. Most research has focused on species with high visual acuity or the adaptive loss of eyes in no light environments. In scorpions, the eyes have been studied to assess their sensitivity and function. However, little attention has been given to the evolution of eye size in scorpions, with the exception of troglobite species. Scorpions are nocturnal predators that rely primarily on specialized setae to detect substrate and air vibrations of their prey. However, the persistence of the eyes in most scorpion species suggests the eyes are functional, albeit not for prey capture. Research has shown the eyes of scorpions are sensitive to changes in ambient light and may assist with celestial navigation and circadian rhythms. Although many scorpions are desert inhabitants, others occupy a variety of habitats, including environments with significant canopy cover. We previously found that relative median eye size, was significantly larger in a species from Florida (high canopy cover), than in a species from the western US (low canopy cover). This research tested the relative size of the median eyes, in multiple species of scorpion, across multiple families and environments. It was predicted that species from greater canopy cover would exhibit larger relative eye size, and differences would be greater among families than within. Controlling for carapace length (measure of body size), eye size was larger in the scorpion species that occupies a forested environment compared to the desert species. These data coupled with phylogenetic analysis could give great insight into our understanding of the evolution of eye size.

P1-135 MINER, KA*; GABOR, CR; Texas State University; *krystieaminer@gmail.com*

Physiology, Behavior and Reproductive Success of (Gambusia affinis) Under Artificial Light at Night

Artificial light at night (ALAN) is light that alters the natural light and dark cycle in an ecosystem and includes streetlights, headlights and flood lights. An estimated two-thirds of the world population is living in areas above the light pollution threshold. ALAN is known to have detrimental effects on wildlife by altering reproduction, foraging, predation, physiology, and orientation in multiple taxa. We used (*Gambusia affinis*), a widespread live-bearing fish, to study the effects of ALAN by exposing female fish to a constant light cycle and comparing cortisol, reproductive success, behavior and growth to those kept under a natural light cycle. We predicted that fish exposed to ALAN would have increased cortisol levels and activity compared to fish kept under a normal light cycle. We measured cortisol release rates five times over 60 days using a water-borne collection method. Cortisol is the primary glucocorticoid in fish and is indicative of an organism's physiological response to disturbance, therefore is an important parameter to measure when looking at anthropogenic influences such as ALAN. Under chronic stress cortisol may become permanently elevated or depressed and could suppress growth and reproduction. To examine this, we measured the stress response to agitation on day 60. We also explored the number and condition of broods from fish exposed to ALAN versus those in the control treatment. Results demonstrate that female (*G. affinis*) exposed to ALAN have lower mass compared to those in the control treatment.

P1-265 MINSKY, G*; GOODHEART, J; GONZALEZ, M; MUñOZ, D; TORRES, E; OAKLEY, T; UCSB; *ggminsky@ucsb.edu*

Developing The California Sea Firefly (Vargula tsujii) as a laboratory organism to study the genetic basis of species diversification by sexual selection

Sexual selection may lead to increased diversification of species, as exemplified by origins of luminous courtship in multiple animal groups, including cypridinid ostracods (Crustacea). Dozens of species of cypridinids radiated in the Caribbean using a wide range of luminous courtship displays. Although the biochemistry and genetics of bioluminescence are well studied, easily culturable luminous animals are rare, making many types of experiments intractable. Here we report progress toward keeping the luminous ostracod *Vargula tsujii* through full life-cycles in laboratory aquariums. The California Sea Firefly (*Vargula tsujii*) is found within the clade of ostracods that uses bioluminescence for courtship, but represents a loss of this ability, using bioluminescence purely for defense. *Vargula tsujii* is geographically isolated from closely related species in the Caribbean, found in Southern California and more accessible to our lab. However, almost nothing is known about the life cycle and development of this species. To address this need, we measured hundreds of wild-collected animals. We present multi-dimensional k-means clustering analyses to quantify the size and shape of instar stages for *V. tsujii* development. Within custom aquariums, we show through measurement of lab-reared animals that we raised a full life cycle of *V. tsujii* in the laboratory, a first for any luminous ostracod. These results, combined with descriptions of development and molting times, provide insight into the life cycle of *V. tsujii*. This research will facilitate the understanding of bioluminescence and will allow a host of new laboratory experiments to study sexual dimorphism, sexual selection, and link genes to the diversification of species and courtship signals.

P3-11 MITCHELL, CT*; DROTLEF, D; DAYAN, CB; SITTI, M; STARK, AY; Villanova University, Max Planck Institute for Intelligent Systems; *cmitch23@villanova.edu*

Elastic modulus affects adhesive strength of gecko-inspired synthetics in variable temperature and humidity

For nearly two decades the gecko adhesive system has inspired the fabrication of synthetic, gecko-inspired adhesive products. Although derived from the study of the natural system, these synthetics can illuminate details about the mechanisms of the biological system by creating a bidirectional pathway of knowledge. For example, geckos take advantage of small, hair-like structures on their toes called setae. The keratin-based setae soften in high humidity and become more adhesive. Consequently, shear adhesion of live geckos shows that whole animal adhesive performance is significantly impacted by humidity, but this is temperature-dependent. Specifically, whole animal adhesion increases as humidity increases, but only at low temperatures. Interestingly, the same is true for a gecko-inspired synthetic, except when ambient humidity was raised to 80% and temperature remains low. One hypothesis for this discrepancy is that the synthetic lacks the ability to change modulus at high humidity, and that this change is the key to improved adhesive performance in the natural system. To test this hypothesis, we measured adhesive performance by exposing polydimethylsiloxane (PDMS) gecko-inspired synthetic tape samples, each with its own modified modulus of elasticity, to the same set of conditions as previous studies (both the live gecko and synthetic). The results of our work elicit potential improvements for the synthetic and shed light on the adhesion mechanism of the natural system. The striking similarities between synthetic and natural adhesive systems offer the opportunity to conduct research that improves understanding of both systems concurrently.

P1-80 MIYAMAE, J.A.*; BHULLAR, B-A S.; Yale University; *juri.miyamae@yale.edu*

Starting to Smile: Comparative Ontogeny of Mammalian Facial Muscle

Facial muscles are a distinctively mammalian feature responsible for daily activities such as communication, sensory exploration, and feeding. Examination of the fossil record suggests that at least a subset of facial muscles - those responsible for the mobilization of mystacial vibrissae - may have been present in stem-mammalian ancestors as far back as the Mid-Triassic. From their deep evolutionary origins, facial muscles in modern mammals have subsequently diversified into an incredible array, including extreme modifications such as the elephant's powerful trunk and the subtle expressive landscape of the human face. In this study, we compare the ontogeny of facial muscles in various marsupial and placental mammal species using both confocal images of fluorescent immunostained and reconstructed microCT scans of iodine contrast-stained embryos and neonates. Our exploration of the sequence of facial muscle differentiation shows some of the conserved as well as the more clade-specific variations in the developmental process, providing insight on the evolution and diversification of this muscle system.

P3-105 MOFFITT, M*; REHMAN, F; AHEARN, G; University of North Florida; *n00666596@ospreys.unf.edu*

Preliminary study: Effects of cell density and media changes in Homarus americanus primary cell culture on 3D matrices

The North Atlantic lobster, *Homarus americanus*, is a cold-water invertebrate that is important fundamentally and economically. Physiological transepithelial transport processes for any nutrient, ion, or heavy metal cannot be studied with ease due to the lobster's complex anatomical arrangements. Previous studies on organ dissociation, i.e. hepatopancreas, antennal gland, and/or gills, into cellular suspensions that could be supported *in vitro* to form functional confluent monolayers provide a technical means to study transepithelial transport. In this preliminary study, 3D culture techniques, and cell density seeding, cellular growth, and morphology of cell colonies were investigated to optimize crustacean cell culture in developing a functional confluent monolayer for transepithelial transport studies. It was found that 3D collagen substrata and regular media changes *in vitro* can support colony growth of cells that were likely undergoing mitosis, forming functional junctions with neighboring cells, and pseudopodal growth. Cell density appears to play an important role in the development of a confluent monolayer. Cells must not be seeded too densely but must be seeded at a specific density to form functional junctions. Adaptation of colony growth appears to be dependent upon specific seeding density and regular media changes along with supportive 3D substrata. The goal of these investigations is to yield a functional analysis of transepithelial transport in cultured monolayers in Ussing Slider cell culture cup inserts placed into an Ussing chamber that separates the monolayer apical and basal membranes so that the nature and regulation of solute movement across the cell layer can be ascertained.

P2-72 MOHAN, U; MANJUNATH, M; SANE, S. P.*; National Centre for Biological Sciences, TIFR; *sane@ncbs.res.in*

Multimodal integration by descending neurons in hawkmoths

Flying insects acquire, process and respond to stimuli of multiple modalities at a time scale of a few wing beats to maintain stable flight. Of the various sensory inputs, antennal mechanosensory input and visual input have been shown to be critical for flight in hawk moths. Acquisition and processing of visual inputs is typically slower than that of mechanosensory inputs. How the stimuli from different modalities across different time scales are combined for stable flight is not well understood. We have addressed this question, in the Oleander hawk moth (*Daphnis nerii*) by recording the electrophysiological activity from single descending neurons in the neck connective, while providing the moth various combinations of visual and antennal mechanosensory inputs. These recordings allowed us to identify multiple classes of descending neurons which respond either to only visual stimuli or only antennal mechanosensory stimuli, or both visual and mechanosensory stimuli. There is a clear bandwidth separation in the neurons' response to the visual and antennal mechanosensory stimuli. Neurons responding to antennal mechanosensory stimuli alone are high-pass and encode at frequencies exceeding wingbeat frequency, whereas neurons responding solely to visual stimuli are low-pass and encode at lower frequency visual stimuli. We classified the descending neurons by algorithmically creating circuit models to explain the responses and grouping neurons with similar circuit models. These diverse classes likely correspond to information used in different flight stabilization scenarios.

P2-99 MOLINA, EM*; MENDONCA, MT; Auburn University ; *emm0044@auburn.edu*

Quantification of oxidative stress and baseline immunity to chronic exposure of low levels of DDT in two species of rodents: Peromyscus maniculatus and Sigmodon hispidus

Chronic exposure to low levels of anthropogenic chemicals in the environment continues to be a major health concern. Due to concerns about the effects on humans and wildlife heavily used persistent organic pollutants (POP's), such as dichlorodiphenyltrichloroethane (DDT), were banned. However, their ubiquitous nature and persistence allows them to remain within the environment at sub-lethal levels for decades. Although levels of POP's have been decreasing, they are still high enough to potentially affect physiological functions such as oxidative stress and immunological response parameters. Two species of small mammals (*Peromyscus maniculatus* and *Sigmodon hispidus*) were collected at the Redstone Arsenal, a designated EPA SuperFund site in a historically impacted vs. reference site (*S. hispidus*: n=12 and *P. maniculatus* n=13 vs 19). Soil samples taken from the DDT abatement site still show levels above the Total Threshold Limit Concentration for DDT (i.e. >1ppm), while other reference areas did not. Preliminary data show significant difference in Body Condition Index (BCI) in both species. Both species had significantly higher BCI in the impacted vs the reference site (*P. m.*: T_{28}=3.6, p= 0.0009; *S. h.* T_{25}=2.5, p=0.02). There was also a significant difference in total WBC counts, with both species (*S. h.*: T_{25}=-2.6; p= 0.01; *P. m.*: T_{28}=-2.6, p= 0.01) exhibiting lower counts in the impacted vs the non-impacted area. It has been suggested that reduction in WBC's is due to redistribution from blood to other organs (i.e. skin, mucosal lining, liver) that may enhance immune function during stress. This study can provide critical information on the potential physiological effects of chronic exposure to sub-lethal levels of POPs.

P2-43 MOLNAR, EJ*; WEBB, JF; University of Rhode Island; *emolnar@my.uri.edu*

Elaborations of the Lateral Line System in Tetras (Family Characidae: Order Characiformes)

The aquarium trade provides an affordable and consistent supply of hundreds of fish species that are underutilized in scientific research. In this exploratory study, we examined the mechanosensory lateral line system in the tetras (Order Characiformes; Family Characidae, ~ 1,000 species). We examined two to four individuals in each of seven species from six genera: *Pristella maxillaris*, *Gymnocorymbus ternetzi*, *Hasemania nana*, *Hyphessobrycon pulchripinnis*, *Hemigrammus bleheri*, *Paracheirodon axelrodi*, and *P. innes*. We also examined *Danio rerio* (n=3) and *Carassius auratus* (n=8) (Order Cypriformes; Family Cyprindae) both of which have well documented lateral line systems. Superficial neuromasts (SNs) and canal neuromasts (CNs) were stained with the fluorescent mitochondrial stain, 4-di-2-ASP, and visualized on a dissecting microscope with a GFP epifluorescence filter. After imaging neuromast distributions, fishes were prepared for SEM analysis. Similar groupings of SNs were found among all species examined, including lines or clusters on the caudal edge of the mandible and in a V-shaped line on the operculum, however the relative size difference between CNs and SNs was not consistent among the genera. For instance *P. innesi*has CNs and SNs of similar size, while in species of other genera, such as *G. ternetzi* and *H. bleheri*, the CNs were substantially larger than the SNs. These results reveal that the number, size, and distribution of SNs among genera of tetras should be evaluated as taxonomic characters, which may contribute to our understanding of their systematic interrelationships.

P1-124 MOODY, TV*; FAGAN, A; CHAN, E; MASS, S; ST. JOHN, P; SUNY New Paltz; *moodyt1@hawkmail.newpaltz.edu*

Quantifying the Rentention of BPA in Regenerating Planaria

Bisphenyl A (BPA) is a xeno-estrogen that mimics the effects of estrogen and is commonly used in human industrial and consumer products such as plastics, cleaning, health and beauty products, and pharmaceuticals. Due to its common use ecological exposure is nearly unavoidable. In prior research in our lab, micromolar concentration exposure of planaria (*G.tigrina*) to BPA causes a myriad of deleterious effects including dramatic behavioral changes, delayed reactions to stimuli, and severely affected ability to regenerate. This research is focused on quantifying the concentration of BPA absorbed and retained by planaria after a set time of exposure in media. We have used HPLC (high performance liquid chromatography) with fluorescence detection to quantify the amount of BPA present in control solutions. We have attempted to extract BPA from planarian tissue using a 50:50 mixture of a chloroform:methanol solution. However, we have identified other biological macromolecules that co-elute with BPA. We therefore have developed separation techniques to further separate these co-eluting species. We found that amino acids such as tryptophan, tyrosine, and phenylalanine co-elute with BPA and also absorb and emit at the same wavelengths as BPA. These amino acids, which are three of the monomeric units used in abundance in protein, may be interfering with the BPA signal. I plan to further experiment with different techniques, such as solid phase extraction columns and removal of the planarian mucous coat post-BPA exposure, in order to develop an amino acid / BPA separation protocol.

P3-148 MOUNGER, JM*; HUGHES, AR; GEHRING, CA; ROBERTSON, MH; VOORS, S; RICHARDS, CL; University of South Florida, Tampa, FL, Northeastern University, Boston, MA, Northern Arizona University, Flagstaff, AZ; *jmounger@mail.usf.edu*

Effects of genetic diversity and epigenetic change on trait variation in the foundation plant Spartina alterniflora

While ecological genetics approaches have informed us about the structure of genetic diversity in natural populations, we still know surprisingly little about the mechanisms that permit organisms to adapt to variable environmental conditions. Using MS-AFLP, our previous work showed a weak, but significant correlation of epigenetic variation with habitat in the salt marsh foundation plant Spartina alterniflora. In this study, we used the more powerful genomics approach of epigenotyping-by-sequencing (epiGBS) to examine differential methylation polymorphisms (DMPs) and single-nucleotide polymorphisms (SNPs) to investigate genetic and epigenetic diversity in natural populations across salinity gradients, and from a reciprocal transplant study of S. alterniflora. In addition, we used sequencing of the ribosomal ITS region to identify variation in fungal endophyte communities, which may be particularly beneficial under stressful environmental conditions. We will present DMPs and SNPs, and associated candidate genes that are correlated with trait response, environmental gradients and symbiotic relationships in this critical coastal species.

P3-27 MOVSESYAN, T*; STOVER, KK; OLBERDING, JP; AZIZI, E; Univ. of California, Irvine; *tmovsesy@uci.edu*

Digging into the burrowing kinematics of Hurter's spadefoot toad

Burrowing is crucial for many terrestrial anurans as it provides protection from predators, high temperatures, or desiccation, as well as access to otherwise inaccessible food resources. In particular, the spade foot toad (*Scaphiopus hurterii*) is well known for its burrowing capabilities. These toads use relatively short hind limbs with a spade-like keratinous tubercle on the foot to excavate burrows. However, the kinematics of this movement remains unclear and the significance of this specialized morphology is unknown. Given the importance of ankle extension in other anuran locomotor behaviors, we hypothesized that this motion would also be critical for burrowing. We examined burrowing behavior in 5 toads using 3D high-speed video. The toads used one limb to dig, the working side, and the other for support, the bracing side. The motion of the working limb was cyclical with two phases, pushing and re-positioning, with an average cycle duration of 256 ± 74 ms. The motion of the joints was tracked by digitizing anatomical landmarks on the toads' limbs. The pushing phase included flexion of the hip (average of -9.0 ± 1.1°) and dorsiflexion of the ankle (average of -29.6 ± 4.3°), indicating that ankle muscles are not contributing significant mechanical work. On the other hand, the knee extended up to 15.8 ± 4.9° during pushing, suggesting that this motion provides much of the work for digging. This finding is reflected in the lower proportion of hind limb muscle mass associated with ankle extensors (11%) compared to other non-burrowing species (19%). Future experiments will identify the morphological or physiological specializations of the knee extensors that may relate to their crucial role in this behavior.

P1-25 MUNTEANU, VD*; DIAMOND, KM; SCHNEIDER, NG; RILEY, AB; MCKAMY, AJ; BLOB, RW; Clemson University; *vmuntea@g.clemson.edu*

Effects of Ecological Transitions on Locomotor Morphology: Do Changes in Bone Loads Have Implications for Limb Elongation in Arboreal Tetrapods?

Across vertebrate diversity, limb bone morphology is typically expected to reflect differences in the habitats and functional tasks with which species contend. Arboreal vertebrates are often recognized to have longer limbs than terrestrial relatives, a feature thought to help extend the reach of limbs across gaps between branches. Among terrestrial vertebrates, longer limbs can experience greater bending moments that might expose bones to a greater risk of failure. However, changes in habitat or behavior can impose changes in the forces that bones experience. If locomotion imposed lower loads in trees than on the ground, such a release from loading demands might have produced conditions under which potential constraints on the evolution of long limbs were removed, making it easier for them to evolve in arboreal species. We tested for such environmental differences in limb bone loading using the green iguana (*Iguana iguana*), a species that readily walks over ground and climbs trees. We implanted strain gauges on the femur and compared loads between a level-stiff surface, a level-compliant surface, and an inclined (60 deg) surface, with the latter two treatments modeling substrate conditions of tree branches and trunks, respectively. Shear strains were similar across treatments; however, counter to expectations, bending strains were greater for both compliant and inclined surfaces than for stiff, level ground. These results suggest that evolutionary changes in limb length among arboreal species may have occurred despite increases in limb bone loads during movement through the trees. The advantages of longer limbs for arboreal taxa may, therefore, have outweighed potential costs.

P2-172 MUKHALIAN, J*; MCBRAYER, L; Georgia Southern University; *jm18915@georgiasouthern.edu*

Variation in metabolic rate and immune response of lizards from long-leaf pine and scrub habitats

Habitat management, by definition, alters an environment to achieve specific outcomes for conservation, preservation, or use of natural resources. Common management techniques include prescribed fire, timber harvest, or species removal; thus, each management protocol has a variety of negative or positive effects on constituent species. In some cases, habitat management techniques may benefit some species, while having negative consequences on non-target species. Long leaf pine and Florida scrub habitats in the Ocala National Forest (ONF) in central Florida undergo prescribed burning (long leaf) and clearcutting (scrub), thereby leading to substantially different microhabitats for small ectotherms such as lizards. As such, these habitats lead to certain physiological adaptations. The Florida Scrub Lizard (*Sceloporus woodi*) is endemic to peninsular Florida and resides in the managed long leaf and scrub habitats in the ONF. Lizards from each habitat are known to differ in key traits such as activity time, thermal environment, and predation rate. Therefore, in this study, we will examine variation in metabolic rate and immune response (swelling), in lizards from each habitat type to test if physiological adaptations are occurring among subpopulations.

P3-152 MURPHY, KM*; BODENSTEINER, BL; DELANEY, DM ; STRICKLAND, JT; JANZEN, FJ; Auburn University, Virginia Polytechnic Institute and State University, Iowa State University, U. S. Fish and Wildlife Service, Iowa State University; *kmm0155@tigermail.auburn.edu*

Nest Temperatures Alter Survival and Emergence of Painted Turtle (Chrysemys picta) Offspring

Environmental conditions during early development critically affect morphology, behavior, and survival. However, nest temperature in oviparous species also could affect post-hatching traits of offspring, such as emergence behaviors. We monitored Painted Turtle (*Chrysemys picta* (Schneider, 1783)) nests to examine how thermal conditions influence offspring survival and nest emergence. We recorded hourly temperatures within nest cavities during embryonic development in summer 2016 and after hatching through the following January. Hatching success was improved by thermal moderation within nests during summer, whereas post-hatching survival was enhanced by warmer average fall temperatures and greater thermal maxima in winter. Emergence of neonates from nests was observed from 19 March through 12 May 2017. More hours spent below 0° C in nests increasingly delayed onset of emergence. For nearly all nests with live offspring, siblings did not emerge en masse, but instead departed the nest across multiple days. This emergence duration was positively correlated with the thermal maxima nests experienced in summer, fall, and winter. Differences in thermal environments among nests during embryonic development and after hatching elicit considerable variation in survival and emergence timing of *C. picta* hatchlings.

P1-232 MURPHY, PR*; ROARK, AM; Furman University; *parker.murphy@furman.edu*

Estrogenicity of Compounds Produced by Anemones and their Algal Symbionts

Many cnidarians form a symbiotic relationship with intracellular, photosynthetic algae, whereby host and symbiont exchange nutrients and other vital compounds. We believe that this relationship extends beyond nutritive benefits and that the algae influence the development of their hosts. For example, we previously demonstrated that symbiotic anemones, which harbor symbionts, develop larger gonads than aposymbiotic anemones, which lack symbionts. The mechanism underlying this pattern is unknown. Free floating photosynthetic algae, like more complex plants, have been shown to produce organic compounds such as sterols, saponins, and alkaloids, and many of these compounds agonize metazoan nuclear receptors (NR). Furthermore, NR agonists are bioactive in cnidarians, as treatment with estrogenic compounds increases the rate of asexual reproduction in both anthozoans and hydrozoans. We propose that symbiotic algae influence the development and reproduction of host cnidarians via such NR-mediated signaling pathways. We tested this hypothesis using *Aiptasia pallida* anemones. Our goal was to screen anemone tissue, algal tissue, and anemone culture water for estrogenic NR agonists using a competitive estrogen receptor (ER) binding assay. The assay leveraged three isoforms of teleost estrogen receptors (ER , ER $_1$, and ER $_2$). We detected estrogenic compounds in multiple sample types. These results will be discussed in a physiological context.

P1-271 MYERS, C.R.*; VAZ, D.F.B.; Mount Holyoke College, Virginia Institute of Marine Science, College of William and Mary; *myers22c@mtholyoke.edu*

Myology of the adhesion disc of Snailfishes (Liparidae: Cyclopteroidea)

Several lineages of teleost fishes have evolved ventral adhesive organs that allow adhesion to substrates. The superfamily Cyclopteroidea contains two families with such organs, the Cyclopteridae (lumpsuckers) and the Liparidae (snailfishes). In both families, the adhesive organs are hypothesized to be modifications of the pelvic girdle and fins. Descriptions of the myology of the ventral adhesive disk is lacking in snailfishes. An account of the myology of the adhesive organ can provide insights into how the adhesive organ functions and allows morphological comparisons that should suggest how these structures evolved. This study provides accounts of the myology of the ventral adhesive organ of several species of the genus *Liparis*. Data was obtained by manual dissections and by microCT scanning specimens stained with PMA (phosphomolybdic acid) for soft tissue definition. In Liparidae, the adhesive organ is built on the basipterygium, that form the base of the pelvic girdle. Its two halves articulate with five laterally expanded fin rays and one spine each. The intrinsic musculature of *Liparis* has bifurcated muscle groups present on the dorsal and ventral sides of the basipterygium. On either side, these muscles originate on the dorsal region of the basipterygium and insert on the same side of the dorsal surface of each fin ray. A relatively larger muscle originates on the antero-ventral edge of the basipterygium and inserts on the dorsal side onto the dorsal surface of the first fin ray. This muscle is proposed to be homologous to the muscle abductor profundus pelvicus found in other percomorphs. Comparisons with the adhesive organ of the lumpsucker, *Eumicrotremus orbis*, and with pelvic fins of few species of Cottidae will be presented and discussed.

P2-17 NAKANISHI, N; University of Arkansas; *nnakanis@uark.edu*

Investigating the developmental regulatory role of the class IV POU/brn-3 gene in a sea anemone

The class IV POU (pou-iv, or brn-3) gene encodes a homeodomain transcription factor that evolved at or near the base of the animal tree. pou-iv genes regulate sensory cell subtype differentiation and maintenance in bilaterian models (e.g. inner ear hair cells and retinal ganglion cells in vertebrates), and their cnidarian ortholog is expressed in a subset of differentiating and differentiated sensory cells in jellyfish, suggestive of a deeply conserved role of POU-IV in regulating sensory cell differentiation. However, mechanistic understanding of how POU-IV regulates neural differentiation and maintenance is wanting in Cnidaria, and thus fundamentally conserved transcriptional control mechanisms underlying these processes remain enigmatic. To address this baseline knowledge gap, I am investigating the molecular mechanisms by which POU-IV specifies and maintains neural subtypes in the sea anemone cnidarian Nematostella vectensis. Preliminary gene expression analyses by in situ hybridization and immunostaining with an antibody against N. vectensis POU-IV show that POU-IV is specifically expressed in neurons in N. vectensis, consistent with the hypothesis that POU-IV plays a role in neural development and maintenance in N. vectensis. I am directly testing this hypothesis by taking a CRISPR-Cas9-mediated gene knockout approach. Comparison of the results of these analyses with existing data from bilaterian models is expected to reveal a deeply conserved mechanism that confers, and maintains, neural subtype identities in animals.

P1-285 NARDUCCI, RE*; HULBERT, RC; BOURQUE, JR; BLOCH, JI; University of Florida/Florida Museum; *rnarducci@flmnh.ufl.edu*

Cranial Armor of the Pleistocene Pampathere Holmesina (Xenarthra, Cingulata, Pampatheriidae)

The skin of cingulates is imbedded with plates of boney osteoderms, sutured together into shields to protect 3 separate areas; the head, body, and tail. Osteoderms vary greatly in shape, number, and arrangement across cingulates. Shields typically disarticulate shortly after death and isolated osteoderms are more commonly recovered from the fossil record. Osteoderms comprising the cranial shield are thinner, more irregular in shape, and poorly sutured together compared to other regions; diminishing preservation potential. Among the extinct group of giant armadillos known as pampatheres, isolated cranial osteoderms are mentioned in the literature, but no complete cranial shield has been described. The Florida Museum houses 9 partial to nearly complete cranial shields of the pampathere, *Holmesina floridanus* and 2 of the larger and younger *Holmesina septentrionalis*. A complete *Holmesina* cranial shield is composed of ~75 osteoderms, and is only slightly longer than wide, bilaterally symmetrical, and widest at post-orbital protuberances, which curve ventrally. Osteoderm shape, number of sides, and thickness varies across the cranial shield, dependent on anatomical position. Compared to extant armadillos, the shield is most similar to that of the euphractines in osteoderm count and shield shape, and differs most from that of *Dasypus*, which exhibit a greater number of osteoderms and narrower shield with a pointed posterior periphery. Great diversity exists in the cranial shield of extinct glyptodonts. They differ from those of *Holmesina* in exhibiting fewer, larger, thicker, and ornate osteoderms comprising broader cranial shields with less pronounced post-orbital protuberances.

P2-254 NARICI , V*; PIRRONE, M; BARNHART, D; MASS, S; SUNY New Paltz ; *naricv1@hawkmail.newpaltz.edu*

Using Force to Characterize the Efficiency of Ambystomoid Locomotion

Axolotls are ambystomoids that are closely related to the North American tiger salamander. They are a neotenic species and remain aquatic throughout their lives. Rarely, they spontaneously metamorphose and become terrestrial animals. Although metamorphosed axolotls are similar to other terrestrial ambystomoids, there are differences in form and function, which are not well-understood due the rare nature of metamorphosis. Upon casual inspection, metamorphosed axolotls seem to lack the coordination of terrestrial movement that the tiger salamanders possess. Are metamorphosed axolotls less well adapted for terrestrial locomotion? Are there developmental timing windows being missed which account for the differences in form and function? We are interested in the functional morphology that can account for these differences. Our first step has been to compare the force of metamorphosed axolotls and tiger salamanders using compressible force sensors. Specific patterns in their movement were identified and the force was measured. Work was then calculated from the force measurements. Analysis of the data shows higher force and work values for the metamorphosed axolotls, which are indicative of lower efficiency at terrestrial locomotion, compared to the tiger salamanders.

P2-146 NASH, S/B*; RAHMAN, MD/ S; University of Texas Rio Grande Valley ; *sarah.nash01@utrgv.edu*

Consequences of high temperatures on gonadal functions, cellular apoptosis and oxidative stress in the American oyster

Global warming is likely to intensify heat stress in marine and coastal organisms, affecting their development, growth, and reproductive functions. In this study, we performed histological observations on gonadal functions, immunohistochemical analyses of heat shock protein (HSP) and nitrotyrosine protein (NTP, an indicator of reactive nitrogen species, RNS) expressions, in situ TUNEL assay for cellular apoptosis, biochemical analyses of caspase-3/7 activity and protein carbonyl (PC, a measure of reactive oxygen species, ROS) contents, and coelomic fluid (CF, body fluid that regulates physiological functions) pH in the American oyster gonad with various water temperatures. Oysters were placed in six different twenty-gallon aquariums and exposed to control (24oC), medium (28oC), and high (32oC) temperatures under controlled laboratory conditions for one week. Higher temperature significantly decreased the number and diameter of eggs in ovary of female oysters and sperm cell growth, development, and production in male oyster's. CF protein concentrations also declined compared to control temperature (24oC). In contrast, CF pH and HSP expression in gonad increased after heat-exposure, consistent with increased cellular apoptosis. The enhanced apoptosis in gonads of heat-exposed oysters was associated with increased gonad caspase-3/7 activity, PC contents, and NTP expression. Collectively, these results suggest that higher temperatures drastically increase ROS and RNS levels leading to increased cellular apoptosis, which subsequently decline gonadal functions in oyster.

P1-98 NAVARA, KJ*; WROBEL, ER; The University of Georgia; *knavara@uga.edu*

Can birds lay more than one egg in a day? Yes they can!

The time interval between successive eggs in a clutch has been known to vary substantially among species; many species lay at a rate of one egg per day while some wait up to 30 days to lay the next egg in the clutch. For no species have time intervals of less than a day been observed between ovipositions. Our current understanding of avian physiology suggests that laying eggs at intervals shorter than 24h should be physiologically impossible, because ovulation and oviposition are timed according to the light/dark cycle, only a single ovarian follicle should be ready to ovulate on a given day, and more than one egg in the shell gland would likely lead to shell abnormalities. However based on anecdotal accounts of hens that routinely produce two fully formed eggs in one day (termed double ovipositions), we hypothesized that laying hens may exhibit this pattern more often than was previously realized. To test this, we observed a flock of laying hens, monitoring the time of oviposition for each hen on each day using a thermal camera. We found that 13% of hens produced a double oviposition, often producing a second egg within 2.5h of the first, at least once during the observation period. One hen produced double ovipositions multiple times, and one produced 3 eggs in a day. Further, we then monitored a second flock of laying hens and found additional evidence of double ovipositions. Eggs that were part of double ovipositions showed no external shell abnormalities and weighed the same as those that were single ovipositions, suggesting that laying hens can, and do, produce two fully formed eggs within hours of one another. This finding refutes our currently understanding of avian reproductive physiology and calls for additional work on the regulation of ovulation and oviposition, particularly in laying hens.

P2-10 NEBHUT, AN*; WORLEY, CA; SHINKLE, JR; Trinity University, San Antonio; *anebhut@trinity.edu*

Individual Variation in Untreated Schizachyrium scoparium Metrics Used to Quantify Responses to UV-B Radiation

Plants have mechanisms to sense dangerous ultraviolet radiation and regulate their responses to changes in their light environment. In particular, plants exposed to UV-B (280 to 315 nm) display unique responses such as inhibited growth and production of UV-protecting pigments. These responses are the can be either global or tissue specific. Little bluestem (*Schizachyrium scoparium*) were sampled at a field site in Travis County, Texas. We chose 3 minimally invasive methods commonly used to measure plant responses to UV stress: UV absorbance spectra taken from leaf extract pigments, reflectance spectrophotometry of leaves, and leaf chlorophyll and flavonoid content. Results indicate that individual plants maintain different protections from UV radiation including changes in leaf structure and composition from bunch to bunch, even within the same field site (120 m2). For instance, there were significant differences between two bunches four meters apart for absorbance, reflectance, chlorophyll, and flavonoids. The consequence of this variation can be seen by comparing a result to the outcome of modifying the UV environment: the 67.9% decrease in absorbance at 300nm between two untreated bunches eight meters apart is comparable to the 69.5% decrease in absorbance in one bunch after one week's time under a UV-B excluding cellulose acetate filter. However, across 10 bunches many pairs showed no differences or differences in only some parameters. Overall, these results inform the design of further research into plant responses to UV-B radiation by demonstrating the need for large samples including many individuals to ensure that the results are actually a response to the treatment and not natural variation between individual plants.

P1-225 NEMANI, S G*; EDWARDS, C J; HALL, M W; MARTIN, IV, W R; EVANGELISTA, D J; United States Naval Academy; *m194668@usna.edu*

Affordable Unmanned Aerial Systems (UAS), Sensors, Modular Payloads and Algorithmic Tools for Ecological Study

Ecological and behavioral studies and conservation efforts are often complicated by the need to gather data in remote or inaccessible areas. In military missions, unmanned aerial systems (UAS) have been instrumental in providing remote access and persistent presence. We will discuss an on-going design effort to develop affordable UAS designs, as well as sensors and modular payloads, aimed at supporting science missions. Our designs leverage developments in hobby radio/control and autonomous flight, 3D printing, and rapid prototyping. We consider both fixed-wing and quadrotor designs and will discuss modular payloads, including visible and thermal imaging and automated image processing. The rugged nature of biological field studies and unique challenges help drive design innovations. We will present concept designs and initial prototyping for notional biology and ecology missions: (1) to image and count organisms and/or nests along a shore; (2) to survey an area, field, or stretch of river, repeatedly to identify areas of interest or to assess damage after natural disasters; and (3) to recover a sample from an inaccessible location on an island top or inside a sinkhole. We will also discuss the logistics of training undergraduate engineers as UAS operators (USNA's "School of Drones") and plans to deploy in support of biologists to accomplish science missions. The UAS designs we develop will be made available for science work, and we hope to connect with potential future missions using UAS to support biological studies.

P2-183 NEUROHR, JM*; PAULSON, ET; KINSEY, ST; Univ. of North Carolina Wilmington; *jmn6284@uncw.edu*

Oxidative damage and protein synthesis in red and white muscle of the pinfish, Lagodon rhomboides

An unavoidable consequence of aerobic metabolism is the production of reactive oxygen species (ROS). While ROS are important molecular signals in cells, excess ROS cause damage to cellular components such as lipids and proteins. While there is general agreement that mitochondria are the primary sources of ROS, it is not clear how variation in mitochondrial density or metabolic rate among tissues influences ROS-induced damage and rates of protein synthesis. Fish skeletal muscle is comprised of highly aerobic red muscle and highly anaerobic white muscle, offering an excellent model system in which to evaluate the role of tissue aerobic capacity on ROS-induced damage. The present study characterizes protein and lipid oxidative damage, as well as markers of protein degradation and measurements of protein synthesis rates, in red and white muscle of the pinfish, *Lagodon rhomboides*. Red muscle had a greater mitochondrial volume density and had more oxidative damage than white muscle, including elevated protein carbonylation and lipid peroxidation. Protein degradation in muscle occurs via the lysosomal-autophagy or ubiquitin-proteasome pathways and has been shown to be tissue dependent. Lysosomal degradation markers and autophagosome volume density were greater in white muscle, while ubiquitin expression and 20S proteasome activity were significantly greater in red muscle. However, ubiquitin ligase expression was significantly higher in white muscle. Red muscle also had a higher basal metabolic rate and higher rates of protein synthesis, presumably due to the higher mitochondrial volume density and the associated increase in oxidative damage. Together these results support the concept that a consequence of an elevated aerobic capacity is greater costs associated with protein synthesis.

P3-51 NGO, T*; KASOJU, VT; FORD, MP; SANTHANAKRISHNAN, A; Oklahoma State University; *askrish@okstate.edu*

Aerodynamic effects of varying pause durations during clap and fling

The smallest flying insects such as thrips and fairyflies have body lengths under 1 mm and operate at very low Reynolds number (Re) on the order of 10 or lower. Flapping flight is challenged in these size scales on account of large viscous forces on the wings. These insects often show unique biomechanical adaptations that include: wings with long bristles at the fringes, and the use of clap and fling wing-wing interaction to maximize wing amplitude. Ellington (1975) observed that the wings of the chalcid wasp *Encarsia* remain clapped (following end of the upstroke) for 20-25% of the wingbeat cycle. It is not clear if there is an inherent aerodynamic advantage associated with this pause time before the onset of downstroke via fling. In this study, we examined aerodynamic effects of varying pause duration using physical models of bristled wings inspired by biological data. A robotic model mimicking clap and fling motion was used to experimentally test different pause times. Non-dimensional lift and drag coefficients were calculated from strain gauge measurements. Peak lift coefficients in fling increased with increasing pause duration, whereas drag coefficients were nearly unchanged. We will present the effects of varying pause duration on chordwise flow structures.

P1-116 NGUYEN, TC*; SALTZMAN, W; University of California, Riverside; *tnguy240@ucr.edu*

Offspring Discrimination by Mothers and Fathers in a Biparental Mammal

The ability to differentiate between kin and non-kin may confer fitness benefits such as altruism or inbreeding avoidance. In parental care-giving species, parents may also benefit from the ability to discriminate offspring between unrelated infants or juveniles to ensure that the appropriate animals are receiving care. Sex differences in offspring discrimination ability may arise if parental behaviors and their underlying mechanisms differ between males and females of a given species. For example, unique to mammals, mothers must gestate and produce milk while fathers do not. Consequently, mammalian mothers experience different hormone changes than fathers, even if the two parents provide otherwise equal care. Thus, we hypothesized that mammalian mothers and fathers may differ in offspring discrimination. We tested this hypothesis in the monogamous, bi-parental California mouse (*Peromyscus californicus*). At four different time points during the postpartum period (PPD 3, 7, 16, and 28), each parent was housed individually and allowed to interact with two mesh balls, one containing one of its own pups and the other containing an unrelated, age-matched pup, for 10 minutes. We compared behavioral responses to the pups, including the duration of time that each animal spent in proximity to each ball, the number of bouts and latency to approach each ball, and the first and second ball approached, between mothers and fathers, finding no significant difference between the sexes. We further examined possible longitudinal changes in offspring discrimination within individual parents, again finding no significant changes over time. Therefore, we found no evidence for sex-differences in offspring discrimination in the California mouse.

P2-42 NICKLES, KR*; WEBB, JF; University of Rhode Island; *krnickles@uri.edu*

Does Habitat Predict Lateral Line Morphology Among Species of Neon Gobies (Genus Elacatinus)?

Gobies (Family Gobiidae, the largest family of marine fishes) have a complex mechanosensory lateral line (LL) system comprised of reduced cranial and trunk canals and a proliferation of small superficial neuromasts (SNs), which are perched on the tips of papillae ("sensory papillae"; bump-like extensions of the skin) that occur in linear series. The LL system in *Elacatinus lori*, a sponge-dwelling goby from Belizean coral reefs is composed of a moderate number of SNs (~300 on one side of the head, trunk and tail) when compared to other gobies described in the literature (which may have 1000's of SNs). The genus *Elacatinus* (21 species), found exclusively on coral reefs, is divided into three clades: a Pacific species (basal clade), coral-dwelling cleaner gobies, and sponge-dwelling planktivorous gobies. The large tube sponges in which the sponge-dwelling gobies live produce a constant flow of water within the lumen, where the gobies reside, creating a unidirectional flow stimulus to which the fish are continuously exposed. In contrast, different sorts of environmental flows are experienced by the coral-dwelling gobies. Using SEM, we tested the hypothesis that SN number, distribution, and papilla length in sponge-dwelling *Elacatinus* species (including *E. lori*) are different from those in coral-dwelling *Elacatinus* species; *Tigrigobius*, its sister group, was used as an outgroup. We predicted that sponge-dwelling gobies have fewer SNs and/or shorter papillae than coral-dwelling gobies, which would reduce overstimulation of the SNs that may occur under the constant flow conditions experienced within their host sponges. Funded by NSF grant 1459224 to JFW.

P1-252 NIELSEN, SV; Florida Museum of Natural History; *stunie@gmail.com*

Multilocus phylogenetics in a widespread African anuran lineage (Brevicipitidae: Breviceps) reveals patterns of diversity reflecting geoclimatic change.

In order to assess the influence of geomorphology and climatic shifts on species diversification in sub-Saharan Africa, I reconstructed the pattern and timing of phylogenetic relationships of rain frogs (Brevicipitidae: *Breviceps*). I generated multi-locus sequence data and then reconstructed phylogenetic relationships and locus-specific networks, inferred dates of divergence among ingroup lineages, and finally used niche modeling to identify possible adaptive divergence. I found that *Breviceps* is monophyletic and comprised of two major, largely allopatric subclades. Diversity within each subclade is concentrated in two areas with contrasting geologic and climatic histories: the arid/semiarid winter rainfall zone in the southwestern Cape, and the semitropical East Coast that receives predominantly summer rainfall. Recognized species diversity in the Cape (based on phenotypic variation) is consistent with observed genetic patterns, whereas the East Coast is shown to harbor unexpectedly high genetic diversity and up to seven putative, cryptic species. Niche models show significant overlap between closely related species. Dating analyses indicate that diversification of *Breviceps* occurred rapidly within the Miocene, with only a moderate decline over the Plio-Pleistocene, suggesting that this process might be slowed but ongoing. I suggest that a combination of two models, a landscape barrier model and climate fluctuation model, can explain patterns of diversification in *Breviceps*, and Miocene epeirogenic events and climatic shifts may have had a considerable influence on contemporary patterns of biodiversity. Topographic complexity and relative geoclimatic stability in the East have promoted cryptic diversification in allopatry, and this area clearly harbors numerous undescribed taxa and is in need of more detailed biotic investigation.

P3-117 NIEVES, NA*; ARNER, A; TOBLER, M; BARTS, N; Kansas State University, Penn State University; *nichole27@ksu.edu*

Reactive oxygen species and their role in H2S toxicity in Poecilia mexicana

Extreme environments are characterized by physiochemical stressors that adversely affect biological processes within organisms. Organisms that inhabit these environments have evolved physiological adaptations that allow them maintain function in the presence of stressors. *Poecilia mexicana*, an extremophile fish that inhabits hydrogen sulfide (H2S)-rich environments, is an ideal system to study how organisms modify physiological processes in response to an environmental stressor. H2S is a naturally occurring toxin in these springs that reversibly binds to cytochrome c oxidase (COX) in the mitochondrial respiratory chain, inhibiting aerobic ATP production. COX is normally responsible for capturing the reactive oxygen species (ROS), which are capable of causing cellular damage. In the presence of H2S, however, COX is incapable of accepting electrons, ultimately resulting in increased production of ROS. Some sulfide-tolerant populations of *P. mexicana* possess a modified COX that allow them to maintain ATP production and maintain cellular function in the presence of H2S, while other sulfide-tolerant - and sulfide-intolerant - populations and an additional population do not. We predict that upon exposure to environmental H2S, concentration of reactive oxygen species should be higher in fish that lack a sulfide-tolerant modified COX. Additionally, we predict that lipid peroxidation, damage used to assess the negative effects of ROS on cells should also be higher in these same populations. Preliminary data shows that there is a significant effect of H2S exposure on ROS production in the liver, but not brain or gill. The data collected in this project will provide further understanding on the role of ROS in H2S toxicity.

P1-57 NIXON, B*; UYANIK , I; YANG, Y; COWAN, NJ ; Johns Hopkins University; *bnixon5387@gmail.com*

Sensory salience affects sensorimotor delay in the tracking response of the glass knifefish

How do sensorimotor computations change in relation to modulations in the salience of sensory information? To address this question, we examined how the refuge-tracking response of the weakly electric glass knifefish *Eigenmannia virescens* changes as a function of electrosensory and visual salience. Our system commanded a refuge to follow a pseudo-random input signal and measured the resulting fish motion. Electrosensory salience was modulated by changing the conductivity of the water, and visual salience was modulated with a light switch. In the light, electrosensory salience had little effect on the input-output response, but in the dark, the phase lag of the tracking response increased with increasing conductivity (i.e., decreasing electrosensory salience). This suggests that the nervous system takes more time to integrate sensory information for control in a manner similar to luminance-dependent tracking in crepuscular moths (Sponberg et al., 2015). We fit these data using the McRuer Crossover Model, a parsimonious model developed to explain visuomotor control in humans. This model captured the salience-dependent change in phase lag with a commensurate change in the time delay parameter with negligible change to other model parameters. More experiments are needed to test the generality of these results.

P2-20 NOLTE, P*; SMITH, FW; Hope College, University of North Florida; *paula.nolte@hope.edu*

Expression Patterns of Gut Genes During Development in Tardigrades

The compact body plan of tardigrades evolved through the loss of several body segments. The metazoan gut is an unsegmented structure divided into foregut, midgut and hindgut regions. Because the gut is an unsegmented structure, we hypothesized that the loss of body segments in tardigrades did not coincide with a loss of a region of the gut. To test this hypothesis, we analyzed three genes that control gut development during embryogenesis in other animals, in the tardigrade *Hypsibius exemplaris*. These genes are *forkhead*, a marker of foregut and hindgut identity; *gata-1/2/3*, an additional marker of foregut identity; and *gata-4/5/6*, a marker of midgut identity. We predicted that these genes would exhibit regionalized expression patterns in the developing tardigrade gut, as they do in other animals. We identified orthologs of these genes in the genome of *H. exemplaris*. Gene expression patterns were visualized using in-situ hybridization during a late embryonic period. *Forkhead* was expressed in an anterior and posterior region of the developing gut in *H. exemplaris* embryos, suggesting that foregut and hindgut regions are retained in tardigrades. However, *gata-1/2/3* was not expressed in the gut, which challenges the retention of foregut identity in tardigrades. Future studies will determine whether *gata-1/2/3* is co-expressed with *forkhead* in an anterior region of the gut during earlier stages of gut development, as predicted if the foregut region is retained by tardigrades, and whether *gata-4/5/6* is expressed in a middle region of the developing gut, as predicted if the midgut region is retained by tardigrades.

P2-277.5 NOORDSIJ, LC*; BELFIORE , ; University of Tampa ; *lindseynoordsij@gmail.com*

Comparative Genomics of Four Mustelid Species: Analysis of LIF gene and its Role in Embryonic Diapause

North American river otters (*Lontra canadensis*) inhabit the second largest latitudinal range of any otter species, from boreal Canada to southern Mexico. Restricted mating and birthing periods are due to seasonal limits. Embryonic diapause, a process which delays the implantation of the blastocyst into the mother's uterus, allows the embryo to rest in a dormant stage until about 40 days before the optimal birth season. Leukemia Inhibiting Factor (LIF), a is an interleukin 6 class cytokine, is a candidate gene involved in the regulation of implantation because it controls cell differentiation and proliferation in the embryo. Here we compare genomic libraries generated by paired-end Illumina TM sequencing at approximately 30X coverage from the North American river otter, the Eurasian otter (*Lutra lutra*), the African clawless otter (*Aonyx capensis*), and the American mink (*Neovison vison*). The African clawless otter and the Eurasian otter do not undergo delayed implantation, while the mink, a member of the same family, but separate subfamily does undergo a limited implantation delay. The domesticated form of the European polecat (*Mustela putorius*), or the ferret, is used as a reference genome. Once we have a draft annotation for these four species, we will be able to compare LIF across dispausing and non-diapausing mustelids.

P1-253 NORDHEIM, C.L.*; RICE, S.A.; DETMERING, S.E.; MCMAHON, T.A.; The University of Tampa; *caitlin.nordheim@spartans.ut.edu*

Growth Rates and Morphology Found in Four Strains of Batrachochytrium dendrobatidis Isolated from Around the World

Batrachochytrium dendrobatidis (Bd) is a contagious pathogenic fungus that has caused amphibian decline worldwide. This is a well-studied species but little is known about the differences in fungal morphology among the Bd strains. Here, we compared the morphology of four virulent strains of Bd, one isolated from amphibians in California, one from Louisiana and two different strains from Panama. The strains were imaged using a scanning electron microscope and we compared the diameter of infectious zoospores, the diameter of the zoosporangia, and the number and size of zoospore discharge tubules found on the zoosporangia. We also grew strains in culture and examined zoospore and zoosporangia production over time. We found that one of the Panama strains zoospores and zoosporangia were larger in diameter ($p < 0.0001$, for both) and had more discharge tubules per zoosporangium compared to the other strains. There were no differences between the strains in respect to the size of the discharge tubules. We also found that the strains differed in zoospore, but not zoosporangia, production in culture ($p = 0.0002$ and $p = 0.6$, respectively). Therefore, one of the Panama strains may be able to grow faster, potentially altering pathogen virulence. Bd is found globally and in laboratory experiments infections are often compared to one another, this morphology and growth information helps us better understand infection dynamics and strain virulence.

P1-190 NORTH , HA*; RAJAMOHAN, A; BOWSHER, JH; North Dakota State University, Edward T. Shafer Agricultural Research Center, USDA, North Dakota State University ; *Heather.ann@ndsu.edu*

Genotoxicity assesment of agrochemicals on honey bee spermatozoa using the TUNEL assay

Agrochemicals and their widespread use are among the suspected reasons for pollinator decline. Some evidence suggests that pesticides are reducing reproductive fitness among bees. Few studies have investigated the contraceptive effects of agrochemicals on spermatozoa. Of special concern is whether agrochemicals impact drone sperm quality, in terms of genotoxicity, having direct or indirect effects on the DNA. Even the slightest changes in spermatozoa can have large impacts on colony health making spermatozoa a reliable biomarker for xenobiotics in the environment. The readily available spermatozoa make them an accessible way to measure the reproductive impacts of agrochemicals found in gathered resources (i.e. pollen and nectar). It is unclear how these stored contaminated resources might affect nest mates, such as drones, who don't actively forage for these resources. Furthermore, how these contaminated resources affect nest mates through all stages of development. To investigate this, we use terminal deoxyribonucleotidyl transferase (TDT)- mediated dUTP nick end labeling (TUNEL) assay as a measure of genotoxicity for spermatozoa. Honey bee spermatozoa were exposed to the agrochemicals Imidacloprid, Thiamethoxam, Clothianidin and Glyphosate. Preliminary results suggest this is an accurate and reliable assay to measure any DNA damage agrochemicals have on spermatozoa. Thus, the purpose of this study is to assess the reproductive impacts agrochemicals have on drones, through direct exposure to agrochemicals and indirect exposure using spermatozoa as a biomarker for these agrochemicals and the effect they have on pollinator decline.

P1-77 NSANGOU, AA*; STAAB, KL; Mcdaniel college, Mcdaniel college ; *aan004@mcdaniel.edu*

Pre-and post-natal development of the lower jaw in two live bearing poeciliid species.

Most larval fish species must begin feeding upon hatching, but livebearing species such as the mosquitofish, *Gambusia affinis*, and mollies,*Poecilia spp.,* develop the feeding apparatus before the need to feed.These two closely-related species have different lower jaw morphologies where *Poecilia spp.* possess an extra joint between the dentary and angular-articular bones,the intramandibular joint (IMJ).The IMJ evolved independently in multiple fish lineages, and in *Poecilia spp.,* has been shown to play a pivotal role in scraping food from substrates, allowing the lower jaw to extend forward when it comes in contact with a food source. In this study, we cleared and stained ontogenetic series of *Gambusia affinis* and *Poecilia spp.* (*mexicana and sphenops*) to determine how the differing lower jaw morphologies develop, in order to make hypotheses about how the IMJ might have evolved in this lineage. Specifically, we establish the onset of lower jaw elements-the dentary, anguloarticular, and Meckel's cartilage (MC)- and compare the allometric growth of the MC between species. We also compare pre-natal and post-natal growth of the lower jaw elements to gain a better understanding of how viviparity affects trait development.

P3-181 NUNEZ, SA*; SANGER, TJ; Loyola University Chicago; *snunez3@luc.edu*

The Effects of Hypoxia and Heat on Early and Late Development of Lizard Embryos

Thermal stress triggered by climate change may negatively affect ecology, reproduction, and life history of many species. Oviparous species may be severely impacted by climate change as their eggs will be laid and incubated at increasingly higher temperatures. The lack of oxygen, or hypoxia, and its role during thermal stress in embryogenesis has been widely debated. In birds and mammals, hypoxia is known to induce craniofacial and neural malformations during development. In lizards, oxygen limitation is thought to set the thermal range of embryonic development. Thermal stress in the early embryonic development of *Anolis* lizards leads to malformations and even death. In our study, hypoxia did not induce malformations in anole embryos. We compared survival rates and developmental staging of embryos incubated under hypoxic and normoxic embryos in early (day 0-14) and late (day 10-20) development. We discovered survivorship of hypoxic embryos was higher in the early than in the late development, with delayed growth and reduced body sizes in late-stage hypoxic embryos, demonstrating that early reptilian development may be more robust to hypoxia. Additionally, we studied whether cellular-level hypoxia is limiting the thermal response of the developing anole embryo of standard and elevated incubation temperatures in both early and late development. Our preliminary results suggest there are stage-specific effects of hypoxia and thermal stress, as they interact to impede the more sensitive late-stage development of anole embryos. Discovering the effects of hypoxia during thermal stress in early and late reptilian development will help us better understand the potential impacts of climate change on reptiles.

P3-121 NZIMA, MZ*; KOLAPE, J; SHIPLEY, M; WATSON, CM; Midwestern State University; *mnzima360@gmail.com*

Chitinase activity during digestion of insect prey by the Ground Skink, Scincella lateralis

Predators that consume arthropods must break down the chitinous exoskeleton in order to effectively and efficiently digest their prey. This is particularly problematic for small insectivores that eat smaller prey who, by virtue of a larger surface to volume ratio, contain more chitin per unit volume than larger arthropods. The enzyme responsible for digestion of the chitin polymer is chitinase. Chitinase has long been considered a product of the insectivore's gut biome and not secreted by their own cells. Here, we use the ground skink, *Scincella lateralis*, to test for chitinase production throughout the digestion of beetle larvae (*Tenebrio molitor*). We find that chitinase production in both the stomach and intestine initially rise upon consumption, level off, then increases as the materials pass through each section. We also show evidence that the lizard rather than its gut biome produce the chitinase.

P2-165 O'CONNOR, E*; CORNELIUS, E; VéZINA, F; JIMENEZ, A.G.; JIMENEZ, ANA; Colgate University, Université du Quebéc à Rimouski; *ajimenez@colgate.edu*

Environmental Mismatch During Cold Shock in Black-capped Chickadees and Its Effects on Muscle Ultrastructure.

Previous work on maximal thermogenic capacity (Msum) in wild black-capped chickadees has revealed that phenotypic adjustments seem slow and begin to take place in early fall, well before the peak of winter cold. However, when mean minimal Ta reaches -10°C, the birds' phenotype provide enough reserve capacity in cold endurance to buffer days with Ta of -20°C or below. Birds and mammals have muscle fiber diameters that typically range from 10-100 µm. Minimal fiber diameters are limited by diffusion constraints for O2 and ATP while maximal fiber diameters seem to be dictated by the cost of the Na+-K+-ATPase on the sarcolemmal membrane. Although muscles mass is flexible in size, often being larger in winter; whether cold acclimated birds change muscle ultrastructure in response to sudden environmental challenges is unknown. Here, we investigated whether cold (-5°C) acclimated chickadees challenged with an experimental decline in temperature alter their muscle ultrastructure at the cell level in the first 3 h after a 15°C temperature drop. We compared muscle ultrastructure in birds that experienced the temperature decline (treatment ; -5°C to -20°C) to that of individuals remaining at -5°C (control). We found that treatment birds had a significantly higher total capillary density (0.005 ± 0.0003 capillaries/um2) compared with control birds (0.004 ± 0.0002 capillaries/um2). Treatment birds also had more nuclei per fiber (113.84 ± 3.72 nuclei/fiber) compared to controls (95.23 ± 2.97 nuclei/fiber) and had significantly smaller myonuclear domain (7432.33 ± 421.19 µm3) compared with control birds (8853.65 ± 369.01 µm3). Our data, therefore, suggest that cold acclimated birds can adjust their muscle cell phenotype within hours during cold spells.

P3-173 OAKEY, SJ*; SCHOENLE, LA; DOWNS, CJ; MARTIN, LB; University of South Florida, Hamilton College; *soakey@mail.usf.edu*

Brains, Sickness, and Longevity: Does a Relationship Between Brain Size and Immunity Underlie Variation in Survival Rates?

Bigger brains are associated with higher survival rates among species, but is greater intelligence the cause? The cognitive buffer hypothesis suggests that animals with larger brains have higher survival rates because greater cognitive abilities can help animals successfully respond to challenges in their environments. However, larger relative brain sizes are associated with numerous other traits, including lower metabolic rates (per gram), and in some cases, stronger immune defenses. The higher survival rates in large-brained species might be at least partially explained by stronger parasite defenses. Alternatively, the high energy requirements of the brain, which consumes more calories per unit mass than other organs in the body, might force a trade-off between maintaining the brain and immune function. As a result, animals with larger brains might exhibit weaker immune defenses. We investigated the relationship between immunity and relative brain size of over 100 species of terrestrial mammals. We also examined how both immunity and brain size relate to longevity. We obtained mammalian brain size data from a database of mammalian species. We assessed constitutive immune function by quantifying the ability of serum to kill four different microbes: *Escherichia coli*, *Salmonella enterica*, *Candida albicans*, and *Micrococcus luteus*. Not only will we look at how brains and immunity relate across a wide list of varying animals, we will discuss how constitutive immune varies with brain size, longevity, and body mass and examine trends between orders such as primate, carnivora, artiodactyla, and rodentia. A comparison between orders, for example carnivora and primate, may reveal how diet and lifestyle impacts immunity and brain size of species.

P3-95 ONTHANK, KL*; CULLER, ME; Walla Walla University; *kirt.onthank@wallawalla.edu*

An Inexpensive pH-stat System Based on Open Hardware for Ocean Acidification Research

Pseudoreplication and similar experimental design errors continue to be prevalent in ocean acidification (OA) research. One of the major impediments to creating properly replicated trials is the cost of purchasing enough control systems to independently regulate CO_2 concentration in separate holding tanks. To bring down the cost of such replication we developed and tested a pH-stat system constructed largely with open hardware. This pH-stat controller was built around an Arduino Mega 2560 microcontroller board, using an Atlas Scientific EZO pH circuit to interface with the pH probe, an Adafruit MAX31865 to interface with a PT100 temperature sensor, and controlling pH by actuating a solenoid valve to deliver pure CO_2 gas to a bubble stone immersed in the holding tank water. These systems were tested over a 3-week period with a single octopus occupying each controlled holding tank. Tank pH was periodically verified using the m-cresol purple photometric method. We found the control system performs comparably to similar units commercially available for a fraction of the price, possibly making appropriately replicated OA treatments available to many more institutions.

P3-49 ORNDORFF, C*; LIBBY, T; DANIEL, TL; University of Washington; *tlibby@berkeley.edu*

A haptic virtual reality device to probe motor integration in tethered moths

Flying insects are known to control orientation via torques arising from at least three distinct affordances: by varying aerodynamic center of pressure, by changing body posture to alter center of mass location, and by swinging body segments or limbs to exert inertial torques. Each affordance is subject to distinct constraints, saturations, and sensitivities, as potential coupling to the control of center of mass forces (e.g. vertical support). We hypothesize that these sources of control are integrated in parallel to increase robustness and agility, are weighted according to behavioral context, and are tuned to body morphological parameters. To investigate affordance integration in flight, we built an actuated armature to apply rapid pitch movements to a tethered flying moth, *Manduca sexta*, while measuring the torque exerted by the moth's flight forces and body movement. Closing the loop between measured torque and applied movement enables control of the forces experienced by the moth while allowing pitch movement (e.g. a haptic environment); a video screen enables visual experience to either match mechanosensory experience or be rotated with the moth to provide sensory conflict (e.g. a virtual reality environment). We used our device to apply short perturbations and examined the magnitude of torques arising from each affordance. Body kinematics were recorded with a high-speed camera and combined with morphometric data to estimate inertial torques and center of mass motion associated with abdominal flexion. These estimates were combined with measurements of total pitch axis torque to estimate the torque generated by the three affordances during the perturbations. Moths appear to employ parallel strategies to generate torques counter to the perturbations, consistent with a stabilizing response.

P3-22 ORTEGA, R*; MCCARTY-GLENN, M; MEHTA, RS; WARD, AB; Adelphi University, Univ. of California, Santa Cruz, 1978; *award@adelphi.edu*

Role of substrate during terrestrial locomotion in Asian Swamp Eels (Monopterus albus)

Highly elongate fish, from a number of distinct lineages, have traversed the water-land boundary. This movement between extreme environments is often motivated by habitat quality or lack of prey. Asian Swamp Eels (*Monopterus albus*) are found in rice fields and have been observed moving on mud flats to locate new bodies of water often around the breeding season. Laboratory study of *Monopterus* indicated that emergence from the water is often linked to starvation or increased population density. Previous study of pectoral fin-based terrestrial locomotion in fishes has shown the importance of the posterior end of the body for forward propulsion. Elongate fish tend to have highly reduced or absent paired fins, especially in the pectoral region, and thus must rely wholly on movement of the axial skeleton to move forward. Our work has shown that, similar to limbless tetrapods, elongate fishes use push-points in their environment during locomotion. In this study, we tested the role of substrate on body mechanics during undulatory locomotion; specifically we examined how compliance of a substrate affects forward movement. Individuals of *M. albus* were filmed moving across three different substrates: hard-packed sand, small loose pebbles, and small fixed pebbles. Fixed pebbles were secured onto the substrate and to each other with glue. We found that substrate did affect movements such as distance ratio and wave amplitude. This research, which is part of a larger comparative study on terrestrial movement in highly elongate fishes, will identify how different substrates may facilitate or constrain movement on those fishes that mostly rely on lateral undulation of the axial skeleton.

P2-198 ORTIZ, TE*; CHANDLER, C; Department of Biological Sciences, SUNY Oswego; *tortiz2@oswego.edu*
Testing for Wolbachia Infection in Aquatic Isopods
Wolbachia is a very common endosymbiotic bacterium that can affect its hosts in various complicated ways. It can affect some nematodes and numerous arthropods, including terrestrial isopods." The focus of our research was the potential effects Wolbachia can have on not only terrestrial isopods, but also aquatic species of isopods as well. Using PCR, specimens were obtained from the Rice Creek Field Station in Oswego, New York, which were then analyzed to determine species and sex. The species, Caecidotea racovitzai, was identified and then several of the collected specimens were tested for Wolbachia. Our initial results showed little to no Wolbachia infection, but may be skewed because of the limited sample size being tested at the time. We are currently testing additional samples, as well as a marine isopod species, Idotea baltica, that we plan on working further with in the lab to test prevalence of Wolbachia in freshwater and marine isopods.

P1-209 OSBORN, AL*; AMBROSE, A; CHAMBERS, C; CORDERO-MARTíNEZ, C; SHRILEY, K; SILVA, S; MARKLAND, S; TWOMBLY, J; GONZALEZ, V; TSCHEULIN, T; PETANIDOU, T; BARTHELL, JF; College of NJ, Savannah St. U, U Kansas, U Puerto Rico, CO College, OK St. U, Cornell U, U Kansas, U Aegean, U Central OK; *osborna3@tcnj.edu*
Effect of Pan Trap Size on Catch: Determining Protocol for Pollinator Monitoring
Bees are key pollinators, but many populations and species are declining. Monitoring bee health and pollination are priorities to safeguard pollinators and secure their services. Pan trapping is a popular method to survey bees, but efficacy assessments of this method are limited. Little is known about effect of bycatch, which increases processing time and costs, and may affect beneficial arthropods. We tested the hypothesis that large traps increase abundance, diversity, species richness, and body size of bees, and bycatch abundance. Field studies were conducted in 3 habitats in Lesvos, Greece: a semi-natural phrygana scrub, an olive grove, and a salt flat. Arthropods were collected from transects of 4 sizes of traps (1.0, 3.25, 5.0, 12.0 Oz). 13,155 arthropods were collected, of which bees accounted for 37.2% and 109 species. Pairwise comparisons indicated that 5.0 and 12.0 Oz traps captured a larger bycatch. 3.25 Oz traps yielded the same abundance, species, diversity, and body size of bees; there was also no correlation between trap size and these variables. Larger traps (5.0, 12.0 Oz) caught significantly more bycatch. Results suggest that 3.25 Oz traps are an optimal size for pollinator surveys; catching the same abundance, species, diversity, and sizes of target arthropods, while minimizing bycatch. This trap size is less likely to tip over or evaporate as quickly as 1.0 Oz traps, and uses fewer resources than larger traps, making it more sustainable. Our findings suggest a practical and reliable means for conservationists to monitor pollinator populations and assess their ecological role.

P1-4 OUFIERO, CE; Towson Univ; *coufiero@towson.edu*
The Organismal Form and Function lab-course: a new C.U.R.E. for engaging students in authentic research experiences in organismal biology.
There is an increasing realization that traditional "cookbook" labs may not expose students to the reality of conducting research. Instead of handing students a set of experiments with known conclusions, more educators are implementing authentic research experiences within the classroom, where the results are often unknown, even to the instructor. These courses, called Course-based Undergraduate Research Experiences, or C.U.R.E.s, allow students to learn laboratory techniques and scientific methods while enabling them to actively participate in research. C.U.R.E.s allow more students to participate in authentic research, and may lead to students presenting their research, becoming co-authors, or continuing in STEM related fields. However, most C.U.R.E. biology courses developed to date have focused on cellular and molecular topics, with few engaging students in other biological disciplines, such as organismal biology, functional biology, or ecology and evolution. As part of TU-REP, funded by Howard Hughes Medical Institute Inclusive Excellence Initiative, I developed a C.U.R.E. on organismal form and function, which was offered for the first time in the fall 2018. Using a scaffolding approach, students were instructed on form, function and performance relationships in the context of ecology, evolution and biomechanics. Students were also instructed on filming with high-speed cameras, digitizing, and analyzing their data to answer questions related to movement. Then, using guided inquiry and locally collected invertebrate species, students developed their own hypotheses on animal movement, collected, analyzed, and presented their data. I will present the course structure and application, student hypotheses and results, the benefits and challenges of teaching an organismal C.U.R.E., and results of student assessment.

P1-39 OZALP, MK*; MILLER, LA; Univ. of North Carolina, Chapel Hill; *mkoz@live.unc.edu*
The Effect of Immersed Structures on Zooplankton Swimming
Zooplanktons are vulnerable to strong flows and currents, such as in storms and flood conditions, given their small size. Reefs, macrophytes, and other structures can provide shelter against wash out as these structures alter the flow field around them significantly. It is not clear how the protective aspects of such immersed structures depend on their volume fraction, arrangement, and flexibility, and it is also not clear how organismal size and swimming speed scale against wash out. We use *Artemia*, or brine shrimps, as a model organism given their hardiness. We then use both experimental and numerical approaches to quantify the effect of macrophyte density and arrangement on flow. As a simplification, we use 3D-printed arrays with cylindrical protrusions as an initial model of the macrophytes. Using 2D Particle Image Velocimetry (PIV), the flow fields in the presence and absence of cylindrical arrays are measured. 3D immersed boundary simulations are then performed to resolve the flow fields around the cylindrical arrays, and the results are validated against PIV. Next, we inject nauplii within different arrays and for different background flow speeds. The distribution of *Artemia* over time is recorded with video. Finally, we compare the experimental results of Artemia distributions with an agent-based model that simulates the movement of plankton within the 3D flow fields produced by the immersed boundary simulations.

P1-246 PABST, E; KOCOT, KM*; University of Alabama, Tuscaloosa; *kmkocot@ua.edu*

Are ultraconserved elements an informative phylogenetic marker for reconstructing deep molluscan phylogeny?

Although recent phylogenomic studies employing hundreds of nuclear protein-coding genes have greatly improved understanding of mollusc class-level phylogeny, placement of some lineages such as Scaphopoda and Monoplacophora remain unsettled. We investigated whether ultraconserved elements (UCEs), putative regulators of animal gene expression with very low rates of sequence evolution, could be used as an alternative to nuclear protein-coding genes. To this end, we downloaded publicly available genomes from ten molluscs (six bivalves, three gastropods, and one cephalopod) and five outgroup taxa (two annelids, one brachiopod, one phoronid, and one nemertean) and screened them for UCEs following established approaches as implemented in PhylUCE. This approach identified 4,759 UCEs shared among at least ten taxa and 325 shared across all fifteen taxa. Using a test set of the 529 UCEs with no less than 70% data completeness, we assembled and analyzed a matrix with 142,817 nucleotide positions. Maximum likelihood analysis in RAxML using the GTR+G4 model yielded a tree with strongly-supported relationships that are largely consistent with the current understanding of molluscan evolution. Thus, these preliminary results indicate that this approach has promise for resolving lingering debates about mollusc class-level phylogeny. To this end, we are expanding this dataset to include other public datasets and new genomic data from representatives of three other molluscan classes.

P3-21 PALECEK, AM*; BLOB, RW; Clemson University; *apalece@g.clemson.edu*

Comparative Kinematics of Flamingos During Terrestrial Walking Versus Wading

Moving between aquatic and terrestrial habitats produces several challenges for locomotion, as animals must accommodate changes in buoyancy, drag, and substrate. Many species change locomotor behavior as they move between habitats, shifting from walking on land to swimming through water. Others, however, do not change locomotor mode and, instead, use walking in both habitats. Species such as turtles and salamanders walk while fully submerged underwater, showing locomotor patterns affected by differences in buoyancy between habitats. However, diverse species engage in wading behaviors, in which the limbs move through the water but the body is partially out of the water. We evaluated how locomotor kinematics are impacted by changes in water depth during wading by filming Chilean Flamingos (*Phoenicopterus chilensis*) at the Greenville Zoo (SC). We predicted that birds will take shorter steps in water than on land and, potentially, take the highest steps at intermediate depths. We also predicted that the head and neck would adopt a position closer to the center of mass during shorter steps in water, and that stride velocity would be slower in water than on land. Preliminary analyses suggest that strides are slower in shallow and deep water than on land, though head position and stride length were not affected by water depth. Our results suggest that flamingos adjust limb movements as they wade through deeper water, shifting from stepping over and into shallow water, to dragging the leg through deeper water when stepping above the surface becomes intractable. These data shed light on potential mechanisms that long-legged animals may use to overcome the challenges of transitioning between terrestrial and aquatic habitats.

P3-128 PADDA, SS*; GLASS, J; STAHLSCHMIDT, ZR; U. Pacific; *s_singh40@u.pacific.edu*

Effects of heat wave and water limitation in an insect—from life history to behavior and physiology

Animals live in complex environments where multiple environmental factors naturally co-vary. For instance, heat waves are often accompanied by droughts. Shifts in complex environments characterized by multiple, co-varying factors may lead animals to adjust life history (e.g., increased allocation of resources from somatic to reproductive tissues), behavior (e.g., increased dispersal or foraging) or physiology (e.g., reduced energy or water use). These biological adjustments may be cooperative. For example, combined conditions of heat wave and water limitation may result in reduced behavioral activity that, in turn, reduces energy use and water loss through respiration. Alternatively, adjustments may work antagonistically where, for example, stressful environments may result in a diversion of resources from immunity to somatic tissue. To investigate how water limitation and simulated heat waves alter life history, behavior, and physiology, we used a 2 x 2 factorial design to manipulate the thermal environment (field-parameterized heat wave or control conditions) and access to water (present or absent) in wing-dimorphic, variable field crickets *Gryllus lineaticeps* during early adulthood. After 4 days of treatment, we assayed behavioral exploration in a novel environment. We also measured rates of metabolism and evaporative water loss via flow-through respirometry, and assayed immune function (total phenoloxidase activity) in females. Last, we determined the key life history traits of survival and investment into tissue types (e.g., flight muscle status, and gonad and body mass). Our results will shed light on how complex environmental shifts influence several levels of biological organization in animals—from life history to behavior and physiology.

P2-7 PARK, MH*; GERSONY, JT; ROCKWELL, FE; HOLBROOK, NM; Harvard University; *mariapark@college.harvard.edu*

Leaf-Level Carbon Dynamics of Trees with Various Phloem Loading Strategies in Elevated CO_2 Conditions

Plants are integral to the functioning of the natural world. Vegetation accounts for a significant portion of global carbon fluxes into and out of the atmosphere, and the terrestrial carbon cycle's existing equilibria could become skewed by climatic changes, such as temperature increases and drought. As atmospheric CO_2 levels rise, it is critical to expand and deepen our current comprehension of how trees will respond to this shifting environmental factor. To study the effects of elevated CO_2 on plant functioning, six tree species were selected based on their different strategies of loading sugars produced by photosynthesis into their phloem transport vasculature (*phloem loading*). We hypothesize that trees dependent on a sucrose concentration gradient to load sugars into the phloem (*passive phloem loaders*) will be less efficient in sugar export in conditions of higher atmospheric CO_2 concentrations. Over the course of 24 hours, rates of net photosynthesis were measured with the Li-Cor 6400, and leaf discs collected for their dry weight. These measurements allow calculation of net C balance and thus temporal patterns of sugar export into the phloem. The observation of relative rates of sugar export in this study will improve our understanding of how trees with different phloem loading types will respond to elevated atmospheric CO_2 concentrations.

P2-28 PARRY, HA*; JOSEFSON, C; TAYLOR, HA; ANDREASEN, V; PARK, NR; HOOD, WR; KAVAZIS, AN; Auburn University; *hap0017@auburn.edu*

Immune Challenge During Reproduction has Minimal Impact on Mitochondrial Respiration and Oxidative Stress

To meet the demands of an immune challenge during reproduction, a female is theorized to reduce the allocation of resources to reproduction or limit allocation to maintenance. We determined if female mice are exposed to an immune challenge (keyhole limpet haemocyanin; KLH) during reproduction, they experience a reduction in mitochondrial performance and increase in oxidative stress. Laboratory mice were paired with a male until just before giving birth and randomly assigned to one of three groups. Female mice in the control group (LC) were injected with saline 2 days after parturition, and then sacrificed 1 week after weaning. In the lactating immune challenge group (LI), females were treated similarly except they were injected with KLH. Finally, in the pregnant-lactating immune challenge group (PLI), females were treated the same as LI group, except the male was left in the box with the female until 3 days post-partum, so the female was pregnant while lactating. The second litter was born within 3 days of weaning, immediately removed, and females were sacrificed 1 week later. No significant differences were observed in liver or hindlimb skeletal muscle mitochondrial coupling as measured by the respiratory control ratio (RCR). Isolated mitochondrial reactive oxygen species emission in the skeletal muscle was significantly lower in LI compared to LC, but no differences were observed in the liver. Skeletal muscle PGC1- was significantly reduced in LI mice compared to LC. We also observed various changes in antioxidant protein levels in both tissues. In conclusion, an immune challenge during reproduction has an impact on females that is organ specific and varies with the intensity of the demand.

P2-216 PARSONS, ZM*; ST. PIERRE, R; BERGBREITER, S; University of Wyoming, University of Maryland, University of Maryland ; *zparsons@uwyo.edu*

Towards Understanding the Role of Resilin in Arthropod Springs and its Applications to Microrobotics

Small insects repeatedly jump with high take-off velocities by storing elastic energy in springs from deformation of the exoskeleton. These jumps allow insects to navigate rough terrain, clearing obstacles many times their own size, making them sources of inspiration in microrobots. However, at-scale microrobots lack the agility of insects, in part due to limited understanding of energy storage in the exoskeleton of insects. Insect springs are often composites of stiff chitin and compliant resilin, with a difference in Young's Modulus over three orders of magnitude. The resilin contributes very little to the springs' stored elastic energy, so its role is unclear. To explore the role of 'soft' materials in springs, the insect spring was simplified to a synthetic analog, a bilayer cantilever beam. We explored the dynamic and failure properties of the springs both experimentally and theoretically. Dynamic properties of the spring did not vary significantly with varying thickness of soft material, but ultimate stored elastic energy did; springs with thicker soft material stored more energy through increased deflection. However, mass-specific stored energy in composite springs decreased, though the mass of insect springs is negligible compared to body mass. Theoretical exploration shows a stark contrast in the design sensitivity of stored potential energy to material thickness. Potential energy storage is less sensitive to soft material thickness in composite springs than the thickness of single material springs, so any mistakes in soft material thickness are negligible compared to mistakes in hard material; this facilitates designing a greater reliability in jumping robots while sacrificing little performance, a key trait for the success of autonomous robots.

P1-211 PATTERSON, LN*; HARRIS, BD; COVI, JA; Univ. of North Carolina at Wilmington; *lnp7743@uncw.edu*

Tiny, but Mighty! Zooplankton, the Missing Link in Assessments of Ecosystem Health for Waters Near Coal-fired Power Plants

Most zooplankton species in inland lakes exploit a life cycle with active life stages occupying the water column and dormant life stages resting in the bottom sediment. Because of this pelagic-benthic coupling, monitoring zooplankton communities in both locations can provide a powerful view of the health of lake ecosystems. The primary objective of the present study was to assess the state of the active zooplankton community in a cooling-water source (Lake Sutton, North Carolina) for a former coal-fired power plant by monitoring zooplankton diversity and abundance in the water column. The secondary objective was to assess the presence of zooplankton embryos in the benthos by identifying dormant life stages of crustacean zooplankton in sediment basins. The present study demonstrated that (1) the diversity of the active zooplankton community decreased over the last 30 years, (2) few zooplankton species have predictable succession patterns over the course of a year, (3) early life stages of copepods are the most common crustacean zooplankton in the water column, and (4) the diversity of embryos in the sediment is extremely low. Together, the decrease in diversity and low recruitment of some species to adulthood indicate that zooplankton in Lake Sutton face serious spatially heterogeneous challenges to recruitment from dormant egg banks that jeopardize community stability, and, in turn, the long-term viability of recreational fish stocks. Managers of freshwater resources should take note; maintaining a stable zooplankton community may decrease the cost of maintaining important recreational fish stocks.

P3-91 PAULSON, DM*; PATTERSON, LN; COVI, JA; Univ. of North Carolina at Wilmington; *dp1865@uncw.edu*

Using Model Species to Explain the Effects of Coal Combustion Residual Contamination on a Zooplankton Community

Recent data have shown that Lake Sutton contains an unstable zooplankton community that has decreased dramatically in biodiversity over the last three decades. This lake is a cooling reservoir contaminated with coal combustion residuals, which could be responsible for the current biological issues in the lake. Because cladocerans are one of the only zooplankton that show predictable patterns of abundance in the lake, we hypothesized that cladocerans have developed a natural resistance to toxicants in the lake. If that is true, non-native species will be impacted by putative toxicants in water and sediment collected from Lake Sutton. The present study addresses this by testing the susceptibility of the non-native cladoceran, *Daphnia magna*, and brine shrimp, *Artemia franciscana*, to native water and sediment from Lake Sutton. Toxicology protocols approved by the Environmental Protection Agency (EPA) test exposures of active zooplankton to putative environmental toxicants, but no standardized protocols address exposures of zooplankton during embryonic dormancy. In addition to testing the water using a standard EPA protocol for larvae of *D. magna*, ephippia of *D. magna* and dechorionated embryos of *A. franciscana* were exposed to Lake Sutton water and sediment during dormancy and early post-dormancy development. Exposure to Lake Sutton water did not increase mortality during early development in either species but did induce some abnormal development in *A. franciscana*. However, exposure of embryos to sediment from the lake during the hatching process caused high larval mortality. These data may explain why daphnids are one of the few stable zooplankton left in Lake Sutton.

P1-146 PAYNE, AA*; HORR, DM; JOHNSON, MA; Trinity University; *apayne2@trinity.edu*

Tail Autotomy in Lizards Not Associated with Tail Use Behaviors or Energy Storage

In many lizard species, the ability to autotomize the tail allows for immediate survival in the face of predation, but may come at a high cost. Tails are often used in communication and energy storage, and so tail autotomy can thus decrease an individual's overall fitness. In this study, we examine this tradeoff in species that use the tail differently. We predict less frequent tail autotomy in species that use the tail for social display or energy storage, as a full tail is particularly valuable. In species that primarily display the tail in a predatory context, we predict the frequency of tail loss will be higher, as the tail is made especially vulnerable to autotomization. We studied seven lizard species that vary in tail use: greater earless lizards (*Cophosaurus texanus*) and curly tail lizards (*Leiocephalus carinatus*) use tails frequently in display, Mediterranean house geckos (*Hemidactylus frenatus*) and crested anoles (*Anolis cristatellus*) use tails occasionally, and green anoles (*Anolis carolinensus*), Texas spiny lizards (*Sceloporus olivaceus*), and Texas spotted whiptails (*Aspidoscelis gularis*) almost never include tail movements in display. We observed lizards of each species in the field to quantify the use of the tail in social contexts, and performed predator simulation trials to quantify tail use in predatory contexts. We approximated energetic content of the tail using the ratio of tail mass to body mass. We found that the frequency of tail autotomy varies from 20 to 60 percent of individuals across the seven species, and lizards that use their tail in a social context also tend to do so in a predatory context. In preliminary analyses, there is no clear relationship between the frequency of tail autotomy and the use of the tail in social, predatory, or energetic contexts.

P1-184 PELLICANO, A*; AZIEVA, G; LYNCH, KS; Hofstra University; *apelli4@pride.hofstra.edu*

Eavesdropping on heterospecifics: Does it modify reproductive physiology in female brood parasites

Social regulation of reproductive hormones is a means by which conspecific males and females orchestrate successful reproductive efforts. We investigate whether social cues modify activity within the hypothalamic-pituitary-gonadal (HPG) axis and the specificity of this response in a social parasite that is known to eavesdrop on the communication signals of other species: the brown-headed cowbird (Molothrus ater). Brown-headed cowbirds are obligate brood parasites that do not build nests or care for their own young. Instead, obligate brood parasites leave their eggs in the nest of a host species and therefore must coordinate their breeding attempts with conspecifics as well as potential heterospecific hosts. Here, we explore whether the vocal signals of potential host species can also be used as a social cue that modifies the HPG axis of female brown-headed cowbirds. Results reveal that both conspecific and heterospecific song-exposed females exhibit significantly greater circulating estradiol concentrations as compared to silence-exposed females. While conspecific song induces the greatest elevation in circulating estradiol, there is no significant difference in circulating estradiol levels in females exposed to either conspecific or heterospecific songs. This pattern suggests both song types are effective at evoking a reproductive physiological response. On the other hand, circulating progesterone concentrations did not differ among the song- and silence-exposed groups nor did the size of the female's ovarian follicles. These results indicate that heterospecific vocal communication signals can effectively be used as a social cue that simultaneously provides necessary information regarding breeding status of hosts and modifies breeding condition of the eavesdropper.

P3-160 PEKAR, KJ*; ONTHANK, KL; Walla Walla University; *katherine.pekar@wallawalla.edu*

Diet analysis of the burrowing octopus Muusoctopus leioderma using stable isotopes and sequencing

As dietary generalists, octopuses play an important role in food webs, with their dietary intake directly impacting many other organisms in their ecosystem. However, traditional analyses of octopus diets rely on middens, or the hard-shelled remains of prey items that are left behind in dens. As a result, studies on octopuses' diets are likely biased against soft-bodied prey items, which may result in a misunderstanding of their ecological impact. Little is known about the diet of *Muusoctopus leioderma*, a deep-water octopus that was recently observed at 10 meters depth. *Muusoctopus leioderma* is a nocturnal octopus that spends daylight hours burrowed into muddy substrate, meaning that no middens are produced. They are also difficult to feed and keep in the lab, limiting current understanding of their diet. These factors make this novel, shallow-water population of *M. leioderma* an excellent candidate for two alternate dietary inquiries: stable isotope analysis, which can be used to provide general clues about long term diet, and genetic analysis of fecal material, which can provide specific insight into a few dietary components. Together, these methods not only provide information about the diet of *M. leioderma*, but also present new methods that may be used to supplement current ecological understanding of octopuses.

P2-239 PENROD, LM; Florida Institute of Technology; *lpenrod2011@my.fit.edu*

Geographic Distribution of Fishes with Cranial Spines

Over the past several decades, research has investigated the role of spines in many forms of life. In most cases, the role of spines is to prevent predation, but what about the small, spine-like, projections on the cranium of fish? These spines and ridges vary in shape and size across species, and are unlikely to be anti-predatory. Before investigating the functional role cranial spines play in the life of fishes, we must understand how these fish interact with their environment. Specifically, we must know where these fish reside and what environmental factors are associated with their presence. I identified over 400 species around the world that exhibit this trait. Spatial models highlight a species richness in the North Sea while predictive models indicate that depth, temperature, productivity, and current are significantly related to the presence of fish with cranial spines. After reviewing the results, we believe that the function of these spines may be related to current.

P3-69 PERAMBA, K. B.*; NASH, C.; WALTERS, D.; HACKWORTH, L.; SCHUMM, M.; PINEDA, O.; EDSINGER, E.; The Marine Biological Laboratory, The University of Chicago; *kperamba@mbl.edu*

Squid Monday: Characterizing population structure in Doryteuthis pealeii

One thing I've learned growing up on Cape Cod is that like tourists in the summer, *Doryteuthis pealeii* will also come and go. Since spending more time on the water in Nantucket and Vineyard Sound this year, I have begun to notice complex seasonal patterns of local squid in size, sexual maturation and lifespan but year-round dynamics remain poorly understood and possible underlying genetic structure is contentious. The species occurs from New Foundland to the Gulf of Venezuela and is fished commercially from Southern Georges Bank to Cape Hatteras, including a long-standing fisheries here in Woods Hole and the Cape Cod region. During summer the Long Fin Inshore squid inhabit the waters close to shore but then go offshore in winter. Beginning in early May there is a distinct size class of very large and sexually mature *D. pealeii* but then by late July mature females are half the size, and potentially have half the lifespan. To characterize genetic structure within the local squid we sampled 30 animals of different size classes once a week for 16 weeks and once a month thereafter. Weight, length, gonad maturity, and sex identification were assessed as well as two arm tips per animal were collected and frozen for sequencing. With over 500 samples, we were able to extract DNA and generate two data sets commonly used in population genetics, microsatellites, expanding on previous work by others, and mitochondrial control region sequencing, which offers potentially greater signal for resolving any genetic structure over time.

P2-280 PEREZ-GALVEZ, FR*; TEETS, NM; University of Kentucky; *fernan954@gmail.com*

Genetic and Environmental Factors Influencing the Efficacy of Transgenic Sterile Insect Technique

Sterile Insect Technique (SIT) is a strategy for controlling insect pest populations in which sterilized males incapable of siring offspring are released into the environment. Transgenic technologies have the potential to improve SIT operations by providing new strategies for sterilization and sex sorting through the use of conditional lethality constructs. The conditional lethality systems that have been developed are tetracycline suppressible such that flies with tetracycline in their diet are able to develop and breed normally under laboratory conditions. Once in the wild, where tetracycline is absent, lethality is triggered by stage- or sex-specific developmental disruption. However, the extent to which environmental and genetic factors affect the expression and activity of these conditionally lethal transgenes has not been assessed. Before such transgenic strategies can be incorporated into management programs, information regarding the efficiency and potential environmental impacts is urgently needed. Here, using *Drosophila melanogaster* as a model, we are evaluating intrinsic (genetic variability) and extrinsic (environmental variability) factors that may jeopardize the effectiveness of transgenic SIT release programs. In this poster, we will present egg viability assays for transgenic SIT as a proof of concept and preliminary data from a quantitative gene expression assay targeting the transgenic construct. Moreover, we are constructing a dose response curve for the conditional lethality system along a tetracycline concentration gradient. Beyond our focus on SIT, these experiments also have broader implications for assessing risks associated with the use of genetically modified organisms in natural and agricultural ecosystems.

P1-206 PERNET, B*; SILVERMAN, E.R.; VALENTICH-SCOTT, P; PERNET, Bruno; California State University Long Beach, Smith College, Santa Barbara Museum of Natural History; *bruno.pernet@csulb.edu*

The seashells of an iconic public artwork: diversity and provenance of the mollusks of the Watts Towers

The structures of the Watts Towers (WT), an iconic Los Angeles artwork created by Sabato Rodia in 1921-1954, are covered with mosaics that include thousands of mollusk shells. Little is known about the diversity or sources of these shells, though such information would be of great utility to WT conservators and to art historians. We documented the diversity of mollusk shells present in the WT and used data on the ranges and habitats of the species, and other characteristics of the shells, to make inferences about their provenance. We identified shells of 34 species of mollusks in the WT, 24 of them bivalves and 10 gastropods. Almost all (29/34) of these species are native to southern California shorelines, especially those of bays and estuaries. Rodia could have accessed these sites on foot, by automobile, or by using the extensive network of Red Car trolleys. Some of the bivalve shells on the structures bear complete drill holes made by naticid gastropods, suggesting that the shells were collected post-mortem, presumably after they had washed up on beaches. These observations are consistent with the sparse documentary evidence on the origin of the shells of the WT. We also discuss the potential origins of the five species not native to California shorelines found on the WT. These data on the diversity of the seashells of the WT should be very useful for conservators, and also of interest to scholars of and visitors to the WT.

P1-16 PFEIFFENBERGER, J.A.*; DONATELLI, C.M.; MEKDARA, P.J.; FATH, M.J.; KHANNA, S.; SHEN, T.H.; TYTELL, E.D.; Tufts Univ.; *eric.tytell@tufts.edu*

Design your own fish! Engaging museum visitors in biomechanics research

Most people enjoy watching colorful fish swim, and they may have even wondered about all the different varieties of fishes, but few people get to participate in the biomechanical research that is helping us understand the diversity of fishes. The goal of this project was to make this process more accessible by engaging museum goers in the research itself. We have developed a prototype for a "Design a Fish" activity, an exhibit that will allow science museum visitors to create their own flexible model of a fish from an assortment of tail and body parts of varying shapes and flexibilities. The fish can then race down a long tank against those of other museum goers, with sensors in the tank recording the speed, kinematics, and body properties of each fish. Preliminary tests show that body shape and flexibility both play a part in a model's speed, although the two factors interact in a complex way. By allowing the public to contribute to the creation and testing of the model fish, we make the complicated processes behind fish locomotion tangible, while simultaneously developing a source of crowdsourced data to quantify the effect of shape and flexibility on swimming performance in fish. To accompany the exhibit, we designed videos that illustrate particle image velocimetry (PIV), a laboratory technique used to quantify fluid flow patterns around swimming fish. We combined animation, clever writing, and science to explain PIV and how we use it to study fish swimming. We hope museum visitors gain a deeper understanding the techniques and scientific process used to study swimming in fish and animal movement in general.

P2-168 PHILLIPS, HA*; KANE, EA; Georgia Southern University; *hp01174@georgiasouthern.edu*

Do Generalists Specialize? Potential for Individual Variation in Trinidadian Guppy Feeding Kinematics

Local adaptation is a phenomenon observed across a variety of species in which populations develop behavioral, morphological, and physiological traits which help them survive in their environment. Trinidadian guppies, *Poecilia reticulata*, are a model for studies of local adaptation. Upstream low predation (LP) populations experience higher population density and lower resource availability compared to downstream high predation (HP) populations. Differences in prey selection, feeding rate, and cranial morphology between populations indicate that feeding kinematics may be a locally adapted trait, however, recent work does not support this hypothesis at a population level. We hypothesize that within dense low predation populations, individuals may be driven to specialize to avoid resource competition, leading to differences in feeding kinematics that are not observable between populations. Using wild caught female guppies from replicate rivers, feeding kinematics were measured for three videos per fish then analyzed to determine how individuals vary when compared to their respective populations. Individuals in at least one HP population tend to specialize, contradicting expectations that intraspecific competition may drive specialization. Because this effect is not correlated to high predation or low predation groups, this suggests that individual specialization can occur, but is not necessarily repeatable across similar environments and may not reflect local adaptation of populations. While local adaptation is present in other physical and behavioral traits, it is likely that a generalist approach to feeding is more advantageous for guppies at both the individual and population levels.

P2-253 PIRRONE, M*; NARICI, V; BARNHART, D; MASS, S; SUNY New Paltz; *pirronem1@hawkmail.newpaltz.edu*

Comparing the Kinematics of Metamorphosed Axolotls and Tiger Salamanders

Axolotls are neotenic ambystomoids which are closely related to North American tiger salamanders. Though axolotls generally remain aquatic, there are rare cases of spontaneous metamorphosis where they become terrestrial. While metamorphosed axolotls appear very similar to other terrestrial ambystomoids, there are significant differences in the functionality of the metamorphosed axolotls which are poorly understood due to the rarity of the metamorphosis. Initial inspection of the terrestrial axolotls indicate that they have issues in locomotion and coordination. Are there developmental timing windows not met by the axolotls, which may cause metamorphosed axolotls to be less adapted to terrestrial locomotion? This study is examining the potential differences of the functional morphology that occur developmentally. In particular, high speed cinematography was used to observe the kinematics of the salamanders. Particular physical landmarks on the salamanders were marked, tracked, and analyzed to compare movement and function. Variables such as velocity, acceleration, and jerk were examined and compared. Initial analysis of the data showed that metamorphosed axolotls had greater amplitudes of acceleration and greater jerk (the rate of change of acceleration), meaning their movement is less smooth and balanced. This is indicative of lower efficiency and less coordination in metamorphosed axolotls than tiger salamanders.

P2-76 PLATFOOT, K. E.*; SATTERLIE, R. A.; University of North Carolina, Wilmington; *kep1294@uncw.edu*

Neuromodulatory Innervation of the Buccal Cone Muscles of the Pteropod Mollusk, Clione limacina

The pteropod mollusk *Clione limacina* is a holoplanktonic gymnosome found in the northern Pacific and Atlantic Oceans as well as the Arctic Ocean. Its relatively complex behavioral hierarchy, which includes various swim states and feeding and reproductive behaviors, is supported by a simple, easily accessible central nervous system which makes it an ideal model organism for neurobiological studies. The buccal cones of *Clione* serve as hunting tentacles and contain three types of muscle tissue: smooth circular, smooth longitudinal, and striated longitudinal. The smooth circular muscle is responsible for buccal cone extrusion and the smooth and striated longitudinal muscles are believed to be involved in buccal cone retraction and prey manipulation, respectively. Several neurotransmitters and neuropeptides have been found to have modulatory effects on hunting behaviors including FMRFamide, serotonin, small cardioactive peptide b (SCP_b), myomodulin, and buccalin. However, the distribution of these modulators relative to the muscle layers is unknown. This study uses immunohistochemistry at the light and transmission electron microscopy (TEM) levels to identify and describe contact locations within the buccal cones. FMRFamide, SCP_b, myomodulin, and buccalin are found near the orally-concentrated, striated longitudinal muscles, while of serotonin can be seen at the bases of adhesive papillae. Synapses between SCP_b reactive neurons and striated longitudinal muscles have been observed with TEM. These results provide further insight into the function of the buccal cone longitudinal muscles relative to the behavioral control of prey acquisition.

P1-229 PLEE, TA*; POMORY, CM; University of West Florida; *taraplee4@gmail.com*

Sea Cucumbers and Sand Dollars as Biomonitors for Nearshore Environments

Plastic production has been continually growing worldwide due to its high durability, low cost, and light weight. Microplastics are either intentionally created, or derived from larger plastic sources via mechanical, photolytic, or chemical degradation. Microplastics can adsorb contaminants and persist in the ocean, often settling in the sediment. This may pose problems for benthic marine organisms that ingest small particles, such as sand dollars and sea cucumbers. Sand dollars (Echinodermata: Echinoidea: Clypeasteroida) are microphagous feeders ingesting particles, and occur in high densities in nearshore sandy environments altering the sediment through bioturbation. Sea cucumbers (Echinodermata: Holothuroidea: Holothuriida/Aspidochirotida) are deposit feeders ingesting sediment in seagrass and sandy habitats. This study had four goals: first, to examine if sediment where sand dollars and sea cucumbers were collected contain microplastics; second, to examine if *Mellita tenuis*, a common sand dollar in the northern Gulf of Mexico, ingests microplastics in two locations along the panhandle of Florida, U.S.A.; third, to determine if sea cucumbers (*Holothuria floridana*, *Holothuria mexicana*, and *Actinopyga agassizi*) ingests microplastics in two locations along the Florida Keys, U.S.A.; and fourth, to conduct a laboratory experiment to examine if *M. tenuis* will ingest microbeads. Sediment samples contained a variety of microplastics, mainly fibers and fragments. *Mellita tenuis* and all three species of sea cucumbers ingested microplastics of different sizes and shapes similar to the microplastics extracted from the collected sediment, which may make them useful as a monitoring tool for nearshore sandy environments.

P2-251 POPP, M*; WAINWRIGHT, DK; LAUDER, GV; Harvard Univ.; *glauder@oeb.harvard.edu*

Thresher Shark Tails: Denticle Morphology in Comparison to Other Pelagic Sharks

Shark skin denticles (scales) are diverse in morphology both among species and on the body of single individuals although the function of this diversity is not well understood. Current views indicate that denticles may both reduce drag and increase thrust during swimming, and the morphology of denticles on different regions of a shark may reflect local flow conditions. We systematically measured denticle morphology on the caudal fin of thresher sharks (genus *Alopias*), and compared thresher tail denticles to those of selected other pelagic shark species. Thresher shark tails are equal in length to the rest of their body and are uniquely used for both locomotion and hunting (by whipping the tail over their head into schools of fish). Using surface profilometry, we quantified 3D denticle patterning and texture in three adult and two embryonic threshers at 27 regions in the adults and 16 regions in embryos. We then measured a suite of variables using these 3D surfaces to compare the surfaces of different regions. The tails of thresher embryos have a membrane that covers the denticles and reduces surface roughness: membrane surface roughness is 4μm, while embryo denticle roughness averages 10 μm. In adult thresher tails, denticles are generally similar to those of other pelagic shark tails, and there is no gradient in roughness from the base to the tip of the tail: tail skin roughness averaged 9 μm. All along the tail there is a leading-to-trailing edge gradient with leading edge denticles larger and lacking ridges (average roughness = 9 μm), while trailing edge denticles are smaller, with 5 ridges, and an average roughness of 7 μm. We found no evidence that the increased undulatory excursions from the base to the tip of thresher tails correlate with surface roughness.

P3-187 POPSUJ, SE*; SEAVER, EC; Agnes Scott College, University of Florida Whitney Laboratory of Marine Bioscience; *spopsuj@agnesscott.edu*

Investigation of Wnt signaling during posterior regeneration of the annelid Capitella teleta

Wnt signaling is a common pathway used in development and has been shown to be important for whole-body regeneration. The phylum Annelida is an important taxon to study because there are varying capabilities in whole-body regeneration. Furthermore, with new technologies, functional studies are possible in annelids.We hypothesized Wnt signaling would be important in the regeneration of the annelid *Capitella teleta*, which can undergo posterior regeneration. In this study, we assessed how inhibition and activation of Wnt signaling during the early stages of regeneration affected regenerative success in *C. teleta*. We pre-exposed animals to known concentrations of C-59, ETC-159 and Alsterpaullone, commercially available inhibitors and activators of Wnt signaling. After thirty-six hours of pre-exposure, we amputated worms and monitored their regenerative success for three to seven days. Animals were continuously exposed to one of the drugs for the duration of the experiment, and the drug was exchanged every twenty-four hours. Control specimens were amputated under the same conditions but in filtered sea water without a drug. All treatments used antibiotics to minimize bacterial invasion. Regenerative success was assessed on the basis of morphology and a cell proliferation assay. Originally, we predicted that inhibition and activation of wnt signaling would result in no regeneration and increased regenerative ability, respectively. Our preliminary results suggest inhibition of wnt signaling is not critical during early stages of regeneration in *C. teleta*. This work will provide insight into the mechanisms controlling the early stages of regeneration and repatterning in *C. teleta*, and will contribute to a larger understanding of the role of wnt signaling in regeneration.

P2-164 PORTER, N; JOST, JA*; Bradley University; *jjost@bradley.edu*

Examining potential links between temperature stress and antioxidants in the invasive zebra mussel

Since being introduced to the US, the invasive zebra mussel has rapidly spread throughout freshwater ecosystems. Zebra mussels cause extensive damage by harming native species and altering water quality, and they are extremely costly to remove from the hard surfaces to which they attach. Therefore, there is great interest in understanding their physiology in an attempt to limit, or at least predict, spread to new habitats. A previous experiment in our lab indicated energy imbalances are occurring during acute cold exposure. One possible explanation is that cold temperatures increased oxidative stress and impaired ATP production. While previous studies suggest reactive oxygen species increase in zebra mussels due to elevated metal concentration, high salinity, and pesticides, little is known about the links between temperature and oxidative stress in this species. Therefore, the specific aims of this project were to determine whether the invasive zebra mussel experiences oxidative stress during thermal fluctuations, and if so, which antioxidant is most active. We exposed zebra mussels to a cold stress in the lab by progressively decreasing water temperature from ambient river temperatures of 26°C to 10°C over three hours. Tissue was collected to determine superoxide dismutase activity, total antioxidant capacity, and the levels of TBARS. No significant changes in total antioxidant capacity or TBARS were seen, but superoxide dismutase activity increased after 12 hours at 10°C. We are currently using qPCR to expand these data to include the mRNA levels of superoxide dismutase, metallothionein, and catalase over time during this acute cold exposure.

P1-108 POWERS, MJ*; WILSON, AE; HEINE, KB; HILL, GE; Auburn University , Auburn Univeristy, Auburn University; *mjp0044@tigermail.auburn.edu*

A Meta-analysis of Patterns of Mate Choice in Copepods

Marine copepods are an excellent model system in which to study mate assessment. Mate choice is well-documented in copepods, and a variety of approaches have been used to instigate copepod choosing behavior. However, while the end-product of copepod mate choice has been studied in a variety of experimental situations and it is now well established that chemosensation plays an important role in copepod mating decisions, the role of other criteria in copepod mating decisions remains unclear. Using powerful meta-analytical tools and current software built for modern phylogenetic analysis, we confirm that across class Copepoda, choice of mates is a commonly observed behavior. A strong signal for mate choice persists when controlling for phylogenetic relationships between species, genera and orders. The inclusion of a phylogenetic control allows us to reliably compare the magnitude of recorded mate discrimination in diverse groups of copepods with different life history parameters, feeding behaviors, and ecological niches. We investigated the influence of experimental design on copepod mating behavior including assessments of the different types of stimuli that were employed and the density of individuals in the test environments. Critically, we grouped individual types of stimuli together under categories of criteria that copepods use to partition among potential mates, and we used these categories to investigate the strength and patterns of mate choice behavior. Although we found evidence for mate choice across comparisons, we also observed that mate choice can be influenced both by unique ecological and experimental factors. The compiled evidence in our meta-analysis suggests that copepods choose mates using multi-leveled criteria including assessment of species identity, discrimination at the population level, and, possibly, choice between mates of variable individual quality.

P2-98 PRADO, DMA*; GOMES, FR; MADELAIRE, CB; SÃO PAULO STATE UNIVERSITY, Assis, UNIVERSITY OF SÃO PAULO; *meyer.unesp@gmail.com*

How Corticosterone Treatment Affects Testosterone Levels, Spermatogenesis and Wound Healing in the American Bullfrog

During reproductive season, males display high testosterone (T) levels that develop and maintain secondary sexual traits. Glucocorticoid (GC) hormones also have an important role during this period, recruiting energy stores to cope with reproductive costs. Nevertheless, the increase of CORT levels for extended periods of time can be deleterious for reproduction, diminishing T concentration and spermatogenesis. The GC also modulates immune response and may act as a mediator in the conflict of investment between immunity and reproduction. Our question is how the increase of acute and chronic increase of CORT levels interacts with spermatogenesis status, T levels and wound healing rate in the American Bullfrog (*Lithobates catesbianus*) during their reproductive season. Males were bought from a commercial farm, habituated for 7 days in individual plastic boxes and randomly divided into four groups: 1. Placebo (daily treated with sesame oil), 2. Acute CORT (daily treated with CORT solution [2µg]), 3. Operated sham (empty silastic tubes) and 4. Operated CORT (silastic tubes filled with CORT). After animals recovered from surgery, their legs were punctured with a biopsy needle. The wound was photographed and measured every 2 days in a stereomicroscopy and image analyzer software. Blood samples were collected during the experiment in order to measure CORT and T levels. Afterwards, animals were euthanized and testicles were dissected and fixed for histological analysis. T concentration, germinative cysts diameter and gonadal maturation stage will be compared between groups and correlated with CORT plasma levels and with wound healing rate.

P1-133 PRATER, CM*; CARR, JA; Texas Tech University; *christine.prater@ttu.edu*

Corticotropin-releasing factor (CRF) does not influence basal or depolarized GABA release from tectal neurons in Xenopus laevis

The 41 amino acid peptide CRF reduces food intake and related behaviors by acting on tectal CRFR1 receptors in the African clawed frog *Xenopus laevis* . Precisely how CRF acts within the optic tectum to inhibit food intake is unclear but may involve inhibitory GABAergic interneurons. We predicted that if tectal CRFR1-induced inhibition of food intake is mediated via inhibitory GABAergic interneurons, that exogenous CRF would increase basal and evoked GABA release from tectal explants *in-vitro*. Tectal explants from *X. laevis* were depolarized with 60 mM K+ and GABA was measured in the medium after derivatization using high-performance liquid chromatography coupled to electrochemical detection. GABA secretion from *X. laevis* tectal explants increased under depolarizing conditions and this evoked release was eliminated in calcium-free medium. Exposure of tectal explants to ovine CRF doses ranging from 1 nM to 1 micromolar (AnaSpec, Inc., Fremont, CA; 0, 0.001, 0.01, 0.1, 1 µM) had no effect on either basal or depolarization-induced GABA release. We conclude that our *in-vitro* assay measures calcium-dependent evoked GABA release from tectal explants and that CRF does not appear to influence basal or evoked GABA release *in-vitro*. These findings do not support a role for GABAergic interneurons in mediating tectal CRFR1 inhibition of food intake. Supported by a grant National Science Foundation IOS #1656734.

P1-143 PREISING, G.A.*; O'ROURKE, C.; RENN, S.C.P.; Reed College; *gapreisin@reed.edu*

Optimization of Cresyl-Stained Brain Micropunch Technique: Investigating the Genetic Regulation of Behavior in Astatotilapia burtoni

Astatotilapia burtoni is a model organism for the study of metabolic dysregulation and starvation behaviors. This model is particularly interesting because while mouthbrooding, females undergo a self-induced starvation that represents a physiological adaptation in that the neural regulation differs from that associated with simple food deprivation. Prior research shows that differential expression of genes involved in neuropeptide signaling between brain regions may account for self-induced starvation behaviors in brooding *A. burtoni*. To study this, mRNA must be extracted and compared between brain regions; however, precise methods such as laser capture microdissection sacrifice RNA quality. We aimed to optimize a technique that isolates discrete brain regions while preserving mRNA integrity. Brain punches isolated using our modified Cresyl-staining technique had significantly higher RIN values than whole-brain tissue isolated and stored in RNALater, and non-significantly higher RIN values than unstained control punches. These refinements offer a potentially more effective way of studying mRNA expression from small target regions.

P1-234 PRESNELL, JS*; WEIS, VM; Oregon State University; *presneja@oregonstate.edu*

Characterization of Scavenger Receptor and TSR-domain Genes During the Onset and Establishment of Symbiosis in the Sea Anemone Exaiptasia pallida

Onset and establishment of cnidarian-dinoflagellate symbiosis is mediated by the host innate immune system through interpartner signaling between host receptors and symbiont surface proteins. For example, in Aiptasia (*Exaiptasia pallida*), a sea anemone that is widely used as a model for cnidarian-dinoflagellate symbiosis, it is known that symbiont glycan and host lectin binding is crucial for symbiont specificity. Additionally, evidence has shown that the scavenger receptor (SR) and TSR-domain protein signaling pathways mediate symbiont re-colonization in aposymbiotic Aiptasia. In these studies, inhibition of the SR and TSR domains caused a reduction in symbiont colonization success. However, the Aiptasia genome encodes many SR and TSR-domain genes, thus it is unclear which specific genes are directly involved in mediating symbiosis. In general, the causal genetic mechanisms underlying onset and establishment of symbiosis in Aiptasia are still largely unknown, mostly due to the lack of tools and techniques for assessing gene function in the context of symbiosis. Here we discuss our efforts in developing molecular genetic tools (e.g., CRISPR/Cas9 genome editing) to investigate the role of candidate SR and TSR-domain genes in mediating the onset and establishment of symbiosis in Aiptasia.

P3-84 PRIOR, J/H*; WHITAKER, J/M; JANOSIK, A/M; University of West Florida; *jp74@students.uwf.edu*

An Exploration of the Epigenetic Effects of Microplastics Exposure on the Common Mysid Shrimp, Americamysis bahia

Microplastics are degraded or manufactured plastic particles <5 mm in diameter. Microplastics pollution has become commonly and publicly recognized as a ubiquitous issue of environmental concern in water systems. Zooplankton of biological and commercial importance, including the easily cultured mysid shrimp, *Americamysis bahia*, have been documented to be primary consumers of microplastics. Toxins and plastics aggregate in these primary consumers, which leads to bioaccumulation in consumers further up the trophic ladder. In the presence of certain environmental stressors gene expression may be altered without changing the sequence of the DNA. One way this occurs is through methylation of the DNA, in which a methyl group can bind to the nucleotide base pairs, commonly a cytosine-guanine sequence. In different situations, DNA methylation has shown to be both short-term and reversible or permanent and potentially heritable. Microplastics exposure is a potential and increasingly common source of environmental stress. Using a Polymerase Chain Reaction (PCR) based technique known as Methylation Specific-Amplified Fragment Length Polymorphism (MS-AFLP) mysid shrimp DNA can be assessed for patterns of methylation that are potentially associated with microplastics exposure. Individuals were dosed with 5 micrometer fluorescent microplastics and compared for differential methylation expression. The experimental groups are compared to a control group sampled before any experiments occured, and to groups that were not dosed, but treated equally in procedure. As part of the experiment, microplastics were delivered with a gradual increase in concentration to determine if methylation is occurring at different rates with different lengths of exposure and different concentrations.

P2-110 PUJADE BUSQUETA, L*; DEYARMIN, JS; MCCORMLEY, MC; CHAMPAGNE, CD; CROCKER, DE; HOUSER, DS; KHUDYAKOV, JI; Univ. of the Pacific, Stockton, Natl. Marine Mammal Foundation, San Diego, Sonoma State Univ., Rohnert Park; *l_pujadebusqueta@u.pacific.edu*

Development of a Biomarker Panel of Stress in Free-ranging Marine Mammals

Anthropogenic disturbance in marine ecosystems can impact the health and survival of marine mammals. Stress activates the hypothalamic-pituitary-adrenal (HPA) axis, resulting in increased circulating glucocorticoids, which alter expression of target genes such as metabolic enzymes. Prolonged or repeated stress may increase catabolism of nutrient stores and suppress immune and reproductive functions, impacting fitness. Our objective was to develop a biomarker panel of stress that can discriminate between acute and chronic stress states in marine mammals. We previously characterized endocrine and metabolic profiles and identified genes differentially expressed in blubber in response to repeated adrenocorticotropic hormone (ACTH) administration in juvenile northern elephant seals. Upregulated genes included those encoding lipid particle proteins, adipokines, and antioxidant and lipid metabolism enzymes, while downregulated genes included inhibitors of adipogenesis, gluconeogenesis and inflammation. To validate our biomarker panel, we collected blood and blubber samples from elephant seals of varying body condition and baseline stress states. We measured endocrine (cortisol, aldosterone, total T3, reverse T3) and metabolic (triglyceride) markers in blood using immunoassays and colorimetric assays and candidate gene expression in blubber using RT-qPCR. Gene expression levels were significantly correlated with elevated stress hormones, decreased triglycerides and lower body condition index. These markers provide insights into molecular mediators of the stress response and comprise a potential diagnostic panel for differentiating stress states in marine mammals.

P1-256 PULVER, O*; WILCOXEN , TE; SEITZ, J; NUZZO , JT; Millikin University , Illinois Raptor Center, Illinois Raptor Center; *twilcoxen@millikin.edu*

Patterns of Seroprevalence of West Nile Virus in Clinic-Admitted Raptor Species in Central Illinois

West Nile Virus (WNV) is a virus that is commonly found in avian species in the Midwest. WNV commonly follows a bird-mosquito-bird transmission pattern, with birds serving as amplifying hosts. Plasma samples from raptor species that were admitted to a rehabilitation clinic in Central Illinois were analyzed for each immunoglobulin Y (IgY) and immunoglobulin M (IgM) antibodies against WNV using an enzyme-linked immunosorbent assay (ELISA). In all, 270 birds from seven different raptor species were tested for IgY and 175 birds from seven different raptor species were tested for IgM. Data were then analyzed for possible differences in patterns of infection between years, among species, and among other studies. There were significant differences in seroprevalence among species. In addition, when compared to a study in Wisconsin, our study had a much higher prevalence in all species that were tested, which may be a product of a longer active season for vectors in Central Illinois.

P1-76 PYLES, R.A.*; MATHIS, K.A.; STEWART, J.R.; ECAY, T.W.; East Tennessee State University; *pylesr@etsu.edu*

Impact of Eggshell Calcium on Skeletal Development in an Oviparous Snake

The mineralized eggshell of Reptilia was a major innovation in the evolution of the amniotic egg. Maternally deposited calcium serves to strengthen the eggshell and provide a source of nutrients for developing embryos. Embryos of oviparous reptiles extract calcium from eggshells but vary in their dependence on this source. In the corn snake, *Pantherophis guttatus*, embryos obtain most calcium from yolk, but also mobilize calcium from the eggshell. This suggests that acquisition of eggshell calcium may be facultative and that yolk provides sufficient calcium for successful development. We tested the hypothesis that embryonic development is not dependent on eggshell calcium by manipulating calcium availability. The outer calcareous layer of the eggshell was either left intact (control) or peeled off recently oviposited eggs. There was no difference in survivorship or length of incubation between treatments. We measured calcium content of hatchlings and analyzed skeletal development using cleared & stained specimens. Hatchlings from intact eggs contained more calcium and were larger in mass and length than siblings from peeled eggs. There were no observable differences in ossification but hatchlings from intact eggs had longer skulls and vertebrae. Our results indicate that mobilization of eggshell calcium is not a requirement for successful embryonic development of *P. guttatus* but does serve to augment yolk calcium. This pattern would favor embryos with a greater capacity to mobilize calcium from the eggshell by promoting growth and enhancing hatchling fitness.

P2-96 QUIMBY, K*; CREWS, SC; SPAGNA, JC; William Paterson University, California Academy of Sciences; *quimbyk1@student.wpunj.edu*

Compensation for leg-loss in rotating prey-strikes of "flattie" spiders (Araneae: Selenopidae)

Spiders in the family Selenopidae, commonly called "flatties," have been characterized as having the fastest rotational prey strikes of any animal. While previous work developed a model of rotational striking based on intact, eight-legged spiders, here we used this model as a basis to analyze the strikes of flatties missing one or two legs. Flatties (*Karaops sp.*) were collected in Australia and filmed using high-speed digital video cameras attacking fruit fly prey. Using rotational speed as a measure of performance, we found that spiders missing one leg were only marginally slower (13% reduction in speed, $p = 0.054$) than intact individuals (2.13 ± 0.38 deg/ms for seven legs, vs 2.48 ± 0.61 for intact spiders) while those missing two legs were much slower (54% reduction, $p < 0.001$, mean speed 1.15 ± 0.50 deg/ms), though all could successfully grab prey. Analysis of changes in leg use by 7 legged spiders in rotational attacks showed that about half of the spiders that had lost a single rear leg would compensate by shifting the roles of the back two legs- as described by the Yu and Crews (2018) model-"forward" by one leg. Seven-legged individuals that compensated this way maintained rotational speeds averaging 93% of the intact spider speed, while those that adopted some other pattern maintained only 65% of the speed of eight-legged individuals. These findings demonstrate that flattie spiders can (but don't always) compensate for leg-loss by substituting anterior legs for missing rear legs. This provides evidence supporting optimality for the modeled pattern, but the effects of gait changes on prey capture rates and overall fitness remain unknown.

P2-74 QUINLAN, PD*; RAMIREZ, MD; DRESCHER, B; KATZ, PS; Univ. of Massachusetts Amherst; *pquinlan@umass.edu*

Behavioral Characterization of Berghia stephanieae: A Novel Laboratory Species for Neuroethological Research

The simple nervous systems and behaviors of sea slugs such as *Aplysia californica* and *Tritonia diomedea* make them useful animals for neuroethological research. However, these species must be caught in the wild or raised in large aquaculture facilities. Here, we introduce the nudibranch, *Berghia stephanieae*, as an experimental system that is easily bred and raised in the lab. The generation time for *Berghia* is approximately two months, allowing developmental studies to be performed. Furthermore, it is inexpensive to generate hundreds of animals, making it amenable for undergraduate research. We are characterizing behaviors in *Berghia* to develop a foundation for further research on the neural basis of behavior. Several behaviors are easily observed in the lab, including navigation with visual or chemosensory cues and feeding behavior. Spatial vision had not previously been demonstrated in nudibranchs; we found that *Berghia* can navigate toward a black stripe outside of a circular arena. Like *Aplysia*, *Berghia* exhibits rhythmic head-waving when searching for food. However, unlike either *Aplysia* or *Tritonia*, *Berghia* can locate food in the absence of water flow in both an open arena and a T-maze. Food localization requires the rhinophores, the olfactory organs. We are combining this behavioral work with transcriptomic and connectomic approaches to study the neural basis of these behaviors.

P3-186 QUIROGA-ARTIGAS, G*; BRADSHAW, B; GAHAN, J; SANDERS, N; BARREIRA, S; JONES, A; BAXEVANIS, A; FRANK, U; SCHNITZLER, C; Whitney Lab, UF, National University of Ireland, Galway, NHGRI, National Institutes of Health; *gonzalo.artigas@whitney.ufl.edu*

Transcriptomic profiling of head regeneration in the cnidarian Hydractinia

Understanding why a diversity of regenerative potential exists throughout the animal kingdom remains a major question in biology. In our lab we use the colonial hydrozoan *Hydractinia*, which is capable of fully regenerating a feeding polyp's head in about 72 hours. This dramatic process is orchestrated by migratory adult stem cells, known as interstitial cells (or i-cells). Cell proliferation and blastema formation are two essential steps of head regeneration in *Hydractinia*. To analyze the genes involved in this process, we extracted the mRNA of presumptive blastema tissue (upper body column) from feeding polyps whose heads had just been removed as well as blastema tissue at 24 hours after head removal, and we performed RNAseq and differential expression analyses. We found 2438 transcripts differentially expressed in blastema tissue at 24 hours, with 1246 transcripts downregulated and 1192 upregulated compared to control tissue. We chose a subset of these genes, many of which are differentially expressed during head regeneration in *Hydra*, another highly regenerative hydrozoan, and carried out qPCR analysis. The results we obtained validated the RNAseq data and led to the observation that similar gene networks are used in head regeneration among hydrozoans. We are also performing *in situ* hybridization on a number of genes to characterize their spatial expression during homeostasis and regeneration. This study provides an overview of gene expression during head regeneration in *Hydractinia*, and enables present and future comparisons of the gene networks used by different animals throughout regeneration.

P2-59 RACICOT, KJ*; CUNHA, FB; HENRIKSEN, R; WRIGHT, D; IWANIUK, AN; Univ. of Lethbridge, Alberta, Canada, Linköping Univ., Sweden, Linköping Univ., Sweden; *k.racicot@uleth.ca*

Chickens Have Larger Cerebella Than Junglefowl: Implications for the Effects of Domestication on the Brain

Domestication is the process by which wild organisms become adapted for human use. Many phenotypic changes are associated with animal domestication, including decreases in brain and brain region sizes. Although the effects of domestication on the brain have been investigated across a range of species, almost nothing is known about chicken (*Gallus gallus d.*) brains relative to their wild counterpart, the red junglefowl (*G. g. gallus*). Here, we tested for differences between junglefowl and chickens in the anatomy of the cerebellum, a brain region that is typically smaller in domesticates relative to wild populations. We quantified cerebellar anatomy of red junglefowl and white leghorn (WL) chickens with unbiased stereology. Relative to body and brain size, junglefowl have smaller cerebella than WL chickens and other chicken breeds. However, chickens and junglefowl do not have relatively smaller cerebella than other galliform species. WL chickens and junglefowl also differed in the proportional sizes of the granule cell and white matter layers within the cerebellum. Purkinje cell size did not differ between WL chickens and junglefowl, but WL chickens had more Purkinje cells. When compared with other galliform species, both WL chickens and junglefowl had fewer and smaller Purkinje cells relative to cerebellum size. Overall, these results suggest that the cerebellar anatomy of *Gallus* species differ from other galliforms and that the effects of domestication on the chicken brain differ from that of other domesticated species.

P2-53 RAMIREZ, S*; MELTON, RL; FUSE, M; RAMIREZ, sergio; San Francisco State University; *sramire6@mail.sfsu.edu*

Protein synthesis is required for long-term nociceptive sensitization in the hornworm, Manduca sexta

Over 100 million Americans nationwide experience chronic pain resulting in over $600 billion spent on treatment each year. Due to this, it is vital to understand the pain signaling pathway and the inhibition of downstream signaling mechanisms with the aid of the insect model, Manduca sexta. M. sexta have been shown to undergo central sensitization after noxious stimuli, such as a pinch or extreme cold, both in vivo and in vitro. These noxious stimuli induce a state of sensitivity, which reduce the force required to elicit a strike, which can last up to 19 hr in M. sexta. In order to determine the role of protein synthesis in the maintenance of nociceptive sensitization in M. sexta, Cycloheximide, a protein synthesis inhibitor, was injected into M. sexta, and nociceptive sensitization was assessed with an in vivo assay. Animals injected with Cycloheximide no longer showed sensitization within 3 hr and up to 19 hr after a noxious pinch, while there was no effect 1 hr after the pinch. Control pinched animals remained sensitized at the 19 hr time frame. Between the first and third hour the greatest changes of sensitization were seen, suggesting full inhibition of protein synthesis taking a minimum of 3 hours post injection. This suggests that protein synthesis is not needed to induce sensitization but is required to maintain this heightened state. Exploration of these mechanisms will help better understand aspects of chronic pain signaling in humans, to aid in the synthesis of improved pharmaceuticals.

P2-63 RAMIREZ, MD*; DWYER, J; BERGAN, JF; KATZ, PS; Univ. of Massachusetts Amherst; *mdramirez@umass.edu*

Creation of a standardized reference brain atlas for the nudibranch, Berghia stephanieae

Identifying neuronal types within brains is key to understanding their roles in circuits underlying behavior. The brains of gastropod molluscs, such as the nudibranch *Berghia stephanieae*, contain a modest number of neurons (~7,000), many potentially identifiable by anatomical and neurochemical phenotypes. These traits make classifying every neuronal type feasible. Despite this, only a handful of neurons in gastropods have been identified and named. Gastropod brain development is determinate, but the precise soma locations and branching patterns are stochastic. This makes comparing brains and neurons across individual animals challenging. To address this obstacle, we are creating a standardized reference brain atlas for *Berghia*. We used CLARITY to clear whole animals and imaged them with lightsheet microscopy, leaving the brain in its true anatomical position. Clearing with CLARITY took ~2 weeks with minimal hands-on time. A lightsheet microscope easily accommodates the small slugs, allowing entire animal to be imaged in only a few minutes. We are currently aligning and averaging multiple 3D autofluorescent brain images together to create the reference brain. The CLARITY protocol preserves proteins in place, allowing us to use immunohistochemistry (IHC) sequentially on the same sample to start identifying neuronal types. So far we have labeled serotonin, small cardioactive peptide, and FMRFamide. Many neurons expressed only one of the 3 neurotransmitters we labeled with IHC. We found cells that are likely homologous to previously identified neurons in other nudibranchs based on position and labelling. Once the reference brain is completed, we will continue to add IHC and *in situ* hybridization labeling for other markers to identify all neuronal types in the *Berghia* brain. This protocol is likely applicable to other smaller invertebrates to create reference brain atlases.

P2-191 REARDON, KM*; HUSAK, JF; Univ of St Thomas; *rear9362@stthomas.edu*

Increasing mitochondria in lizards raises metabolic rates, but does not enhance endurance

Acquired resources must be allocated to a combination of reproductive output, as well as traits that enhance survival. Whole-organism performance traits are key for survival, but they are also energetically expensive. Previous work with green anoles showed that aerobic exercise (endurance training) forces allocation of resources to enhanced performance at the cost of current reproduction and immunocompetence. In general, aerobic exercise elicits the same response from all vertebrates, both mammalian and non-mammalian, which is an increase in hematocrit and heart size, as well as metabolic changes. In mammals, gene expression is often dramatically altered, and can be done so to increase mitochondria biogenesis for more ATP production, helping with sustained muscle contraction. However, it is unknown if non-mammals use these same molecular pathways to increase aerobic performance. In our study, we experimentally manipulated 48 male green anole lizards that were split among four treatment groups, with endurance training and a supplement as the two balanced factors. The supplement, pyrroloquinoline quinone (PQQ), stimulates the expression of PGC-1a, which in-turn enhances mitochondria biogenesis. We expected PQQ to increase mitochondria densities in muscles and enhance aerobic performance. We recorded time for each lizard to reach exhaustion, both before and after the treatments. We found that training increased endurance, but supplemented lizards did not have further increased endurance. Training alone decreased standard metabolic rates (SMR), but supplemented lizards had significantly increased SMR, suggesting a higher number of mitochondria. Our results suggest that enhanced endurance due to endurance training is likely not due to increased mitochondrial numbers, but instead mitochondrial efficiency.

P2-272 REDAK, CA*; HALANYCH, KM; Auburn University; *czr0057@auburn.edu*

Mitochondrial genome of Parborlasia corrugatus (Nemertea: Lineidae)

Parborlasia corrugatus is a large dioecious, broadcast spawning heteronemertean found in marine systems at higher southern latitudes from the intertidal to 3950 m in depth. Like other nemerteans, *P. corrugatus* has limited external morphology but can display a range of color variation. Additionally, there are at least two populations of *P. corrugatus* with one on the Antarctic continental shelf and one on the South American shelf. Despite having pelagic larvae, these populations have been reproductively isolated by temperature differences created by the Antarctic Polar Front, an open-ocean barrier to gene flow. Within the 15,499 bp mitochondrial genome, we recovered 13 protein coding genes as well as two rRNA and 22 tRNA. The order of tRNA genes have been relatively conserved across nemertean mitogenomes, except for one inversion of tRNAL1 between tRNAL2 when compared to other heteronemertean taxa. The GC% was 35.9% across the genome. Phylogenetic analyses yielded a topology consist with the current understanding of heteronemertean relationships, however, interestingly, *P. corrugatus* exhibited a long branch in our analysis.

P1-29 REGAN, MC*; GIBB, AC; Wake Forest Univ., Winston Salem, Northern Arizona Univ., Flagstaff; *regamc13@wfu.edu*

Comparison of resistance to tearing in the skin of two flatfishes of the Pacific Northwest

Fishes use skin as their first line of defense against predation or hazards in their habitat, and scales have evolved to armor the skin against potential dangers. Flatfishes are a particularly interesting group in which to examine resistance to tearing, because they rest on the substrate with their "blind" (eyeless) side in direct contract with the substrate. We examined the ability of the skin of two flatfishes, *Platichthys stellatus* (n=6) and *Isopsetta isolepis* (n=6), with two different scale types, tuberculate and ctenoid, to resist tearing. The tuberculate scales of *P. stellatus* are rigid, protruding scales that are sparsely distributed, while the ctenoid scales of *I. isolepis* are overlapping thin scales that cover the entire body. We hypothesized that scale type may affect how the skin resists tearing. Squares of skin were taken from each side (blind or eyed) of the specimen and torn in two different directions (along the dorso-ventral or anterior-posterior axis). Work and extension were measured for each trial and compared across side, species, axis, and organism size. Overall, the species differed ($p < 0.001$) in work required to tear the skin; however, size of the individual also had an effect on work ($p < 0.01$). Because *Platichthys* specimens tended to be larger than *Isopsetta*, the work required to tear a skin sample may be confounded by organism size. The extension of the skin during tearing varied based on the direction the skin was torn ($p < 0.05$); the skin extended more when torn along the anterior-posterior axis vs. the dorso-ventral axis. Ultimately, observations of how scale type influences resistance could yield insights into animal-environment interactions and generate bio-inspired materials for human use.

P1-91 REHFELDT, E*; PATEL, S; HIATT, DJ; KARJASEVIC, A; MCCUE, MD; HATLE, JD; Univ. of North Florida, Sable Systems International; *jhatle@unf.edu*

Effects of dietary restriction on the organismal oxidation of leucine in female grasshoppers

Dietary restriction (energy deficit diet without malnutrition; DR) extends the lifespan of a wide range of animals. Recent studies show that restriction of protein is vital to this extension. Lifespan extension is also achieved through RNAi knockdown of the Target of Rapamycin pathway (a cellular growth pathway; TOR). The TOR pathway is potently stimulated by leucine, which may contribute to the life-shortening effects of a protein-rich diet. Given the energy deficit upon DR, we hypothesize that DR extends lifespan in part through enhanced oxidation of leucine (which would render leucine unable to activate TOR). We predict that female Lubber grasshoppers on DR would oxidize dietary leucine at higher rates than grasshoppers fed *ad libitum*. In past work, leucine oxidation has been observed to increase significantly in some trials and non-significantly in others, with high variability across individuals. In this experiment, grasshoppers (total n=28) each were fed either *ad libitum* or DR for ~40 days, then measured for leucine oxidation (trial 1). These same lubbers were then switched to the other feeding level (*ad libitum* to DR; DR to *ad libitum*) for an additional ~40 days before a second leucine oxidation measurement (trial 2). Oxidation rates did not differ in trial 1, but in trial 2 leucine oxidation rates were higher from 4-8 hr after tracer ingestion (all $P<0.05$; 90-187% increases). These results suggest that leucine can be oxidized at higher rates in lubber grasshoppers upon DR. High variation exists but is not due to individual differences. Overall our results are consistent with previous work in the lab: leucine oxidation can be higher upon DR, but it is not consistently higher.

P1-23 REHOREK, SJ*; STIMMELMAYR, R; GEORGE, JC; SUYDAM, R; MCBURNEY, DM; THEWISSEN, JGM; Slippery Rock University, Slippery Rock, University of Alaska, Fairbanks, North Slope Borough, Barrow, Slippery Rock University, NEOMED, Rootstown; *susan.rehorek@sru.edu*

Role of Desmosomes in the Annual Molting of the External Acoustic Meatus Lining of the Bowhead Whale (Balaena mysticetus): A Preliminary Study.

The external acoustic meatus (EAM) of most baleen whales has no functional connection to the external environment. As a result, as whales age debris accumulates annually in the lumen, in the form of a lamellated ear plug, which have been used to age whales. Most analyses of the ear plug have either been anatomical (counting the layers) or biochemical (determining fat content). Recently it was shown in bowhead whales that the ear plug is formed by an annual molting of the EAM lining. The molting process proceeds with the entire epithelium being torn, at the level of the stratum basale, from the underlying dermis during the spring migration (May). Epithelial regeneration is mostly completed by the fall migration (October). Thus the epithelium remains intact for 6-7 months before it is torn off the following spring. Desmosomes are commonly found in skin, and are a diagnostic feature for maintaining strong cell adhesions. Desmosomes are held together intercellulary by desmoglein and desmocollin proteins, both of which are necessary for desmosomal adhesion. Several paraffin sections of EAM lining of both spring and fall bowhead whale were immunohistochemically examined for the presence of desmoglein and desmocollin. The results revealed near ubiquitous presence of desmoglein (both seasons) and desmocollin (fall), but absence of desmocollin in the stratum basal of the spring specimens. A similar absence of desmocollin has been described in several pathological conditions (e.g. dermatitis, hereditary tissue-fragility disorders), but its role in epithelial injury is not well understood.

P2-133 REILLY, ME*; ZARDUS, JD; College of Charleston, SC, The Citadel, Charleston, SC; *reillyme@g.cofc.edu*

Impact of Salinity on Larval Survival and Settlement in the Commensal Barnacle Chelonibia testudinaria

Chelonibia testudinaria is an epibiotic acorn barnacle that attaches to sea turtles, manatees, and crabs. Much is unknown about the mechanisms by which this epibiont finds a host during the planktonic larval stage. This study identified the salinity tolerance of *C. testudinaria* larvae in order to understand in what water masses they are likely to occur and be able to settle on a host. Egg masses were collected from adult barnacles growing on horseshoe crabs and sea turtles. Larvae were reared in filtered seawater at 20 or 30 ppt salinity until they reached the cyprid stage and then groups of cyprids from the same cohort were transferred into beakers with salinities at 10, 15, 20, 25, and 30 ppt respectively. After 72 hours all cyprids were counted and classified as alive, settled, metamorphosed, or dead. Percent mortality and percent settlement were calculated based on total larvae per beaker. Mortality ranged from 2-100% and settlement ranged from 0-89%. Mortality was significantly reduced in the 10 ppt salinity treatment ($P < 0.01$). Settlement (i.e., the sum of both settled and metamorphosed larvae) was significantly reduced in the 10 ppt salinity treatment ($P < 0.01$) but had greater variability between trials than mortality rates.

P2-285 REITZEL, AM*; WALLER, J; KNIGHTON, L; STROM , O; TRUMAN, AW; Univ. of North Carolina, Charlotte; *areitze2@uncc.edu*

Interactome Complexity and Dynamics Involving Hsp70 Proteins from the Anemone Nematostella vectensis

Heat shock protein 70 (Hsp70) is a nearly universal class of molecular chaperones that are involved in diverse molecular pathways through specific interactions with other proteins. Most organisms have numerous Hsp70s encoded in their genome but it is not understood how similar the client proteins are for these Hsp70 homologs in ambient or heat stress conditions. Here we provide the first description of the homolog-specific diversity of Hsp70 clients for a marine invertebrate species, the cnidarian *Nematostella vectensis*, through heterologous expression in yeast. Using mass spectrometry we determined that three Hsp70s from this sea anemone interact with 100s of proteins. Despite the high sequence similarity of the Hsp70s, less than 50% of identified interacting proteins were common to all three anemone Hsp70s and as many as 18% were unique to an individual Hsp70. The overall enrichment of functions for these interacting proteins was similar for each Hsp70 despite this limited conservation of particular client proteins. Our study provides the first data set defining the potential "interactome" of Hsp70s for a marine species and suggest numerous specific interactions for Hsp70 homologs. Together, these data reveal a rich set of interacting proteins for Hsp70 that may be novel biomarkers to characterize the response of cnidarians to their rapidly changing environments.

P1-205 RICHARDS, JC*; VECCHIONE, M; University of North Carolina at Chapel Hill, Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution; *jaredunc@live.unc.edu*

The Diversity and Distribution of Cephalopods in the Charlie-Gibbs Fracture Zone

In the summer of 2009, NOAA surveyed the nekton fauna of the fracture zone on the Mid-Atlantic Ridge halfway between Iceland and the Azores as a small-scale follow-up to a previous large-scale Norwegian expedition. Midwater sampling by NOAA with a Norwegian Krill Trawl resulted in 64 discrete-depth samples from 12 stations at depths from near-surface to 3000 m. An additional seven bottom samples were collected with a large trawl at depths of 2000-3500 m. The expedition collected 471 cephalopods in ca. 24 species. For comparison, over 50 hours of ROV submarine video from the Norwegian expedition was viewed to determine diel migratory patterns of the most common species of cephalopod in the region, *Gonatus steenstrupi*. We found that trawl stations below the subpolar front were generally most diverse. Cluster analysis showed that bottom trawls were more dissimilar in species composition than midwater trawls. Unlike in the ROV observations, the small *Gonatus steenstrupi* from trawl samples did not participate in diel vertical migration; suggesting that juveniles in the samples are ecologically distinct from those visible in submersible videos.

P2-204 RIEGLER, MS*; GILL, BC; ANEMONE, RL; NACHMAN, B; STOCKER, MR; University of Florida , Virginia Tech, UNC Greensboro, UNC Greensboro, Virginia Tech ; *msr2322@ufl.edu*

Isotopic Geochemistry as an Ecological Proxy in Lizards: Diet and Aridity in Early Eocene Squamates

The paleoecology of lizards over time is largely unknown. This paucity of data is problematic for understanding lizard response to climate change, especially considering the climate change modern species are currently experiencing. Fortunately, Cenozoic hyperthermals represent comparable events to today's perturbations, and many Paleogene deposits preserve squamate fossils. Inferring paleoecology has historically been based on form equaling function, correlating certain features with certain behaviors. Though this applies to certain taxa, there are many confounding examples. Stable isotope geochemistry, however, provides an independent test for several ecological parameters. We developed a novel method examining isotopic ratios in enamel as a proxy for ecology and applied it to lizards, providing new data testing the connection between squamate morphology, their diets, and the environments they occupy. We analyzed $\delta^{18}O$ and $\delta^{13}C$ ratios from tooth enamel in five extant lizard species. We found trophic separation in $\delta^{13}C$ values, and indications of aridity through $\delta^{18}O$ values. We applied this framework to extinct squamates from an Early Eocene herpetofaunal assemblage, where we identify xenosaurid and glyptosaurine squamates as well as alethinophidian snakes. The xenosaurid is one of the youngest representatives of *Restes rugosus*, and we provide the first testable hypothesis of its ecology. $\delta^{13}C$ results indicate an insectivorous or carnivorous diet for both lizard taxa, representing the first hypothesis for the diet of *R. rugosus*. $\delta,^{18}O$ results indicate a wet, warm environment, confirming prior hypotheses of a tropical community present in the Western Interior of North America in the Paleogene.

P3-109 RIMKEVICIUS, T*; JARRETT, A; IVANINA, AV; SOKOLOVA, IM; University of North Carolina at Charlotte, Charlotte, NC, USA, Department of Oral Biology, School of Dental Medicine, University of Pittsburgh, Pittsburg, PA, USA, University of North Carolina at Charlotte, Charlotte, NC, USA , Department of Marine Biology, University of Rostock, Rostock, Germany; *aivanina@uncc.edu*

Effects of salinity on activity of key biomineralization and acid-base regulation enzymes of Mercenaria mercenaria

The molluscan exoskeleton provides mechanical support and protection from predators and environmental stressors. The mantle edge (ME) and hemocytes (HCs) play a major role in molluscan shell formation. Salinity is one of the key stressors that affect bivalve populations and is predicted to be decreased in the future. The aim of this study was to determine how conditions unfavorable for $CaCO_3$ deposition would affect cell-mediated shell biomineralization process in bivalves. Adult hard shell clam *Mercenaria mercenaria* were exposed for two weeks to three salinities (30, 18 or 10) and activity of biomienralization and acid-base regulation enzymes (Na/K ATPase, H^+ ATPase, Ca^{2+} ATPase, carbonic anhydrase and chitin synthase) was measured in isolated ME cells and HCs. Salinity shifts has different effects on biomineralization enzymes from ME and HCs in clams. Activities of the studied biomineralization and acid base regulated enzymes from HCs was not affected by change in salinity, where Na/K ATPAse and Ca^{2+} ATPase activity in ME were elevated at intermittent salinity (18) compared to high (30) or low (10) salinity. Change in salinity regime had no effect of activity of carbonic anhydrase and chitin synthases in HCs or ME cells of clams.

P1-19 RIMKUS, B*; SHEHAJ, A; KONOW, N; UMASS Lowell; *barbora_rimkus@student.uml.edu*

Do Muscles with Distinct Fiber Architecture, Fiber-type Composition, and Mechanical Function have Different Modulatory Scopes for Power and Work Production?

Skeletal muscles are arranged in flexor-extensor groups to produce opposing joint movements and enable variations in cycle frequency (gait), duty-factor, and movement mechanics (operation as a motor, strut, or brake). However, it is unclear if flexors and extensors, which often vary in fiber architecture and composition, have equal scope for modulating power and work across movement conditions. To address this, we systematically varied stimulus phasing and cycle frequency parameters in the work-loop paradigm to dissect the modulatory scope of power and work output from two mouse hindlimb muscles; a fast-fibered, slightly pennate dorsiflexor (tibialis anterior; TA), and a mixed-slow fibered, plantarflexor (soleus; SOL) with near-parallel fiber architecture. We used literature values for mouse *in vivo* stride frequencies and duty factors for walk, trot, and gallop. Three stimulation phases were calculated to simulate muscle motor, spring, and brake performance. Our data suggest that SOL mostly operates as a brake (in line with available *in vivo* data) and TA as a motor or strut. SOL has the greatest modulatory scope and a clearer response to stimulus phasing than to variations in cycle frequency on power and work. However, comparing only the active work-loop portions reveal clear similarities in function between these muscles, consistent with the conserved contractile properties of vertebrate skeletal muscle. Perhaps unsurprisingly, muscle type appears to profoundly influence the modulatory scope of muscle performance. Our ability to measure from more than one muscle in a given individual provides a powerful framework for forthcoming evaluations of how mechanical insults and dietary variation shape muscle adaptability and performance.

P1-24 RIORDAN, KC*; TAYLOR, JRA; West Chester University of Pennsylvania, Scripps Institution of Oceanography; *kr877841@wcupa.edu*

Mechanical Adaptions for Climbing in Grapsid Crabs

Vertical climbing is a biomechanically challenging behavior that many vertebrates and insects have mastered for their arboreal habitats. Less is known about arboreal crabs and their adaptations in overcoming the challenges of climbing. To gain insights into crab climbing, we compared the walking leg morphology and mechanics of two closely related crabs (family Grapsidae): the arboreal mangrove crab, *Aratus pisonii*, and the rocky intertidal shore crab, *Pachygrapsus crassipes*. *A. pisonii* lives and climbs in mangrove trees, whereas *P. crassipes* climbs rocks easily, but not trees. We hypothesized that mangrove crabs would require relatively shorter, stiffer legs and harder gripping structures (dactyls) to overcome gravity and maintain balance when scaling trees. Crab mass and carapace dimensions were measured (*A. pisonii*: N = 9; *P. crassipes*: N = 15), along with dimensions of the second pereopod. We also measured the flexural stiffness and failure strength of the meropodite, and the hardness of the dactyls. Results show that *A. pisonii* have relatively larger, more flexible meropodites than *P. crassipes*, which may aid them to cling to narrow branches. The meropodites of both species are similar in strength, but failed by buckling in *A. pisonii*, and cuticle fracture in *P. crassipes*, which likely reflects differences in cuticle morphology. There was no difference in dactyl hardness and stiffness between the species, suggesting that the dactyls are sufficient for gripping and supporting a crab on a variety of substrates. Overall, the walking leg morphology of grapsid crabs appears to require minimal modifications to enable vertical climbing, but a broader comparison among aboreal and non-arboreal crabs would yield greater insights into adaptations for tree climbing in crabs.

P2-176 RIPPE, JP*; BAUMANN, JB; CASTILLO, KD; DAVIES, SW; University of North Carolina at Chapel Hill, Boston University; *jpr6mg@gmail.com*

Coral Connectivity on the Belize Barrier Reef: Is Gene Flow Sufficient to Foster Reef-Scale Adaptation to Ocean Warming?

Rising ocean temperatures are often implicated in the widespread demise of coral reefs, as high temperatures can lead to a fatal breakdown of the relationship between coral hosts and their single-celled algal symbionts in a process known as coral bleaching. However, recent research has revealed that the effect of warming on corals of the same species may vary widely depending on their thermal history. Specifically, corals from nearshore reef habitats, which experience relatively extreme daily and seasonal seawater temperature fluctuations, have demonstrated higher tolerance to thermal stress than their forereef conspecifics, which experience more thermally stable conditions. Importantly, this intraspecific variation in thermal tolerance has also been shown to be heritable, implying that genetic linkage between resilient nearshore reefs and sensitive forereef populations could foster reef-scale adaptation to ocean warming. Here, we use restriction site-associated DNA sequencing to explore the fine-scale population genomics of the massive starlet coral, *Siderastrea siderea*, throughout the Belize Barrier Reef System. Tissue micro-samples were collected from 176 colonies of *S. siderea* across four pairs of nearshore and forereef sites in November 2014 and 2015. These sampling sites were intentionally selected based on their distinct thermal characteristics, where nearshore sites experience both warmer and more variable temperature conditions than those on the forereef. By resolving the patterns of genetic exchange between nearshore and forereef sites on the Belize Barrier Reef, this study provides insight into the prospect of dispersal-driven adaptation, which may be essential to the survival and evolution of Caribbean coral reefs as oceans continue to warm.

P2-228 RIVERA, G*; WHALEN, M; WORTHINGTON, AM; Creighton University; *gabrielrivera@creighton.edu*

Do Patterns of Fluctuating Asymmetry Reflect the Strength of Natural and Sexual Selection in the Sand Cricket (Gryllus firmus)?

Selection, both natural and sexual, has the ability to produce morphologies that increase performance of individuals. While many studies examining this ability have focused on the effects of shape, for many paired structures the degree of symmetry has also been shown to impact performance. As a result, the morphology of traits vital for locomotion (e.g., legs or wings) or reproduction (e.g., sexually-selected ornaments or weapons) may rely more heavily on overall symmetry to remain functional than other non-vital structures, and therefore may be more developmentally constrained. Fluctuating asymmetry (FA) refers to deviations from perfect symmetry in bilateral structures and may serve as a useful tool in evaluating the strength of selection acting on individuals. In the sand cricket (*Gryllus firmus*), two distinct morphs with unique life histories exist: Short-wing (SW) morphs are incapable of flight, but have high reproductive potential as early adults; long-wing (LW) morphs have enlarged wings for dispersal, but produce fewer offspring and do so later in life. Early reproduction in SW morphs places stronger selective pressures on reproductive structures, while dispersal in LW morphs places stronger selective pressures on locomotor structures. Because the two morphs rely on different body structures to maximize their fitness, and because many structures used by males for courtship and fighting do not serve the same function for females, we expect to see predictable differences in FA both between morphs and sexes.

P1-11 RIVERA, AS; AHMADYAR, S; EITOKU, J; HA, J; IMADA, K; LEE, A; LO, A; NAVALTA, K*; PANAGLOTOPOULOS, A; VU, K; YEE, C; Univ of the Pacific; *arivera@pacific.edu*

Student-generated resources for an EvoDevo Open Textbook (OER)

When creating new resources for teaching and learning biology, two huge problems immediately arise: What do students want to learn? and What do students already know? Here we describe an attempt to address these problems through a "Learning by Teaching" approach. Undergraduate and first year Master's students volunteered to edit and illustrate an Open Textbook for their EvoDevo course or to write case-study modules for inclusion in the text. EvoDevo's integrative nature and combination of philosophy and experimental approaches make it a natural choice for student contribution. To make these resources, students must think deeply about this complex field and consider how Evolution, Development, Genetics, Anatomy, and Physiology act together and on each other to produce life's riotous diversity. The end product is a resource written at an undergraduate-appropriate level with approachable language, illustrations, and topics.

P1-278 ROBERTS, A.S.*; SCOTT, E.R.; DONATELLI, C.M.; University of California, Davis, Tufts University ; *asroberts@ucdavis.edu*

Fish Motion in the Ocean: Predicting Swimming Kinematics from Vertebral Morphology

Fish have evolved a variety of swimming mechanisms to move through diverse habitats. While some fish primarily use pectoral and caudal fin motion to propel themselves through water, others use body undulation to locomote. Many studies have characterized kinematic features of swimming mechanisms such as swimming speed, tail beat frequency, and bending period, but few have examined the role of vertebral morphology in swimming kinematics. Because the vertebral column is a conserved skeletal element in fishes and the main structure used for body stiffening during swimming, it can provide critical information about fish swimming kinematics. In this study we used a statistical model originally created to predict 3D swimming kinematics in elongate fishes to predict 2D swimming kinematics in six fish species that vary from elongate (elong.) to deep-bodied (non-elong.). We collected swimming kinematic data from video trials and measurements of vertebra size and shape from CT scans of *Anoplarchus purpurescens* (Stichaeidae; elong.), *Pholis ornata* (Pholidae; elong.), *Ammodytes personatus* (Ammodytidae; non-elong.), *Ophiodon elongatus* (Hexagrammidae; non-elong.), *Myoxocephalus polyacanthocephalus* (Cottidae; non-elong.), and *Cymatogaster aggregata* (Embiotocidae; non-elong.). Specifically, we collected size and shape data from multiple centra along the vertebral column to predict body bending amplitude along the length of the body during swimming. This estimate was then compared to the bending amplitude measured from fish swimming videos. We determined that vertebral morphology has significant power to predict body bending amplitude during swimming in both elongate and non-elongate fishes, with centrum body length and cone angle being the most important factors.

P2-261 ROBERTSON, JC; Westminster College, PA; *robertjc@westminster.edu*

Characterizing Gill Pigmentation in Paddlefish (Polyodon spathula)

Juvenile and adult paddlefish have striking, darkly-pigmented gill respiratory lamellae. To investigate this unusual condition, a visual assessment protocol was developed to quantify the degree of pigmentation of gill filaments. Four groups of larval and early-juvenile stage (30, 50, 60 and 100 day post-hatch) fish were analyzed. For each fish, multiple gill arches from both the right and left sides were studied. Each filament in a gill arch was scored, based on the extent to which pigment was observed along the length of the filament. This approach thus assessed the degree of gill pigmentation in post-hatch, early paddlefish development. Results clearly indicate a dramatic change in gill pigmentation over the period examined. There was no gill pigmentation in 30 day post-hatch fish, low but increasing levels in 50 and 60 day fish, and markedly higher pigment in gills of 100 day post-hatch fish. Pigment changes appeared to be independent of numbers of filaments per gill arch, which stabilized at 50 days post-hatch. Histology indicates that primary lamellae melanocytes are responsible for paddlefish gill pigmentation. These cells are generally perivenous - localized adjacent to and along the central vascular elements of the filament. Results are considered in light of possible functions associated with gill pigmentation as well as developmental origin and activation of gill melanocytes.

P2-108 ROBICHEAUX, JR*; ALMOND, GF; PERKINS, HR; GOFF, CB; FORSBURG, ZR; GABOR, CR; Texas State University, TSU; *jar475@txstate.edu*

Validating and Using Water-Borne Hormone Methods with Tadpoles: ACTH Challenge, Recovery Time, Repeatability, and Optimal Rearing Designs

We monitored the physiological health and stress response of tadpoles using non-invasive water-borne assays to measure the stress hormone, corticosterone (CORT). We performed an adrenocorticotropic hormone (ACTH) challenge and additional experiments to explore repeatability, recovery time from stress, and optimal rearing methods for Rio Grande Leopard frog, *Rana berlandieri*, tadpoles. Tadpole CORT release rates were higher after ACTH injections, validating water-borne hormone methods. We then examined the recovery time for water-borne CORT release rates after exposure to an external stressor (agitation). CORT began to decline after 2h and had recovered after 6h indicating that it is important to wait an extra hour (or up to 6hrs) if you want to avoid measuring the initial stress response. We also examined CORT and repeatability using water-borne hormones from tadpoles reared individually vs isolated in groups. We then examined whether these tadpoles show an acute stress response after exposure to agitation. Individuals isolated in groups showed hypothalamus-pituitary-interrenal axis (HPI) activity in response to a stressor and higher CORT release rates on D7. These individuals also lost mass by D7, whereas individuals reared alone did not. Repeatability was high for both treatments. These results indicate that either rearing method is viable but the two methods differ in their physiological costs. We show that the water-borne hormone method allows for repeated measures from individuals when the experiment is appropriately designed to consider social behavior of the species. This will be useful in management and health assessment of wild and captive populations of *R. berlandieri*.

P1-204 RODAS, AM*; WRIGHT, RM; BUIE, LK; AICHELMAN, HE; CASTILLO, KD; DAVIES, SW; Boston University, Boston University & Harvard Medical School, University of North Carolina at Chapel Hill, University of North Carolina at Chapel Hill & Boston University, University of North Carolina at Chapel Hill; *amrodas@bu.edu*

Environmental variation and plankton genetic diversity across inshore and offshore coral reefs

In the ocean, environmental variation in light and temperature can influence the genetic diversity and structure of plankton communities. Here, we aimed to characterize environmental variation and its influence on plankton communities from the Bocas Del Toro Archipelago reef complex in Panamá. We visited eight reef sites: four inshore and four offshore reefs to characterize variation in thermal and light profiles across sites. Temperature loggers were deployed at each reef site for one year and a light data logger was deployed at each site at midday to quantify noon light values. Plankton tows were conducted in triplicate at midday and 18S DNA metabarcoding was used to characterize plankton communities. In addition, at STRI Point, plankton communities were characterized in the morning and evening in order to investigate the effect of time of day. We found that inshore sites exhibited larger variation in temperature, while offshore sites exhibited increased light levels. However, these environmental differences across reef type did not drive differences in plankton communities. We found no significant differences in overall plankton community composition or genetic diversity across time of day, reef type (inshore/offshore), or reef site. Instead we found that several specific taxa were significantly enriched at different sites, but overall plankton communities appear relatively panmictic across our study sites. This study is limited to taxonomic differences detectable by 18S metabarcoding: the possibility of selection on other genetic loci within these taxa remains a possibility and future work should investigate fine scale population structure within a genus.

P1-176 RODRíGUEZ-SALTOS, CA*; DUQUE, FG; Psychology Department, Emory University, Atlanta, GA 30322, Neuroscience Institute, Georgia State University, Atlanta, GA 30302; *carodr5@emory.edu*

Precise Decrease in the Tempo of the Song of a Tropical Wren

Animals often time their behavioral displays with precision. Sometimes, they change the tempo of the display in a single session, as some southern nightingale-wrens (*Microcerculus marginatus*) do with their songs. In these songs, the tempo is slowed down due to a progressive increase in the lengths of silence intervals between syllables. The first interval lasts around 0.7 seconds, while the last interval may reach 12 seconds. By analyzing several songs downloaded from the database Xeno-Canto, we found that a simple pattern describes the increase in interval duration. The duration of a given interval was equal to that of the preceding interval plus a time constant. For example, in a single rendition, a bird added 0.6 seconds of silence to each consecutive interval, even when the preceding interval was already more than 10 seconds long. The timing of the intervals did not seem to follow Weber's law, because the time constant was precisely kept despite increasing silence intervals. It is unknown how nightingale-wrens achieve this remarkable degree of precision in timing. Not all nightingale-wrens, however, change the tempo of their songs; songs vary considerably across populations. Geographic song variation in oscine passerines, such as the Nightingale-Wren, is often a by-product of vocal learning. If the same applies to southern nightingale-wrens, then the change in tempo in some populations may be at least partly learned.

P3-44 RODERICK, WRT; CHIN, DD*; CUTKOSKY, MR; LENTINK, D; Stanford University; *wrtr@stanford.edu*

Preparing for takeoff and sticking the landing: Bird behavior and biomechanics at the interface of flight and surface locomotion

Birds frequently take off and land on branches that vary widely in size and texture. Yet, despite our familiarity with these behaviors, we do not fully understand how they integrate the use of aerodynamic support from their wings, energy transfer from their legs, and friction at their feet to take off and land so reliably. To study these behaviors in detail, we made high-speed recordings of Pacific parrotlets (*Forpus coelestis*) taking off and landing from instrumented perches with a range of surface properties and diameters. The kinematics and force/torque measurements give insight into the biomechanics and control strategies that enable birds to perform these maneuvers consistently on different perches. By further integrating these results with experimental data on the contact mechanics at the foot-surface interface, we develop a model of the force space in which birds can maintain a stable grasp during takeoff and landing. This insight into the biomechanics and behavior of how birds take off and land on a variety of surfaces can also inform the design of more robust and versatile perching aerial robots.

P3-169 ROHLF, CM*; HUSAK, JF; Univ of St Thomas; *rohl0016@stthomas.edu*

The Effects of Varying Immune Challenges on Performance Traits in Green Anole Lizards

In order to maximize lifetime reproductive success, organisms often must allocate limited energetic resources to life history traits that are important to survival, such as immunity and locomotion. Consequently, trade-offs can occur between traits, depending on the traits' energetic costs and energy available to each organism. Previous work on green anole lizards reveals that when energy is forced to be allocated to endurance performance via exercise training, the immune system becomes compromised. We tested whether the opposite relationship was true. We predicted that when an organism faces an immune challenge such as infection and/or wound healing, its endurance performance should decrease, with greater immune challenges decreasing performance more. To test this prediction, male and female green anoles were given or not given cutaneous wounds and underwent two rounds of lipopolysaccharide (LPS) or saline injections to induce an integrated immune response. We measured endurance, sprint speed, and bite force before and after each round of injections. We predicted performance to vary in the order: no wound-no LPS > no wound-LPS > wound-no LPS > wound-LPS. However, we found that neither wound healing nor LPS injections affected any performance trait in either males or females after the first injections. However, after the second round of injections, LPS decreased bite force, suggesting a lack of motivation due to sickness behavior.

P3-5 ROMANOVICH, LA*; VOLTZOW, J; Univ. of Scranton, PA; *janice.voltzow@scranton.edu*

Anemones in Hot Acid: The Effects of Elevated Temperature and Enhanced Carbon Dioxide on Anemones and their Symbionts

Like some corals, many sea anemones have symbiotic relationships with photosynthetic dinoflagellates of the family Symbiodiniaceae, sometimes referred to as zooxanthellae. In the process known as bleaching, this relationship is disrupted and the dinoflagellates are expelled from the cnidarian tissue, causing it to turn white. We were curious about the individual and combined effects of two consequences of climate change, rising sea surface temperature and ocean acidification, on bleaching. We exposed individuals of the symbiotic anemone *Exaiptasia pallida* to one of three treatments: warmed water, water acidified by the addition of carbon dioxide, or water that was warmed and acidified, and compared their responses with controls. Data from chlorophyll fluorometry and images from fluorescence microscopy permitted us to monitor symbiont loss. Anemones in the heated and combined treatments showed different rates of bleaching whereas those in the acidified treatment showed no loss of symbionts. These results indicate that there is a complex interaction between the effects of elevated temperature and enhanced carbon dioxide on this symbiotic relationship. Thus, it is important to take both factors into account when evaluating the potential impact of climate change on bleaching.

P2-13 ROOT, ZD*; JANDZIK, D; MEDEIROS, DM; University of Colorado Boulder; *zaro7315@colorado.edu*

Straw, Sticks, and Bricks: Understanding Vertebrate Musculoskeletal Evolution through Fibrillar Collagens and their Diversification

Fibrillar collagens are a metazoan novelty that are a critical part of the extracellular matrix of muscle, skeleton, skin, and connective tissues. Comprised of three families of genes (Clade A, Clade B, Clade C), they underwent considerable duplication and neofunctionalization in jawed vertebrates (gnathostomes). Previous work has suggested that ancestral chordates possessed four fibrillar collagens (2 A's, 1B, 1C) while most jawed vertebrates have eleven (5 A's, 4 B's, 2 C's). We asked whether the expansion of this gene family coincides with gnathostome morphological novelties by investigating these genes in the sea lamprey *Petromyzon marinus*, an early diverging jawless vertebrate. To do this, we used phylogenetics and synteny to identify fibrillar collagen orthologs in the sea lamprey. We then performed *in situ* hybridizations on lamprey embryos for these genes across developmental stages, preparing plastic sections to identify tissue-specific expression. Overall, we have identified eight new fibrillar collagen genes in the sea lamprey and categorized their expression during head morphogenesis. We believe that *Petromyzon marinus* may have twelve fibrillar collagen genes (7 A's, 4 B's, 1 C), four being lineage-specific duplicates. Our phylogenetic and syntenic analyses have identified orthologs of Clade A / C genes in lamprey with strong certainty while Clade B remains uncertain, possibly due to more divergence. Our *in situ* hybridizations reveal expression of these genes that is less tissue-specific than their gnathostome orthologs. Lastly, we discuss how the the duplication and specialization of these collagens may have been involved in the diversification of musculoskeletal tissues during vertebrate evolution.

P1-270 ROSENBLOOM, JE*; GIDMARK, NJ; Knox College; *jerosenbloom@knox.edu*

Quantifying physiological constraints of prey capture in Centrarchid fishes

Predator-prey interactions put attributes of the predator (e.g. biting force) against those of the prey (e.g. body size). These attributes are constrained by both physical phenomena (e.g. lever mechanics) and physiological phenomena (e.g. force-length and force-velocity performance of skeletal muscle) in the predator. The force-velocity relationship is important for prey capture in centrarchid fishes, because these species often captures elusive prey. This family of fishes has a wide range of feeding behaviors, 2 examples of this are: largemouth bass swim quickly and then close the mouth over the prey, whereas bluegills suction feed. Both of these species need rapid mouth closure to preclude prey escape. These species also vary in skeletal anatomy; largemouth have long jaws, whereas bluegills have short jaws. Other members of this family fall along the continuum between largemouth and bluegills, and exhibit a range of jaw shapes and attack behaviors. Jaw-closing performance is governed by the interaction of skeletal anatomy and muscle physiology, and yet only skeletal anatomy and behavior have been deeply investigated to date in this group. We measured jaw-closing velocity across forces (i.e. the force-velocity relationship) in 5 species: Redear Sunfish,*Lepomis microlophus*; Black crappie,*Pomoxis nigromaculatus*; Largemouth bass, *Micropterus salmoides*; Bluegill, *Lepomis macrochirus*; and Green sunfish, *Lepomis cyanellus*. After accounting for the effects of skeletal leverage, we found that crappie and largemouth show similar patterns of force and velocity, whereas green sunfish, bluegill sunfish, and redear sunfish show similar patterns with each other. Interestingly, green sunfish skeletal anatomy is more similar to crappie and largemouth than it is to either other sunfish species. These results suggest that in this group, physiological performance of the jaw-closing muscle does not necessarily mirror lever mechanics in the skeleton.

P3-80 ROSSO, A. A.*; NICHOLSON, D.; CHUNG, A. K.; CURLIS, J. D.; KNELL, R.; GRANER, T.; LOGAN, M.; MCMILLAN, W. O.; COX, C. L.; Georgia Southern University, Queen Mary University, University of Michigan, Smithsonian Tropical Research Institute; *adam@rosso.com*

Ectoparasites and the Expression of Sexual Signals in a Tropical Lizard

Sexual signals are often associated with costs that can impact fitness through survival, reproduction and fecundity. The brightly colored dewlap of anoles can be used as a sexual signal to attract mates. In general, females are attracted to males with the larger and more brightly colored dewlap. The expression of these dewlaps may be associated with costs in the form of ectoparasites, such as mites. However, there is little known about the costs associated with sexual signals and ectoparasites. We studied the relationship between mite intensity, habitat use, and expression of a sexual signal in the Panamanian slender anole (*Anolis apletophallus*). Specifically, we tested whether the larger sexual signal in males relative to females resulted in increased mite intensity. We found that males had significantly more mites than females, but this difference was not driven by physiological or ecological factors like body temperature or habitat use. Interestingly, the difference in total number of mites between the sexes was driven by the preponderance of mites on the dewlaps of males, with similar amounts of mites on other regions of the body for both sexes. Males had many more mites on their dewlap than females and dewlap mite intensity increased with dewlap size for males. Our study shows that expression of sexual signals in male slender anoles are associated with ectoparasite costs. More broadly, these results suggest that sex-specific costs imposed by ectoparasites could structure the evolution of sexual signals.

P2-160 ROWSEY, LE*; KIEFFER, JD; SPEERS-ROESCH, B; University of New Brunswick; *lrowsey@unb.ca*

Why Be Cool? Behavioral Thermoregulation and Physiological Recovery After Exhaustive Exercise in Juvenile Brook Charr (Salvelinus fontinalis)

The effects of temperature on post-exercise recovery in fishes are widely studied, but questions remain about which metabolic processes are most important in driving temperature-dependent recovery. For example, is it more advantageous to recover oxygen debt faster at cooler temperatures or remove lactate quickly at warmer temperatures? We examined the influence of temperature on recovery processes and thermoregulation following exhaustive exercise in juvenile brook charr (*Salvelinus fontinalis*). Fish were acclimated to and exercised at 15°C, then allowed to recover at either 15°C or 10°C while their excess post-exercise oxygen consumption (EPOC) was measured. Additionally, post-exercise metabolite levels were measured in fish assigned to one of three thermal recovery regimes (i) 6 hr recovery at 15°C, (ii) 6 hr recovery at 10°C, as well as (iii) 3 hr recovery at 10°C followed by a 3 hr recovery at 15°C (to simulate behavioral thermoregulation). We found that EPOC was completed more rapidly at 10°C compared with 15°C, but the lower temperature had the trade-off of hindering the recovery of plasma lactate and osmolarity levels. Specifically, post-exercise plasma lactate and osmolarity remained elevated for the entire recovery period in fish recovering at 10°C, whereas these variables recovered fully by 6 hr in fish from the other two recovery regimes. Currently, we are completing behavioral preference experiments to determine if brook charr will utilize behavioral thermoregulation and which physiological advantage they choose to optimize: EPOC recovery or lactate clearance.

P2-39 ROY, T*; SURIYAMPOLA, PS; FLORES, J; LOPEZ, M; MARTINS, EP; Arizona State University; *troy15@asu.edu*

Habitat Features and Artificial Selection Determine Color Preferences in Zebrafish Danio rerio

The sensory drive hypothesis has been supported by many previous studies that show animals to preferentially approach colors that are also used as sexual signals. Studies in fish have shown modifications in such preferences depending on the ambient water color. Turbidity alters ambient color and organisms may compensate for visual obscurity in turbid environments through shifts in visual sensitivity towards higher wavelengths. Here, we asked whether zebrafish from more turbid habitats developed an increased preference for a prominent body color blue (on their stripes) or a presumed habitat color green, and whether relaxed selection on domesticated zebrafish has altered this preference. We subjected zebrafish from 4 populations (3 wild & 1 hatchery reared) to a dichotomous choice task (blue vs green door). We found the wild fish to show a clear preference for green over blue, while the domesticated fish entered green and blue doors equally often. The preference for green was strongest in fish from a turbid stagnant water population. Wild fish may tend to associate the green color with features of the natural habitat consisting of vegetation or with the diet consisting of microalgae and zooplanktons. This indicates that vegetation/food color and not turbidity might influence development of visual preference in wild zebrafish. Domestication has eliminated the preference, perhaps explaining why other zebrafish studies yield conflicting results on color preferences. These results are also suggestive of zebrafish offering an intriguing example where a color signal does not drive visual preferences.

P2-105 RUBIN, AM*; WADA, H; Auburn University; *amr0101@auburn.edu*

Effects of Periodic Cooling During Incubation on Heart Rate and Hatchling Morphology in Zebra Finches

The developmental environment is known to have lasting effects on phenotype and fitness. In oviparous species, the thermal environment embryos experience during incubation has been shown to strongly determine a range of traits. However, the exact mechanisms by which temperature during development influences phenotype remain largely unknown, and this is especially true for environments that experience temperature fluctuations. In birds, eggs can experience large temperature fluctuations when parents leave the nest to forage or due to weather events. Additionally, a predicted consequence of global climate change is a higher degree of climactic variation meaning less stable and consistent temperatures. To evaluate how temperature fluctuations during development may influence organism phenotype at hatch and beyond, we incubated zebra finch (*Taeniopygia guttata*) eggs under one of three conditions; one that periodically cooled eggs five times a day, one that held a constant optimum control temperature (37.4°C), and one that held a constant low temperature (36.4°C), which was the average incubator temperature of the periodically cooled eggs. Embryonic heart rate was measured at two time points during development via a Buddy digital heart rate monitor. Incubation duration, mass change during incubation, hatching success, and hatchling morphology were also recorded. We are currently analyzing the effects of periodic cooling during incubation on embryonic development, as well as morphology at hatch, in order to assess the relationship between embryonic heart rate, hatchling success, and hatchling phenotype.

P1-217 RUIZ, A; California State University, San Marcos; *ruiz112@cougars.csusm.edu*

Quantifying biodiversity temporally across a 15 year period: Biodiversity varies year to year and by seasons in the San Elijo Lagoon

Wetlands are vastly important in maintaining avian diversity worldwide. Aquatic, migratory species, and species that inhabit yearly rely heavily on wetlands. Management of wetlands should take into consideration biodiversity. I examined the annual and seasonal changes to biodiversity (species richness [R] and Shannon diversity index [H']) in the San Elijo Lagoon, California over a 15 year period. I found that both species richness and Shannon diversity vary from year to year vastly. In particular, Fall and Winter H' increased positively across years ($R2 = 0.677$, $p < 0.0001$ and $R2 = 0.577$, $p = 0.001$, respectively). The influence of seasons on biodiversity was examined to assess which seasons expressed the highest levels of biodiversity, and species richness and Shannon diversity values were highest in Spring. Wetland use varies greatly from season to season, but overall, the relatively high Shannon diversity values over the 15 years indicate consistently high levels of species diversity and evenness throughout the wetland.

P2-100 RYAN, TA*; TAFF, CC; ZIMMER, C; VITOUSEK, MN; Cornell University; *tar87@cornell.edu*

Relationships between weather and circulating glucose concentrations in tree swallows

The regulation and use of energy stores are important elements of coping with environmental variation. Glucose is a common molecule involved in the use and storage of energy in vertebrates. Food limitation typically causes a decrease in glucose levels; however, under acute stress, circulating glucose levels can rise through gluconeogenesis, providing energy to help survive challenging conditions. Because of the effect of weather on energy availability and foraging efficiency, weather may influence glucose regulation; however, these dynamics remain poorly understood, particularly in birds. We tested the hypothesis that baseline glucose levels would be higher in free-living tree swallows (*Tachycineta bicolor*) experiencing challenging weather conditions. Specifically, we predicted that baseline glucose levels would be positively associated with temperature, and negatively associated with windspeed under non-acute starvation conditions. We also tested the hypothesis that the rapid glucose response to acute restraint stress would be higher in birds experiencing challenging weather conditions. Specifically, we predicted that 30-mintute post-capture glucose would be negatively associated with temperature, positively associated with windspeed, and negatively associated with measures of body condition and energy reserves (high body mass, low plasma -hydroxybutyrate). We utilize multiple timescales of weather data to understand how free-living birds respond physiologically to variation in weather --a major source of challenging environmental conditions with which organisms must cope.

P3-108 SAFFOLD, C/E*; LINSER, P/J; University of Tennessee at Martin , Whitney Laboratory for Marine Bioscience ; *cheesaff@ut.utm.edu*

The Molecular Physiology of Carbon Dioxide in the Larval Mosquito Tracheal System

The physiology of carbon dioxide elimination in the larval mosquito, a potential target for controlling the animals that cause more than 1 million deaths each year, is poorly understood. It is known that one method of carbon dioxide removal is by direct diffusion through the larva's cuticle. However, the molecular components that propagate this transcuticular diffusion are unknown. Previous study has shown that carbonic anhydrases 9 and 10, the anion exchanger AE1, and Na^+/K^+ ATPase play critical roles in pH regulation of the alimentary canal by ionizing carbon dioxide and transporting its ionic derivative, bicarbonate (Linser et al. 2009). The purpose of this study is to determine where these three molecular components are located in the tracheal system of *Aedes aegytpi* and *Culex pipiens* larvae. Paraffin sectioning, whole mount preparation, antibody labeling, confocal microscopy, and protein analysis by SDS- page western blot were used to achieve these goals. The immunohistochemical data strongly suggests that all three components are present in their predicted locations. The western blot suggests that carbonic anhydrase 9 is present in the tracheal epithelium, but its presence in the hemolymph is inconclusive. The hypothesized molecular physiology of each component is supported by the data.

P1-82 SAINTSING, AJ*; FULL, RJ; Univ. of California, Berkeley; *andrew_saintsing@berkeley.edu*

Metabolic cost of robustness: Running after losing one or two legs

After losing legs, cockroaches can still run, showing phenomenal fault tolerance. We hypothesized that this remarkable robustness is likely to increase the metabolic cost of locomotion. We tested this hypothesis for cockroaches, *Blaberus discoidalis*, running on a treadmill. We used open-flow respirometry to measure steady-state oxygen consumption at a range of speeds (2.5-12.5 cm/s) and video cameras to determine stride frequency and ground contact time. We compared cost for individuals missing one and two middle legs with intact controls. Animals maintained steady-state locomotion for at least 5 min. For all conditions, oxygen consumption and stride frequency increased with speed, whereas contact time decreased. Losing one leg increased cost by 8-30%, whereas the loss of two legs increased cost by 27-76% relative to the 6-legged condition. Middle leg loss showed no gait change, but resulted in an increase in stride frequency and a decrease in leg contact compared to intact controls. Middle leg loss destabilized animals in roll and caused animals to take more, smaller steps than intact animals to maintain the same speed. Correcting for the faster rate of force generation in animals with reduced leg number by calculating the cost per stride resulted in no significant differences, but animals with two middle legs missing did show significantly greater ground contact costs. Cockroaches exhibit fault tolerance, but at a metabolic cost.

P3-29 SANDES DE SOUZA, AP*; SMITH, NS; WILSON, RS; University of Brasilia, Brazil, University of Sydney, Australia, University of Queensland, Australia; *r.wilson@uq.edu.au*

Testing a model of escape performance in terrestrial animals

Once prey is detected, survival depends on out-running, out-manoeuvring, or fighting off the predator. Though predation attempts involve at least two individuals—namely, a predator and its prey—studies of escape performance typically measure a single trait (e.g. sprint speed) in the prey species only. Recently, a theoretical model of escape success was developed that is based on the relative performance of prey versus predator with regards to their acceleration, top speed, agility and deceleration. The model suggests acceleration, top speed, and agility are all important determinants of running performance along curved paths, and that prey with higher agilities should exploit their higher performances along curved paths to outrun predators. This model is based on the premise that the relative importance of acceleration, top speed and agility changes with increasing path curviness. Here, we test this mathematical model using analyses of human performance when running along paths of varied curvature.

P3-97 SANDOVAL HERRERA, NI*; WELCH , KC; University of Toronto; *natalia.sandovalherrera@mail.utoronto.ca*

Sublethal Effects of Neurotoxic Pesticides on Bats: from Cells to Behavior

Agricultural intensification and the consequent increase of pesticide use has been considered a major threat for bat populations in Europe. However, no research on this topic has been conducted in tropical agrosystems, where most of the arable land is frequently treated with pesticides, particularly large monoculture plantations like banana and pineapple. Considering that bats can eat more than 90% of their body mass every night, species that forage preferentially in crops could be highly exposed to pesticides through their prey. This study seeks to determine the sublethal effects of organophosphate pesticides on bat species foraging in or near crops. Organophosphate pesticides are commonly used neurotoxic chemicals that can impair vital functions such as the ability to feed, escape predation or reproduce. In order to assess the risk of exposure, we have studied foraging activity of bats in crops in Belize, Mexico and Costa Rica, countries known for their great bat diversity and extensive use of pesticides. To estimate intake by bats, we will analyze pesticide levels in insects collected in the same locations. Subsequently we will use an integrative approach to study the toxic effects of organophosphates on captive and wild bats. This approach involves measuring molecular (enzyme activity), physiological (metabolic rate, immune response) and behavioral (echolocation) biomarkers, aiming to extrapolate these responses across levels of biological organization. Understanding the mechanisms and effects at different scales will enable to better predict the implications on populations and communities and help to inform mitigation strategies.

P3-99 SANDOVAL-HERRERA, N*; ENGLISH, SG; BISHOP, CA; ELLIOTT, JE; WELCH, KC; University of Toronto, Environment and Climate Change Canada, Environment and Climate Change Canada; *simon.english@mail.utoronto.ca*

Effects of neonicotinoid insecticides on hummingbirds

Neonicotinoids are neurotoxic systemic insecticides that have become the most widely used group of insecticides worldwide. These compounds affect the nervous system, interfering with the transmission of nerve impulses and impairing vital physiological processes. There is a growing concern about their environmental impacts, particularly linked to bee colony collapse disorder and drastic reductions in insect populations. While the loss of pollination services provided by bees to ecosystems and agriculture has been widely studied, the neonicotinoid effects in other pollinators such as hummingbirds haven't been assessed yet. Hummingbirds in particular present a great risk of exposure to pesticides due to their high daily nectar intake, making them also more vulnerable to the adverse effects of these toxic substances. We examined the sublethal toxic effects of the neonicotinoid imidacloprid in captive Ruby-throated hummingbirds (Archilochus colubris). Using a multibiomarker approach we evaluated biochemical, physiological and behavioral impairments. Two doses were tested, a high dose based on previous toxicity assessments in similar size species and a low dose calculated from the potential daily consumption of imidacloprid by hummingbirds feeding in blueberry crops. To determine cellular neurotoxic effects, Cholinesterase activity and oxidative stress response were measured. As physiological response Resting Metabolic Rate and immune function were examined. Likewise, the toxicokinetics of the insecticide were assessed through urine analyses. This is the first study assessing the effect of pesticides in hummingbirds, our results will provide insights of pesticide exposure as a potential threat for populations of these species and will help management agencies improve regulation.

P2-229 SANTYMIRE, RM*; WALLACE, SC; Lincoln Park Zoo, East Tennessee State University; *rsantymire@lpzoo.org*

Has post-bottleneck inbreeding reshaped the baculum in the black-footed ferret?

In the mid-1980's, the last remaining black-footed ferrets (Carnivora: Mustelidae: *Mustela nigripes*), an obligate carnivore that feeds on prairie dogs throughout North America's Great Plains, were removed from the wild to initiate a captive breeding program to save the species from extinction. After more than 30 years of captive breeding (starting with 7 founders), the rate of reproductive failure has increased from 20-30%, to nearly 70%. This reduction could be attributed to declining semen quality in males and/or the increased rate of ovulation failures in females. Moreover, because the baculum plays an important role in semen deposition and the degree of stimulation of the female reproductive tract (induced ovulation), its morphology provides information on male quality and female mate choice. Consequently, we wanted to determine if the baculum shape and size had changed over the duration of the breeding program, thereby potentially influencing reproductive success. Hence, we measured 50 bacula from captive adult ferrets born between 1993 and 2007, and obtained siring histories (studbook records) and semen data from 27 of these males. With no novel genes to bring into the population (naturally), inbreeding coefficients (*F*) will continue to increase over the years. Not surprisingly, we found that as the male *F* increased, the number of kits sired declined. Ferret body length was not related to baculum size and shape. However, we found that the baculum base width declined over time, while baculum length remained the same. The thinning baculum base was not directly linked to reproductive success in these males. Next steps are to continue measuring bacula from historic and modern specimens as a comparison between wild and captive born ferrets to further explore the role of the captive environment on the baculum morphology.

P2-112 SANTYMIRE, RM*; SACERDOTE-VELAT, AB; GYGLI, A; KEINATH, DA; POO, S; HINKSON, KM; MACK-MCKEAG, EM; Lincoln Park Zoo, The Chicago Academy of Sciences, US Fish and Wildlife Service , US Fish and Wildlife Service , Memphis Zoo; *rsantymire@lpzoo.org*

Investigating the stress physiology of Wyoming toads (Anaxyrus baxteri) using dermal cortisol analysis among various environmental conditions

Amphibian populations are declining worldwide, and increased exposure to environmental stressors, including diseases like *Batrachochytrium dendrobatidis*, has been proposed as one reason for these declines. Our goal was to use a novel, noninvasive dermal swabbing method to measure glucocorticoids and investigate the relationship among disease, environmental conditions and stress physiology in the critically endangered Wyoming toad. Our objectives were to validate the use of dermal swabs to measure cortisol using an adrenocorticotropic hormone (ACTH) challenge on 8 captive Wyoming toads (4 ACTH: 2M, 2F and 4 saline as a control: 2M, 2F); 2) compare fecal glucocorticoid metabolites (FGMs) pre- and post-ACTH experiment; and 3) investigate stress physiology of toads across three different reintroduction sites with varying population success and disease prevalence. Results validated the use of dermal swabs cortisol peaking immediately after the ACTH injection, while saline remained consistent over time (up to 2 hours). FGMs were elevated on Day 1 post-ACTH for the male and Days 2-4 for the female compared to FGMs before the experiment. Saline-injected toads had no change in FGM over time. Dermal cortisol was similar across one reintroduction site compared to captive toads. We also collected additional samples to compare habitat type and disease prevalence across two other sites. Dermal hormonal analysis is a novel tool that can be used to study amphibian stress physiology and can provide information on how environmental conditions are impacting population success.

P1-216 SARKIS, C*; SENEY, EE; FORSMAN, AM; University of Central Florida; *anna.forsman@ucf.edu*

Optimizing NextGen DNA Metabarcoding Methods for Characterizing the Diet of Free-Living Sea Turtles

Sea turtles consume both plant and animal prey and there is significant variation in diet composition among species and life stages. Visual inspection of gut contents is an effective but very time-consuming approach, which becomes increasingly difficult with digestive breakdown. Therefore, the objective of our current work is to optimize and validate the use of DNA metabarcoding techniques for characterizing sea turtle diet alongside visual inspections. Here we present results from testing multiple metabarcoding primer pairs with diet samples collected from turtles stranded off the coast of Florida. We tested a panel of animal- and plant-specific primer pairs, targeting multiple genomic regions (e.g., CO1, 18S, TrnL), for effective PCR amplification. Our goal was to maximize diversity of diet items detectable by Illumina sequencing of amplicon libraries. Although metabarcoding primers are referred to as being universal, each primer pair will have biases against certain taxa. Thus, it is critical to establish an appropriate suite of primers to capture the best representation of true diet composition. Results from this work contribute rigorous methods and critical baseline data to inform our ongoing studies of sea turtle diet in the context of life history, ecology, and disease dynamics.

P2-77 SATTERLIE, R*; NOREKIAN, TP; HERMANS, CO; University of North Carolina Wilmington, Arizona State University, Friday Harbor, WA; *satterlier@uncw.edu*

Buccal Cone Structure and Prey Acquisition in the Pteropod Mollusk Clione limacina

The pteropod mollusk *Clione limacina* is a feeding specialist, only consuming shelled pteropods. As a result *Clione* use the hydraulic eversion of six tentacle-like buccal cones to catch the actively swimming prey. The surface of the buccal cones is covered with adhesive papillae that possess terminal packets of electron dense granules. At the base of the epithelium is a thin layer of circular, smooth muscle, which is presumably used to help extend the buccal cones. Medial to the circular muscle are two layers of longitudinal muscle. The outer layer is made up of bundles of smooth muscle cells, and is equally distributed around the buccal cones in a sub-epithelial position. This layer functions as retractor muscles for returning the deflated buccal cones into the mouth. The other, more medial layer of longitudinal muscle is comprised of larger bundles of striated muscle, which are concentrated on the oral side of the buccal cones. These muscle bundles are used for the closure of the everted buccal cones on the prey, and presumably for prey manipulation, which rotates the prey until the shell opening is over *Clione's* mouth. Once the prey is gripped by the radula and oral hooks, the buccal cones are partially or fully retracted. The radula and hooks are then used to pull the prey tissue, intact, from the shell.

P2-145 SAYAVONG, N*; GUNDERSON, AR; STILLMAN, JH; TSUKIMURA, B; California State University, Fresno, Tulane University, San Francisco State University; *sayavongnathan@gmail.com*

Effects of interspecific interactions, increased population density, and thermal stress on vitellogenesis on intertidal crabs Petrolisthes cinctipes and P. manimaculus.

Increased temperatures from global warming can lead to lethal temperatures for the intertidal crab *Petrolisthes cinctipes* (Decapoda: Anomura). Physiological stress from increased temperature may force redistribution into cooler environments (Stillman and Somero 1996). As a result, interspecific interactions and increased population density may occur that threaten the fitness of its congener, *P. manimaculus*, through behavioral encounters. To investigate the effects of interspecific interactions, increased population density, and thermal stress, *P. cinctipes* and *P. manimaculus* were collected from November 2017 through July 2018 and exposed to thermal stress and placed at high and low densities with conspecifics and congeners. Hemolymph samples were taken from each crab before and after density and thermal stress treatments. To quantify the effects of treatments, an ELISA was used to quantify Vg levels in hemolymph before and after treatment (Delmanowski et al. 2017). During summer months, *P. cinctipes* showed decreased vitellogenesis, likely due to annual thermal stress (Salas 2017). Increased interspecific and intraspecific species interactions in high densities with thermal stress impaired vitellogenesis in *P. manimaculus*. At low densities vitellogenesis in *P. manimaculus* increased. These data suggest that the relocation of *P. cinctipes* into the lower intertidal can cause interspecific species interactions that are stressful for *P. manimaculus* at high densities. Thus, an increase in thermal stress to *P. cinctipes* that causes a migration into *P. manimaculus* habitat, can also cause a decline in the latter's reproductive output.

P1-295 SCHAALE, LE*; BAXLEY, JB; PRICOPE, NG; DANNER, RM; Univ. of North Carolina, Wilmington; *Les6953@uncw.edu*

Viewing habitat through another lens: Bird nest-site selection and productivity across the beach thermal landscape

Little is known about the fine-scale temperature variations of the coastal landscape, which limits our ability to assess its effect on animal productivity. In 2018, we studied the effects of the thermal landscape on the least tern (*Sternula antillarum*), in a breeding colony on Lea-Hutaff Island, NC. Our three hypotheses are: (1) the thermal landscape, as measured by thermal imaging, will be highly variable and will reflect ambient environmental conditions. (2) The thermal landscape, as measured from thermal images, influences nest-site selection by least terns. Specifically, we predict that birds avoid nesting in the hottest locations. (3) The thermal landscape, as measured from thermal images, limits nest success for least terns. We predict lower nest success for nests in the hottest locations. We monitored 157 nests. Nest success was determined by successful hatching of chicks. We recorded surface temperatures via a fixed-wing mapping unoccupied aerial vehicle (UAV). We launched the UAV ~250 m away from the colony and maintained an altitude of 122 m to minimize bird disturbance. The UAV carried a thermoMAP thermal camera with a temperature resolution of 0.1°C. At the study location, we recorded ambient environmental conditions at ground-level throughout the season. The weather data will help determine which variables influence sand surface temperature and explore the cause of nest success. Our preliminary results indicate that there is a wide range of temperatures across the landscape, supporting hypothesis 1. Tern nest locations varied in surface temperature. Nest success decreased in nests incubated in hotter locations and during a weeklong heat wave, providing tentative support for hypothesis 3.

P1-241 SCHAMMEL, KS*; MOOI, R; ARMSTRONG, AF; Pomona College, Claremont, CA, California Academy of Sciences, San Francisco, CA; *kssh2015@mymail.pomona.edu*

Applying molecular data to problems in sand dollar phylogeny (Echinodermata: Clypeasteroida)

The Clypeasteroida (sand dollars and sea biscuits) is among the most easily recognized of irregular (burrowing) echinoid groups. These animals are of increasing interest due to their excellent fossil record, and for their ecological responses to climate change over geologic time. Morphological phylogenies of clypeasteroids and their closest relatives, an informal group known as "cassiduloids" (lamp urchins), have questioned clypeasteroid monophyly -- a clade supported by many morphological features. Recent molecular trees suggest that some features have evolved more than once. For example, most urchins have an Aristotle's lantern, a five-part jaw apparatus used in morphological analyses. Outgroups of Clypeasteroida, including "cassiduloids" and heart urchins (Spatangoida and Holasteroida), lack a lantern as adults. Distantly related "regular" urchins and clypeasteroids have a lantern, suggesting that it reappeared in a monophyletic Clypeasteroida. The molecular work suggests reacquisition of the lantern separately in sea biscuits and sand dollars. A weakness in those analyses has been the lack of a focus on clypeasteroids, usually because of inadequate taxon sampling. We address this using Sanger sequencing methods on a set of key clypeasteroids and "cassiduloids". Several other problems, such as the phylogenetic position of miniaturized, bean-shaped clypeasteroids such as fibulariellids with the bizarre, but otherwise sand dollar-like rotulids, are also explored. Problems with, and possible solutions for resolving the phylogeny are discussed in view of differing evolutionary rates and geologic depth of nodes implied by our phylogenetic results.

P2-201 SCHERR, MP*; BADE, LM; ANGELINI, DR; Colby College; *mscherr@colby.edu*

Microbiome analysis of gut contents from the cownose ray, Rhinoptera bonasus, a species with a complex history of synanthropy

Cownose rays, *Rhinoptera bonasus*, are migratory cartilaginous fish native to the western Atlantic. This species migratory patterns can bring it into conflict with humans. While their feeding ecology is not well defined, they are known to feed on mollusks and crustaceans. Current high-throughput sequencing technology offers the potential to gain more insight into the feeding ecology and the potential for impact of these rays on aquaculture. We apply this novel approach with an analysis of the contents and microbiome composition of these marine vertebrates. Cownose rays collected from Chesapeake Bay, Virginia and off the coast of North Carolina were dissected, and DNA samples were isolated from multiple prey items within the stomach and spiral valve. These samples were sequenced for the *16S* ribosomal RNA gene in order to determine bacterial composition. The barcode region of *cytochrome oxidase subunit I (COI)* was also sequenced for identification of prey species. Gut microbial communities were highly diverse. Microbial composition was found to differ significantly by age, capture location, and time of year.

P3-1 SCHLEIFER, HJ*; ELLERS, O; JOHNSON, AS; Bowdoin College; *hjschlei@bowdoin.edu*

Using circuit theory to model flow and pressure outputs of the circulatory system of the American lobster, Homarus americanus

Interest in modeling the human circulatory system has driven a significant amount of research on the topic, resulting in well-developed models based in electric circuit theory. This raises the question, however, of whether this model can be applied to morphologically different organisms with pulsatile hearts. Additionally, the circuitry-based model of the human circulatory system has been used extensively in modeling the behavior of isolated parts of the human circulatory system, where very few have tried building a comprehensive model of the entire circulatory system. This project, therefore, has two major objectives: applying the electrical circuitry analogy to the circulatory system of the lobster, and stringing together a model of the entire system, instead of multiple models of isolated parts of the system. Similar to mammalian circulatory systems, lobsters have a circulatory system made up of compliant vessels, suggesting that the Windkessel pump circuitry theory can apply to lobster as well as human vessels. These systems differ, however, in a few fundamental ways: the lobster heart only has one chamber, there are seven vessels leaving the lobster heart instead of the one leaving the human heart, and the lobster has an open circulatory system instead of the closed mammalian circulatory system. These differences suggest that models built around the human circulatory system would need to be modified to model the lobster circulatory system. From initial analysis, in a system of compliant vessels (treated as individual Windkessel units), increasing compliance with distance from the heart produces a pulse-smoothing effect. Pulse smoothing reduces fluctuation in power in the outer vessels. Compliance also appears to affect the filling and emptying of vessels, causing vessels to fill in a staggered fashion.

P3-139 SCHREY, A*; RUSSELL , A; LIEBL, A; Georgia Southern University, University of Exeter, University of South Dakota; *aschrey@georgiasouthern.edu*

Temporal Variation in DNA Methylation Among Chestnut Crowned Babbler from Three Developmental Periods

Ecologically important variation in DNA methylation can be induced by changes in local environment, allowing DNA methylation to vary over an individual's development. We compared DNA methylation among three developmental periods (i.e. at hatching, just before fledging, and as an adult) in multiple chestnut crowned babblers (*Pomatostomus ruficeps*); this allowed us to track changes in DNA methylation over time within a single individual. Our objective was to determine how liable DNA methylation is among developmental periods, and to determine the amount of induced change within individuals. Using the epiRADseq protocol we were able to generate 148,881 unique fragments indicating considerable variation in DNA methylation among individuals as well as within individuals through time. Equally, although differences existed through time at some sites, other sites remained relatively stable through time. Broadly, we show here that differences among individuals exist in methylation profile but that portions of these profiles are not stable over time, suggesting the environment is also an important player in the induction of different epigenetic states at multiple points in life.

P2-29 SCHWARTZ, TS; KLABACKA, RL*; GANGLOFF, EJ; BRONIKOWSKI, AM; Auburn University, Station d'Ecologie Théorique et Expérimentale du CNRS, Iowa State University; *klabacka.randy@gmail.com*

Population genetics of the electron transport chain in snake populations exhibiting divergent resting metabolic rates.

Although evidence for the importance of mitochondria in the evolution of natural populations continues to accumulate, studies attempting to link natural variation in mitochondrial function to mitochondrial DNA (mtDNA) variation and/or environmental variation have had mixed reports. Variation in mtDNA contributing to variation in metabolic rates can, in turn, be expected to drive differences in how organisms process energy from their environment. Previously we documented two distinct ecotypes of western terrestrial garter snakes (Thamnophis elegans) with differences in mitochondrial function, reaction norms of metabolic rate to temperature, and mtDNA sequence data. While mtDNA contributes significantly to processes within mitochondria, most gene products involved in mitochondrial function originate within nuclear DNA (nDNA). The electron transport chain (ETC), the centre for ATP production, is composed of 13 mtDNA-coded proteins and 73 nDNA-coded proteins. Here we use an expanded sequence-capture genomic sequence dataset from 96 individuals of the same and additional populations to validate previous findings that the ecotypes have unique mtDNA haplotypes with two amino acid changes in ND5 and CYTB that are highly segregated between ecotypes. This striking population structure at the mtDNA is in contrast to the low genetic structure seen in the background nDNA. We now incorporate analyses from the nDNA-coded ETC genes, comparing several bioinformatics approaches for sequence assembly and extraction of SNP data. Contrasts between the variation in mtDNA-coded and nDNA-coded ETC genes are made at the level of the gene, protein, and ETC complex and interpreted in the context of mitochondrial physiology and function.

P2-182 SCHWIETERMAN, GD; WINCHESTER, MM*; SHIELS, HA; MARSHALL, HM; BUSHNELL, PG; BRILL, RW; BERNAL, D; Virginia Institute of Marine Science, Univ. of Massachusetts, Dartmouth , Univ. of Manchester, Atlantic White Shark Conservancy, Indiana University, South Bend; *maggiewinchester4@gmail.com*

The Impact of Simulated Capture Stress on Elasmobranch Cardiac Function using Isolated Myocardial Strips

Recent work on capture stress in sharks suggests that elevated levels of potassium in the blood (i.e., hyperkalemia) may be correlated with higher rates of post-release mortality. In teleosts, the negative effects of hyperkalemia appear to be exacerbated when combined with other common by-products of the stress response (i.e., hypoxia, acidosis) or with unfavorable environmental conditions (i.e., elevated temperature). This study investigates how hyperkalemia (7.4mM K^+), hypoxia, acidosis (0.26 pH decline) and changes in temperature may affect myocardial function in three phylogenetically disparate (but sympatric) species of elasmobranchs (sandbar shark, smooth dogfish, and clearnose skate). We measured myocardial strip contractility and force production *in vitro* and evaluated the ability of a -adrenergic agonist to ameliorate negative effects of simulated capture stress. All species demonstrated declines in the net force of contraction in response to hyperkalemia but only sandbar sharks showed a significant decline in force when compared to baseline levels of potassium (5 mM K^+, $p = 0.001$). Clearnose skates were the only species to show a decrease in net force in response to hypoxia and acidosis ($p=0.026$) as well as in response to high temperature ($p=0.0002$). This study provides the first indication that hyperkalemia may negatively affect heart function in some elasmobranchs, however, there are likely important interspecific differences that allow varying tolerances to hyperkalemia resulting from capture-related stress.

P3-52 SCIBELLI, A E*; AONUMA, H; TRIMMER, B A; Tufts University, Medford, MA, USA, Hokkaido University, Hokkaido, Japan; *anthony.scibelli@tufts.edu*

Proleg muscles in Manduca sexta: Segmental differences suggest anteroposterior specialization.

Larval *Manduca sexta* have become an important model system for understanding the neuromechanics of soft body locomotion. In addition to *Manduca*'s readily accessible nervous system, its tissues and body structures have been described in increasing detail throughout the 20th century. While dissection techniques and talent have captured most of the musculature and body wall, they all rely on flattening the three-dimensional structure which causes considerable distortion and tissue damage. To gain better insights into the control and mechanical properties of the abdominal prolegs we have used X-ray microtomography of intact animals to capture structures at tens of micron of resolution. Here we describe intact proleg muscle morphology, highlighting previously undiscovered fiber bundles and attachments, as well as differences in fiber quantity and attachment area between anterior and posterior segments. Larvae were fixed, stained and scanned to distinguish the primary tissues types with minimal distortion. Structures were labelled and morphological statistics were calculated from these three-dimensional models. In addition to muscles described in the literature attached to the proleg planta (PPRM), we found three previously undescribed groups of fibers that attach to the body wall in a highly stereotyped manner. Data from several animals revealed an increased number of fibers in specific muscle groups in posterior segments. Additionally, there is a reduction in the cross-sectional area of individual fibers and a greater total muscle volume. Total fiber volume for all muscles inserting in the planta show an approximately two-fold increase from segments A3 to A6.

P1-42 SEBER, E.K.*; KARAKAS, F.; MURPHY, D.W.; BYRON, M.L.; Penn State University, University of South Florida; *elizabeth.k.seber@gmail.com*

Fluid dynamics of ciliary propulsion at intermediate Reynolds number: locomotion across ontogeny in the Atlantic ctenophore Mnemiopsis leidyi

Ctenophores, at 1 - 15cm in length, are the largest organisms which rely exclusively on cilia for locomotion. In contrast to "typical" cilia, which are a few microns long and operate at Reynolds numbers (Re) much less than one, ctenophore cilia are around a millimeter long and arranged into platelike structures called ctenes, which have $10 < Re < 300$. We investigated the scaling of cilia morphology and beat kinematics within a single ctenophore species, the lobate comb jelly *Mnemiopsis leidyi*. Using specimens in various stages of development, ranging from 0.6 to 4.5cm in length, we measured body size, ctene length, and ctene spacing. We found that while ctene length increases linearly with body size, ctene spacing increased nonlinearly. We used several synchronized high-speed video streams of actively swimming animals to measure kinematic variables such as ctene beat frequency, which were then correlated with 3D-reconstructed bulk variables such as overall body velocity. During passive drifting, we found that animals maintained a relatively constant beat frequency across a large range of body sizes and developmental stages. To further elucidate these differences and similarities, we performed Particle Shadow Velocimetry (PSV) on the actively-beating ctene rows of several size classes, allowing us to calculate the velocity and vorticity fields around the ctenes. These results yield valuable insight into changes in locomotor strategy across ontogeny in ctenophores, and more generally into the operation of flexible propulsors at the milliscale.

P1-179 SEHRSWEENEY, M*; WILSON, D; BAIN, M; BOUTIN, S; HUMPHRIES, MM; LANE, JE; MCADAM, AG; DANTZER, B; University of Michigan, Memorial University, University of Guelph, University of Alberta, McGill University, University of Saskatchewan, University of Guelph; *dantzer@umich.edu*

Effects of acute stress and glucocorticoids on acoustic structure of territorial vocalizations of North American red squirrels

Acoustic signals are an important way in which animals communicate with another and vocalizations may convey much information about the state of the signaler to receivers such as their sex, age, or individual identity. Less is known about the ability of acoustic signals to communicate labile information to receivers, such as short-term changes in hormone levels. We examined the influence of changes in physiological stress state on the acoustic structure of the territorial vocalizations of wild North American red squirrels (*Tamiasciurus hudsonicus*) known as rattles. We assessed the effects of physiological stress state on the acoustic structure of rattles by applying an acute stressor (trapping and handling the squirrels) and by treating squirrels with exogenous glucocorticoids (GCs). We characterized the acoustic structure of rattles emitted by these squirrels by measuring rattle duration, mean frequency, and entropy. Our results provide mixed evidence that rattles show a "stress signature". Squirrels experiencing an acute stressor produced rattles that were dramatically different from those recorded from squirrels at baseline conditions. However, the same shifts in rattle acoustic structure were not observed when squirrels were treated with GCs compared to those fed supplemental food or those that were unmanipulated. Our results indicate that acute stress impacts the acoustic structure of vocalizations but changes in circulating GC levels are not solely responsible for such changes.

P1-175 SEWALL, KB*; BECK, ML; Virginia Tech, Rivier University; *ksewall@vt.edu*

Multimodal signal processing: how do female songbirds prioritize song and plumage cues?

Research in animal communication often examines receivers' responses to unimodal signals — signals that are transmitted and received through only one sensory channel. However, receivers are regularly exposed to multimodal signals - signals that are transmitted and received concurrently through two or more sensory channels, such as song and plumage color in birds. Behavioral responses may vary among individuals as a function of how they integrate and prioritize signals from different modalities. To determine how variation in the mechanisms underlying signal processing contributes to variation among receiver responses to signals, we examined receiver responses to compound plumage color and song quality signals in female house finches. Specifically, we were interested in whether plumage cues influenced neural response to song cues within the auditory forebrain. To determine this, we exposed female house finches (n=47) to a red or yellow male house finch (n=10) coupled with one of 20 pre-recorded house finch songs (categorized as being long and complex or short and simple). We measured the number of contact calls each female gave during presentation and then measured neural activation within three subdivisions of the auditory forebrain using immediate early gene expression. We found a non-significant trend for females exposed to red males and long complex songs to call more. Additionally, neural activity in one region of the auditory forebrain differed with song but not color treatment. These data suggest that females do integrate plumage and song cues but that the auditory forebrain is not centrally involved in the prioritization of multimodal signals.

P2-214 SEIDEL, R; CHAUMEL, J; BLUMER, M; HERBERT, A; MORENO-JIMENEZ, I; SUMMERS, A; DEBIAIS-THIBAUD, M*; DEAN, MN; MPIKG, Medical Univ. Innsbruck, U Alaska, U Washington, U Montpellier; *mason.dean@mpikg.mpg.de*

Mineralization in Chimaera Cartilage: Tessellated but not Tesserae?

An accepted uniting character of cartilaginous fishes (sharks, rays, chimaera) is the presence of mineralized tiles (tesserae) on the outside of the cartilage skeleton. Tesserae have, however, never been demonstrated in modern chimaera and it is debated whether the skeleton mineralizes at all. We use materials and biological tissue characterization techniques to show, for the first time, the presence of a tessellated mineralized layer in chimaeroid fish, in several skeletal elements (jaws, cranium, vertebral column) and three genera. The mineralized "tiles" are irregular and not uniformly distributed, unlike most shark and ray tesserae, yet share several features with tesserae. The mineralized layer is peripheral in the unmineralized cartilage and seems to grow by periodic accretion of mineral at edges, forming laminated patterns of mineral density variation similar to those in shark and ray tesserae (e.g. in Liesegang lines, hypermineralized "spokes"). Chimaeroid mineralized cartilage, however, appears to lack the network of cell spaces that characterize tesserae, although we observe poorly mineralized regions suggesting infilled cell spaces. Significant is the apparent absence of the cell- and fiber-rich joints that link shark and ray tesserae, suggesting that cells and true intertesseral joints may be vital to the development of more geometric tessellations. Our data indicate that skeletal mineralization is more widespread and diverse in extant cartilaginous fishes than previously thought; developmental studies of chimaeroid mineralization are necessary to determine the mechanisms underlying skeletal patterning and their conservation across cartilaginous fishes.

P1-263 SHANNON, RP*; LOVE, AC; BOLEK, MG; Oklahoma State University; *shannrp@okstate.edu*

White blood cell differentials of amphibians naturally infected with multiple trypanosome morphotypes

Disease is one of the leading factors contributing to the global decline of amphibians. While diseases such as chytrid fungus and ranavirus have been implicated in amphibian decline, considerably less is known about how blood protozoa, such as trypanosomes, affect amphibian populations. Furthermore, despite the common occurrence of trypanosome infection in amphibian populations, we still know relatively little about how amphibians respond to trypanosome infection. In this study, we characterize differential white blood cell counts—the relative proportion of five different immune cell types in the blood—in four anuran species (*Rana catesbeiana*, *Rana sphenocephala*, *Rana blairi*, *Hyla cinerea*) with and without trypanosomes. Frogs were wild caught and naturally infected with one to four distinct trypanosome morphotypes, differing in size, presence of a free flagellum, and cell motility. Trypanosome species can have multiple morphological stages in their life cycles, however the species associations of amphibian trypanosome morphotypes are not known. In this study, we found differences in white blood cell differentials between infected and uninfected individuals of a given species. For example, trypanosome infection was associated with lowered lymphocyte counts in *R. catesbeiana*, while trypanosome infection was associated with lowered neutrophil counts in *R. sphenocephala*. Additionally, white blood cell profiles differed depending on the specific trypanosome morphotypes present. This study helps characterize one of the immunological responses of anuran amphibians to trypanosome infection and provides insight into how blood protozoa interact with their amphibian hosts at an immunological level.

P2-70 SHARP, SL*; BREDA, JR; TODD, KL; Westminster College , Westminster College; *sls1013@westminstercollege.edu*

Identical reproductive behaviors rely on different motor circuits

It is widely known that during electronics design complex circuits are made from standardized components. Many individuals often think biological systems are organized in this same way. It is attractive to hypothesize that homologous neurons should participate in similar circuits to produce homologous behaviors between species. However, differences in neuronal activity of homologous neurons have been observed in shell-less mollusks. This work has shown, in swimming behavior, that homologous neurons form different circuit connections in two closely related species. Despite this, little research has been done on differences in homologous neurons in different species analyzing similar behaviors. This research analyzed the circuits involved in reproductive behavior in two closely related leech species, *Hirudo verbana* and *Macrobdella decora*. Both species respond to a hormone (hirudotocin) by progressing through the same reproductive behaviors. Additionally, both synthesize this hormone in two segmentally repeated neurons called Leydig cells. Furthermore, both species have the same cohort of motor neurons that produce behaviors. We hypothesized that if a species-specific circuit difference existed, we might observe it in different motorneuron activity. We have found that there are significant differences in the reproductive behavioral circuit. Quantifiable differences in motorneuron dynamics include: burst duration, inter-burst interval, burst frequency, and the number of spikes per burst. These results indicate that there is a difference in neuronal participation between the two species when producing the same reproductive behavior. The outcome of this research raises a question as to why evolutionarily two closely related species producing the same behavior do so using different circuitry.

P2-258 SHEEHAN, MJ*; FISH, FE; ADAMS, DS; TENNETT, KA; GOUGH, WT; West Chester Univ., Stanford Univ.; *ffish@wcupa.edu*

A 60/40 Split: Differential Weight Support in Dogs

Tetrapod mammals must distribute their weight between fore and hind legs when standing. The proportion of weight by each couplet can vary with species. An elephant carries 55% of its weight on its fore legs, but a monkey has only 44%. There has been no systematic study of weight distribution to determine if the proportion of supported weight on the fore and hind limbs is dependent on body size. Over a four year period, 595 dogs from 123 breeds ranging in size from Chihuahua to Saint Bernard were measured at the Kennel Club of Philadelphia's National Dog Show. Each dog was weighed on a digital scale while standing in a show position alternating fore leg and hind leg support. The overall mean proportion of weight on the fore legs to the total weight was 60.4+4.8% (range: 40.3-78.3) with a fore leg to hind leg ratio of approximately 60/40. When separated into AKC categories, only the working group (e.g., Newfoundland, Rottweiler) was significantly above the 60.4% mean. Using the genetic groups by Parker et al. (2017), dogs with large heads were significantly greater than the mean (e.g., bulldog, mastiff), while herders and coursers (e.g., sight hounds) were lower. The genetic groups sorted by von Holdt et al. (2010) indicated that the group containing only retrievers, mastiff-like dogs, and small terriers were significantly greater than the mean. Using AKC-related categories from von Holdt, mastiff-like dogs were significant greater and sight hounds were lower than the mean proportion of weight supported by the fore limbs. The weight of the head, chest, and musculature for propulsion and braking could explain the greater weight supported by the fore limbs. Despite differences in morphology and size, dogs generally display a consistent differential between fore leg and hind leg support.

P1-20 SHEHAJ , A*; RIMKUS , B; KONOW, N; UMass Lowell; *andrea_shehaj@student.uml.edu*

Differences in Stress-strain and Power-velocity Properties between Muscles with Distinct Fiber Type Composition, Architecture and Mechanical Function

Antagonist muscles with differences in fiber type composition, architecture and mechanical function provide useful models in comparative vertebrate muscle physiology. We have developed a framework to evaluate the physiological performance (length-tension, force-velocity-power) for different muscles within a given individual. Here, we compare active and passive stress-strain, as well as power-velocity properties for TA, a fast-twitch, and relatively pennate-fibered muscle, to SOL, a slow-twitch parallel-fibered muscle in the mouse (n = 4). We test the ideas that parallel-fibered muscle is more compliant and capable of retaining near-maximal force and power production across broader ranges of strain and speed than pennate muscle. Our results show that SOL has significantly more passive compliance than TA, a difference we expect can be explained by different titin isoforms in the two muscles. SOL also has a broader stress-strain curve (Δ = 29% ± 7%), than TA (Δ = 12% ± 2%). The differences in stress-strain are reflected in the power-velocity properties with SOL having the broadest power curve: At 2.5 L_o s^{-1}, SOL retains 87% ± 5% peak power and TA only 56% ± 4%. Our results support the idea that parallel-fibered muscles retain force and power output over greater operating strains and speeds compared to pennate muscles. These differences likely have important implications on muscle mechanical function during movement. Going forward, similar comparisons between muscles from the same individual will allow us to determine the effects of diet and eccentric injury on muscle mechanical function.

P2-233 SHEPHERD, RM*; EMBERTS, Z; ST. MARY, CM; MILLER, CW; University of Florida, 1999; *r.shepherd@ufl.edu*

The Evolution of Defensive Displays in Leaf-footed Bugs

Many organisms use defensive displays to escape predators. Such displays have both visual and behavioral components that operate in concert. A great example is the startling display of mountain katydids. There have been two hypotheses put forward to explain how defensive displays evolve, the startle-first hypothesis and the defense-first hypothesis. The startle-first hypothesis proposes that the behavioral component evolves first, and is subsequently complemented with a visual component. Alternatively, the defense-first hypothesis proposes that the visual component of the deimatic display evolves first, and is then concealed. In our study, we evaluated these two hypotheses by investigating the evolution of the visual and behavioral components of a deimatic display in leaf-footed bugs (Insecta: Hemiptera: Coreidae). Preliminary phylogenetic comparative analyses suggest that the behavioral component of the deimatic display predates the morphological component. Moreover, the morphological component has independently evolved multiple times and larger species are more likely to possess both components.

P3-70 SHERIDAN, NE*; SEYOUM, S; TITUS, BM; DALY, M; SCHREY, A; RICHARDS, C; Univ. of South Florida, Tampa, Florida Fish and Wildlife Consv. Comm., St. Petersburg, The American Museum of Natural History, New York, The Ohio State Univ., Columbus, Georgia Southern Univ., Savannah; *nsherida@mail.usf.edu*

Genetic Differentiation in the Giant Caribbean Sea Anemone Condylactis gigantea in Florida, U.S.

Condylactis gigantea is an ecologically important member of benthic habitats in Florida. It serves as a host to many species, including cleaner shrimp, and is recognized by many reef fishes as a cleaning station indicator. This phenotypically diverse anemone is considered a single species throughout the Tropical Western Atlantic, but the genetic population structure has not been examined throughout most of its range. Investigating structure may reveal subdivided populations that could be evolving independently. Therefore, to assess structure, we collected tentacle samples from 250 individuals at 7 locations and used restriction site associated DNA sequencing (RADseq) as well as nuclear and mitochondrial DNA sequencing. Initial analyses of the RADseq data suggest two clusters with partial geographic partitioning and some admixture. Individuals in the Dry Tortugas, Upper Florida Keys, and Biscayne Bay were genetically differentiated from individuals in the Lower Florida Keys. The two clusters co-occur in the eastern Gulf of Mexico, west of Key West, and the Middle Florida Keys. Mitochondrial DNA sequences were invariant. Ribosomal DNA (rDNA) analysis supports two clusters with admixture, but not similar geographic partitioning. Here, we detected two clusters co-occurring in all locations, which is concordant with prior results from Jamaica. The discordance between the results could be due to a more robust signal provided by the large number of RADseq loci compared to the rDNA.

P2-24 SHIN, SH*; SARWAR, PF; CHENG, C; SUZUKI, Y; Wellesley College; *sshin6@wellesley.edu*

The role of Ventral veins lacking in endocrine gland development and molting

Hormones are necessary for the proper growth and development of multicellular organisms. However, the development of endocrine glands and transcriptional regulation of hormone biosynthesis remain elusive. Recent studies have demonstrated that the POU transcription factor, Ventral veins lacking (Vvl), plays a major role in ecdysone and juvenile hormone production in several holometabolous insects. In this project, we explored the roles of Vvl in the flour beetle, *Tribolium castaneum*, and the milkweed bug, *Oncopeltus fasciatus*, and examined the potential mechanism by which Vvl regulates hormone biosynthesis. Knockdown of Vvl prevented molting in both species and *vvl* expression was found in the prothoracic glands of both species. Our current efforts are directed towards investigating the mechanism of gland development in *Tribolium* and possible interactions with other major signaling pathways. Given that POU factors also play major endocrine roles in vertebrates, regulation of endocrine processes may share deep homology.

P2-142 SHIRLEY, K*; OSBORN, A; CHAMBERS, C; AMBROSE, A; MARKLAND, S; TWOMBLY ELLIS, J; GONZALEZ, VH; KANTSA, A; PETANIDOU, T; TSCHEULIN, T; BARTHELL, JF; HRANITZ, JM; Colorado College, The College of New Jersey, Univ. of Kansas, Savannah State Univ., Oklahoma State Univ., Cornell Univ., Univ. of Kansas, Univ. of the Aegean, Univ. of Central Oklahoma, Bloomsburg Univ. of Pa; *jhranitz@bloomu.edu*

A Plant-Pollinator Network in a Coastal Agricultural Field on Lesvos Island, Greece

Plant-Pollinator (p-p) networks describe ecological services essential to ecosystem function. Because climate change poses severe threats, especially where environmental extremes will be intensified, we studied a p-p network in a post-harvest, agricultural field on the coastal plain of Lesvos Island where low-lying coastal habitats are susceptible to thermal stress and saltwater intrusion. P-p network studies reveal species relationships in communities useful to conservation efforts. We conducted field surveys in July 2018 at two transects within 100 M of the shoreline. We collected insect pollinators and recorded p-p combinations daily. Insects and plants were identified to lowest taxon and analyzed in a network. The network consisted of 57 pollinator and 12 plant species distributed within six modules, i.e. groups of interacting species that are more tightly connected to each other than with the rest of the network. Pollinator services indices were generally low to moderate, with the most variation in the Diptera and Hymenoptera. Modules within the p-p network were distinct. Most pollinators in modules were peripherals, i.e. extreme specialists (86.0%), with some (12.3%) connectors (species connecting modules), only one module hub (1.7%). No pollinator was a network hub. The pollinator community seemed to be mainly comprised of generalist species that interacted with many other species in the community and are not tightly linked in a strong modularity structure.

P1-287 SHISHKOV, O*; JOHNSON, C; HU, M; HU, DL; Georgia Institute of Technology; *olga.shishkov@gatech.edu*

Feeding Fly Larvae Form a Fountain

Black solder fly larvae are edible maggots that are raised by startups all over the world as a source of sustainable protein. A larva competes with its thousands of neighbors to eat twice its body weight per day in decomposing organic waste. We investigate how the collective motion of an aggregation of larvae "pumps" larvae towards a piece of food by considering the feeding behaviors of larvae from individuals to groups of 60,000. We perform time-lapse photography and particle image velocimetry analysis of top and bottom side views of larvae in glass dishes. Around food, larvae from a fountain with their bodies where larvae crawl towards food through the middle of the fountain and fall down the sides once they are done eating. This distributes food between the individuals in the fountain, rather than only allowing a select few larvae to eat.

P2-88 SHOR, EK*; FREEMAN, DA; Univ. of Memphis; *ekshor@memphis.edu*

Brain Sites Mediating Melatonin Regulation of Immune Function and Stress in Siberian Hamsters (Phodopus sungorus)

Siberian hamsters (*Phodopus sungorus*) exhibit robust seasonal rhythms in immune function and stress responsiveness. The environmental cue driving these seasonal adjustments is photoperiod, which is encoded endogenously by the duration of rhythmic pineal melatonin (Mel) secretion. The central neuroendocrine targets mediating Mel-dependent regulation of stress responsiveness and immune function remain unspecified. There are multiple neural Mel targets in Siberian hamsters, including the suprachiasmatic nucleus (SCN), the nucleus reuniens (NRe), and the paraventricular nucleus of the thalamus (PVt). The PVt is of particular interest with regard to stress and immunity as it has been implicated in the neural regulation of the stress response. To address the role of the PVt in seasonal alterations of these measures, male Siberian hamsters underwent PVt ablation or sham ablation. Animals from each group were then exposed to either short- or long-day light cycles. On Week 5 post-ablation, blood samples were collected and used to perform a white blood cell (WBC) count and differential, and a bactericidal capacity assay. On Week 7, animals were exposed to a restraint stress test, during which blood samples were collected and used to perform a WBC count and differential, and a cortisol EIA. Results indicate that the PVt is necessary for the expression of the short-day bactericidal phenotype. PVt status also impacted WBC differential. In addition, these results will be considered in the context of ongoing hormone assays for circulating cortisol. These findings implicate the PVt in mediating seasonal regulation of immunity and stress responsiveness.

P2-33 SHORT, L.J.*; JOHNSON, D.H.; WRIGHT, M.A.; DEEMER, G.A.; MACKAY, S.B.; BERGMAN, D.A.; Grand Valley State University, Grand Valley State University , Grand Valley State University ; *short.lindsey3@gmail.com*

Olfactory Alarm Signaling in Crayfish

Chemical signaling among freshwater animals has been studied to provide insight into the functions of complex predator-prey relationships. A subset of chemical signaling systems is the alarm pheromone, which is typically released when an animal is threatened or has been injured. Crayfish are an integral part of the freshwater food web and utilize chemical communication in many capacities ranging from aggression to reproduction. Crayfish are also hypothesized to release alarm chemicals which elicit a negative or flight response in other crayfish. Our study compared the behavioral responses of *Orconectes propinquus* crayfish using three odorants: a crushed conspecific crayfish, food and predator (*Trachemys spp.* turtle). We hypothesize that subjects will be repelled from the crushed conspecific crayfish and predator odors due to the presence of an alarm odor, whereas food odorants will be attractive. Furthermore, it is expected that crayfish will prefer neutral territory in the maze or spend more time in the non-odor arm when presented with an alarm/stress signal.

P1-47 SIENKIEWICZ, R; BILLINGS, M; KENNEDY, JH; FISH, FE; GOLDBOGEN, JA; POTVIN, J*; Saint Louis University, Chaminade College Preparatory High School, West Chester University, Hopkins Marine Station - Stanford University; *potvinj@slu.edu*

Evaluating Airship Drag as a Predictor of Baleen Whale Drag

Baleen whales (Mysticeti) are a group of marine mammals that travel across oceanic basins in order to migrate between foraging areas and breeding grounds, thereby incurring high total energetic expenditures. These costs are minimized, mostly by a high degree of body streamlining which enables efficient, low-drag locomotion. Calculating the latter becomes a crucial element towards understanding the larger story of metabolic locomotor costs. As cetacean propulsion can be characterized by swimming modes ranging from carangiform to thunniform, drag generation is decoupled from propulsion by the flukes (Fish & Rohr 1999) and allows the evaluation of low-swim speed drag coefficients from rigid body steady-state hydrodynamics. Over the past decades (e.g. Webb 1975, Kooyman 1989), calculations of the drag generated by baleen whales and their sister taxon (Odontoceti) have used a correlation based on tunnel test data collected on blimps and airships (Hoerner 1962). We have used Computational Fluid Dynamics (CFD) to revisit - and re-confirm - Hoerner's old equation relating drag coefficient to body length-to-width ratio, by using digital reconstructions of the HMA R100 airship of the late 1920's, along with other profiles of differing fineness ratio (3 to 36). A comparison of these results was also carried out with CFD data of (gliding) rorqual drag, and showed agreement within 20% over the fineness ratios found in the field. The differences are traced from the enhanced pressure drag generated by the details of rorqual body shape, including those of the head and tail taper among other features.

P2-95 SIMONITIS, LE*; MARSHALL, CD; Texas A&M University at Galveston; *laureneve@live.com*

Preliminary Data on the Effects of Ink on Shark Swimming Behavior

Inking is a dramatic predator defense system that has interesting neuroecological relevance. When ink is used as a predatory defense, it affects predators visually (as a smoke screen) and chemically (as a deterrent), which may be used to disrupt the reception of chemicals or by being aversive to the predators. However, the physiological mechanisms of ink as a deterrent are still poorly understood. The use of ink as a defense is known for a variety of animals such as: sea hares, cephalopods, and even whales. To determine how ink acts as a chemical deterrent, ink from California sea hares (*Aplysia californica*), common cuttlefish (*Sepia officinalis*) and pygmy sperm whales (*Kogia breviceps*) were introduced into the path of free swimming bonnethead sharks (*Sphyrna tiburo*). Bonnethead sharks are abundant in local waters, are well suited for captivity, and have broad cephalofoils that provide easy access to their olfactory systems. Moreover, the olfactory system of bonnethead sharks is well known, allowing us to further test this sensory system to provide answers regarding the antipredatory function of ink. Sharks were individually placed in a circular mesocosm with a camera mounted overhead. Locomotory kinematic variables (e.g., swimming path, turning radius, angular velocity, etc.) were recorded in response to each of the experimental treatments: the three inks, food odor, food coloring, and sea water. Kinematic variables were used to test the hypothesis that ink negatively impacts swimming behavior. Preliminary data shows sharks change their swimming pattern upon introduction of ink into the water. This reaction confirms that ink negatively impacts shark swimming behavior and supports the hypothesis that ink is used as a deterrent. Future studies will address the ability of ink to deter a predation event and the electrophysiological reaction of shark olfactory systems to ink

P1-119 SIMPSON, RK*; MCGRAW, KJ; DOUCET, SM; University of Windsor, Arizona State University; *rksimpson9@gmail.com*

The Evolution of Complex Courtship Traits: Covariation and Interactions between Hummingbird Displays, Feather Structure, and Color Appearance

There is an astonishing diversity of animal signals, and often animals possess multiple signals. Selection will favor signals that can effectively be transmitted through the environment and detected by the receiver; and how multiple signals interact with each other and the environment during use can further influence signal efficacy. Angle-dependent, coloration often co-occurs with behavioral displays and can vary among species, providing an excellent model to study signal interactions. In these signaling systems, the environment and behavioral displays will interact directly with the angle-dependent structures to create the ornament's appearance to the receiver (i.e. color appearance). We tested how interactions between these three factors produce variation in color appearance, and how micro- and nano-structures of angle-dependent ornaments covary among species with behavior, the environment, and color appearance. We tested these hypotheses in "bee" hummingbirds, as nearly all species in this tribe possess a variant of an angle-dependent ornamental throat patch and stereotyped courtship display. We found interspecific variation in feather structure/reflectance, display behaviors, solar-positional environment, and color appearance, and a negative co-evolutionary relationship between properties of the feathers and behaviors. We also found both positive and negative relationships between feather and behavioral properties with color appearance, illustrating the complex evolutionary relationships between these traits. By integrating the study of intricate behavioral displays, specific color production mechanisms, and environment, our results help improve our understanding the diversity of signals and their interactions.

P2-104 SIMPSON, DY *; TELEMECO, R; LANGKILDE, T; SCHWARTZ, TS; Auburn University , California State University, Fresno, Pennsylvania State University; *dys0004@tigermail.auburn.edu*

Contrasting Differential Gene Expression to heat or fire ant envenomation in Sceloporus undulatus

Environmental stressors, such as extreme temperature change, invasive predators, and other disturbances, can negatively affect an organism's performance, survival, growth rate, and ultimately its fitness. The underlying molecular mechanisms of how organisms respond to diverse stressors are still poorly understood. *Sceloporus undulatus*, the eastern fence lizard, has become an ecological model organism for addressing questions in ecophysiology, and life history evolution. Recently we have developed a high-quality reference genome that furthers its utility for investigating molecular and physiological mechanisms. We are interested in understanding how stress responses may vary when an organism is exposed to diverse environmental stressors such as an extreme heat event as predicted by climate change, or attack by an invasive predator such as a fire ant. In this study, we test whether stress response to either acute heat or fire ant attack diverges at the endocrine level (plasma corticosterone levels) or at the gene expression level. We found that male *S. undulatus* (n = 24) who were either exposed to heat (43C) for up to 3 hours or fire ant envenomation (receiving ~10 stings) each had the same response in corticosterone levels, with an increase relative to the control. Liver RNA seq data are being analyzed to test whether the gene expression response to acute heat and fire ant envenomation is also highly similar or is divergent. These results will bring further insight into the similarity of molecular responses to ecologically relevant stressors.

P1-282 SINGH, A *; KEEFFE, R; BLACKBURN, D; University of Florida; *snakesalot@gmail.com*

Tips and Fits: Tricks to 3D Puzzle Making

Engaging the public and successfully articulating complex ideas about our scientific research are essential for promoting public awareness and support of science. The growing popularity of 3D-printers and CT- scanning have opened new avenues for engaging the public with biodiversity research. Large-scale digitization efforts of museum specimens such as oVert are making 3D models of real specimens widely available via online platforms such as MorphoSource. These models, especially those of skeletons, easily lend themselves to creative outreach opportunities, such as puzzle making. Puzzles are easy to approach, provide hands-on experience, and can demonstrate complex problems in an engaging way. Here we present our process for developing 3D skeletal puzzles from the specimens available at the Florida Museum of Natural History. We explore a selection of specimens, reconstruction practices using VG Studio Max 3.2, printer types, plastic types, coloring, and attachment mechanisms. These newly created puzzles were created for the purpose of presenting easily identifiable homologous structures to the public in hands-on learning activities. Puzzles can be made more complex or simple depending on the learning objectives and the audience. Educators, students, and the general public can freely download these 3D files for printing at home or in the classroom.

P2-195 SINGH, A.*; FABER-HAMMOND, J. J.; RENN, S.C.P.; Reed College; *avehi.singh@gmail.com*

The Effects of Social Rank on the Gut Microbiome of Astatotilapia burtoni

Social dominance hierarchies are a common system of within-group social ranking. Animals occupying subordinate and dominant ranks differ in their access to food and mating opportunities. They thus exhibit differential behavioral and physiological phenotypes associated with stress, nutrient availability and metabolic activity. We sought to evaluate the effects of social rank in male Astatotilapia burtoni on the gut microbiome, a community of microbes intimately involved in host physiological and metabolic processes. We used non-invasive sampling techniques that are novel in this system to track individual changes in microbial communities. Strikingly, we found a lag between microbial community shifts and behavioral and physiological changes associated with rank. Given this, subordinates had higher levels of pathogenic clades and decreased overall community diversity (alpha diversity) while dominants had higher levels of protective clades and increased alpha diversity. The distributions of several differentially abundant operational taxonomic units (OTUs) were correlated with alpha diversity, suggesting that these clades might be involved in structuring the community as a whole. Taken together, our results indicate that behavioral and phenotypic states associated with social rank induce dynamic, population-level shifts in microbiome composition, an effect putatively mediated by the abundances of certain clades. This study is one of the first to evaluate and track the effects of social rank on teleost microbiomes and highlights the need to integrate microbiome-derived effects into studies of behavior.

P1-18 SINGH, K*; HIDALGO, F; VOESENEK, CJ; BERG, O; MüLLER, UK; California State University Fresno, Wageningen University; *umuller@csufresno.edu*

A dynamically scaled mechanical model of a suction feeder based on the traps of the carnivorous plant Utricularia

Dynamically scaled mechanical models are a valuable tool to address bio-fluid-dynamic questions. Here we describe a mechanical model of a suction feeder based on the traps of the carnivorous plant *Utricularia*, commonly known as bladderwort. Bladderwort traps are among the smallest, fastest, and most specialized suction feeders, thus an ideal model system. This combination of small size and extreme speed makes it difficult to study the mechanics of their suction events. Here we present the design of a mechanical suction-feeder that can simulate the entry flows generated by bladderwort traps. We use scaling laws to preserve flow patterns, and experimental and computational data to simply the design. One such simplification is that opening the trap door is effectively instantaneous. Therefore, we can eliminate the door, approximate the mouth as a fixed-diameter aperture, and employ sudden-onset volume-change or pressure histories. Furthermore, the design of the cylinder and piston can be simplified, knowing that the external flow is effectively inviscid. The mechanical model is scaled up in size by a factor of 200 and in time is slowed down by a factor of 1000. The model comprises a constant-diameter cylinder and piston, actuated by a linear motor, submerged in mineral oil. The set-up is optimized for particle image velocimetry to quantify flow and pressure fields. The resulting parameter space maps will allow us to explore the lower size limit of suction feeding.

P2-114 SIRMAN, AE*; KUCERA, AC; KITTILSON, J; HEIDINGER, BJ; North Dakota State University; *aubrey.sirman@ndsu.edu*

Does chronic stress impact insulin-like growth factor signaling in house sparrows?

Animals can respond to environmental stressors through activation of the hypothalamic-pituitary-adrenal (HPA) axis and subsequent release of glucocorticoids. In the short-term, release of glucocorticoids can facilitate survival and escape from immediate threats. However, chronic, long-term activation of the HPA axis and glucocorticoids (GCs) can have detrimental impacts on fitness and senescence. Recent studies have suggested that the HPA axis may be closely linked with insulin/insulin-like signaling (IIS) pathway, a highly conserved endocrine pathway responsible for regulating resource allocation and stress resistance. Previous work has suggested GCs may play a role in regulating growth hormone (GH) and insulin-like growth factor-1 levels (IGF-1), relative to nutritional conditions. However, little is known about the impacts of chronic stress on the IIS pathway. To test the effect of chronic stress on the IIS pathway we captured adult male house sparrows (*Passer domesticus*), brought them into captivity, and randomly assigned them to one of two treatment groups: control and chronic stress. After a period of acclimation, birds in the chronic stress treatment group were exposed to daily rotating stressors for approximately 7 months. Control birds were housed separately and only disturbed during husbandry tasks once a week. At the end of the experiment, liver and pectoralis tissue samples were collected to measure IGF-1, IGF-1 receptor (IGF-1R), IGF-2, and IGF-2 receptor (IGF-2R) gene expression. Baseline and stress-induced corticosterone were measured at 4 separate time points throughout the experiment. We predicted that birds exposed to chronic stress would have reduced IIS signaling than controls. Results will be discussed within the context of life history theory.

P1-126 SISTI, AR*; JOHNSON, EL; EARLEY, RL; University of Alabama; *arsisti@crimson.ua.edu*

Maternal effects and the mismatch hypothesis: dietary exposure to endocrine disruptors in mangrove rivulus fish

Introduction of synthetic contaminants to ecosystems challenges organisms to respond to novel pollutants. 17 -ethinylestradiol (EE2) is an endocrine disrupting compound frequently found in wastewater effluent. Even trace concentrations of EE2 can induce significant phenotypic and physiological changes in fish. In wild populations, exposure to EE2 is unlikely to be confined to a single life history stage or generation. We were interested in determining the effects of compound (EE2, nonylphenol, mix) and route of exposure (water, diet, mix) on phenotypic development in juvenile mangrove rivulus (*Kryptolebias marmoratus*). We found that EE2 elicited higher liver vitellogenin (yolk protein) expression than unexposed controls, independent of route. EE2 administered through the diet resulted in fish with smaller gonads and body mass, and larger liver mass. These results suggest that EE2 has greater effects when fish are exposed through their diet than through the water, but that exposure through any route may impair reproductive function. This prompted a study of whether the environment experienced by a mother would impact offspring responses to exposure. We hypothesized that EE2 administration - via maternal exposure only, juvenile exposure only, or both - would impair growth and development compared to unexposed controls. We also hypothesized that the extent to which such impairments manifest will depend on whether juvenile and maternal exposure regimes match or mismatch. Offspring of exposed and unexposed fish were randomly assigned to an exposure environment that either matched or mismatched their mother's. Growth, behavior, liver vitellogenin and gonad steroid receptor gene expression, and reproductive development were quantified. Here we present preliminary findings of that work.

P2-113 SLACK, K. L.*; VANGORDER-BRAID, J.T.; SIRMAN, A.E.; HEIDINGER, B.J.; Mississippi State Universtiy , North Dakota State University ; *kls942@msstate.edu*

Does experimentally elevated stress exposure influence heterophil-lymphocyte ratios in developing chicks?

Most vertebrates respond to environmental and social stressors by increasing glucocorticoid secretion, which is expected to promote survival. However, when individuals are unable to evade stressors they can be exposed to chronically elevated glucocorticoids, which can have several negative long-term effects. One measure that may be a sensitive physiological indicator of chronic stress exposure is leukocyte counts, however this has seldom been experimentally tested. Here we experimentally manipulated chronic stress exposure in developing house sparrow (*Passer domesticus*) chicks and examined the effects on the heterophil to lymphocyte ratio (H:L ratio). After hatching, broods were split, and half of the chicks were randomly assigned to a control or chronic stress treatment. Chicks from both treatments were handled on days 2, 6, and 10 to measure growth. Blood samples were collected on day 10 to measure H:L ratios. Between days 2 and 10, chicks in the chronic stress treatment were also removed from the nest daily and exposed to restraint stress by placing them in a cloth bag for 30 minutes. We predicted that chicks in the chronic stress treatment would have a higher H:L ratio than their siblings in the control treatment. H:L ratios were analyzed blindly with respect to treatment using a compound microscope and were highly repeatable (R=.883, p=<.001). We found that although there was no effect of treatment on growth (F1,30.33=1.61, p=.21), H:L ratios were significantly higher in chicks in the chronic stress treatment than controls (F1,36=11.21, p=<.001). This study suggests that chronic stress increases the H:L ratio and that the H:L ratio may serve as a sensitive, minimally invasive tool to monitor chronic stress in developing chicks.

P1-166 SLEVIN, MC*; NIEDERHAUSER, JM; ZIADI, P; NOONBURG, EG; ANDERSON, RC; Florida Atlantic University; *mslevin2018@fau.edu*

Linking territory quality to behavioral syndromes in Bachman's sparrow

Behavioral syndromes are suites of correlated behaviors expressed within or across behavioral contexts. For example, individuals that are more aggressive when confronting rivals are often bolder when confronting novelty. We tested for a behavioral syndrome linking aggression and boldness in male Bachman's sparrows (*Peucaea aestivalis*) and asked whether these traits correlate with aspects of territory quality. We predicted that 1) males that were more aggressive in response to rivals would also be bolder when approached by a human, and 2) aggression/boldness would show a positive relationship with territory quality. We studied male sparrows breeding in Jonathan Dickinson State Park, Florida, USA from March - July in 2018. For each male we measured boldness (flight initiation distance) and aggressiveness (proximity to a sparrow decoy and song playback during a simulated territorial intrusion) to test for positive association between these traits. We also mapped each male's territory and assessed various metrics for territory quality. Our analysis involves generalized linear models describing the relationship between behavioral traits (boldness and aggression) and territory characteristics. Our results will add to an understanding of how behavioral traits and their resulting social dynamics shape how individuals sort in a population, with the aim of connecting our results to conservation practices. Because behavioral syndromes can predict how individuals respond to environmental stimuli (e.g., food shortage, increased predation threat), habitat management strategies may favor individuals with certain behavioral syndromes, thus affecting how the population responds to conservation efforts.

P1-238 SMIRNOFF, DS*; GOSLINER, TM; Cal Academy of Sciences; *dsmirnoff@calacademy.org*

More Robust Phylogenetic Data Reveal Cryptic Clade and Species Diversity within the Nudibranch Family Goniodorididae

Much evolutionary, ecological, and biodiversity research depends on an accurate understanding of species relatedness and robust phylogenies. Such an understanding is hindered by lack of observations, sampling, and misidentifications based on morphology alone. The presence of pseudocryptic and cryptic species often complicates this matter further. The addition of molecular characteristics has lead to the reinforcement as well as the restructuring of established systematic relationships. With more than 3,000 named species, nudibranchs are a group of commonly studied, shell-less marine gastropod molluscs; yet many clades remain unstudied. For the nudibranch family Goniodorididae, there has been no comprehensive phylogenetic analysis using molecular data. This study investigates the molecular phylogeny four of this family's major genera: *Goniodoridella*, *Goniodoris*, *Okenia* and *Trapania*. By incorporating partial sequences of the molecular marker 18S into an existing data set of COI, 16S, and H3 sequences, we present several well-supported clades that have profound bearing on the nomenclature of this family. Our analysis confirms *Trapania* as a monophyletic genus, with strong support for biogeographically based clades within the Indo-Pacific, Eastern Pacific, and Atlantic. Contrary to their presumed monophyly, our data reveal confusion among *Goniodoris*, *Goniodoridella*, and *Okenia*. Nomenclature adjustments, identification of cryptic species, and confirmation of new species identification have brought to light previously unknown clades at the genus level. Our results continue to elucidate fundamental evolutionary relationships in the family Goniodorididae and lay a foundation for future evolutionary, ecological and conservation biology research.

P3-134 SMITH, EB*; TSUNEKAGE, T; LEVIN, II; Agnes Scott College; *esmith@agnesscott.edu*

Do Barn swallows (Hirundo rustica erythrogaster) leave a signature maculation pattern on their eggs?

Eggshells of many bird species have distinctive maculation patterns that have led biologists to pose a number of adaptive hypotheses. The signature hypothesis proposes that eggshell patterns allow females to recognize their own eggs in the face of inter- and intraspecific brood parasitism. In barn swallows (*Hirundo rustica erythrogaster*), which are colonially nesting passerine birds, 17% of nests are subject to intraspecific brood parasitism. Our research aims to better understand the range of maculation patterns on the surface of barn swallow eggs. We asked whether eggs in the same nest exhibit a "signature" maculation pattern that was quantifiably more similar to the other eggs in the nest than to eggs in other barn swallow nests. We photographed 23 clutches of eggs, and after uniformly filtering all the images, we analyzed the images in SpotEgg and NaturePatternMatch. SpotEgg quantifies many features of an individual egg, including shape of the egg and the color, shape, size, and dispersion of spots, whereas NaturePatternMatch generates similarity scores between eggs. From these data, we could identify how closely an egg resembled another egg within a given set of eggs. Based on a preliminary data set, we found that 31% of eggs matched most highly to other eggs in the nest of origin, and 54% of eggs included an egg from the nest of origin among the top three best matches. Our work revealed substantial variation in egg maculation patterns among barn swallow clutches which may provide evidence for the signature hypothesis.

P2-52 SMITH, TD*; MCBURNEY, DM; REHOREK, SJ; SMITH, Timoth; Slippery Rock University, NEOMED, Slippery Rock Univ; *timothy.smith@sru.edu*

Presence of lipocalin in the vomeronasal gland of primates: a preliminary study.

The enigmatic Harderian gland (HG), an orbital gland, is connected to the vomeronasal organ (VNO: an accessory olfactory organ) via the nasolacrimal duct (NLD) in many tetrapod vertebrates. Though not all three are always present, at least one is found in any given tetrapod clade. When fully connected (snakes and frogs), the secretions of the HG pass though the NLD and into the VNO, presumably to act as a solvent for odorants. In primates and other mammals, the NLD no longer connects to the VNO. Instead, it is reduced to a vertical canal ending in the inferior meatus (e.g., monkeys), or it drains orbital fluids toward the external nose (e.g., lemurs and lorises). Whether the VNO still requires access these fluids (e.g., through the nasopalatine duct) is unclear. Yet, an alternative exists since the VNO has co-opted nearby nasal septal glands into vomeronasal glands. Very little is known about the structure, function or composition of such gland secretions. Tear specific lipocalin (TSL), an antimicrobial binding protein, has been identified in the orbital fluid of various tetrapods. By using immunohistochemical techniques, we found TSL present in the vomeronasal glands of three New World monkeys (marmoset, tamarin and black-headed spider monkey). In strepsirrhine primates, however, the TSL reactivity ranged from light staining (fat-tailed dwarf lemur, ring-tailed lemur, bushbaby and potto) to absent (loris). The precise role of TSL in the vomeronasal system remains to be determined. However, it is striking that TSL reactivity was stronger and more consistent in New World monkeys, all of which lack any route for HG secretions to reach the VNO.

P1-68 SMITH, LB; ANDERSON, CV; ROBERTS, TJ; LIEBL, AL*; LIEBL, Andrea; University of South Dakota, Brown University; *Andrea.Liebl@usd.edu*

Transcriptome Gene Expression and Muscle Performance in Anolis Lizards

Animal muscles are exceptionally diverse in structure and function as they meet a variety of demands for an individual's survival. Through natural selection, muscles develop to meet these demands. Additionally, however, individual muscles may vary in gene expression to best suit each of their roles in promoting organism survival. *Anolis* lizards display remarkable diversity in terms of number of species, ecotypes, and geographic locations into which they have radiated. Additionally, their muscles have been shown to exhibit variation in performance (e.g., peak contractile velocity) among muscle types. Specifically, the contractile performance of jaw and leg muscles, likely influenced by natural selection because of their use in survival (e.g. to escape predation and to bite prey), have been shown to vary both across and within individuals. However, the differences in the molecular mechanisms underlying the variation of the metabolic and mechanical properties between the jaw and leg muscles are largely unknown. Here, we used RNA-seq to measure gene expression of jaw and leg muscles from *Anolis* lizards. Gene networks have been identified differentiating the two types of muscles. This data may allow us in the future to compare gene expression differences between the muscles with differences in muscle (e.g. twitch time and peak contractile velocity) and whole-organism (e.g. bite force and sprint speed) performance to elucidate the molecular mechanisms that create variation in performance in anoles.

P1-22 SMITH, SK*; PHELPS, SM; Univ. of Texas, Austin; *samksmith@utexas.edu*

Vocal Morphology and Elaborate Display Behavior in Singing Mice

Elaborate displays are pervasive across the animal kingdom and although much work has explored their ultimate explanations, less attention has been given to the mechanisms underlying them. How does morphological adaptation enable display elaboration? We examine this question using Alston's singing mouse, *Scotinomys teguina*, a murid rodent that produces a highly elaborate, sexually dimorphic song used in mate attraction and male-male competition. Notes are more rapidly repeated, have a lower frequency, and span a greater frequency range than other rodents' vocalizations. For example, the Northern pygmy mouse, *Baiomys taylori*, belongs to a sister genus and their songs include slower, less dramatic, and entirely ultrasonic frequency modulation. Laboratory mice, *Mus musculus*, make highly frequency modulated notes but in a narrower frequency band and entirely ultrasonic. To examine whether changes in larynx morphology underlie these behavioral differences, we characterize species differences in collagen, elastin, and glycosaminoglycan abundance in the vocal folds using Masson's Trichrome, Verhoeff-Van Gieson, and Alcian Blue stains of laryngeal sections. Initial results show all three species have dense bands of elastin and collagen in deep layers and glycosaminoglycans in superficial layers of the vocal folds. Compared to pygmy mice, *S. teguina* vocal folds seem to exhibit hypertrophy and have a vocal membrane, a structure not present in many rodents, but that has evolved independently in at least four mammalian orders. We are now performing more exhaustive morphometric studies of species differences in larynx structure, along with μCT imaging to relate larynx morphology to other aspects of the vocal and respiratory tracts. This work lays the foundation for understanding what morphological innovations contribute to *S. teguina* song elaboration.

P1-210 SMOOT, SC*; ZOHDY, S; SCHWARTZ, TS; WILSON, AE; Auburn University; *scs0051@auburn.edu*

Meta-analysis of publication year and latitude on the Dilution Effect Hypothesis

The Dilution Effect (DE) hypothesis has played a central role in disease ecology as a way to describe the likelihood of zoonotic disease emergence. The DE states that infectious diseases are less likely to emerge in communities with rich biodiversity because more species diversity can act as a buffer, diluting the number of infected individuals and protecting against emerging infections. The objective of this project was to analyze whether the heterogeneity observed in conclusions in DE hypothesis-based research could be explained by moderators like year of publication and latitude. We performed a meta-analysis using a previously published dataset by Civitello et al. 2015 on vertebrate and invertebrate animal systems and excluded plants. Year of publication could explain some of the variation and graphically reflect changes over time. We were particularly interested in investigating whether there were more studies published supporting the DE hypothesis, since its introduction in the year 2000, suggesting publication bias. A total of 101 animal studies were analyzed using Odds Ratio as the effect size to examine the effect of year of publication estimated 0.0608 (SE=0.025) with marked large heterogeneity (I^2=90.30%) using the random effects model. A smaller subset of 25 field studies were used to examine the effect of latitude. We found no significant effect of year of publication or latitude in the smaller data subset. The effect of publication year was significant (p-value = 0.0152) in the full dataset, with an increase in each year more likely to publish research rejecting the DE hypothesis, suggesting potential publication bias in support of the DE hypothesis soon after publication. These results suggest that caution should be taken when implying the DE hypothesis in management decisions based on science conducted more than ten years ago.

P1-172 SNEKSER, JL*; DIESTLER, E; WYNNE, RD; LIU Post, St. Thomas Aquinas College; *jennifer.snekser@liu.edu*

Sex differences in zebrafish shoaling behavior: Are stress and cortisol the underlying proximate mechanism?

Understanding the social behavior of animals involves the integration of ultimate and proximate explanations. Evolutionarily, the social choices made by individuals are vital to their survival and reproduction. The ultimate evolutionary explanations of social behavior have been well-supported by numerous empirical studies: one or more of the animals involved in the social interaction experiences some benefit. Determining the proximate mechanisms of affiliative behaviors are a bit more complex. Cortisol expression has been suggested, as social contact, or the lack thereof, is often associated with the stress response. Interestingly, studies have also indicated significant sex differences in measured cortisol levels. Our goal is to utilize zebrafish (*Danio rerio*) to determine if the expression of social behavior is related to differences in cortisol levels. We have found that while both sexes readily shoal with groups of zebrafish rather than spend time alone, significant sex differences are apparent when examining specific aspects of shoaling choices, related to shoal size and body coloration. We are currently using a water-borne hormone extraction protocol and EIA to determine how these real-time shoal choice behaviors, and the observed sex differences, correlate with endogenous cortisol expression.

P1-101 SNYDER, N M*; DICKERMAN, L D; REED, W L; North Dakota State Univ., Univ. of Minnesota Duluth; *nicole.snyder@ndsu.edu*

Seasonal trends in nesting physiology of adult Laughing Gulls (Leucophaeus atricilla)

Timing of breeding can be important indicator of offspring phenotype & survival in many regions. Offspring produced later in breeding season typically suffer lower survival. Because strong selection is associated with timing of breeding I expect breeding adults to have evolved mechanisms to respond to cues of season & therefore moderate seasonal cues they give to their offspring. Again, because strong selection exists, I expect offspring to also evolved mechanisms to receive, interpret, & respond to cues from both their mothers & environment. We are providing a tractable system to understand how organisms integrate these cues & communicate environmental information. Birds are often seasonal breeders making good models for exploring seasonal effects on timing of reproduction & development. In seasonal breeders, I hypothesize adults adjust offspring phenotype (i.e. egg shape, size, embryo growth) in accordance to timing of breeding, not solely to adult condition. I hypothesize their offspring integrate cues of season from environment (photoperiod) & mothers (hormones), resulting in seasonally different phenotypes (growth & hatch survival) adaptive for the timing of breeding season. To test these predictions, we monitored a breeding colony of Laughing Gulls (*Leucophaeus atricilla*). We observed nest initiation & egg laying. We trapped adults on observed nests to gather information about the breeding adult's condition & physiology. Further, we collected first-laid eggs across the nesting season & incubated the eggs under experimental photoperiods (14 hr vs. 18 hr of light) to evaluate hatched chick phenotypes. By integrating seasonal information from adult, egg, & chick, we provide insight on the underlying mechanisms evolved to regulate offspring phenotype.

P2-25 SOCKI, FM*; PANHUIS , TM; Ohio Wesleyan University, Delaware; *francesca.socki@gmail.com*

Comparative Histological Investigation of the Ovarian and Placenta Structure in The Viviparous Fish Genus Poeciliopsis

Across the fish genus Poeciliopsis there are varying degrees of placentation, determined by the amount of continued maternal nourishment provided to the embryo after fertilization. This placenta variation can be studied using a morphological approach to examine the placenta structures involved in maternal-fetal nutrient exchange. Possible comparative features include the maternal follicle that surrounds the developing embryo, the amount of yolk present in the yolk sac of embryos, and embryo structures potentially utilized for nutrient absorption. Recent comparative morphological studies in Poeciliopsis have used scanning electron microscopy techniques, finding surface features of the maternal follicle and embryos that vary across species. We present a preliminary histological analysis that compares the gestating ovaries from four different species of Poeciliopsis representing placentation variation. Histological slides were previously prepared from fixed, embedded, sectioned, and hematoxylin and eosin stained gestating ovaries of Poeciliopsis gracilis, P. infans, P. prolifica, and P. turneri. Slides were observed at 40x under light microscopy and digital images were captured using the program Infinity Analyze. We are in the process of creating an extensive digitized collection and panoramic images of entire ovaries. With these panoramas we have begun to grasp a clearer picture of the overall features of the ovary, embryos, maternal tissues and cellular structures. We are currently using these images to determine which ovarian and placenta structures to compare across species. Once determined, future microscopy at higher magnification will enhance our understanding of the evolution of placentation in Poeciliopsis.

P2-31 SOKOLOV, E; MARKERT, S; HINZKE, T; SOKOLOVA, IM*; Leibniz Institute for Baltic Sea Research, University of Greifswald, University of Rostock; *inna.sokolova@uni-rostock.de*

Proteomic rearrangements underlie mitochondrial responses to intermittent hypoxia in a hypoxia-tolerant marine bivalve Crassostrea gigas

Oxygen variability represents a major stressor for aerobic organisms, and mitochondria are the main target of hypoxia-reoxygenation (H/R) injury. Many hypoxia-tolerant species such as intertidal bivalves are adapted to frequent and drastic oxygen fluctuations, but the mechanisms allowing their mitochondria to maintain integrity and function under these conditions are not well understood. We investigated the effects of H/R stress (24 h of hypoxia followed by 1 h of recovery) on mitochondrial (phospho-)proteome in an intertidal bivalve, the Pacific oyster *Crassostrea gigas* . Oyster mitochondria showed functional robustness maintaining oxidative phosphorylation capacity and mitochondrial membrane potential during H/R stress. The functional stability of oyster mitochondria associated with rearrangements of mitochondrial proteome and phosphoproteome that started in hypoxia but became considerably more pronounced during reoxygenation. Exposure to H/R stress upregulated mitochondrial electron transport system proteins (most notably Complexes I and IV), suppressed pathways channeling electrons to ubiquinone, stimulated mitochondrial quality control mechanisms and modulated protein synthesis and transport pathways. These shifts in the mitochondrial proteome may play an important role in adaptive responses to intermittent hypoxia in oysters complementing adaptive shifts in anaerobic metabolism and metabolic rate depression.

P1-145 SOLIS, GM*; HUSAK, JF; Univ of St. Thomas; *soli8428@stthomas.edu*

Effects of arginine vasotocin and mesotocin on aggression in male Caribbean Anolis lizards

Although testosterone (T) is typically a primary mediator of male aggression in lizards, Caribbean *Anolis* lizards do not all seem to follow the rule of more testosterone-more aggression. We manipulated non-steroid hormones to determine what might mediate behavior in a low-T-high-aggression species (*Anolis sagrei*), as well as to determine whether similar responses would be observed in a high-T-high-aggression species (*A. cristatellus*). Following a 3-week period of acclimation in the laboratory, 17 male *A. sagrei* and 14 male *A. cristatellus* were randomly assigned experimental groups (arginine vasotocin, mesotocin, or saline IP injection), using standard doses. Behavioral responses to a mirror were video-recorded for 20 min after a 15-min acclimation period. Analysis of the responses noted the type(s), frequency and duration of aggressive bouts for each individual. We then compared the experimental groups to the controls before making a comparative analysis between the species. In *A. sagrei*, mesotocin-injected lizards tended to be less aggressive than the other treatments, but much more variable. In *A. cristatellus*, mesotocin-injected lizards also had more variable responses, but they tended to be more aggressive than the other treatments. Our results suggest that more than just T signaling may be responsible for variation in aggression among Caribbean anole species.

P2-224 SOLLA, A*; O'ROURKE, CF; RENN, SCP; Reed College; *sollaau@reed.edu*

Fish Don't Care About Your Gender Assumptions: Genital Morphology of Three Cichlid Fishes

The *Julidochromis* genus of African Rift Lake cichlids provides an excellent opportunity to investigate differences in social role between closely-related taxa. Previous work has been focused on describing the social roles of two species in the genus; *J. marlieri* females are socially and reproductively dominant, whereas *J. transcriptus* females display the reverse social pattern. Based on work done in non-fish systems that showed differences in genitalia based on social role, we performed a morphometric analysis on the genital papillae of both sexes of *J. marlieri* and *J. transcriptus*, to determine if the differences in social roles were reflected in genital morphology. We performed the same analysis on the lekking species *Astatotilapia burtoni*, which was used as an outgroup for taxonomic distance and behavior. *J. marlieri* displayed clear dimorphism between the sexes, while *J. transcriptus* displayed ambiguous genital structures; the strong dimorphism in *J. marlieri* may not be true sex role reversal, but suggests that sexual selection might be occurring within this species. *A. burtoni* genital morphology appeared to change based on position in the social hierarchy. To the best of our knowledge, this is the first time plasticity in external genital papillae has been documented in fish that do not change sex.

P3-8 SONG, Y*; FULL, R J; DAI, Z; Nanjing Univ. of Aeronautics and Astronautics , Univ. of California, Berkeley; *ysong_cn@berkeley.edu*

Geckos Actively Align Toes against Gravity during Sideways Wall Running

Geckos agilely maneuver on smooth surfaces using millions of tiny foot hairs (setae) that attach via van der Waals interactions. The morphological arrangement of the setae results in toes possessing directional sensitivity generating more force when pulled by the foot. Geckos tend to align their toes more vertically against gravity when racing up walls. We hypothesized that toes represent an opportunity for distributed control, whereby their alignment can be actively adjusted to remain more oriented against the gravity vector as geckos change direction on vertical surfaces. To test the hypothesis, we ran Tokay geckos sideways on a transparent acrylic wall while measuring orientation with high-speed cameras and contact area of the setae using frustrated total internal reflection. We used vertical climbing of the same individual as our control. Sideways wall running geckos aligned the toes of their top fore and hind feet against gravity, more like the toe orientation observed in the front feet during vertical climbing. Contact area was not compromised, but redistributed among toes to generate adequate forces. To further test the hypothesis, we induced slipping and discovered strong passive toe alignment against gravity. We conclude that distributing control among multiple adjustable structures can increase the effectiveness of maneuvers in complex environments.

P2-79 SOUTH, KE*; LEININGER, EC; New College of Florida; *kelly.south15@ncf.edu*

The role of laryngeal physiology in generating advertisement calls of Xenopus muelleri

Understanding the mechanisms underlying the evolution of behaviors relies on identifying modifications to neural and muscular circuit physiology. Male African clawed frogs (*Xenopus*) produce species specific advertisement calls that vary in temporal complexity. Species that produce temporally simplified advertisement calls (*X. borealis* and *X. boumbaensis*) utilize different laryngeal mechanisms for generating these calls. Unlike *X. boumbaensis*, *X. borealis* faithfully converts neural stimulation into muscle contractions that mirror call temporal patterns. To understand whether this mechanism is conserved, we examined *X. muelleri*, a species closely related to *X. borealis*, that produces advertisement calls of intermediate complexity. We identified stimulation parameters required to produce muscle contractions approximating the burst advertisement call of *X. muelleri*. After recording vocalizations from live frogs, we stimulated laryngeal nerve rootlets of the isolated larynx with stimulus bursts over a range of inter-stimulus intervals while recording electromyograms and tension from the laryngeal muscle. Stimulus bursts delivered to the larynx with inter-stimulus intervals (50 - 60 ms) longer than the average inter-pulse interval recorded from intact frogs (45 ms) produced the two discrete EMG and tension transients necessary for a burst call. However, stimulus bursts delivered to the isolated larynx with shorter inter-pulse intervals (20 - 40 ms) resulted in maintained tension, which would correlate to producing a single sound pulse rather than a burst. These results confirm that *X. muelleri* displays faithful conversion of neural stimulation to muscle contractions, but can only do so at intervals at or longer than those of *in vivo* calls.

P1-260 SPOONER, HC*; HERNANDEZ, GV; BURRIN, D; MAJ, MA; MANJARIN, R; BLANK, JM; California State University, San Luis Obispo, Baylor College of Medicine, Houston; *hspooner@calpoly.edu*

Intramuscular Lipid Accumulation in a Pig Model of NAFLD

This study is part of a project to develop a model for pediatric non-alcoholic fatty liver disease (NAFLD) using leptin resistant neonate pigs. NAFLD is characterized by a build up of lipids in the liver related to insulin insensitivity. In the skeletal muscles of humans, rats, and pigs, insulin insensitivity is known to be accompanied by an increase in intramuscular fat, both between muscle cells and inside the cells. Since skeletal muscle normally uses the greatest proportion of the body's dietary lipids, this build up indicates that lipids are being stored instead of oxidized, leading to further build up in other places. The purpose of this experiment was to quantify the lipid accumulation in muscle of high-fat fed pigs compared to control animals and to assess changes in muscle fiber composition in response to the diet. 10 day old piglets were allocated to either control or high-fructose high-fat diet for 10 consecutive weeks. On week 10 animals were euthanized and longissimus dorsi, gastrocnemius and soleus were collected for histology and immunohistochemistry analysis. Tissue sections were stained for lipid with the oil red O stain. Lipid deposition was analyzed based on stain intensity, number of cells stained, and extracellular lipid deposit areas. The results are discussed in the larger context of previous research and the overall project. Funding from ARI#58873, STRIDE#35466

P1-8 STAAB, KL*; MARTINSON, HM; SCULLION, J; McDaniel College; *kstaab@mcdaniel.edu*

A framework to incorporate collaborative research on habitat health in the undergraduate classroom

We piloted a course-based undergraduate research program assessing ecosystem health in a restored stream. Freshwater ecosystems are sensitive to anthropogenic changes and while restoration efforts are noble, measurements of ecosystem function are often superficial rather than integrated. With funding from HeidelbergCement through the Quarry Life initiative, we infused authentic research projects into three upper-level courses: Conservation Biology, Ecology, and Animal Physiology. Our model is flexible to serve as a template for partnerships between industry and small undergraduate institutions to assess effectiveness of habitat restoration. Each course used complementary methods to examine presence, abundance, physiological condition, and activities of animals at restored sites to identify functional indicators of habitat health, contributing to an integrative robust assessment. Students in Conservation Biology deployed camera traps to assess presence, diversity, and behaviors of terrestrial mammals in the ecosystem, while students in Ecology examined plant communities and invertebrate abundance and diversity. Students in Animal Physiology assessed health metrics of fish living in the stream. Each student group developed their own hypotheses, research design, and data analysis under this framework resulting in high-impact outdoor learning. Because small schools are often resource-poor or lack field sites, we see mutualistic benefits in collaboration with green-minded industry partners. We propose that professors anywhere, in differing areas of expertise (e.g., chemistry, microbiology, geology) can integrate research into classes by incorporating small changes that not only increase productivity for industry partners, but also broaden participation in undergraduate research.

P3-46 STEVENSON, JPJ; CHENEY, JA*; DURSTON, NE; USHERWOOD, JR; WINDSOR, SP; BOMPHREY, RJ; Univ. of Bristol, UK, Royal Vet. College, Hatfield, UK; *jcheney@rvc.ac.uk*

Pose and shape changes of avian flight surfaces for control

Birds control their flight by changing the orientation (pose) and shape of their wings and tail. There is a large combination of parameters that can be altered, and the way in which these are coordinated to achieve specific flight trajectories is not well understood. To gain insight into these control strategies, we reconstructed time-resolved point-cloud sequences of falconry birds making fine changes to their flight surfaces as they glided down a straight corridor. The point clouds were derived from disparity maps between high-speed cameras positioned above and below the flight test region. We report on changes to the pose and shape of the birds, and assess whether coordinated wing-tail movements exhibit consistency and covariance.

P1-112 STEELE, A*; LANGRO, J; HUNTER, T; LYNCH, KS; Hofstra University; *asteele1@pride.hofstra.edu*

The role of prolactin in female brown-headed cowbird responses to nestling begging stimulus

Nearly 1% of all bird species are obligate brood parasites. Obligate brood parasites do not build their own nests, incubate their own eggs or provision their own young. Recent results from our lab reveal that a critical maternal care-related brain region exhibits prolactin transcriptome insensitivity. Here, we further examine the effects of prolactin on brain and behavior of brood parasites. Adult female brown-headed cowbirds (Molothrus ater), a brood parasite ubiquitous across North America, were treated with either estrogen, estrogen + prolactin or saline as a control. We measured behavioral response of females in these treatment groups in a dichotomous choice test in which random tones and nestling begging sounds were broadcast. Immediately following behavioral measures, female subjects were placed in soundproof auditory chambers and exposed to random tones or nestling begging sounds to examine neural responses to these auditory stimuli among the treatment groups. Behavioral result revealed no significant difference across treatment groups in time spent near nest, time spent on nestling begging side or time spent on nest/control cup. In addition, no significant difference was observed within each treatment group in the time females performed these behaviors simulated nestling/nest side of the chamber as compared to the random tone/control cup side of the chamber. Examination of neural responses to random tones or nestling begging in treated and non-hormone treated females will determine whether a combination of auditory stimuli and hormone treatments also exhibits prolactin insensitivity. We are repeating these same tests in a closely related non-parasitic species (i.e. red-winged blackbird; Agelaius phoeniceus) to determine if these same measures do exhibit prolactin sensitivity in a maternal species.

P1-28 STEWART, MS*; KRUPPERT, S; SCHMITZ, L; SUMMERS, A; Scripps College, Univ. of Washington, Claremont McKenna College; *morganstewart012@gmail.com*

Written in Bone: Damage Patterns in Agonopsis vulsa Armor Plates

Armor, in the sense of heavy plates or scutes, has evolved many times in fishes suggesting a common selective pressure or many different selective pressures. In the engineering world armor can defend against impact, abrasion, cutting, and/or crushing. In the realm of biology we must add display, offensive battery, and ritualized combat to the functions of armor. Here we explore the notion that looking at the damage pattern on armor over ontogeny can reveal something of function. For example, armor that is unscathed from birth to death likely serves only as display, else it would bear the marks of use. We used the Northern Spearnose Poacher (*Agonopsis vulsa*), a heavily armored benthic fish, belonging to the family Agonidae. *A. vulsa's* bony scales preserve damage incurred during the fish's life. Using CT scans and digital 3D modeling, a categorical systemization of damage was created, assigning values to specific degrees of macroscopic damage. These degrees of damage were investigated before data collection through observation of many scales, both damaged and undamaged. To ground truth damage modes scales were intentionally damaged (shattered, abraded, snapped, and crushed) and observed using SEM. Categories of damage were designated as caused by impact (mild or severe breakage) or caused by abrasion (mild or severe wear). This systemization was applied to 34 *A. vulsa* specimens ranging in trunk length from 2.3 cm to 14.2 cm. Large fish (over 9 cm) and small fish (under 9 cm) showed different patterns of impact damage locations along the fish. Large fish also showed significantly more abrasion damage. These patterns of damage may provide new insights into the life history of this small, largely unstudied fish.

P3-17 STEWART, TA*; AIELLO, BR; GAU, GF; BHAMLA , S; SHUBIN, NH; University of Chicago, Georgia Institute of Technology; *tomstewart@uchicago.edu*

The convergent evolution of blinking in mudskippers and tetrapods

Approximately 360 million years ago, tetrapods colonized the terrestrial environment. This water-to-land transition is marked by a suite of behavioral and morphological adaptations. Among these, was the origin of blinking - the periodic occlusion of the eye by one or more membranes. Blinking behaviors coat the cornea in a liquid film, which is critical for epithelial cell health, lubrication, and cleaning the eye of debris. Mudskippers (Oxudercidae) are a second lineage of fishes that have evolved to spend the majority of their day on land. Here we describe how mudskippers have evolved the ability to blink, convergent with tetrapods, by studying the Indian mudskipper *Periophthalmus septemradiatus*. High speed kinematics show that the eye is retracted ventrally and this displaces the dermal cup (an epithelial fold analogous to the lower eyelid of tetrapods), which moves dorsally to cover the cornea. Rates of blinking are associated with ambient humidity, indicating the behavior functions for eye-wetting. To characterize how this anatomy has evolved, we compare *P. septembradiatus* with the closely related fully-aquatic round goby, *Neogobius melanostomus*; specimens were soft-tissue contrast stained by phosphomolybdic acid and CT-scanned. We also describe histology of the eyes and the dermal cup, which reveals that, unlike extant tetrapods, mudskippers lack associated 'tear' glands. Collectively, these behavioral and anatomical data show how complex behavior, such as blinking, can occur in systems that are unexpectedly simple (i.e., without new associated musculature or glands), and this informs the range of strategies that could have been deployed during initial stages of the water-to-land transition of tetrapods.

P1-110 STIERHOFF, ES*; CARPENETTI, JM; BUTLER, MW; Lafayette College, Easton, PA; *stierhoe@lafayette.edu*

The Relationship Between Degree of Immune Challenge in House Sparrow Nestlings and Parental Feeding Behavior

Ecoimmunologists model bacterial infection in free-living animals using lipopolysaccharide (LPS), a macromolecule found in bacterial membranes, but the concentration of LPS varies among these studies. It is unclear what dose triggers a response that is most reflective of the natural avian response to pathogens. Additionally, little is known about how immune challenges may alter parental feeding behavior. To test how the dose of LPS administered to nestlings influences parental provisioning, we injected house sparrow nestlings with either 0, 0.01, 0.1, or 1.0 mg LPS per kg body mass prior to fledging. We conducted behavioral observations three times per nest: 18 h pre-injection, 6 h post-injection, and 30 h post-injection. We observed each nest for one hour and recorded the number and duration of parental visits and sex of the parent during each visit. Preliminary analyses suggest that there were no differences in feeding rate 6 h post-injection in response to LPS doses. However, parental feeding rate after 30 h was higher for nestlings injected with 0 or 1.0 mg LPS per kg body mass than it was for nestlings injected with 0.1 and 0.01 mg LPS per kg body mass. These findings suggest that house sparrow parents alter their feeding rate based on the degree of immune challenge experienced by their nestlings. It is possible that the highest dose initiates a more rapid immune response, which is thus completed more quickly, whereas the lower doses incite a less intense but longer immune response, so nestlings reflect longer-lasting sickness behavior, such as decreased begging. The variability of parental behavior in response to LPS dose in nestlings stresses the importance of using various LPS concentrations in ecoimmunology studies.

P2-58 STILSON, K/T*; ROSS, C; REED, D; The University of Chicago Department of Organismal Biology and Anatomy, The University of Illinois at Chicago College of Dentistry; *kstilson@uchicago.edu*

Periodontal ligament innervation in Didelphis virginiana informs the study of neuronal function and evolution at the Eutherian-Metatherian split

The periodontal ligament (PDL) is a network of unmineralized collagen fibers that connects teeth to alveolar bone, the innervation of which transformed teeth into multimodal sensory structures that transduce and integrate sensations of pressure, vibration, pain, and temperature to the cortex. This evolutionary innovation occurred in concert with other dramatic changes in the orofacial skeleton such as the emergence of heterodont dentition and expanding brain. The metatherian opossum, *Didelphis virginiana*, is a key phylogenetic comparison to the well-studied eutherians because it is an omnivore, heterodont, and retains a PDL. Here we identify and map individual nerve types and locations in the lower first molar of *D. virginiana* using immunofluorescence. Glial and glial-related cells that surround neurons were immunolabeled with S100, SMI 312 and NF-M, and PGP 9.5 and imaged with a confocal microscope. PDL collagens were quantified using picrosirius Red (PSR). PSR revealed that the majority of collagen fibers are oriented in a dorsomedial "sling". Immunolabels showed neurons running dorsoventrally (DV) in neurovascular bundles and parallel to both the alveolar socket and tooth root. Other nerve bundles appear to be Golgi-Mazzoni corpuscles, very thin corpuscles, and free nerve endings. Innervation of the PDL in opossums shows a DV organization more analogous to nerves seen in eutherian carnivoran incisors than in the molars of their omnivorous counterparts. This suggests the last common ancestor of Eutheria and Metatheria, ~150 million years ago, had a conserved PDL structure and DV organized neurovascular structure, the function of which we will be testing in future research.

P1-7 STINSON, CM; California State University, Bakersfield; *cstinson4@csub.edu*

Incorporating Ethics Into Introductory Biology and Human Physiology Curriculum

Working in public forums or in health professions, it is critical to have an understanding of and road map for navigating ethical issues. While teaching courses in Human Physiology and Introductory Animal Biology, I introduced a module to discuss the importance of ethics in our personal and professional lives. Students utilized the Rutland Model to identify ethical issues in case studies and "sticky situations", analyzed why a given situation may involve ethics, justified responses to the issue, and ultimately decided on their course of action. These activities required students to think critically about plausible situations they may encounter in the work place while building on their current knowledge base from the course. Communication skills were enhanced through various group discussions, as well as through a written reflection on the scenarios. Overall, by adding this module to multiple courses students have been able to apply the standard course material to more "real world" situations and have built a foundation to use ethical assessments in their future professions. These activities allow students to become further invested in the material, and because there are often multiple correct answers to the situations proposed, students actively shared their opinions and responses to the scenarios at hand.

P1-62 STOKES, KA*; DIMITRI SKANDALIS, ; JIMMY LIAO, ; University of Utah, University of Florida; *katieannestokes@gmail.com*

Chronic stimulation during larval zebrafish development affects startle response

In stress disorders such as PTSD, chronic exposure to a threat stimulus results in sensitization or hypervigilance. Much remains unknown about the neurophysiological mechanisms underlying this phenomenon. The genetic tools and robust startle response of the zebrafish make it a tractable model to study the molecular basis of stress-induced behavioral changes. In zebrafish, the lateral line is a structure containing hair cells, sensory receptors that allow the fish to sense the flow of surrounding water. This mediates a startle response wherein a hydrodynamic stimulus is perceived as a threat. The startle response behavior demonstrates an intensity-dependent relationship where the magnitude of the stimulus and latency of response are inversely related. This project aims to explore how the established relationship between the intensity of stimulus and latency is affected by chronic stimulation of the lateral line during early larval development. To test this paradigm, we used transgenic zebrafish containing blue light-sensitive channelrhodopsin-2 (ChR2) in hair cells of the lateral line. Administration of blue light stimulus allowed for remote activation of the lateral line via depolarization of hair cells mediated by ChR2. The latency and probability of startle response were recorded using a high-speed camera. The data showed no significant relationship between the intensity of stimulus and response latency or probability, though significant improvements can be made in experimental design. Although results from this study were inconclusive, further study may indicate a level of developmental neuroplasticity in the mechanosensory system of larval zebrafish and illuminate the neural mechanisms underlying stress-related behavioral response.

P2-222 STORCH, JS*; STAAB, KL; BETANCUR-R, R; HERNANDEZ, LP; The George Washington University, Washington, DC, McDaniel College, Westminster, MD, University of Puerto Rico - Rio Piedras, San Juan, Puerto Rico; *jdstorch@gwu.edu*

Driving the Power Stroke of Premaxillary Protrusion: The Evolution of Diverse Cranial Musculature in Cypriniform Fishes

Cypriniform fishes comprise over 25% of the world's freshwater species. These fish exhibit a suite of morphological novelties--including kinethmoid-mediated premaxillary protrusion, a muscular palatal organ, and the loss of oral teeth--associated with feeding and occupy a variety of trophic niches. Diverse morphology within the trophic apparatus provides a biological model with which we can investigate the evolution of complex systems. Prey capture is effected by protrusion of the premaxilla. Are there as many ways to drive this effector as there are targets? We survey the anatomical diversity of the A1 division of the adductor mandibula muscle in Cypriniformes. We interpret these morphological data using a functional lens to characterize diversity in this element of the trophic apparatus. We use phylogenetic comparative methods to reconstruct the evolutionary history of trophic morphology in cypriniform fishes and to investigate the role morphological diversity plays in supporting trophic diversity across this group. Specifically, we demonstrate the early recruitment of protrusile morphology for post-capture prey processing and transport associated with benthic feeding modes. We expect strict suction performance to be constrained by the integration of protrusile morphology with other functional elements of the trophic apparatus.

P2-2 STUBBS, RL*; THEODORIDIS, S; KELLER, B; CONTI, E; University of Zurich, University of Copenhagen; *stubbsrl@ufl.edu*

The evolutionary roles of hybridization and introgression: investigating species and genomic boundaries using the model plant system Primula (Primulaceae)

Studies have suggested that parts of the genome are differentially affected by introgression as a result of hybridization, with some regions being resistant to gene flow while others are exchanged freely between related species. However, distinguishing between differential introgression and evolutionary processes, such as incomplete lineage sorting, historical gene flow, and genetic drift, that equally shape the heterogeneous genomic landscape requires the integration of both macro- and micro-evolutionary approaches, but studies are limited. To address this gap, we present the largest, most inclusive study, using the model plant system *Primula* (Primulaceae). This is being accomplished through extensive sampling spanning the entire range of our study system (~660 individuals in seven species), in conjunction with resequencing of whole genomes utilizing the high quality reference genome currently available within of study system (*P. veris*). Our downstream analyses will include both phylogenomic analyses (e.g., RAxML, ASTRAL, SNAQ, PhyloNet) and inference of ancient gene flow (ABC, ADMIXTURE). As a result of intensive sampling at multiple temporal (from phylogenomic to population genomic) and geographic scales (from allopatric to sympatric comparisons), replicate comparisons between species pairs with different strengths and directionality of crossability and reproductive isolation, and availability of a reference genome and linkage maps in the model system this research will generate new knowledge on the genomics of hybridization at levels of resolution unprecedented in plants. In total, this research will provide innovative contributions to the growing field of hybridization and speciation studies.

P1-197 STUDIVAN, MS*; VOSS, JD; Florida Atlantic University, Harbor Branch Oceanographic Institute; *mstudiva@fau.edu*

Mesophotic-omics: Integrating Transcriptomics, Transplants, & Algal Symbiosis to Understand Coral Adaptation in the Gulf of Mexico

Coral habitats are highly abundant in the Gulf of Mexico, including mesophotic coral ecosystems between 30-150 m, but there is a lack of understanding regarding the ecological roles of mesophotic corals & the functional differences among depth-generalist conspecifics. We designed an integrative approach examining transcriptomics, morphometrics, & algal endosymbionts to quantify natural variation of shallow & mesophotic *Montastraea cavernosa* colonies. RNA-Seq profiling was conducted across 4 sites with shallow & mesophotic habitats in the Gulf of Mexico & Caribbean, including Belize, Flower Garden Banks, Pulley Ridge, & Dry Tortugas. Variability across regions was a stronger driver of coral gene expression compared to differences between depth zones within regions. Metabolic gene pathways were consistently under-expressed at depth, while cell division pathways were highly expressed & may reflect increased algal symbiont density in mesophotic corals. Additionally, transplant experiments at the Flower Garden Banks identified plastic gene expression within 6 mo. after relocation across depth zones. During a bleaching event at 12 mo., we observed lower stress resilience in transplants from mesophotic to shallow depths as compared to shallow controls. However, gene expression during bleaching suggested potential metabolic & symbiont recovery in transplants and was corroborated by follow-up observation at 36 mo. This integrative study provides a better understanding how variation in gene expression can contribute to corals' flexibility in different environments. Knowledge of coral adaptation to light-limited environments can improve predictions regarding the roles mesophotic coral ecosystems may play in survival of shallow coral reefs.

P2-101 SUMMERS, R.R.*; BAKER, D.M.; University of Mary Washington; *rsummers@mail.umw.edu*

Embryonic Development of the Stress Hormone Axis in Two Model Teleost Species

Glucocorticoid hormones mediate stress responses in all vertebrates, from teleost fishes to mammals. In teleosts the primary glucocorticoid, cortisol, is synthesized by the interrenal gland via a series of enzyme-mediated reactions. Cortisol synthesis in adults is controlled by hormones produced via the hypothalamic-pituitary-interrenal (HPI) axis in response to stressors. The hypothalamic peptide corticotropin-releasing hormone (CRH) stimulates release of the pituitary protein adrenocorticotropin hormone (ACTH), which stimulates interrenal cortisol production. Cortisol exerts its effects on target cells via two types of receptors, the glucocorticoid receptor (GR) and mineralocorticoid receptor (MR). The timing and sequence of events that leads to a functioning HPI axis in developing teleosts are not fully known. To address this gap, we measured the mRNA from genes involved in cortisol synthesis and signaling throughout embryogenesis in two model fishes, the zebrafish (*Danio rerio*) and Japanese medaka (*Oryzias latipes*). We isolated RNA from embryos collected at multiple developmental stages in both species, and used qPCR to measure relative mRNA levels of key HPI axis genes, including CRH, steroidogenic acute regulatory protein (StAR), and MR. In zebrafish, MR transcript levels remained fairly constant throughout embryo development, whereas in medaka, MR transcripts increased 10-fold. Zebrafish CRH mRNA doubled from 6 hours post fertilization (hpf) to hatching (48 hpf). However, in medaka, CRH mRNA levels rose over 90-fold from 2 days post fertilization (dpf) to hatch at 8 dpf. In zebrafish, StAR mRNA levels increased 40-fold from 24 hpf to hatch, whereas levels rose only 5-fold in medaka. In conclusion, we found noteworthy differences in mRNA profiles for CRH, MR, and StAR in both species.

P3-176 SURBAUGH, KL*; ROHR, JR; University of South Florida; *ksurbaugh@mail.usf.edu*

Assessing acquired resistance of the adult Cuban Treefrog (Osteopilus septentrionalis) to the pathogenic chytrid fungus (Batrachochytrium dendrobatidis)

Emerging fungal pathogens have been proposed to be the greatest threat to biodiversity over other parasitic groups. Batrachochytrium dendrobatidis is an infectious fungal pathogen of the chytridiomycete class which has been found to be a contributing factor to hundreds of amphibian species extinctions worldwide. Because amphibians have illustrated an ability to acquire resistance to Bd, inducing resistance via treatment with flash-frozen, dead Bd may be the key to protecting susceptible populations. To determine the dose and duration of exposure necessary to induce resistance, we manipulated the duration and dose of exposure of adult frogs to dead Bd using a 5x5 response surface experimental design in the laboratory that includes the full vertical and horizontal dose and duration gradients and the four corners of the treatment matrix so that we test 13 of the 25 possible treatments. We exposed Cuban tree frogs (Osteopilus septentrionalis) to 5 levels of dead Bd, as well as a control, every other day for 1, 2, 3, or 4 weeks. After the exposures, we exposed all frogs to live Bd (1ml of 1x106 zoospores/ml) and maintained them at 18°C for two weeks in an environmental chamber. Frogs were swabbed and Bd burdens quantified by estimating the density of zoospores using a StepOne Real-Time PCR System. We hypothesize assessment of infection intensity by dose and duration will provide this missing information needed for conservation efforts.

P2-273 SWAFFORD, AJM*; OAKLEY, TH; UC Santa Barbara; *andrew.swafford@lifesci.ucsb.edu*

Opsin Family Macroevolution and the Origin of Light Sensitivity in GPCRs

Illuminating the origins and evolution of vision in animals hinges on understanding the evolution of the underlying gene families. The most crucial of these genes is the photosensitive G-protein coupled receptor (GPCR), Opsin. GPCRs are a family of diverse sensory and signaling proteins, and until recently, Opsins were thought to be the only light sensitive GPCRs. This hypothesis was supported by an ultra-conserved lysine found in all functional Opsins. The lysine allows the Opsin to bind a chromophore that induces signaling when it absorbs a photon. However, recent studies hypothesized that there are alternate binding sites also capable of facilitating retinal binding. If these binding sites exist in non-Opsin GPCRs, we must change the way we think about the origins and evolution of vision in animals. However, support for alternate binding sites in GPCRs is scarce, with only a single publication showing evidence of functional light sensitivity outside of Opsins. Here, we construct a phylogeny of GPCRs and reconstruct ancestral states to show that light sensitivity in GPCRs likely first evolved at the ancestor of Opsins and not before. However, we also find at least thirteen other independent origins of a putative light-sensitive alternate site across non-opsin GPCRs. Additionally, we investigate the broader question of how the emergence of image forming vision effects Opsin family evolution. We find that Opsins involved in image formation maintain duplicate copies at a higher rate when associated with a yet unknown character. Our results suggest that light sensitivity may have evolved multiple times within GPCRs and that Opsins emerged early as a specialized and efficient photosensor.

P2-130 SWAIN, K. C.*; LANE, Z.; ZARDUS, J. D.; The Citadel, Univ. S. Mississippi; *kswain@citadel.edu*

Barnacles in Motion: A New Method for Rearing and Maintaining Barnacles in the Laboratory

Sea turtle barnacles (*Chelonibia testudinaria*) develop through multiple larval stages in the plankton. At the final cyprid stage, the larvae search for a suitable substratum on which to settle, metamorphose, and grow into adulthood. While the larvae of many barnacle species have been successfully reared and settled in the laboratory, there has been little attention or success in maintaining adult stages *ex situ*. To address this gap and make possible studies on live adults of largely inaccessible barnacle species, we devised two apparatuses utilizing rotating PVC pipes to facilitate barnacle attachment and growth, the settlement-promoting ‘larvulator' and a grow-out tank, the ‘maturation spinner'. The larvulator operates by a motor driven, double gear system that rotates a rack of six concurrently revolving pipes within a circular chamber; whereas, the maturation spinner employs a belt and pulley system to spin pipes about their central axis, upright in a standard table-top aquarium. Each device operates on the principle of generating the effects of flow in a static chamber without needing to pump water. In the case of the epibiotic barnacle *C. testudinaria*, the PVC pipes serve as a synthetic mobile host, moving through the water. We demonstrate that these devices can be used to achieve larval settlement and growth with *C. testudinaria*. Settlement rates of this species on PVC pipes was consistently low relative to the quantity of larvae supplied, but typical settlement rates for this species remains unknown. Growth rates were similar or reduced relative to wild populations, but we were able to maintain adults on pipes in excess of two years. Increased understanding of larval and adult barnacle diets may improve outcomes but our methodology presents a viable way to grow adult barnacles in the laboratory.

P3-124 SWALL, M.E.*; BENRABAA, S.A.; MYKLES, D.L.; Colorado State University; *mswall@rams.colostate.edu*

Characterization of Shed genes in the molting gland (Y-organ) of the land crab, Gecarcinus lateralis

Molting in decapod crustaceans is controlled by ecdysteroid hormones synthesized and secreted by the molting gland, or Y-organ (YO). Halloween genes encode cytochrome P450 enzymes in the ecdysteroid synthetic pathway. The current paradigm is that YOs secrete inactive precursor (e.g., ecdysone), which is hydroxylated at the #20 carbon to active hormone (20E) by a cytochrome P450 20-hydroxylase in peripheral tissues. 20-Hydroxylase (*CYP314A1*) is encoded by *Shed* in decapods and *Shade* in insects. We used spiny lobster *Shed* sequences to extract and characterize orthologs in the *G. lateralis* YO transcriptome. Six contigs encoding *Shed* sequences were identified. Analysis of RNA-Seq data from animals induced to molt by multiple limb autotomy showed that *Gl-Shed3* and *Gl-Shed4* mRNA levels were highest in intermolt and lowest in postmolt animals. mRNA levels of *Gl-Shed2* and *Gl-Shed5* were highest in premolt and lowest in postmolt. Activin/Transforming growth factor beta (TGF&beta) signaling is responsible for transitioning the YO from activated state in early premolt to committed state in mid premolt. qPCR was used to quantify the effects of SB431542, an inhibitor of TGF&beta signaling, on mRNA levels in YO from control and experimental animals induced to molt by eyestalk ablation (ESA). ESA increased *Gl-Shed5* mRNA level and decreased *Gl-Shed6* mRNA level in control animals at 14 days post-ESA. SB431542 lowered *Gl-Shed2* and *Gl-Shed3* mRNA levels relative to those in controls at 14 days post-ESA, while SB431542 had no effect on *Gl-Shed1*, *Gl-Shed4*, *Gl-Shed5*, and *Gl-Shed6* mRNA levels. *Shed* genes were expressed in all tissues examined. These data suggest that the YO is capable of secreting active ecdysteroid. Future work will determine whether the YO can synthesize and secrete 20E *in vitro*.

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P3-50 SWITZER, C.M.*; BUSTAMANTE, J.; DANIEL, T.L.; Univ. of Washington; *callin.switzer@gmail.com*

Learning a non-linear controller for insect flight dynamics with a deep neural network

Insect flight is a highly non-linear dynamical system. As such, strategies for understanding control have typically relied on either simulation methods (e.g., Model Predictive Control (MPC), genetic algorithms) or linearization of the dynamical system. Here we develop a new framework that combines MPC and deep learning to create an efficient method for solving the inverse problem of flight control. We used a feedforward, fully-connected neural network to answer the question, "What is the temporal pattern of forces required to follow a complex trajectory?" Combining neural networks with simulations based on dynamical systems models yields a data-driven controller where the data are derived from a non-linear physical model. We first trained a deep neural network (4 hidden layers, with hundreds of nodes) on ~8 million simulated 2D insect trajectories. Our network accurately predicted the force, force angle, abdomen angle, and tangential and angular velocities (7 outputs), when it was provided with initial conditions and a goal location (12 inputs). The coefficient of determination (r^2) for all predictions was > 0.999 on a validation dataset (1 million additional trajectories). Next, we evaluated the neural network's ability to control a simulated insect. We used the aforementioned predictions and compared the final conditions generated to simulations. Again, we found that network-prescribed final conditions were nearly identical to numerically solved conditions (r^2 > 0.999). Overall, this work shows that machine-learning may be an efficient approach for controlling nonlinear dynamical systems.

P2-162 SYKES, B.E.*; BALENGER, S.L.; University of Mississippi; *besykes@go.olemiss.edu*

The effects of nest heat manipulation on development, physiology, and parasitism in the eastern bluebird (Sialia sialis)

Selective pressures produced by climate variability have led to differential thermal tolerances amongst animal species. Endothermic animals expend large amounts of energy maintaining their body temperature, and the critical temperatures (maximum highs and minimum lows) that they are able to tolerate depend largely upon the geographic range that they evolved in. When temperatures become unfavorable, adaptations that allow organisms to respond plastically provide an advantage. Those unable to physically migrate must deal with elevated heat metabolically. Altricial nestling birds, which are born naked and unfeathered, cannot maintain their own body temperature until their feathers grow in, and are essentially ectothermic in the early stages of their development. While in the nest, their growth, body condition, and immune response are directly linked to the microclimate in which they are raised. Factors that disrupt their development, then, can be costly. By experimentally manipulating the temperature of nest boxes, I am quantifying a response to heat in eastern bluebird *(Sialia sialis)* nestlings using heat-shock protein 70 as a biomarker for physiological stress. Heat-shock protein 70 is constitutively expressed at baseline levels, but is upregulated under high temperatures. The effects of high HSP70 levels are not known, but there are implications for reduced lifespan and changes in immune effects in other organisms. I am also measuring changes in body condition as well as differing loads of a parasitic bacteria that degrades feathers and thrives under a temperature optimum. Parasites often impose a cost to physical condition, so any observed changes in growth rate under heat must also be examined in relation to parasite load.

P1-99 TAMONE, SL*; DEAL, CK; FESTER, M; LEVY, T; MANOR, R; SAGI, A; University of Alaska Southeast, Ben Gurion University of the Negev; *sltamone@alaska.edu*

Development of an enzyme-linked immunosorbent assay for Northern spot shrimp Pandalus platyceros vitellogenin and its application for studies into sexual differentiation

Vitellogenin (Vg) is a protein synthesized and secreted from the hepatopancreas of crustaceans during ovarian maturation. Vg is taken up by ovaries during maturation and is modified to vitellin (Vn); it is the yolk-protein that will nourish the developing embryos. We purified Vg and Vn from the Northern spot shrimp (*Pandalus platyceros*) in order to develop a homologous ELISA with which to study the reproductive physiology of this species. *P. platyceros* is a commercially important protandric shrimp species and as such transforms from a functional male to a much larger adult female. Polyclonal antibodies were generated by a commercial vender against vitellogenin/vitellin that was previously purified from homogenates of ovaries obtained from mature adult female shrimp. Western blot analysis demonstrated that the immune serum specifically recocnized the Vn from *P. platyceros* ovarian homogenate and Vg from female but not male *P. platyceros* hemolymph. The standard curve was linear over a range of 75 to 1,800 ng/ml. The Vg ELISA will be used to assess the reproductive physiology of *P. platyceros* as they transform from males to females through a transitional phase. We hypothesize that the hormone that regulates male morphology and physiology (insulin-like androgenic hormone (IAG)) is no longer expressed in *P. platyceros* undergoing the male to female transition. The ELISA will be used in experiments in which the IAG gene is silenced by injection of males with double stranded RNA specific to IAG. Vg will be quantified in hemolymph samples from IAG silenced male and controls.

P3-177 TASSIA, MG*; HALANYCH, KM; Auburn University, Auburn, AL; *mgt0007@auburn.edu*

Evolution of pattern-recognition receptor pathways and the identification of novel domain architectures in Deuterostomia

Immunity fundamentally relies on the host's capacity to distinguish unwanted, potentially pathogenic microbes from a slurry of endogenous biological materials and other functionally inert molecules saturating the environment. To combat this colossal task, animals utilize various pattern-recognition receptors (PRRs) to identify and initiate immune responses against individual groups of pathogens. The patterns PRRs recognize, such as lipopolysaccharide (found in Gram-positive bacteria) or dsRNA (found in viruses), are often essential to the structure/biology of the potentially pathogenic agent on/in which they are found, and thus remain consistent/present over evolutionary time. Moreover, individual PRR proteins often only recognize a single classification of molecular pattern, like Gram-positive cell wall components or viral nucleotide polymers, suggesting an increase in the number of PRRs encoded in a single genome may represent increased immune capacity against a larger breadth of pathogens. In this study, we investigate the molecular conservation of the Nod-like receptors, Rig-1-like receptors, and Toll-like receptor PRR pathways among deuterostomes - a clade encompassing Echinodermata (e.g., sea stars, urchins, and sea cucumbers), Hemichordata (e.g., acorn worms and pterobranchs), and Chordata (e.g., sea squirts, lancelets, and vertebrates). In addition to findings on the ancestral repertoire of these pathways in the context of Deuterostomia and its composite clades, we will discuss novel domain architectures in close association with these core PRR pathways, and their potential role in immunity.

P2-257 TAYLOR, ED*; SEGRE, PS; University of Florida, Stanford University; *ebonytaylornew@gmail.com*

Maximal Load Carrying Performance of Leaf-cutter Ants

Leaf-cutter ants play an important role in maintaining the biodiversity of neotropical forests by cutting and transporting leaf fragments from the canopy to their underground colonies. After cutting the leaves, ants lift the fragments overhead and carry them for long distances over well-established foraging trails. Previous studies have demonstrated that larger ants carry heavier leaves and that larger loads decrease walking speed. However, little is known about the maximum limits of load carrying ability in leaf-cutter ants, particularly in relation to the size of the self-selected fragments they carry and the excess power reserves they maintain to overcome obstacles. By incrementally adding weights to leaf fragments carried by foraging ants, we examined the relationship between body mass and maximum lifting power. As the ants reached maximum load carrying ability, their stepping pattern changed: walking speed slowed, leg stance widened, and staggering increased. Maximum load carrying ability scaled isometrically with body size and leaf-cutter ants were able to carry 7.8 times their body weight. However, larger ants chose to carry leaf fragments that represented a lower proportion of their body mass compared to smaller ants. This suggests that larger ants have the capacity to carry heavier leaves than they normally select and that the mechanism by which leaf-cutter ants choose leaf fragments to transport is not optimized for maximum foraging efficiency.

P1-60 TAYLOR, BK*; CORBIN, S; The University of North Carolina at Chapel Hill, The University of West Florida; *brian.taylor@unc.edu*

Bioinspired magnetoreception and navigation in non-orthogonal environments

Diverse taxa use Earth's magnetic field in conjunction with other sensory modalities to accomplish navigation tasks ranging from local homing to long-distance migration across continents and ocean basins. However, despite extensive research, how animals use Earth's magnetic field in a strategy to successfully navigate is an active area of investigation. Concurrently, Earth's magnetic field offers a signal that engineered systems can leverage for navigation in environments where man-made systems such as GPS are unavailable or unreliable. Building on previous work, this study uses a proxy for Earth's magnetic field, and implements a behavioral strategy inspired by migratory animal behavior that uses combinations of magnetic field properties as rare or unique signatures to mark specific locations. In particular, this work allows constant lines of proxy inclination and intensity to be either rectilinear or curvilinear, and rotated relative to one another so that they are either perpendicular or non-uniformly non-perpendicular. The strategy is tested under a variety of environmental parameters (e.g., rotation angle, degree of curvilinearity), and strategy parameters (e.g., measurement frequency, measurement noise). The results provide support for existing notions of some animals using combinations of magnetic properties as navigational markers, and provides insights into features and constraints that may enable navigational success or failure. The findings also offer insight into how autonomous engineered platforms might be designed to leverage the magnetic field as a navigational resource.

P3-18 TEWKSBURY, CD*; WILKINSON, K; GERSTNER, CFE; GERSTNER, GE; University of Michigan, Ann Arbor, University of Michigan, Ann Arbor , A2 Hosting, Ann Arbor, MI; *geger@umich.edu*

Masticatory Jaw Movements in Pigs, Where and When Does Variation Occur? Insights with Functional Data Analysis

Mastication is a mammalian motor behavior used to reduce and mix food with saliva before swallowing. During mastication, the jaw moves rhythmically through openings and closings, tracing a three-dimensional path. Variability in these movements results primarily from variation in food properties; however, feedforward and feedback mechanisms work to reduce the variation. Most mastication studies are based upon measurements taken at a finite set of heuristic time points in the continuous movements. This omits considerable information content in the movements. We hypothesize that critical food- and individual-specific variation occurs during times that are not typically analyzed. We employ functional data analysis (FDA) to test this hypothesis. FDA transforms complete movements into basis functions, which serve as observations for statistical analyses. We used masticatory jaw movements from four omnivorous pigs fed three foods, viz., almonds, carrots, and apples. Time series representing jaw movements were provided by Dr. Susan Williams' lab as part of a collaborative project. Functional analysis of variance (fANOVA) was used to test main effects of individual pig and food and two-way interactions. Results demonstrate that significant differences exist in time points that are rarely if ever analyzed with traditional methods. Thus, FDA is a useful approach for understanding the dynamics of complex, continuous movements in functional morphological and motor control studies.

P2-18 TEWS, V/H*; BARNETT, A/A; DeSales University, DeSales Univeristy; *veronikatews@yahoo.com*

Interrogating the Evolution of Epidermal Growth Factor (EGF) Pathway Ligands in Insects

The EGF pathway is a conserved and ubiquitously used cell signaling cascade in animal development. In the highly studied insect *Drosophila melanogaster*, four ligands (Vein, Gurken, Spitz and Keren) are used to activate the pathway, and the protein Argos represses activation of the EGF pathway by binding to the EGF receptor. An arthropod-centered phylogenetic analysis showed that the genes encoding the ligands Vein and Argos were present in the last common ancestor of all arthropods. However, this analysis showed the genes encoding Gurken evolved in the last common ancestor of the Diptera, the clade including flies. Our analysis also provides evidence that spitz and Keren are the result of a gene duplication event in the Tephritid flies. In an attempt to determine the ancestral role of the *spitz/Keren* gene in the context of insect development, we used RNA interference targeting the orthologues of the genes in two separate lineages, Orthoptera and Hemiptera. These lineages are represented by the cricket *Gryllus bimaculatus* and the milkweed bug *Oncopeltus fasciatus* respectively.

P3-114 THOMAS, PA*; LOPEZ-LEGENTIL, S; WILBUR, AE; KINSEY, ST; University of North Carolina, Wilmington; *pat3805@uncw.edu*

Effects of Air Exposure on Markers of Oxidative Damage in an Invasive Tunicate (Styela plicata) and a Native Shellfish (Crassostrea virginica)

The Eastern oyster, *Crassostrea virginica*, co-occurs with the invasive tunicate, *Styela plicata*, and the latter species is particularly prevalent in oyster hatcheries, where it is a potential competitor of oysters for food and space. We evaluated the role of air exposure on oxidative damage in both species to help understand environmental tolerances. 70 individual tunicates and 70 individual oysters were collected from the docks of UNCW's Center for Marine Science. Tunicates were of various sizes (ranging from 19-80 mm) while oysters were of similar sizes (ranging from 28-57 mm, ages 6 to 9 months). 10 individuals from each species were randomly placed in one of the following 7 groups: control (continuous water immersion), 6, 12, or 24-h air exposure, or 6, 12, or 24-h air exposure followed by 6 h of water immersion. Tissues from both organisms were examined for oxidative damage using immunoblotting procedures for ubiquitin (protein degradation), protein carbonylation (protein oxidative damage), and 4-HNE (lipid oxidative damage). Tunicates had greater increases in oxidative damage markers than oysters, suggesting that air exposure may lead to increased physiological stress in this species. There was also evidence of a negative correlation between tunicate length and each marker of oxidative damage, suggesting that size of the individual plays a role in the extent of the stress induced by air exposure. This interaction could mean that frequent air exposures will prevent larval and juvenile *S. plicata* recruitment. This research has implications for the use of air exposure as a method to reduce invasive tunicate densities on oyster cages without significantly dampening oyster growth and viability.

P1-85 THOMPSON, SJ*; POWERS, DR; George Fox University; *sthompson16@georgefox.edu*

Is Daytime Mass Management and Pre-Roost Hyperphagia Common in Hummingbirds?

Several studies assume hummingbirds fill their crop prior to roosting, and have included crop filling in nighttime metabolism protocols. To test the validity of this assumption, we examined daytime mass management in both males and females of three SE Arizona hummingbird species that differ in size and ecological role: the black-chinned hummingbird (*Archilochus Alexandria*, 3.0g; opportunistic forager), the Rivoli's hummingbird (*Eugenes fulgens*, 7.5g; trap-liner), and blue-throated hummingbird (*Lampornis clemenciae*, 8.0g; territorialist). Male Rivoli's and black chinned hummingbirds maintained mass throughout the day, but appeared to crop load prior to roosting. Blue-throated hummingbirds maintained mass but did not crop load, and fed infrequently during the last 30 minutes of activity, possibly due to unlimited access to resources. Female black-chinned hummingbirds exhibited high variation in mass and no crop-loading even though they were numerically dominant at the feeders during the last 30 minutes of activity. In contrast, female blue-throated and Rivoli's hummingbirds had higher activity in the beginning and end of the day, but were infrequent visitors to feeders mid-day when temperature was high. These data suggest that daytime mass management and pre-roost crop loading is likely influenced by social interaction and to some degree thermal tolerance. Additionally, since this study was conducted during the breeding season, females were likely influenced by egg production, and all phases of nest construction and attendance.

P1-294 THOMPSON, MC*; FENG, H; WUCHTY, S; WILSON, ACC; University of Miami, Coral Gables, FL; *mct30@miami.edu*

Evidence of Plant-encoded miRNAs in Green Peach Aphid (Myzus persicae) Gut

The aphid/*Buchnera* symbiosis was the first insect nutritional endosymbiosis for which the genome of both the insect and its symbiont were known. In this model, *Buchnera* are housed intracellularly in bacteriocytes within bacteriomes where they work to provide essential amino acids to the host aphid. Recently, we worked to characterize miRNAs that are implicated in regulation of the symbiosis in the green peach aphid, *Myzus persicae*. To do this we generated small RNA-seq datasets from aphid gut and bacteriome tissue. Remarkably, we found that 45% of reads in gut samples failed to map to the aphid and/or *Buchnera* genomes. In contrast, only 5% of reads from bacteriome samples failed to map to the aphid and/or *Buchnera* genomes. Here we report our interrogation of the 45% of small RNA-seq reads in gut samples that failed to map to the insect and/or symbiont genome. We found that viruses and possible secondary symbionts were not likely sources of these reads. Rather, 67% of these unknown reads mapped to the genome of the host plant, *Brassica oleracea*. *B. oleracea* reads represented 31% of all reads from gut tissue samples. A subset of these *B. oleracea*-mapped small RNAs were annotated as plant miRNAs with putative targets in the both the *B. oleracea* and *M. persicae* genomes. Our results provide foundational evidence for the regulation of aphid gene expression by plant-encoded miRNAs. This knowledge both advances understanding of cross-kingdom gene regulation in plants and insects, and expands understanding of the regulatory interactions surrounding aphid feeding.

P1-237 TIVEY, TR*; COLEMAN, TJ; WEIS, VM; Oregon State University; *ttivey@gmail.com*

Symbiont-specific recolonization patterns in a cnidarian-algal symbiosis

In cnidarian-dinoflagellate endosymbioses, algal symbionts must colonize host tissues and proliferate within cnidarian host cells. Despite the importance of colonization, little is known about the cellular mechanisms that govern the rate of proliferation and pattern of colonization of symbionts through host tissues. To explore these colonization patterns we used the sea anemone Aiptasia and its symbiont partner alga from the family Symbiodiniaceae. To capture symbiont proliferation dynamics within Aiptasia tentacles we used an epifluorescence microscope to rapidly and repeatedly image live Aiptasia and monitor symbiont colonization. We estimated the number of symbionts within each symbiont cell cluster, indicating localized proliferation as opposed to symbiont migration through the gastrodermal tissue or gastrovascular cavity. We also tracked total cluster number, density, and location within tentacles. To determine the effect of temperature stress on colonization dynamics, we inoculated Aiptasia with *Breviolum minutum*, a homologous symbiont to Aiptasia. We imaged partially colonized anemones for one week and then exposed half of the anemones to a sublethal temperature stress of 32 C. In combination with temperature stress, we further examined colonization processes using heterologous symbiont species and found differences in the rate of symbiont cluster formation, symbiont density, and response to temperature stress. In summary, our results describe the rate of formation and growth of different sized symbiont clusters (singlets, doublets, etc.), and indicate the importance of new cluster growth to colonization. These symbiont colonization patterns will hopefully enable us to better understand processes involved in the initiation of symbiosis and recolonization after periods of dysbiosis.

P2-234 TO, KHT*; GIGNAC, PM; O'BRIEN, H; STOCKER, M; Virginia Tech, Oklahoma State University Center for Health Sciences, Tulsa; *khanhto@vt.edu*

Cranial musculoskeletal study of black-throated finch (Aves: Passeriformes: Estrildidae)

Cranial kinesis, the movement of cranial bones in relation to the neurocranium, requires the coordination of muscles and ligaments to finely move the bill and mandible. These soft tissues are often extremely small, making studying their growth and development in many groups difficult, especially for taxa with convoluted musculature and small body size such as Passeriformes. We used micro-computed tomography (μCT), diffusible iodine-based contrast-enhanced CT imaging, and digital dissection to study and quantify the ontogeny of mandibular and kinetic musculature in the passerine jaw (black-throated finch, Poephila cincta) for comparison to a common non-passerine model (domestic chicken, Gallus gallus domesticus). Notably the altricial finch had more muscle partitioning than the precocial chicken, particularly among *Musculus adductor mandibulae*. This was apparent throughout ontogeny, indicating that the passerine jaw adductor and protractor bauplan is set relatively early in development. Such partitioning, seen in several species of finch, is a hallmark of passerine jaw anatomy. Ontogenetic shifts in muscle mass were unexpected in our dataset, however. For example, absolute jaw muscle mass was reduced in the adult finch as compared to the fledgling individual. This may be from low sample size, or it may represent the peculiarities of avian life-history patterns (e.g. displaying males often show declining body mass with courtship, and females demonstrate similar declines associated with parental care). Thus, selecting specimens from outside of the breeding season is likely crucial for obtaining high-quality, comparative data that includes quantifying functional anatomical features in birds.

P2-166 TOBIN, K*; ANDERSON, K; CORNELIUS, E; VéZINA, F; JIMENEZ, A.G.; JIMENEZ, ANA; Colgate University, Université du Quebéc à Rimouski, Université du Quebéc à Rimouski; *ajimenez@colgate.edu*

Environmental Mismatch During Cold Shock in Black-capped Chickadees and Its Effects on Tissue Oxidative Stress.

Maximal thermogenic capacity (Msum) in wild black-capped chickadees suggests that phenotypic adjustments are slow and begin to take place before winter peaks. However, when mean minimal Ta reaches -10°C, birds' phenotype appears to provide enough reserve capacity in cold endurance to buffer days with Ta of -20°C or below. This would imply that reserve capacity could also affect other systems. For example, birds could maintain a higher antioxidant capacity as part of their cold acclimated phenotype. In terms of oxidative stress, this may mean that RS (reactive species) production associated with increases in metabolic rate for thermogenesis would remain below antioxidant capacity in cold-acclimated birds to avoid damage during periods of high metabolic rate. Here, we tested how environmental mismatch affected oxidative stress by comparing variation of specific parameters in cold acclimated (-5°C) black-capped chickadees exposed to a 15°C drop in temperature (treatment; -5°C to -20°C) to that of control individuals (remaining at -5°C). We measured sodium dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx) activities, as well as lipid peroxidation (LPO) damage, and antioxidant scavenging capacity in pectoralis muscle, brain, intestine and liver. We found that SOD, CAT and GPx varied with regards to tissue type. LPO did not differ by treatment, tissue or treatment*tissue. Peroxyl varied with regards to tissue type. Hydroxyl varied with regards to tissue and treatment*tissue. Control liver hydroxyl values were marginally higher than treatment liver values and control muscle hydroxyl values were lower than treatment muscle values. The increase in OH scavenging capacity during cold shock in muscle could be related to an increase in food intake.

P1-121 TOKAR, DR*; MILANO, L; KARJASEVIC, A; HATLE, JD; Univ. of North Florida; *jhatle@unf.edu*

Characterizing the activation of Target of Rapamycin pathway in Lubber Grasshoppers in response to alteration of diet

Dietary restriction (DR) is known to increase lifespan. Recent work has concluded that protein restriction is more effective at extending lifespan than DR. Amino acids in proteins, especially branched chain amino acids (BCAAs), stimulate a major cellular growth pathway, the Target of Rapamycin (TOR) pathway, resulting in growth but also accumulated damage. This has been observed in a wide range of organisms, from *S. cerevisiae* to *D. melanogaster* and *M. musculus*. In mammals, increased BCAA consumption activates proteins of the TOR pathway, while reduced BCAA consumption has beneficial effects such as improved glucose tolerance and decreased fat levels. To further investigate the role of BCAAs in life-extension, Eastern lubber grasshoppers (*Romalea microptera*) were fed different quantities of lettuce and supplemental BCAAs in a 2 x 2 design. Treatment groups were: DR lettuce & BCAAs, DR lettuce & buffer, ad libitum lettuce & BCAAs, or ad libitum lettuce & buffer. BCAA supplementation was equivalent to the BCAAs in the additional lettuce consumed by ad libitum grasshoppers in comparison to DR grasshoppers. In two similar studies BCAAs were administered for ~50 days (1/3 of the normal lubber lifespan). DR lettuce & BCAA grasshoppers, in comparison to DR lettuce & buffer grasshoppers, had significantly increased isoleucine in the hemolymph (P=0.042). There was a similar trend for leucine and valine (P=0.105). These data suggest our dietary regimens successfully altered the BCAA availability in the grasshoppers. Molecular analyses such as Western blot will determine the degree to which proteins in the TOR pathway have altered phosphorylation. Transcript levels for proteins will also be quantified to further characterize the TOR pathway when the diet of an insect is altered.

P3-157 TOMPKINS, ET*; ANDERSON, DJ; Wake Forest University, Winston Salem, NC; *emtompki@gmail.com*
Breeding Responses to the El Niño Southern Oscillation are Age- and Trait- Dependent in a Long-Lived Seabird
Breeding responses to environmental quality may be age-dependent, with implications for population dynamics under environmental change and our understanding of the ageing process. We investigated relationships between age, reproductive performance, and the El Niño Southern Oscillation (ENSO; the dominant mode of interannual climatic variation in the eastern tropical Pacific) in a long-lived Galapagos seabird, the Nazca booby (*Sula granti*) using 18 years of longitudinal data from known-age females. Breeding date, clutch size, and offspring production were modeled as a function of age, sea surface temperature (SST, an index of ENSO) and their interaction, among other predictors. All breeding traits varied with age. Performance first improving during early life then declining in late-life. Clutch size increased linearly with SST while the relationship between offspring production and SST was hump-shaped (warm and cool SST extremes each depressed fledging success relative to neutral conditions). Age interacted with sea surface temperature to explain variation in all breeding traits. Considering early life, SST values associated with poor average performance increased the performance discrepancy between young versus middle-aged individuals for clutch size and breeding date. Differences in the fledging success of middle-aged versus old females were also greatest in poor environmental conditions, although the opposite pattern (smaller age effects in poor breeding environments) occurred for breeding date. Age influenced the direction and magnitude of individuals' responses to climatic variation; patterns were complex and trait-dependent and are discussed with respect to age and environment acting on the constraints individuals' face and their optimal reproductive effort.

P2-129 TORJMAN, BZ*; MULLINEAUX, LS; MEYER, KS; WHEELER, JD; PECHENIK, J; Muhlenberg College, Woods Hole Oceanographic Institution, Swiss Federal Institute of Technology, Zurich, Tufts University; *bt250902@muhlenberg.edu*
Food affects swimming behavior of larval Crepidula fornicata
The slipper shell, *Crepidula fornicata*, is an ecologically important species with strong impacts on its surrounding community. It is native to New England but invasive on the west coast of North America and in Europe. *C. fornicata*, like many other invertebrates, develops via a swimming larval stage. Their swimming and feeding are both accomplished using the velum, meaning that larvae must alter their swimming behavior to feed successfully. We explored the swimming behaviors of larvae when feeding and how food availability can influence these behaviors. Larval swimming was recorded and tracked during different levels of nutrition: continuous feeding versus 4-day starvation prior to the experiment, and food present during the experiment or not. In treatments with food present, larvae (both fed and starved prior to the experiment) spent more time at the tops of experimental flasks. When food is available, larvae may prioritize feeding and remain in their planktonic stage for longer, whereas those without food present may settle and transition sooner to juvenile feeding strategies. Starved larvae swam more slowly than fed larvae, spent more time near the bottom, and consumed less food than previously-fed larvae. Thus, emaciation may cause ineffective swimming even when food is available. This study provides the first description of swimming and feeding behavior of *C. fornicata* larvae and marks an important step in developing this species as a model organism for studying larval feeding behavior and larval ecology.

P1-164 TOTH, A J*; EVANGELISTA, D E; United States Naval Academy; *m196438@usna.edu*
Can we redirect a crowd by seeding it with informed leaders?
When considering the collective behavior of large groups, such as human crowds in physical or cyber spaces, schools of fish, large flocks of birds, etc., a natural question to consider is what it would take to change the direction of motion of the group. We will discuss simulations and initial experiments with Naval Academy midshipmen to test whether "informed" leaders, seeded within the group with an unannounced but coordinated agenda, can adequately alter the motions of the group. We will consider both the number and physical location of the informed leaders (spread throughout, or at the periphery) within the crowd. Testing with live midshipmen is, by necessity, limited to small numbers, so we will also use crowd simulations to explore the scaling effect of crowd size as well as the effect of a calm versus agitated state. We will also consider the relevance of such results to public safety, civil applications, and cases where it is desired to alter or redirect a swarm or flock.

P3-31 TRAVIS, KG*; HOFFMANN, SL; GIBB, AC; California State Univ., Long Beach, Florida Atlantic Univ., Northern Arizona Univ.; *kevin.travis@student.csulb.edu*
Give Me a Brake: Comparative Pectoral Fin Kinematics and Mechanics Across Sculpin Species
Braking ability in fishes is an important indicator of their ability to maneuver, evade predators, and colonize new habitats, especially across environmental gradients. Sculpins (Scorpaeniformes: Cottoidea) are a diverse group of benthic fishes ranging from subtidal to high intertidal habitats. The sculpin species living within and across these environments exhibit high morphological variation, especially in their pectoral fins. However, the functional implications of this interspecific variation have not been investigated. We measured the pectoral fin movements during braking of three sculpin species that come from different habitats and vary in fin morphology. We calculated the instantaneous change in fin angle and fin area as indicators of drag production, while changes in whole-animal velocity represented braking performance. Preliminary results suggest that the high intertidal species, *Oligocottus maculosus*, incorporated more fin area during braking and abducts the fin at greater angles, resulting in greater deceleration compared to the subtidal species. Additionally, full-fin passive-bending tests were used to determine the *in situ* stiffness of the fin rays for *O. maculosus* and one of the subtidal species, *Leptocottus armatus*. Preliminary observations suggest that the fin is mechanically regionalized in *O. maculosus* (that is, the rays show different degrees of resistance to bending), and *L. armatus* appears to have greater resistance to bending overall. High-intertidal sculpin species may perform better at braking and have regionalization of fin mechanical properties that allow them to inhabit highly complex tidal zones. Ongoing analyses of sculpin pectoral fin kinematics and their mechanical properties will provide insight into how ecology, behavior, morphology, and mechanical properties change along environmental gradients.

P3-57 TRAVITZ, LS*; MORAN, CJ; GERRY, SP; COUGHLIN, DJ; Widener University, Chester, PA, The Citadel, Charleston, SC, Fairfield University, CT; *lstravitz@widener.edu*

Seasonal Changes in Pectoral Fin Muscle Histology in Temperate Labrid Fishes

Cunner (*Tautogolabrus adspersus*) and tautog (*Tautoga onitis*) are temperate wrasses with different strategies for overwintering. While cunner enter torpor during winter, tautog migrate off shore into stable deep-water habitats. Previous work has shown significant decreases in muscle and locomotor performance at temperatures ≤10°C. In the present study, we use immunohistochemistry with fast and slow myosin heavy chain antibodies to explore how the muscle fiber composition of the abductor superficialis varies across a range of thermal acclimation temperatures in these two species. The abductor superficialis powers the thrust-generating downstroke in these labriform swimming fishes. Preliminary analysis reveals that the bulk of this muscle is composed of a fast-twitch fibers while the slow-twitch muscle fibers are distributed in a discrete slip along one edge of the abductor superficialis. This work will explore how the relative amount of fast- and slow-twitch varies with thermal acclimation in cunner and tautog. To maintain performance in winter would require a relative increase in the contribution of fast-twitch fibers. For instance, tautog may differ from cunner in their pectoral muscle fiber distribution due to differences in over-wintering behavior.

P3-15 TSENG, ZJ; GRABOWSKI, C*; University at Buffalo; *jacktsen@buffalo.edu*

A Cost-Effective System for Capturing Chewing Movements Using Small Fluorescent Paper Markers

Commercial 3D motion-tracking systems are readily available, albeit expensive, options for motion research in comparative biology. Most applications using these devices are in whole-body or whole-limb model systems. The extent to which smaller-scale, finer movements can be captured precisely with such systems is limited by factors such as marker size, and the ability of markers to non-invasively track movements without impediment. Motion capture markers in commercial systems range from 3 to 25 mm in diameter, many of which may be inadequately sensitive to smaller-scale movements that occur in motions such as chewing. We designed and tested a cost-effective alternative to commercial turn-key systems for capturing jaw motion in mammals. Using a VROMM (Video Reconstruction of Moving Morphology) based approach, we analyzed the precision and accuracy of a motion capture system based on videos of 3 mm diameter fluorescent paper markers, recorded by two synchronized cameras coupled with blue light filters and blue LED light source to enhance marker-to-background contrast. Using free software (XMALab and R) and custom scripts, our protocol achieved a mean reprojection error of 0.23 pixels. This value translates to a mean accuracy level of 0.04 mm, more than twice as accurate as those reported for several mainstream commercial systems (0.10 to 0.30 mm). For angular measurements, our protocol achieved an accuracy of <1 to 2 degrees. These experimental results suggest that this relatively simple and cost-effective protocol has comparable or lower levels of measurement error compared to commercial systems, and could be suitable for kinematic studies of finer-scale movements in model systems with small ranges of motion. The non-invasive nature of the protocol makes it a viable alternative to expensive commercial systems for deployment in field or lab settings.

P1-2 TSUNEKAGE, T*; BISHOP, CR; LONG, CM; LEVIN, II; Agnes Scott College; *ttsunekage@gmail.com*

Integrating information literacy training into an inquiry-based introductory biology laboratory

Information literacy is an essential skill for biologists; however, most biology curricula do not intentionally integrate information literacy into classroom and laboratory exercises. There is increasing evidence that developing information literacy skills in undergraduates improves their research skills, writing, and GPAs. Our objective was to integrate information literacy skills into the first semester of Agnes Scott College's introductory biology class with a multi-week, inquiry-based laboratory module that leverages primary literature. We describe our approach to incorporating information literacy and the module we have developed, which challenges students to develop and test a hypothesis related to parental care behavior in barn swallows (*Hirundo rustica erythrogaster*). Students form their hypothesis based on the literature searching done during the information literacy session led by college librarians, produce an annotated bibliography, collect and analyze video data of barn swallows feeding their offspring, and present their findings as a three-minute 'lightning talk'. Our analysis of students' annotated bibliographies indicates that 80% of the papers referenced in the bibliographies were appropriate for developing the specific hypotheses that students would test in the following weeks. The key elements of a successful information literacy training plan include faculty-librarian collaboration, multiple classroom or laboratory sessions that introduce or utilize information literacy, and relevance of the information literacy training to an assignment or exercise. Ideally, by introducing information literacy early in biology curricula, departments can develop tiered information literacy plans within the biology major that incorporates opportunities for students to use and refine these skills throughout their studies.

P3-35 TUMMINELLI, AN*; BARTOL, IK; Old Dominion University, Norfolk, VA; *atumm002@odu.edu*

Fin Motion Diversity in Squid During Turning

Squid use an integrated fin/jet system powered by muscular hydrostats to swim. The fins are capable of diverse movements with high degrees of freedom and provide propulsive and control benefits that complement the vectored jet system. The complex fluid-structure interactions associated with the fins pose unique challenges for researchers, particularly during turning maneuvers when the fins are especially active. To better understand fin movements and flow generation during turns, we used proper orthogonal decomposition (POD) and defocusing digital particle tracking velocimetry (DDPTV) to study the brief squid *Lolliguncula brevis*; and the longfin squid *Doryteuthis pealeii*; as they performed maneuvers in a viewing chamber. Both flap and wave components were present in all fin motions, but the relative importance of the wave components changed with swimming orientation and turning behavior. Fin wave components were generally more prominent during arms-first turns and during controlled tight turns. While a diversity of fin wake patterns was observed, the most complex fin wakes with interconnected vortex structures correlated most closely with fin movements with significant undulatory characteristics. Our results demonstrate that fin motions are diverse and an integral complement to the jet during turning behaviors and our integrative POD/DDPTV approach can be a powerful tool for decoupling fin motions and understanding their momentum consequences.

P3-28 TURNBULL, KF*; MCNEIL, JN; SINCLAIR, BJ; University of Western Ontario; *kturnbu9@uwo.ca*

Does the Energetic Cost of Burrowing through Different Soils Determine Insect Overwintering Site Selection?

Burrowing through soil is among the most energetically costly forms of terrestrial locomotion. Many temperate insects burrow to protected sites beneath the soil surface prior to winter dormancy. Because soil buffers the effects of air temperature, insects that overwinter deeper underground may exploit mild, thermally-stable microclimates. However, the benefits of deeper sites could trade-off with the energetic costs of entry and exit from soil, constraining insects to shallow sites if moving through the soil is costly. To test this hypothesis, we used the western bean cutworm, *Striacosta albicosta* (Lepidotera: Noctuidae) which burrows deep into soil to overwinter. Using two artificial soils that varied in clay content, we described the burrowing behavior of the cutworms, and examined the effect of soil properties on the net cost of burrowing. The distribution of overwintering sites was measured in each artificial soil, and in two natural soils in the field. Initial results suggest that cutworms penetrate further into soils with lower clay content. Our work will provide insight into the costs of burrowing into soil to overwinter: a strategy used by many temperate insects.

P3-131 TURNER, MK*; TIATRAGUL, S; HALL, JM; WARNER, DA; Auburn University; *MKT0018@auburn.edu*

Testing Different Methods for Creating Ecologically-relevant Incubation Temperatures in the Lab

Ecological studies of reptile development traditionally employed constant incubation temperatures to assess the effect of temperature on embryos and hatchling phenotypes. Constant temperature regimes do not accurately represent natural thermal fluctuations in nests. With the advent of programmable incubators, researchers can simulate nest conditions in the lab. A common method is to construct daily temperature regimes by averaging temperatures recorded at each hour of the day by temperature sensors across multiple nests. Calculating hourly means over multiple nests, however, may obscure some of the variation that exists in natural nests since microenvironmental conditions affect how nest temperatures rise and fall at different rates across the landscape. To address this, we used temperature data recorded from 22 nest sites of anole lizards (*Anolis cristatellus* and *Anolis sagrei*) over a period of 43 days. We created two 24-hour daily temperature fluctuations. One was created by taking hourly mean temperatures across all nests. A second used the same nest data, but we first aligned the peak temperatures of each nest prior to calculating hourly means. This method better approximates the natural daily rise and fall of temperature. These regimes had the same mean temperature but differed in how rapidly temperature rose and fell throughout the day as well as the maximum daily temperature. We randomly distributed eggs from a captive colony of anoles to incubate at each regime and measured developmental rate, water uptake, and hatchling morphology. We found no significant effect of incubation treatment on developmental rates, water uptake, or hatchling phenotype for either species. Our results suggest that researchers have some flexibility in how they replicate nest conditions in the lab.

P2-241 TURNER, MS*; DONATELLI, CM; Univ. of Washington, Seattle, Tufts University, Boston; *msturn@uw.edu*

#Scanallstars: Comparison of the Calcareous Endoskeletons of Sea Stars Using High Resolution 3D Imaging and Fractal Analysis

Sea stars, echinoderms of the class Asteroidea, are found in all ocean basins from the intertidal to the abyssal zones. Members of this class are radially symmetric as adults and contain an endoskeleton composed of small calcium carbonate spines called ossicles.This endoskeleton supports diverse morphologies among this group, with ossicle shape varying from spines to plates. Although the ossicle structure has been compared using 2D x-rays, little work has been done to compare their organization in three dimensional space. We took high resolution micro-CT scans of nine species of stars that live around the San Juan Islands in Washington, USA. We modified a fractal analysis technique called box counting for application to 3D data to measure the complexity of the ossicle structure. The scans revealed a huge diversity in the composition of the ossicles, which varied in shape, size and arrangement. Three dimensional fractal analysis indicated highly complex organization of ossicles across all sea star endoskeletons. Using a fractal number scale of 0 to 4, 4 being the most complex, the stars included in this study ranged from 3.3 to 3.5. Ossicles may provide a range of functions for each species, including specialized prey capture, defense against predation, or habitat requirements. Future study could determine how differences in ossicle arrangement are related to the niches these species occupy.

P1-242 TWEETEN, KA*; EZENAGU, N; St. Catherine University; *katweeten@stkate.edu*

Genetic Analysis Supports Classification of Diploid and Polyploid Populations of Lumbriculus as Distinct Species

Diploid and polyploid populations of *Lumbriculus* were genetically compared through sequence analysis of mitochondrial 16S rRNA and cytochrome oxidase subunit 1 genes and the nuclear ITS and 18S rRNA genes. These genes are useful markers in the determination of phylogenetic relationships between organisms with differences in sequences being correlated with evolutionary divergence and speciation events. The populations examined were those, mostly from North American sources and natural habitats, that we have previously characterized using flow cytometry for DNA content and protein profiles, with results indicating that the diploid and polyploid populations should be classified as distinct species. DNA was isolated from the specimens of *Lumbriculus* and the marker genes were amplified using the polymerase chain reaction. PCR products were sequenced and then analyzed using genomics databases. Phylogenetic trees were constructed and showed that polyploid and diploid populations segregated into separate lineages. This genetic data was consistent with our biochemical data, further supporting the taxonomic separation of populations of *Lumbriculus* into at least two distinct species. Resolution of the taxonomy is important, as ploidy levels could impact interpretation of the results of physiological, transcriptomics, toxicological, ecobiology, and other studies being done using different populations from the *Lumbriculus* complex.

P1-233 TWELE, LR*; MOLINE, RE; MIDDLEBROOKS, ML; University of Tampa; *mmiddlebrooks@ut.edu*

Phototaxic Behavior Differs Between Kleptoplastic and non-Photosynthetic Sea Slugs

Sacoglossan sea slugs are a group of small herbivorous marine gastropods which typically are dietary specialists on green macroalgae. Several species of sacoglossan engage in kleptoplasty, the process of sequestering chloroplasts stolen from algae inside of the slug's own cells in order to photosynthesize. Because they gain energy from sunlight through photosynthesis, it is expected that photosynthetic sacoglossan species will spend more time in direct light than non-photosynthetic species. Phototaxic behavioral experiments were conducted on two species of long term photosynthetic sacoglossans and three species of non-photosynthetic sacoglossans. The photosynthetic species were significantly more likely to spend time in the light, demonstrating that photosynthesis provides a strong incentive for light exposure despite potential risks of predation. On the contrary, non-photosynthetic species either prefer shade or do not exhibit a strong phototaxic response. Examining differences between these two groups of slugs provides valuable insight into the impact that the evolutionary novelty of kleptoplasty has had on the ecology and behavior of these animals.

P1-150 TWOMBLY ELLIS, JF*; MARKLAND, S; AMBROSE, AF; ORTIZ ALVARADO, CA; GONZALES BETANCOURT, VH; BARTHELL, JF; PETANIDOU, TF; TSCHEULIN, T; ABRAMSON, CI; GIRAY, T; Cornell University, Oklahoma State University, Savannah State University , University of Puerto Rico, Kansas University, University of Central Oklahoma, University of the Aegean; *jt574@cornell.edu*

Color and Scent as Cues for Reward Association During Honey Bee Foraging

The European Honey bee, *Apis mellifera* , is a generalist and forages on many different flowers. In order to orient themselves to high reward sources *A. mellifera* uses the color and fragrance of flowers. The extent to which color and scent can be important is not well understood. This experiment seeks to determine if scent itself is a reward or if it is a learning cue. To conduct this experiment feeders were used to lure bees to an artificial flower patch with pink, blue, and white colored flowers. The bees were then subjected to series of different assays with varying sucrose molarities, color, and scent combinations. We found that the bees only visited flowers with scent more frequently than those without when the scented flowers had higher molarity solutions. Additionally, we found that when put through more than one phase the bees failed to modify their behavior to follow the higher reward. This shows that honey bees do not treat scent as a reward but they do use it as a learning cue. Furthermore, bees can be conditioned to use scent and/or color as a cue for the higher reward, but when presented with this cue without previous experience, or with contradictory previous experience, it is not recognized as a cue.

P1-214 URGILES, VL*; SAVAGE, AE; University Of Central Florida; *vurgiles@Knights.ucf.edu*

Diversification of terrestrial frogs in a remote high altitude tropical hotspot.

The Ecuadorean Andes sustains one of the most remarkable frog diversifications. In this region, nearly one in three known species of amphibians belong to the *Pristimantis* genus, which contains the majority of the direct-developing terrestrial frog species. Although efforts are ongoing to understand the diversity of *Pristimantis* in the Ecuadorean Andes, large regions, particularly the high altitude ecosystems, remain poorly documented and speciation and diversity of this genus remain widely misunderstood. Within this context, an interesting taxon with many unresolved questions regarding the patterns and process of diversification is the *Pristimantis orestes* species complex which is distributed across Páramo landscape and montane forest in the eastern and western slopes of southern Ecuador. Although some species have been recently included within this group, the small number of samples, geographic regions and loci included in these previous studies have prevented any definitive conclusions from being drawn. Moreover, delimiting and identifying species within this group is problematic because of the lack of molecular data, most notably from holotypes and paratypes. In this work we present a new molecular phylogeny for the *P. orestes* complex, reflecting the complex evolutionary relationships and diversification of the group with morphological, biogeographical and molecular evidence to support several new terrestrial frog species, as a result of a three-year series of expeditions, conducted in the high elevation ecosystems of southern Ecuador between 2500 and 4500m of elevation. Our results identify previously unrecognized species and suggest that the species exhibit restricted distributions, driven by particular elevational and habitat associations.

P3-24 USHERWOOD, JR*; GRANATOSKY, MC; The Royal Veterinary College, The University of Chicago; *jusherwood@rvc.ac.uk*

Work minimization and foot contact timings in slow upright and inverted quadrupedal gaits

The consequences of footfall phasing in terms of limb work has previously been considered for a range of walking quadrupedal species with models using highly idealized limb forces (Usherwood and Self Davies 2017; also SICB, 2017). In the current study, we extend previous methods to exploit empirical force profiles (see Granatosky, 2016), and relate limb work cost contours to observed phasings across a range of duty factors. We take advantage of measurements on 10 species observed locomoting upside-down, 8 of which are also measured walking upright. This inverted/upright comparison presents different mechanical loading demands, and so contrasting cost surfaces. While the phases used during inverted and upright gaits broadly match low limb work conditions (varying as a function of duty factor), pure work minimization alone is insufficient to account for the selected phases. Upright primates tend to adopt a diagonal footfall sequence, whereas a lateral sequence is usually - very marginally - better. Similarly, a diagonal sequence would be narrowly predicted for many inverted gaits; however, vampire and fruit bats adopt a lateral sequence at very high duty factors, populating a slightly less favourable (though still low-cost) region. The mechanical principles underlying the limb work cost surfaces are discussed, as are non-energetic constraints that may prohibit certain duty factor / limb phase combinations. Granatosky, M.C. (2016). A mechanical analysis of suspensory locomotion in primates and other mammals. PhD thesis, Duke University. Usherwood J.R. and Self Davies Z.T. (2017) Work minimization accounts for footfall phasing in slow quadrupedal gaits. eLife 2017;6:e29495 doi:10.7554/eLife.29495.

P2-85 VACHON, JC*; NEWCOMB, JM; New England College; *jvachon_ug@nec.edu*

The Nudibranch Berghia stephanieae Exhibits Circadian Rhythms of Crawling

Daily patterns of activity in a majority of organisms are influenced by endogenous circadian clocks that entrain to external cues. Recently, the nudibranch *Melibe leonina* has been used for circadian studies due to its relatively simple central nervous system. However, this animal poses challenges to researchers, such as unreliable access to populations for study, and difficulties establishing breeding colonies due to diverse developmental needs of larvae vs adults. The nudibranch *Berghia stephanieae* is readily available in the marine pet trade as a predator of the invasive anemone *Aiptasia pallida*. Since *B. stephanieae* has direct development, successive generations of this nudibranch, as well as sufficient food supplies for all stages of growth, can be conveniently maintained in the laboratory. The goal of this study was to determine if *B. stephanieae* exhibits circadian rhythms of crawling. *B. stephanieae* were visually tracked over a seven-day experiment, with three days of normal light/dark cycles followed by four days of constant darkness. Animals exhibited an overwhelmingly nocturnal pattern of activity. All individuals that remained healthy during the entirety of the experiment also exhibited circadian rhythms of crawling that persisted in constant darkness with an average *tau* value of 21.1 ± 2.5 h (mean ± standard deviation). It was also discovered that *B. stephanieae* are capable of crawling out of the water for extended periods of time (e.g., close to an hour), suggesting possible intertidal adaptations. Based on this evidence, we recommend *B. stephanieae* as an organism for future studies of circadian rhythms at the genetic and neurological level.

P3-20 VALENCIA, M/M*; KAWANO, S/M; Long Beach State Univ.; *MrMilesValencia@Gmail.com*

Comparative kinematics of the forelimb during terrestrial locomotion in semi-aquatic versus terrestrial salamanders

Locomotion is affected by the physical features of the environment that may affect loads applied to the bones, such as buoyancy in water versus greater effects gravity on land. Salamanders live in aquatic and terrestrial habitats and must accommodate the contrasting demands of both environments, but do those that primarily live underwater exhibit decreased locomotor performance on land? To evaluate differences in salamander forelimb function, we compared how semi-aquatic adult Spanish ribbed newts (*Pleurodeles waltl*) and predominantly terrestrial adult tiger salamanders (*Ambystoma tigrinum*) overcome a similar challenge: terrestrial locomotion. We quantified the 3D kinematics of the forelimbs on level ground in *P. waltl* and then compared these data to those published on *A. tigrinum*. Preliminary analyses suggested that *P. waltl* and *A. tigrinum* exhibited similarities about the elbow and wrist, with a few distinct differences. The kinematic profile of the elbow in *P. waltl* generally followed the same pattern as *A. tigrinum*, except with slightly more extension throughout stance. The timing of maximum flexion about the wrist in *P. waltl* occurred later in stance compared to *A. tigrinum*, and the duty factor of *P. waltl* was lower than *A. tigrinum*. These preliminary results suggested that the degree of terrestriality in salamanders may not affect these kinematic variables during terrestrial locomotion, but ongoing analyses of locomotor function along the entire forelimb will provide a more comprehensive evaluation of whether semi-aquatic salamanders employ different strategies than terrestrial salamanders for moving on land. Findings from this research may provide new insights into the many-to-mapping of forelimb function for terrestrial locomotion.

P2-115 VANGORDER-BRAID, JT*; SIRMAN, AE; GHIMIRE, A; KITTILSON, J; HEIDINGER, BJ; North Dakota State University; *jennifer.vangorderbr@ndsu.edu*

Does Chronic Stress Exposure Influence TERT Expression and Telomere Loss in Developing House Sparrow Nestlings (Passer domesticus)?

Early life telomeres, protective caps at the end of eukaryotic chromosomes, are predictive of lifespan. Exposure to chronic stress during development can have long-term consequences on individual fitness and longevity. Chronic stress can detrimentally impact an organism through shortening of telomeres, which limits cellular lifespan. However, telomerase, an enzyme that lengthens telomeres, has been shown to upregulate in times of chronic stress in adult mice. Telomerase is made up of two subunits: a reverse transcriptase protein (TERT) and the RNA template (TERC). To better understand the impacts of chronic stress during development, we measured TERT gene expression in early life of house sparrow nestlings in response to chronic stress. Nestlings were randomly assigned a stress or control treatment group, and the stress treatment group received handling in a cloth bag for 30 minutes, daily, from 3 to 10 days post-hatch. At 10 days post-hatch, tissue samples were collected for TERT expression and telomere analysis. We predicted that experimentally stressed nestlings would have higher TERT gene expression than control nestlings. Variation in TERT expression could have important effects on telomeres and contribute to individual differences in resilience to stress exposure.

P1-1 VARNER, J; CONNORS, PK*; BROWN, JS; DIZNEY, L; DUGGAN, JM; ERB, LP; FLAHERTY, EA; HANSON, J; LANIER, HC; YAHNKE, CJ; Colorado Mesa Univ., Grand Junction, Univ. of Utah, Salt Lake City, Moffitt Cancer Center, Tampa, Univ. of Portland, Portland, California State Univ. Monterey Bay, Seaside, Warren Wilson College, Asheville, Purdue Univ., West Lafayette, Columbus State Univ., Columbus, Univ. of Oklahoma, Norman, Univ. of Wisconsin Stevens Point, Stevens Point; *patrice.kurnath@utah.edu*

Squirreling Around for Science: Incorporating Sciurid Behavioral Research into Undergraduate Curriculum

Course-based Undergraduate Research Experiences (CUREs) have been proposed as a way to engage undergraduates in authentic research and to teach core concepts using inquiry-based activities. Compared to traditional labs, CUREs may better enhance intellectual independence and critical thinking because scientific outcomes are unknown. Here, we present preliminary outcomes of a CURE investigating tradeoffs between foraging and vigilance behaviors in squirrels. We developed and piloted a simple, focal-animal observation protocol that works across habitats and species. Students submitted data via Google and then analyzed the nationally aggregated dataset to test their own hypotheses. Last year, we implemented this activity across an array of colleges and courses (upper/lower division, majors/non-majors). Preliminary assessments suggest that students gained confidence in their research abilities and became more interested in science career paths after participation. Additionally, several students sought out independent research opportunities to extend their results (e.g., giving up density and/or camera traps). Our results suggest that participation in course-based research projects enhances not only students' research skills but also their confidence in conducting research, which has important implications for their future as scientists and for increased retention/persistence of students from under-represented groups.

P2-206 VARNEY, RM*; SPEISER, DI; KOCOT, KM; Univ. of Alabama, Univ. of South Carolina; *rvarney@crimson.ua.edu*
The Genome of the Chiton Acanthopleura granulata: A Model System for Studying Molluscan Biomineralization
Chitons (Polyplacophora) are a group of marine molluscs with remarkable biomineralization capabilities. Chitons graze on algae by scraping rocks with a toothed organ called the radula. Feeding is facilitated by teeth coated with iron (magnetite), offering abrasion resistance without compromising flexibility. Rather than a single shell, chitons bear eight valves composed of aragonite. Embedded within the valves are sensory organs known as aesthetes. In *Acanthopleura granulata*, the fuzzy chiton, some aesthetes are modified into lensed eyes that provide spatial vision. To better understand the mechanisms of biomineralization in chitons, we sequenced a draft genome of *Acanthopleura granulata*. A single individual was collected from the Florida Keys and DNA was extracted from foot (muscle) tissue. Sequencing was performed using a hybrid approach with data from the Oxford Nanopore and Illumina HiSeq X platforms, assembled in MaSuRCA. N50, annotation with MAKER, and assessment of completeness with BUSCO indicate that this cost-effective hybrid assembly approach is suitable for producing high-quality draft genomics for integrative biological research. Moving forward, Bionano SAPHYR optical mapping will be employed to further improve assembly quality. This resource will facilitate comparative studies of gene expression in the developing chiton radula to shed light on the genomic basis of their remarkable iron biomineralization. Further, this genome will join fewer than 10 sequenced molluscan genomes and is the first genome from the clade Aculifera (Polyplacophora and Aplacophora, sister group to all other molluscs).

P3-41 VEGA, K.*; CLARK, C.J.; California State University, San Bernardino, University of California, Riverside; *vegak303@coyote.csusb.edu*
Limits to Top Speed in Hummingbirds
Vertebrates such as hummingbirds can fly at high speeds. The limit that prevents hummingbirds from flying faster is the amount of forward-direct thrust. Thrust is affected by the kinematics of flight at high speed, such as the maximum wingtip velocity during the wing beat. The wingtip velocity hypothesis states that top speed is limited by purely kinematic factors at higher flight velocities. The muscle power hypothesis states that the size of the pectoralis muscle is a determining factor of the top speed a bird can reach. We tested 25 hummingbirds from 4 species (that vary in body size, wing length, and muscle size) to determine whether muscle size, body size, or wing length is correlated with limiting thrust. Top speed was determined by placing birds in a wind tunnel starting at 9.5 ms^{-1} and increased in increments of 0.03 ms^{-1} every 10 seconds. A high-speed camera was used to capture wing kinematics at 9.5, 11, and 13 ms^{-1}. In a separate assay, we measured the maximum load lifting capacity in still air. Top speed increased as calculated wingtip velocity increased across species. Hummingbirds that showed an increase in stroke amplitude at the highest airspeeds. Top speed showed a negative correlation with total body weight lifted during the load lifting exercises. This could indicate that wing kinematics alone are responsible for the amount of thrust produced and limits how fast a hummingbird can fly during forward flight.

P2-143 VENKATESWARAN, V*; KUMBLE, LK; BORGES, RM; Indian Institute of Science; *vvignesh@iisc.ac.in*
Resource Dispersion influences Dispersal Evolution of Highly Insulated Insect Communities
Communities in which species are obligately associated with a single host plant are ideal to test adaptive responses of community traits to selection since such communities are often highly insulated. Fig species provide oviposition resources to co-evolved fig-wasp communities. Dispersing fig-wasp communities move from one host plant to another for oviposition. We compared the spatial dispersion of two fig species and the dispersal capacities of their multitrophic wasp communities. Dispersal capacities were assessed by measuring vital dispersal correlates, namely tethered flight durations, somatic lipid contents and resting metabolic rates. We suggest that dispersal-trait distributions of congeneric wasp species across the communities are an adaptive response to host plant dispersion. Larger dispersal capacities of the entire multitrophic community are related to more widely dispersed resources. Our results provide evidence and a novel perspective for understanding the potential role of adaptation in whole-community dispersal-trait distributions.

P3-146 VERHAGEN, I *; LAINE, V N; MATEMAN, A C; PIJL, A; KAMPHUIS, W; GIENAPP, P; VAN OERS, K; VISSER, M E; NIOO-KNAW, NIN-KNAW; *i.verhagen@nioo.knaw.nl*
Assessing individual gene expression patterns in the reproductive axis in relation to timing of reproduction in the great tit (Parus major)
The causation of variation in avian timing of reproduction is ultimately rooted in its underlying physiology, as, after transduction and integration of cues, reproductive timing results from a cascade of neuro-endocrine processes. Current knowledge on the physiology underlying avian breeding time is still limited despite its importance as a key trait involved in how species adapt to climate change. This study assesses whether (individual) differences in egg-laying date can be explained by differences in candidate gene expression in a number of tissues and if so, whether these differences occur in the upstream (i.e. hypothalamus), or the downstream (ovary and liver) part of the neuroendocrine system. We used 72 female great tits from lines artificially selected for early and late laying, which were subjected to two contrasting temperature environments in climate controlled aviaries and sacrificed at three time points throughout the breeding season. For each organ for a set of candidate genes, known to be important or potentially important mediators of reproductive biology, individual gene expression levels were assessed using qPCR methods. Instead of analyzing candidate genes separately, we first conducted a Principal Component Analyses (PCA) per organ and subsequently analysed whether gene expression patterns differed in relation to egg-laying date, time point of sacrifice, and temperature treatment. A better understanding of individual gene expression patterns can contribute greatly to understanding the molecular evolutionary processes in natural populations, and the adaptive potential of species to adapt to environmental change.

P2-153 VIMMERSTEDT, JC*; YOUNGBLOOD, JP; ANGILLETTA, JR, MJ; QUINLAN, MC; LEE, AH; VANDENBROOKS, JM; Midwestern University, Arizona State University; *jvimmerstedt23@midwestern.edu*

Testing the OCLTT hypothesis in quail embryos by manipulating thyroid hormone

Currently, the primary mechanism establishing upper thermal limits is unknown. The classic protein denaturation hypothesis remains unlikely as most proteins denature at temperatures higher than the critical thermal limits for organisms. Alternatively, the oxygen and capacity-limited thermal tolerance (OCLTT) hypothesis predicts that increasing temperatures cause a mismatch between oxygen supply and demand, forcing the animal to transition to anaerobic metabolism, which fails to meet energetic demand leading to organismal death. Most support for the OCLTT hypothesis has come from aquatic animals with relatively little support in terrestrial animals. Yet in the embryonic stage, terrestrial animals may be more susceptible to oxygen limitation due to underdeveloped cardio-respiratory systems and living in an aquatic medium. We tested this hypothesis in Japanese quail (*Coturnix coturnix*) embryos by attempting to artificially increase basal metabolic rate with treatment of thyroid hormone (T3). Halfway through development, T3 dissolved in DMSO was injected into the yolk of half of the eggs, while the other half received vehicle only. Embryos were then exposed to 48.0°C for one hour to measure survivorship. If the OCLTT hypothesis were correct, the embryos injected with T3 should show reduced survivorship at high temperatures due to increased oxygen demand. In fact, survivorship in the T3 injected group was one quarter of that in the control group suggesting that oxygen availability may be limiting thermal tolerance. However, the relationship between metabolic rate and survivorship was weak indicating a possible secondary effect of T3 independent of metabolic rate. Therefore, further studies are necessary to elucidate the direct mechanisms behind this effect.

P3-170 VIRGIN, EE*; FRENCH, SS; Utah State University; *emilyevirgin@gmail.com*

Effect of immune challenge on metabolism and oxidative capacity in the Side-blotched lizard (Uta stansburiana) across reproductive stages

Activation of the innate immune system is costly and can result in an energetic deficit for other physiological processes, such as reproduction. Both immunity and reproduction can induce a suite of physiological changes, including an increase in metabolic rate. A byproduct of metabolism is the production of reactive oxygen species (ROS), which have the potential to cause cellular damage and early senescence. It is unclear how competition between the immune and reproductive systems influence metabolic rate, and how simultaneous investment between reproduction and immunity relates to metabolic and oxidative costs in females. Here, we immune challenged 77 wild-caught female side-blotched lizards (*Uta stansburiana*) varying in reproductive stage with lipopolysaccharide (LPS), a non-pathogenic mitogen that induces an immune response, and measured the effects on standard metabolic rate, innate immune function (BKA), and oxidative capacity (both antioxidants and reactive oxygen species). Understanding the metabolic and oxidative costs of immunity and how they may vary depending on reproductive status (and the tradeoffs therein) is crucial to understanding how life history traits evolve in animal populations.

P1-286 VITEK, NS*; MORSE, PE; STRAIT, SG; BOYER, DM; BLOCH, JI; University of Florida, Gainesville, FL nvitek@ufl.edu, Duke University, Durham, NC, Marshall University, Huntington, WV, Florida Museum of Natural History, Gainesville FL; *nvitek@ufl.edu*

Changes in relative molar size in the small-bodied mammal Macrocranion across the Paleocene-Eocene Thermal Maximum follow predictions of nutritional deficit

Variation in relative molar crown area (RCA) is a promising phenotype in which to measure mammalian response to climate change because of its links to diet and nutritional deficit in modern species. A relevant interval in which to study these responses is the Paleocene-Eocene Thermal Maximum (PETM) ~56 Ma. It is associated with a shift towards warmer mean annual temperatures (MAT) by ~5-8 °C for ~175 ky, followed by a recovery to pre-PETM MAT. Changes in RCA in response to these climatic shifts should follow predictions of the inhibitory cascade model (ICM). However, much of the PETM mammalian fossil record consists of isolated teeth instead of the complete molar rows for which the ICM was intended. To test the possibility of environmentally-linked change in RCA, we first asked if we could reconstruct RCA from averages of isolated molars. Using simulations from modern populations, we demonstrate that this approach accurately reflects molar-row RCA. Next, we asked whether RCA changed through the PETM, and, if it did, whether changes in RCA through the PETM follow expectations of the ICM. We measured RCA from isolated M_{1-3} of the small-bodied (~24 g), insectivorous *Macrocranion junnei*. RCA changes across the PETM in proportions consistent with the ICM. Macrocranion has smaller M_{2-3} during the late and post-PETM at most. The timing and direction of change is consistent with nutritional deficit associated with turnover in the surrounding flora and associated insect fauna at the end of the PETM.

P3-14 VYAS, P*; PRAKASH, M; Stanford University; *vpranav@stanford.edu*

Dynamics of Placozoa cellular reaggregation: Self-organization of tissue architectures via assembly/disassembly of Trichoplax adhaerens

Placozoans are one of the earliest diverging metazoans with a simple body plan. They have six cell types arranged in a three-layered sheet morphology without ECM. Their extreme diversity of shape and tissue plasticity are properties arising from local interactions between cells, whose emergence can be probed due to the simplicity of the system. The animal reproduces asexually through fission induced by uncoordinated flocking of cilia, but also sometimes buds spherical pelagic swarmer balls from its dorsal surface. These balls have been reported to undergo a topological transition during which the ventral epithelium enclosing an inner cavity is exposed to the outer environment. The dorsal and ventral surfaces have characteristic functions illustrated by unique distinguishable cell arrangements. We aim to better understand the role of self-organization processes that lead to these simple tissue architectures. A shear-based dissociation assay allows us to obtain tissue fragments with tens to hundreds of cells. These fragments show motility and reaggregation followed by slow rearrangements of cells to gain defined arrangements. This process provides room for *in vitro* formation of swarmer balls along with other artificial morphologies with multiple cavities. The assay also allows us to obtain animals with tuned sizes which show a transition from a more rounded to a flatter morphology with increase in size. Comparative study of this process between aggregates and native animals allows us to probe the development of robust architecture in these animals using a few cell types. Our current work opens doors to building artificial animals with non-native cellular compositions, further enabling us to decipher the role of various cell types in this self-organization process.

P1-289 WAINWRIGHT, DK*; LAUDER, GV; Harvard University; *dylan.wainwright@gmail.com*

The structure and hydrodynamic function of tuna keels

Tuna have laterally projecting wings of soft tissue at the narrowing of their body just anterior to their tail in the region of the caudal peduncle. These features are known as keels and have evolved independently multiple times in fast swimming bony fishes and in lamnid sharks. We use micro CT, histology, and simple robotic models to understand the morphology and function of these keels in tunas of the genus *Thunnus*. In these fishes, keels are extremely flexible and are composed largely of collagen with a cartilage rod running anterior to posterior. Previous research has suggested that lateral keels might decrease lateral forces experienced near the tail and reduce caudal torque of these high-performance fish by streamlining the caudal peduncle in the lateral direction. We test this hypothesis for the first time using simple physical models of tuna-like tails with and without lateral keels. We actuate these model tails in a flow tank using biologically relevant parameters based on kinematic data collected from captive tuna, and we compare performance of models with and without keels. Multi-axis force-torque sensors allow us to compare forces in the drag, thrust, and lateral directions to help elucidate any performance benefits of lateral keels. In addition, we can record and compare mechanical power consumption and self-propelled speed of keeled and keel-less models at a range of motion parameters and speeds. Experimental cases where keeled models outperform keel-less models can be further studied by imaging flow using particle image velocimetry.

P1-169 WALDRON, J*; KAJIURA, SM; Florida Atlantic University; *kajiura@fau.edu*

Seasonal Abundance and Spatial Distribution of Blacktip Sharks (Carcharhinus limbatus) in Southeast Florida

Southeast Florida's marine ecosystem experiences a seasonal influx of upper trophic level predators each winter due to the large-scale annual migration of blacktip sharks (*Carcharhinus limbatus*). Blacktip sharks occupy shallow, coastal habitats and are distributed from Georgia to North Carolina during the late spring and summer, migrate south during the fall to overwinter in Florida, and then migrate north in late winter and early spring. As they migrate, blacktip sharks form dense aggregations along Florida's coastline. Although these large shark aggregations attract significant public interest, surprisingly little empirical data have been collected on the shark abundance, spatial distribution, and the factors driving their migration. Manned aerial surveys of coastal waters were conducted from Boca Raton to Jupiter (2011-2014), and Miami to Jupiter (2015-2018). A high definition video camera mounted out the open window of the plane recorded the transect to a distance approximately 200m seaward of the beach. These videos were analyzed to determine blacktip shark abundance, and shark densities within inlet-bound sections of the coastline. Water temperature was also recorded to examine correlations with shark abundance. Results indicate that the highest shark densities, exceeding 2,000 sharks km^{-2}, were in the northern-most sections of the transect (Palm Beach County) in February and March, when water temperature was at its lowest. Peak shark abundance was significantly inversely correlated with water temperature. This strong correlation between water temperature and shark abundance suggests that warming oceans might shift the southern terminus of the migration towards higher latitudes, causing ecological changes along the United States Eastern seaboard.

P1-258 WALKER, MA*; ASHER, VJ; URIBASTERRA, MG; CAMPIONE, AM; RYAN, SJ; BLACKBURN, JK; University of Florida, Turner Enterprises; *m.walker@ufl.edu*

Ungulate use of locally infectious zones (LIZs) in the re-emerging anthrax zone of Southwestern Montana

Environmentally mediated indirect pathogen transmission is explicitly linked to host movement and foraging in areas where pathogens are maintained in the environment. In the case of anthrax, spores of the causative bacterium *Bacillus anthracis* are released into the environment following host death creating localized infectious zones (LIZs). In grassland anthrax systems, the most likely route of infection in herbivores is ingestion of spores while grazing at LIZs. Here we used camera traps to assess how ungulate species utilize carcass sites in Southwest Montana and evaluated how these behaviors may promote indirect anthrax transmission. Data were collected from August 2016 to September 2018 at 14 carcass sites (proxies for LIZs) and 13 control sites (comparable habitat without LIZ) for a total of 470,221 independent photographs during 12,533 camera trap days. Data analysis is ongoing; however, initial results suggest that adult male bison spend more time grazing at LIZs than calves, yearlings, or adult females. Similarly, adult male elk are more likely to graze at LIZs than control sites. These data are consistent with previous findings in the study area that during anthrax outbreaks adult male bison and adult male elk were disproportionately affected. Further, white-tailed deer (WTD), mule deer, and moose show no preference for LIZs over control sites; anthrax in WTD is rare in the study area and not reported in mule deer or moose. Serological surveys mirror these findings with little *B. anthracis* exposure in female elk and frequent exposure in males. Our findings suggest that LIZs promote grazing and differentially attract male and female hosts.

P1-228 WALTERS, LJ*; KIBLER, KM; COOK, G; CHAMBERS, L; DONNELLY, M; HAWTHORNE, T; RIVERA, F; University of Central Florida; *linda.walters@ucf.edu*

Integrating sense of place into ecosystem restoration: a novel approach to achieve synergistic social-ecological impact

It is a challenge to predict the impact of ecosystem restoration because many critical relationships and feedbacks between natural and human systems are poorly understood. To address this knowledge gap, we introduce a novel framework to characterize restoration dynamics within coupled human-natural systems. As dynamics surrounding restoration are complex, we investigate the potential for sense of place (i.e. emotional attachment to place) to elucidate relationships between human and natural systems during times of change, such as restoration. Integrating sense of place with ecological metrics, a typology of restoration scenarios that exemplify complex relationships between social and ecological drivers emerges. We propose an Identify-Visualize-Create framework for parsing restoration objectives and curating sense of place around the functional ecosystem state. Achieving coupled human-natural objectives thus requires evaluation of baseline sense of place early in the restoration process and active pursuit of opportunities that build stakeholder attachment over the long-term.

P3-155 WANG, Q*; HERNANDEZ-OCHOA, E; BLUM, I; VISWANATHAN, M; GRANGER, J; YANG, J; LOVERING, R; SCHNEIDER, M; CAMMARATO, A; WU, M; BEVER, G; ANDERSON, M; Johns Hopkins Univ., School of Medicine, Univ. of Maryland, School of Medicine; *qinchuan.wang@jhmi.edu*

A Critical Role for Oxidative Regulation of CaMKII in the Origin of Vertebrates

Origins pose difficult problems for evolutionary biologists. Comparative analyses are powerful at identifying the stem lineage along which a particular feature finds its origin but relatively weak at providing details of the origin itself. Fossils can mitigate this weakness, and experimental biology is becoming increasingly adept at engineering meaningful outgroups and ancestral conditions. We explore the integration of these approaches for our understanding of vertebrate origins; in particular the emergence along the vertebrate stem lineage of a metabolically active, predatory existence from the sessile, filter-feeding ecology of our deuterostome ancestors. We identify oxidative-mediated activity of the Calcium/Calmodulin-Dependent Protein Kinase II (CaMKII) as a key innovation that helped facilitate the functional potential of such iconic vertebrate apomorphies as an internal skeleton, sympathetic nervous system, increasingly efficient respiratory and circulatory systems, prechordal head, and placode-derived organs of special sensation. Using mutant taxonomic strains that lie phylogenetically inside and outside crown-clade Vertebrata, we provide support that the acquisition of this oxidative-mediated kinase activity ushered in a number of novel modalities for stem vertebrates that included heightened performance of skeletal muscle. The cruel irony of these results is that the same oxidative regulatory pathway that likely played a key role in our early success as vertebrates is also identified in a number of human disease processes, including heart disease, pulmonary disease, and cancer.

P3-164 WARNER, DA*; HALL, JM; HULBERT, A; TIATRAGUL, S; PRUETT, J; MITCHELL, TS; Auburn University; *daw0036@auburn.edu*

Recent Extinction of a Viable Tropical Lizard Population from a Temperate Area

Human activity is responsible for numerous introductions of species to areas outside of native ranges. However, because many introduced populations may not persist long enough to be noticed, and hence remain unreported, the factors responsible for population establishment or extinction are often difficult to quantify. We studied a viable population of brown anoles (*Anolis sagrei*; native to Cuba and The Bahamas) at a temperate latitude that is farther north than its continuous invasive range in the southeast United States. This population was first reported in 2006 at a commercial greenhouse near Auburn, Alabama and likely arrived via propagules transplanted in ornamental plants. The warm confines of the greenhouse presumably shielded this population from lethally cold winters for at least 12 years (~12 generations). However, the greenhouse rapidly degraded after the facility went out of business (in 2016) and lost its roof due to strong winds from Hurricane Irma (in 2017). Prior to winter 2017, individuals of both sexes and all age classes were present (from eggs to adults), and the population size was at least 225 individuals. Post-winter surveys in 2018 revealed that no *A. sagrei* survived winter. Without the thermal buffering of the greenhouse roof, temperatures dropped well below the population's critical thermal minimum, and individuals were presumably exposed to lethally low temperatures. This study provides a rare documentation of an extinction of a viable introduced population and illustrates the role that anthropogenic structures and natural weather events play in population establishment and extinction.

P1-221 WATSON, A*; GEORGE, SB; Georgia Southern University, Statesboro, GA, Georgia Southern University Statesboro, GA; *georges@georgiasouthern.edu*

Does Shading by Cordgrass Reduce Physiological Stress in RIbbed Mussels in a Local Salt Marsh?

According to NOAA, the highest temperature in the US was recorded in 2016, followed by the third highest in 2017. Rising temperatures and increasing drought frequency could affect marsh health, though in the presence of ribbed mussels, *Geukensia demissa*, marsh recovery can take as little as 10 years versus 100 years without them. Mussels are usually found on mounds (raised portions of the substrate), at the base of cordgrass, *Spartina alterniflora* stems. These two species, along with others, work together to maintain the health and biodiversity of the marsh. But as temperatures rise they may be undergoing considerable stress. This study will examine whether cordgrass provides enough shade to decrease stress and enable increase in mussel abundance despite the increase in temperatures in the salt marsh. Eight large mussel mounds (198-243 cm in diameter) with similar cordgrass densities were flagged in the mid-zone of a local saltmarsh at Tybee Island, Georgia. Four of these mounds were tagged as short cordgrass mounds (cordgrass ≤ 40cm, less shade) and the other four as tall cordgrass mounds (cordgrass ≥ 60cm, shaded). During the Spring and Fall of 2018, temperature, sediment organic content, mussel abundance, cordgrass density and height were recorded. In September, three mussels/mound were collected. In the lab, mussel tissue was lysed, and the supernatant was stored at -80°C. Ten microliters of the sample were used to determine total protein concentration. Our results revealed significantly higher sediment organic content and mussel abundance on mounds with tall cordgrass (100-173 mussels/mound) than on mounds with short cordgrass (51-132 mussels/mound). These results further indicate the importance of the interaction between these two species in maintaining salt marsh health.

P1-187 WEBB, AC*; LILLY, N; WOOD, J; WARREN, C; HUDSON, S; FRENCH, SS; Utah State University; *alisoncarey4@gmail.com*

Interactions of behvaior, temperature, and metabolism in response to an immune challenge in side-blotched lizards, Uta stansburiana

The goals of this study were to **1)** understand how a measure of innate immune function, bacterial killing ability, responded to different immune challenges, **2)** how environmental temperature and lizard thermoregulatory behavior influenced this immune response, and **3)** how metabolic rate was altered during an immune response. To accomplish this, three separate experiments were performed. In the first experiment, lizard bacterial killing ability (BKA) was measured following a cutaneous wound, lipopolysaccharide (LPS), or phytohemagglutinin (PHA) challenge while lizards were allowed to thermoregulate. We found that the LPS challenge, but not PHA or a cutaneous wound, significantly increased BKA and that all lizard plasma, regardless of treatment, performed better at higher assay incubation temperatures. In the second experiment, lizard thermoregulatory behavior in response to an LPS challenge was monitored and quantified. We found that LPS challenged lizards spent more time in warm zones of the thermal gradients when compared to the control treatment. Finally, we measured immune function and metabolic rate of lizards in response to an LPS challenge when lizards were held at a constant temperature. In this experiment, we found that BKA was higher for lizards held at the warm temperature and that the LPS treatment groups for both temperatures had higher BKA compared to the control animals held at the same temperature. Metabolic rate increased following the LPS challenge but decreased or did not change for control animals. Together, these results demonstrate the importance of assessing the environmental context and individual variation when interpreting immune measures.

P3-122 WEBB, EA*; MCGRAW, KJ; Arizona State University, Tempe; *eawebb1@asu.edu*

Variation in Tissue Carotenoid Profiles: A Tale of Two Species

Carotenoid pigments are fat-soluble nutrients that are obtained via the diet and have diverse physiological and morphological functions. Despite all the attention paid to internal carotenoid functions in animals, surprisingly little has been paid to where in the body carotenoids may be exerting their functions, even though there is evidence of function-associated tissue allocation of carotenoids. As part of two separate studies, we characterized the tissue carotenoid profiles of two different carotenoid-colored species, king quail (*Excalfactoria chinensis*) and house finches (*Haemorhous mexicanus*). For the king quail, we manipulated an environmental variable and measured the effect on their carotenoid profiles. For the house finches, we measured the natural variation across sexes and seasons. In king quail, we found that the environmental variable had an effect on their carotenoid profiles, and there were sex differences in how the carotenoids were distributed generally. House finch carotenoid profiles are different from king quail carotenoid profiles. Further analyses will reveal if there are seasonal differences and/or sex differences among house finches.

P2-14 WEBSTER, NB*; MEYER, NP; Clark University; *nwebster@clarku.edu*

How conserved are centralized nervous systems across Bilateria? Investigating the role of BMP receptors in specifying neural fate and the dorsal-ventral axis in the marine annelid Capitella teleta

The repeated evolution of key features is a theme in evolution, but whether centralized nervous systems (CNSs) fit this pattern is still under debate. Within Bilateria, the three main clades (Deuterostomia, Ecdysozoa, Spiralia) all show a great diversity in CNS development. In vertebrates and insects, specification of neural ectoderm is largely a result of inhibition of BMP signaling during dorsal-ventral axis specification. This in conjunction with the discovery that BMP signaling has been involved in specification of the directive axis in at least some cnidarians—albeit not for neural specification—and thus possibly prior to the evolution of bilaterians, has led to a hypothesis that BMP signaling in axis formation, and possibly CNS formation is homologous across Bilateria. Under this hypothesis, the full diversity of CNS morphologies, such as a dorsal vs ventral nerve cord or degree of cephalization, may result from later diversification from a single primordial CNS. Sorely lacking to complete our understanding of evolution of CNSs is data from the third major group of bilaterians, Spiralia. Initial attempts to understand the role of BMP signaling in spiralians contradicts the idea of homologous CNS development, but further work is needed to thoroughly evaluate potential evolutionary scenarios surrounding the origin of bilaterian nervous systems. Here we investigated the role of BMP type 1 and 2 receptors during development of the spiralian annelid *Capitella teleta* to deepen our understanding of CNS formation in the third major clade of Bilateria.

P1-50 WELLS, LA*; HERNANDEZ, LP; STAAB, KL; McDaniel College, The George Washington University ; *law016@mcdaniel.edu*

Kinematics of cypriniform suction feeding: emerging patterns of functional diversity across sixteen species

The capturing of prey in a dense and viscous environment presents many hydrodynamic challenges for aquatic organisms. Suction-feeding fishes, like bluegill, have solved this problem by coordinating the timing of feeding movements (e.g., peak gape and peak premaxillary protrusion) in an all-or-nothing rapid expansion of the head. These peak movements are correlated with peak flow that draws prey into the buccal cavity. While this suction-feeding mechanism is common, goldfish have been previously shown to not fit this exact model. It has been observed that goldfish can sustain maximal flow for longer than bluegill, but the kinematics behind generating this flow profile are not yet known. Goldfish are members of the order Cypriniformes, a diverse group of freshwater fishes that all have a kinethmoid bone that aids in premaxillary protrusion and is not present in other fishes. In this study, we sought to quantify the relationship between morphological and kinematic variables of cypriniform feeding mechanisms. Because goldfish may not represent all cypriniforms, sixteen species were analyzed to attain a broad, phylogenetic sampling of this diverse order. Based on collected kinematic data of cypriniform feeding mechanisms, several patterns emerged. Bottom-feeding species show similar patterns to goldfish with sustained protrusion and slower times to peak gape while more derived species mirror bluegills and non-cypriniform kinematics with a faster time to peak gape and non-sustained protrusion. These findings suggest that cypriniforms do not fit a single model of suction-feeding and that diverse strategies for prey capture are found across the order.

P2-8 WELP, EW*; KOTARA, K; SHINKLE, J; Trinity University; *ewelp@trinity.edu*

Contrasting Results for Responses of Plants to Short Wavelength UV-B Radiation in Laboratory and Natural Light Environments

The differences in plant responses due to short wavelength ultraviolet-B radiation (UV-B) (290 - 300 nm) was evaluated in both laboratory and natural light environments (field studies). UV-B radiation has been observed to cause plants damage, in addition to leading to acclimation. We characterized response of Texas native grasses to full spectrum UV radiation and those receiving radiation that blocks the short wavelength UV-B. Big Bluestem *(Andropogon gerardi)*, Little Bluestem *(Schizachyrium scoparium)*, and Sideoats Grama *(Bouteloua curtipendula)* were used for the experiment. To test the effects of UV-B radiation, we used two types of treatments to generate differences in UV-B radiation, a UV supplementation protocol in a greenhouse and a pair of UV exclusion enclosures covering plants placed at sites across South Texas during summer (highest UV-B) and fall. For greenhouse supplementation treatments, plants were maintained in a greenhouse supplying no UV-B radiation and exposed for five days to either UV-B radiation excluding wavelengths shorter than 300 nm or UV-B radiation including 15% at wavelengths below 300 nm. From both field sites and greenhouse studies we found that effects of short wavelength UV-B tend to be species specific. For four different field sites, the exclusion of short wavelength UV-B caused a decrease in absorption at 330 nm in Big Bluestem ranging from 3% to 40%. Two greenhouse studies exhibited opposite results with the addition of short wavelength UV-B causing increases in 330 nm absorption ranging from 50% to 58%. Considering that both sets of plants were grown in the same pots and soil, and were kept watered, it appears that other unidentified abiotic factors were the cause of the marked differences observed.

P1-118 WESTRICK, SE*; STUDD, EK; BOUTIN, S; HUMPHRIES, MM; LANE, J; MCADAM, AG; DANTZER, B; University of Michigan, McGill University, University of Alberta, University of Saskatchewan, University of Guelph, University of Michigan ; *westse@umich.edu*

Methods of Measuring Maternal Behavior in a Wild Small Mammal

Behavior of small mammals can often be difficult to actively observe in the wild due to their secretive nature. In particular, maternal care behavior is often performed in enclosed areas, making frequent or continuous behavioral observation of mothers interacting with pups during development near impossible. Much of our understanding of the neuroendocrine mechanisms contributing to maternal behavior stems from small mammal research conducted in laboratory environments. By developing methods to measure maternal behavior in a wild small mammal, we can expand our understanding of maternal behavior by investigating natural variation and ultimately fitness consequences of this variation. By using accelerometer collars with temperature sensors on wild red squirrels, we measured multiple behaviors, including nest usage, without direct observation of the animal. Additionally, we used brief observational periods during standardized nest entries to gather a metric of maternal motivation. Using these data, we compared frequency and duration of nest entries of lactating squirrels with maternal retrieval behavior observed during nest entries. We also compared activity levels while in the nest between lactating and non-breeding red squirrels to identify a specific movement signature of interacting with pups as opposed to resting in the nest. Additionally, we used data collected from squirrels in a glucocorticoid supplementation experiment to investigate the effects of maternal glucocorticoids during pregnancy or lactation on these behavioral measures.

P1-243 WHELPLEY, JM*; PAULAY, G; RYAN, JF; Whitney Laboratory for Marine Bioscience, University of Florida, St Augustine, FL, Florida Museum of Natural History, University of Florida, Gainesville, FL; *jwhelpley@ufl.edu*

Phylogenomic Analysis of Sea Cucumbers: Contextualizing a Unique Echinoderm Across Evolution

Sea cucumbers are perhaps the most morphologically derived echinoderm; they possess a worm-like body plan, which sharply juxtaposes the pentaradial symmetry and armored body of other echinoderms. The group has evolved bizarre specializations such as anal suspension feeding, evisceration, sticky Cuvierian tubules that entangle attackers, and a "melting" body wall. Sea cucumbers are ubiquitous throughout all marine landscapes and include >1700 species in 25 families. Despite their diversity, abundance in the marine ecosystems, and economical importance as food, our understanding of their evolutionary history is limited. Here, we present a phylogenomic analysis of Holothuroidea using 9 unpublished and 16 published transcriptomes. Our analysis pipeline includes transcriptome-assembly with Trinity, orthology assignment with OrthoFinder, and alignment construction using MAFFT and Gblocks. We conduct both concatenated and coalescent-based phylogenomic reconstruction. We estimated clade divergence in BEAST and performed an ancestral state reconstruction analysis on 12 discrete traits using the Phytools package in R. This study provides an important initial framework that will allow us to further explore the evolution and biodiversity of this ecologically and economically important group of animals.

P1-3 WHITENACK, LB*; STAAB, KL; DANOS, N; Allegheny College, McDaniel College, University of San Diego; *lwhitena@allegheny.edu*

What are the core concepts of vertebrate morphology?

Although there are entire journals dedicated to the teaching of medical anatomy, the pedagogical literature on teaching comparative vertebrate anatomy is lacking. This has created a situation where new instructors are lacking research into best practices and core concepts to teach. In addition, recent reports calling for change in science education ask that learning objectives focus on proficiency of core concepts. Focusing on core concepts, or big ideas, is thought to help students achieve meaningful learning, as they are transferable across sub-disciplines, foster retention, build problem-solving skills, and provide scaffolding for learning new concepts later. However, before we can employ these core concepts, we must define them. This interactive poster will discuss the pedagogy of core-concepts and serve as place to gather input on core concepts from SICB attendees in conjunction with the Teaching and Learning Workshop.

P1-104 WHITLOW, S. W.*; BUTLER, J. M.; MARUSKA, K. P.; Louisiana State University; *swhitl6@lsu.edu*

Behavioral, physiological, and neural correlates of ovulation in the African cichlid fish Astatotilapia burtoni

Ovulation in fishes occurs when eggs detach from the ovary lining and is associated with distinct behavioral and neuroendocrine changes. Despite these changes, gravid females are often grouped together independent of ovulation status. In female *Astatotilapia burtoni*, measures of gravidity (gonadosomatic index) correlate with affiliative behaviors and levels of circulating sex steroids. However, whether these changes are linked to ovulation, rather than gravidity, is not known. To investigate behavioral, physiological, and neural changes associated with ovulation, we collected gravid, naturally ovulated, and hormonally-induced ovulated females after interactions with a dominant male. The hormone prostaglandin F2 is commonly used to stimulate ovulation in fishes, but how closely it mimics natural ovulation remains unknown in most species. Naturally and hormonally-induced ovulated *A. burtoni* females performed more affiliative behaviors than gravid, non-ovulated females. Further, males court ovulated females more than non-ovulated females. Levels of circulating sex steroids (estradiol (E2) and 11-ketotestosterone (11-KT)) were higher in naturally ovulated females compared to non-ovulated females. PGF2 induced ovulation did not increase E2 and 11-KT levels, and lowered circulating levels of progestins. To understand where in the brain increased ovulation-regulated affiliative behaviors are mediated, we are using the neural activation marker pS6 to compare neural activation patterns in socially and reproductively relevant nuclei between ovulated and non-ovulated females. Together, these results provide an integrative approach towards understanding the behavioral, physiological, and neuroendocrine changes specifically associated with ovulation.

P1-102 WIBBELS, T*; NAVARRO, E; MANTANO, J; ROSAS, M; MARIN, G; BONKA, A; LOPEZ, M; ACOSTA, H; ILLESCAS, F; PENA, LJ; BURCHFIELD, P; Univ. of Alabama at Birmingham, Gladys Porter Zoo, Brownsville, TX, Univ. of Alabama Birmingham, CONANP, Ciudad Victoria, Tamaulipas, Mexico, CDEN, Ciudad Madero, Tamaulipas, Mexico; *twibbels@uab.edu*

In-water Movements and Arribada Nesting Behavior in the Kemp's Ridley Sea Turtle Using Preprogrammed UAV Surveys During the 2018 Nesting Season

The Kemp's ridley (*Lepidochelys kempii*) exhibits pan-specific migration behavior followed by mass nesting behavior (i.e. arribada behavior. In the current study, UAV-based aerial surveys using preprogrammed flight plans were used at the Kemp's ridley sea turtle's primary nesting beach at Rancho Nuevo, MX. Several different commercially available UAVs were used in the study using preprogrammed flight plans. Over 200 missions were flown during the 2018 nesting season. The results indicate that turtles gradually moved closer to shore several days prior to arribada nesting, and some relatively large in-water aggregations were recorded. The locations of the in-water aggregations as well as the locations of the arribada nesting was variable. The results also indicate that several days immediately prior to arribada nesting, turtles could move very close to shore and aggregate in the surf zone and adjacent waters. The in-water as well as nesting behaviors suggest that the turtles may be using specific aggregation cues and or nesting cues (e.g. social, environmental, etc.) to select aggregation and nesting locations. Collectively the results provide basic insight on migratory and arribada nesting behaviors in the Kemp's ridley sea turtle. This research was conducted as part of the ongoing Kemp's Ridley Bi-National Conservation Program.

P1-212 WICKER, VV*; BORUM, EM; BUGAY, MJ; CHEBLI, GY; PASCH, HN; POPSUJ, SE; ROOT, KM; SANTIAGO, TE; SAYRE, GE; SOTELO, J; TAYLOR, LEA; LEVIN, II; Agnes Scott College; *vwicker@agnesscott.edu*

Effects of Prescription Grazing on an Urban Forest Fragment Invaded by English Ivy (Hedera helix)

In urban areas, nonnative plant species often dominate forest fragments and reduce the biodiversity of these areas by altering species interactions and abiotic conditions. The removal of nonnative plants can benefit the community, but different removal methods, as well as legacy effects, can influence plant community restoration. Prescription grazing practices have been used to control nonnative plant species, but the impacts of grazing on plant communities have not been well characterized. In this study, we applied a grazing treatment in an urban forest fragment heavily invaded with English ivy (*Hedera helix*). Twenty-four goats (*Capra aegagrus hircus L.*) grazed in two fenced areas for eight days each. These grazed sites, as well as two control sites, were surveyed via permanent transects for changes in ivy cover, species richness, and abundance of native and nonnative plants before grazing, 2.5 weeks after grazing, and 9.5 weeks after grazing. Grazing reduced ivy cover in the short term, but this effect is not predicted to last in the long term; one grazed site was already indistinguishable from the control sites 9.5 weeks post-grazing. There was no observed difference in species richness or abundance by treatment between grazed and control sites. Our results indicate that grazing by goats is effective for reducing ivy cover, but full restoration of this forest will require the use of other methods to combat invasive plant species and increase the abundance of native species.

P3-40 WILCOX, SC*; CLARK, CJ; Univ. of California, Riverside; *swilc002@ucr.edu*

Individual Variation in Flight Performance during a Hummingbird Courtship Display

Males of many animal species have evolved elaborate morphological ornaments and behavioral displays to attract the opposite sex. Some courtship behaviors seem challenging to perform and thus may serve as a means by which females judge male quality. In particular, locomotor performance during display could be tied to aspects of survival and genetic quality that may be of interest to choosy females. Black-chinned Hummingbird (*Archilochus alexandri*) males perform a repetitive side-to-side aerial "shuttle" display for females during which wingbeat frequency is nearly doubled and acceleration can be high. We examined individual differences in shuttle-display and burst-flight performances to test the hypothesis that individual variation in burst-flight performance is correlated with variation in shuttle-display performance. A significant link between shuttle-display performance and burst-flight performance would support the hypothesis that the shuttle display functions to signal male quality.

P2-269 WILLIAMS, KL*; EVANS, KM; SIMONS, AM; University of Minnesota; *will5761@umn.edu*

A model for tooth replacement and tooth function in a terrestrial fish, Alticus arnoldorum (Blenniidae)

The goals of this study are to **1)** establish a model of functional tooth replacement in a terrestrial blenniid, *Alticus arnoldorum*, exhibiting extreme tooth detachment from the jaws; **2)** demonstrate that classical descriptions of tooth attachment in combtooth blennies are inadequate to describe tooth function. The process of tooth replacement across most osteichthyan fishes has been well-described. Tooth replacement in osteichthyans occurs either in sockets within the bone of attachment (intraosseous) or within the soft tissue that surrounds the bone of attachment (extraosseous). In nearly all fishes, replacement teeth form into functional teeth that become anchored to the bone of attachment. Multiple lineages within the combtooth blennies (Blenniidae: Teleostei) serve as exceptions to these observations, as they exhibit functional teeth loosely attached to the bones of the jaw, or weakly attached via loose connective tissue and extending beyond the margins of the jaw bones. Combtooth blennies also occupy a wide range of habitats that span subtidal to supralittoral zones. Although several studies on habitat, diet and feeding behavior across Blenniidae have been conducted, descriptions of tooth development and tooth function in these fishes are limited to classical external observations. We describe tooth replacement using techniques that include staining and clearing, histology, and micro-CT scanning. The results of our study will expand upon current knowledge of the modes in which teeth are developed and replaced in osteichthyan fishes. In addition, our study will provide insight into how *A. arnoldorum* uses its oral teeth to feed in a novel terrestrial habitat.

P3-102 WILLIS, SC*; WINEMILLER, KO; ROCHA, LA; WILLIS, Stuart; California Academy of Sciences, Texas A&M University; *swillis4@gmail.com*

Osmoregulatory evolution in freshwaters: Juxtaposition of differentially expressed genes and outlier loci of an Amazon cichlid in contrasting pH and ionic environments

Freshwater habitats of the Neotropics exhibit a gradient from neutral, relatively ion-rich whitewater to acidic, ion-poor blackwater. Closely related species often show complementary distributions among ionic habitats, suggesting that adaptation to divergent ionic environments may be an important driver of Neotropical fish diversity. However, little is known about the evolutionary tradeoffs involved in osmoregulation across distinct freshwater environments. First, we surveyed gill mRNA expression of a Neotropical cichlid that inhabits both environments, *Cichla ocellaris var. monoculus*, in laboratory conditions mimicking whitewater and blackwater. Gene ontology enrichment indicated that the gills were remodeled during both forms of environmental challenge, with changes biased towards the cellular membrane. Differential expression of genes related to paracellular tight junctions and transcellular ion transport showed responses similar to euryhaline fishes in fresh versus seawater. Second, we performed a population genomic survey using ddRAD markers of populations in different habitat types. These data confirmed previous results from microsatellite markers: strong population structure not strictly correlated with habitat type, indicating recent gene flow or co-ancestry across water chemistry in the central Amazon. Finally, using the Nile tilapia genome, we estimated the physical proximity of loci strongly divergent across habitats and differentially expressed genes to identify loci most critical in facilitating osmoregulatory adaptation. We discuss why these approaches may emphasize different genomic regions.

P1-17 WILSON, AE; POLLACK, JL; BILLICK, I; DOMINGO, C; FERNANDEZ-FIGUEROA, EG; NAGY, ES; STEURY, TD; SUMMERS, AP*; Auburn University, NIH, RMBL, San Francisco State University, Mountain Lake Biological Station, University of Washington; *fishguy@uw.edu*

Structured Undergraduate Research Programs Make a Difference!

Training in science, technology, engineering, and mathematics (STEM) is a top priority for driving economic growth and maintaining technological competitiveness. We propose that exposure to a rigorous research program as an undergraduate leads to success in a research STEM career. We compared the scientific outcomes of 88 participants from five National Science Foundation Research Experiences for Undergraduates (REU) Site programs with demographically similar applicants to assess the impact that formal, organized, and funded undergraduate summer research experiences have on participants. Our study demonstrates that REU participants are more likely to pursue a PhD program and generate significantly more valued products, including presentations, publications, and awards, when compared with applicants. We believe that key components of the program include funding for personal and professional needs; access to diverse intellectual, analytical, and field resources; and the presence of other undergraduate researchers who support each other and share their goals and interests.

P2-171 WILSON, LE*; CURLIS, JD; LONSDALE, G; COX, CL; Georgia Southern University, University of Michigan, Operation Wallacea, GSU; *lw16271@georgiasouthern.edu*

Predator-based selection on coral snake mimicry components in the tropics

Studying the evolutionary drivers of aposematism and mimicry is crucial for understanding the origins of phenotypic diversity. In particular, understanding how selection acts upon the signal components of mimicry can give insight into how and where mimicry will arise. Our research focuses on coral snake mimicry, where brightly colored and venomous coral snakes are imitated by harmless snakes. Previous research found that components of coral snake color pattern must be precise in edge sympatry, may be relaxed in deep sympatry, and may not convey a fitness advantage at all in allopatry. However, this research has focused on species-poor temperate systems, and thus we know relatively less about the evolution of signal components in the diverse tropics. We tested which mimetic signal components are important for deterring predation in sympatry and allopatry with coral snakes in a tropical cloud forest in Honduras. We placed plasticine models that were 1) brown 2) white and black 3) red and black 4) white, red, and black (mimetic) in habitats that were both sympatric and allopatric with coral snakes. We found that while overall attack rates on models were similar among localities, predatory attacks by birds, but not mammals, were highest at the two low elevation localities. While overall attack rates were similar among all models, models with either bands or red color were attacked with less frequency by birds, but not mammals, than other models at one low elevation site. These results lend insight into how geographic range and predator assemblages may alter selection for signal components of coral snake mimicry systems in the tropics. Ultimately, this work highlights the processes that generate and maintain phenotypic diversity.

P2-173 WILSON, E*; BARTS, N; COFFIN, J; KELLEY, J; TOBLER, M; GREENWAY, R; Kansas State University, Washington State University; *libbywilson719@gmail.com*

Comparative Analyses of Gene Expression Responses to Variation in Salinity across Distantly Related Fish Species

Transitions between marine and freshwater environments drive osmoregulatory adaptations of many aquatic organisms. Bidirectional transitions have occurred repeatedly during the diversification of fishes, allowing for broad scale examination of repeatable patterns in evolution. We are comparing genome-wide patterns of gene expression across six distantly related species pairs from high and low-salinity environments, including South American silversides (*Odontesthes*), scaleless carp (*Gymnocypris*), ide (*Leuciscus*), stickleback (*Gasterosteus*), killifish (*Lucania*), and livebearers (*Limia*). For each pair, we mapped raw reads to a close reference, identified orthologous genes, and compared the expression levels in an explicit phylogenetic framework. Identifying convergent patterns of physiological responses across distant lineages sheds insight about conserved mechanisms underlying osmoregulation in fishes.

P2-163 WILSON, AM*; MELICHER, DM; BOWSHER, JH; RINEHART, JP; North Dakota State University, USDA - ARS; *amanda.wilson.1@ndus.edu*

Effects of fluctuating temperatures on the longevity and fecundity of Drosophila melanogaster

Reduced temperatures have shown to increase the longevity of cold-tolerant insects. Insects that are not cold-tolerant experience elevated mortality when held at static reduced temperatures. A fluctuating thermal regime (FTR) has been shown to increase longevity and survivability in multiple insect species. During a fluctuating thermal regime insects are held at a reduced temperature with a one hour pulse of increased temperature each day. We measured the effect of FTR compared to constant temperature (CT) on the longevity and fecundity of Drosophila melanogaster held at CT-6°C, CT-22°C, and a FTR that oscillates between 6°C and 22°C. We demonstrate that a fluctuating thermal regime which oscillates between the cold and warm static temperatures greatly increases longevity with mean survival approximately seven times as long as other treatments and up to 241 days. We assessed the effects of FTR on male and female fecundity at 20-day intervals from 20 to 100 days and fecundity in the subsequent generation. Under the FTR treatment the fecundity of both JW and Oregon-R female flies declined steadily but after 60 days when no CT-6°C flies remained alive the fecundity of both strains remained at approximately 53% of control. Male flies of both strains exhibited an increase in fecundity under FTR peaking at 80 days before dropping significantly after 100 days. The reduction in female fecundity is likely a combination of the high cost of egg production and adult flies not consuming FTR culture media, while the increase in male fecundity remains unexplained. Offspring reared from each treatment group did not exhibit the patterns found in FTR parents.

P1-139 WINTERS, TJ*; LUTTERSCHMIDT, DI; Portland State University; *treven@pdx.edu*

Low-temperature winter dormancy alters thyrotropin immunoreactivity in the pituitary pars tuberalis of garter snakes.

The synchronization of physiology and behavior with favorable environmental conditions is tightly linked to an animal's fitness. This synchronization depends on an organism's ability to transduce environmental cues, such as photoperiod and temperature, into neuroendocrine signals that regulate physiological and behavioral processes. These neuroendocrine signals are critical to understanding the seasonality of vertebrate reproduction. Relative to photoperiod, however, there is comparatively little research on the potential role of temperature, despite the fact that many vertebrates (especially ectotherms) use temperature as a cue for timing seasonal mating. We hypothesized that temperature-activated reproduction is mediated by changes in thyrotropin synthesis within the pituitary pars tuberalis. We tested this hypothesis in red-sided garter snakes (*Thamnophis sirtalis*) using simulated winter dormancy, immunohistochemistry, and behavior assays. Field-collected snakes were hibernated at 4°C or 12°C in complete darkness and euthanized at 0, 4, 8, or 16 weeks in hibernation. Brains were collected and processed for thyrotropin (a.k.a. thyroid stimulating hormone, TSH) immunohistochemistry; we quantified the number of immunoreactive cells within a subregion of the anterior pituitary gland that is akin to the pars tuberalis. Our results suggest that TSH immunoreactivity in this pars tuberalis-like region changes in response to hibernation at 4°C for at least 4 weeks. Moreover, the observed changes in TSH mirror the effects of low-temperature dormancy on male courtship behavior. We suggest that TSH within the pars tuberalis can be modulated by environmental temperature, and these temperature-induced changes may in turn facilitate the effects of temperature on seasonal reproduction.

P3-67 WOLF, CJ*; SASSER, KT; SENNER, NR; CHEVIRON, ZA; Univ. of Montana, Univ. of South Carolina; *colejwolf@gmail.com*

Landscape Genetics of Peromyscus maniculatus across the Colorado Front Range

Species distributed across heterogeneous environments may adapt to local conditions as a result of differing selection pressures. This process can lead to adaptive divergence, where populations are subdivided based on the different environments they inhabit. High levels of gene flow have the potential to homogenize genetic variation across the landscape, particularly if migration rates are high and the strength of selection for locally adapted loci is low. In this case gene flow is only limited by dispersal, and population structure will arise as a result of geographic distance. However, local adaptation can still occur in the face of gene flow if selection for a local optimum is sufficiently strong. High altitude environments impose strong selective pressures on homeothermic endotherms, as the dual stressors of cold temperatures and hypobaric hypoxia constrain their ability to maintain a stable body temperature via aerobic thermogenesis. The deer mouse (*Peromyscus maniculatus*) is continuously distributed from sea level to over 4,300 meters in elevation, so this species is an ideal system to investigate the interaction between gene flow and local adaptation to high altitude. We sampled thirty deer mouse populations along seven transects spanning a 3200-meter elevational gradient in the Colorado Front Range in the summers of 2016 and 2017. We then used restriction-site associated DNA (RAD) sequencing to generate a dataset of thousands of single nucleotide polymorphisms. The program STRUCTURE and R-package BEDASSLE were employed to examine population structure and test the relative strength of geographic versus environmental distance on population structure.

P2-282 WOMACK, MC*; LEMMON, EM; LEMMON, AR; HOKE, KL; National Museum of Natural History, Florida State University, Colorado State University; *mollywo@berkeley.edu*

Signatures of Relaxed Selection Characterize Earless Toad Lineages

Here we integrated genetic, morphological, physiological, and developmental data to propose potential selection pressures contributing to convergent loss and potential regain of middle ear structures across the family of true toads (Bufonidae). Middle ear structures are shared by most tetrapods for hearing airborne sound, yet they have been lost at least eleven times in Bufonidae, despite the fact that frogs and toads are known to use acoustic communication for mate attraction and other conspecific interactions. Sequence analysis of coding regions in 60 bufonid species (16 earless, 44 eared) nominates six of 30 candidate genes known to be important for tetrapod middle ear development as possible contributors to middle ear loss. These six candidate genes exhibited relaxed purifying selection in earless lineages when compared to closely-related eared lineages. Earless lineages did not share any parallel amino acid changes or evidence for positive selection within coding regions associated with tetrapod middle ear development, complementing our lack of evidence for shared selection pressures acting on anuran middle ear loss in relation to ecology or pleiotropic skull trade-offs. The relaxed purifying selection associated with anuran middle ear loss provides an intriguing starting point for the investigating the genetic basis of anuran middle ear development in relation to better-known tetrapod groups. With this added genetic evidence, we further support the hypothesis that middle ears are lost by a combination of relaxed selection on the middle ear and changes in development rate.

P2-86 WOOD, M/N*; SOLTIS, J; Disney's Animal Kingdom; *michelle.n.wood.-nd@disney.com*

Measuring and Mediating Night Light at the Zoo

Light and light cycles produced by the sun have shaped the adaptations of animals on earth over millions of years. Artificial light produced by humans has imposed new sources of light that can profoundly impact animals. These impacts can be particularly strong on animals in managed care, where sources of artificial light compete with or replace natural light. Light exposure drives circadian rhythms and can affect multiple biological processes across all taxa including; sleep wake cycles, activity budgets, behavior, body condition, reproduction, immune function, digestive function, and much more. Disney's Animal Kingdom® has extended its operating hours resulting in artificial light sources illuminating animal habitats past natural sunset. With this in mind we began to measure light sources and mediate brightness and/or spectral distribution as appropriate. Our goals are to keep illuminance measurements in a range that would be typical at night, and reduce or eliminate wavelengths below 500nm (blue, violet, and UV wavelengths) which have the strongest impacts on circadian rhythms. We will discuss examples of mitigation techniques and their effectiveness.

P1-272 WOODRING, A*; ZIMMERMAN, M; LANDBERG, T; Arcadia University, Glenside; *awoodring@arcadia.edu*

Carry-over effects of larval hydroperiod and conspecific density on the phenotype and urban translocation success of American Toads (Anaxyrus americanus)

Urban translocation success of native species is often low because of habitat degradation due to invasive species, lack of phenotypic variability, and differences between source and release environments. We marked and released 327 American Toads (*Anaxyrus americanus*) raised under different experimental conspecific densities (10 or 29 tadpoles/tank) and hydroperiods (60, 75, or 90 days) to a 12-acre wooded suburban park with a manmade pond. Introduction success was expected to increase with body mass if selection was strongest against individuals vulnerable to resource deprivation (low moisture or food levels). Alternately, introduction success was expected to increase with jumping distance if selection was strongest against toads unable to escape predators by jumping. Time to metamorphosis was highest in the 75-day hydroperiod, with a greater effect at low density (significant hydroperiod*density interaction, ANOVA, $p=0.0017$). Body size (snout-vent length, leg length, and mass) at metamorphosis significantly increased with density (ANOVA, $p<0.0001$, $p<0.0001$, $p=.0052$ respectively). Survival rate through metamorphosis was highest in the higher density with a significant interaction between density and hydroperiod (ANOVA, $p= 0.0311$ and $p=0.0175$ respectively). Similar to our first (unsuccessful) introduction attempt of 670 toads in 2016, recapture success this year has been very low. Generating different phenotypes may increase introduction success, however, poor habitat quality, priority effects (green frog predation), and relatively low numbers for an introduction attempt still present difficulties in experimentally studying and restoring urbanized habitats.

P1-160 WOODRUFF, MJ*; HILL, HM; NOONAN, M; Indiana University, Bloomington, St. Mary's University, Canisius College; *woodrufm@iu.edu*

Individual Difference in the Behavior of Beluga Whales (Dephinapterus leucas)

The topic of individual differences in animal behavior has garnered a great deal of attention across many species, but questions remain as to whether behavioral differences change over time or across age and sex. The present study focused on beluga whales (*Delphinapterus leucas*), a species in which a high degree of behavioral variability may be expected due to the fact that belugas are large-brained, long-lived, and highly social in nature. We recorded a suite of 33 behavioral measures related to boldness, playfulness, sociability, and other traits, with the goal of assessing age and sex differences in behavior, as well as consistency within individuals over time. Our subjects were seaquarium-based, and mixed in age and sex (N=41). Findings showed that immature whales were rated as more spontaneous and more likely to be at the observation window, suggesting perhaps investigative behavior varies with age. Adult whales, on the other hand, were more likely to swim in non-standard body orientations, to display vigilant behavior, and to be rated as dominant. Most importantly, 22 of the 33 behavioral measures showed significant within-subject consistency over time, suggesting that stable behavioral differences appear to exist in this species (behavioral syndromes). However, very few measures showed significant correlations with each other, indicating that they could not be grouped into identifiable factors that comprised recognizable "personalities." Instead, we suggest that personality may be built in different ways depending on an individual's age, sex, and contextual variables that may influence the degree to which specific sets of behaviors co-vary.

P2-9 WORLEY, CA*; NEBHUT, AN; SHINKLE , JR; Trinity University, San Antonio; *cworley@trinity.edu*

Long Term Effects of High Energy UV-B on Texas Native Grass Pigmentation and Structure

Plants have mechanisms to sense dangerous ultraviolet radiation and regulate their responses to changes in their light environment. In particular, plants exposed to UV-B (280 to 315 nm), which includes photons of the highest energy levels found in sunlight, display unique responses such as inhibited growth and production of UV-protecting pigments. These responses may be permanent or transitory. Persistence of plant responses to a reduction in UV radiation in field setting was studied as follows. Texas grasses were placed, in full sunlight, under two filters: aclar, which is UV transparent, and cellulose acetate, which blocks almost all energy at wavelengths shorter than 300nm. The immediate and long-term effects of high energy UV-B radiation on plant function were tested using UV absorbance spectra taken from leaf pigment extracts and reflectance spectrophotometry of leaves. Both spectra were taken three times for each test plot, once at the beginning of the experiment, once after the treatment period, and once after two weeks of recovery. Results from rural and urban field sites in addition to greenhouse studies support that exposure to UV radiation sometimes leads to changes in leaf structure and composition that can persist after treatment concludes. However, this result is not identical across species or field sites. For instance, the Bandera county sideoats grama (*Bouteloua curtipendula*) extracts exhibited lower absorption in the 300-320 nm band after treatment than before treatment, but for Travis county sideoats grama there were no differences between initial, treatment, and recovery absorbance readings. These results indicate that under different circumstances as yet unidentified, grasses of even the same species exhibit different responses to UV-B radiation.

P2-106 WRIGHT, SK*; LAMBERT, FN; WOOD, MW; ALBA, A; FONTENOT, DK; WHEATON, CJ; Disney's Animal Kingdom®; *sarah.k.wright.-nd@disney.com*

Fecal Corticosterone Evaluation of Individual Potential Translocation Candidacy in Threatened Avian Species

Populations of avian species (e.g. golden white-eyes (GOWE), Mariana fruit doves (MAFD), rufous fantails (RUFA), and Tinian monarchs (TIMO)) in the Mariana island chain have declined since the regional introduction of the brown tree snake to Guam. Efforts to establish security populations of these species through collection and translocation to nearby islands have occurred via the Marianas Avifauna Conservation Program since 2004. Using a previously validated enzyme immunoassay, we measured fecal immuno-reactive corticosterone (B) in daily (24h total fecal output) samples from individual birds collected from mist nets (April-May, 2015-2018) and placed in a holding facility for health evaluation for up to two weeks before release. We observed considerable variation in fecal B on day of collection (=day 0) and day 1 in holding in all species, with most birds acclimating by day 2-3. GOWEs had the least amount of variation on day 0, highest variation on day 1, and took 1-2 days longer to acclimate. Some MAFDs and TIMOs had secondary B responses (days 3-5) attributed to concurrent health exams for recently collected birds added to the holding room. Individuals that sustained injury during collection, lost body mass during holding, or expired, exhibited a pattern of elevated B on day 0, 1, or the day of injury. Our results suggest that 1) most birds acclimated quickly to holding (>97%); 2) current management and husbandry strategies did not adversely affect health or mortality; and 3) fecal B can be used as a complement to disease and health assessment to help choose the best individuals for translocation. These methods have the potential to be applied to other avian species targeted for field conservation initiatives.

P2-175 WULF, G/W*; MEY, K; SETHURAMAN, A; SUSTAITA, D; California State University San Marcos; *wulf001@cougars.csusm.edu*

Population Genetics, Form, and Function of Loggerhead Shrikes in California

Population genetics studies of Loggerhead Shrikes (Laniidae: *Lanius ludovicianus*) in California have indicated considerable intraspecific genetic differentiation. Other morphological and behavioral studies have also shown geographic phenotypic variation. However, the concordance between genetic and phenotypic differentiation remains obscure. Here we explore the extent to which genetic differences among populations are correlated with phenotypic differences (beak shape and bite force) among populations of Loggerhead Shrikes throughout California. Feather samples were collected from shrikes in locations along an approximately 950 km range. Genomic DNA was then extracted and we genotyped each individual at 7 different nuclear microsatellite loci. Preliminary pairwise F_{st} values, along with MULTICULST analyses show evidence of population structure among some of these locations, suggesting a potential genetic basis to the observed phenotypic differences among some, but not all, populations. We expect that by increasing our genotyping with more microsatellite loci and sampling more individuals across California, we can perform more rigorous analyses of population structure that will shed light on the relative roles of local adaptation and plasticity in shaping differences in feeding morphology and function.

P3-185 WYETH, A.*; QUIROGA ARTIGAS, G.; SCHNITZLER, C. E.; Hope College, Whitney Laboratory for Marine Bioscience; *alexandra.wyeth@hope.edu*

A detailed head regeneration timeline in the cnidarian Hydractinia symbiolongicarpus

Tissue regeneration is widespread throughout the animal kingdom, although most regenerative animals have a limited capacity for the structures they can regenerate. The colonial cnidarian *Hydractinia*, however, has the remarkable ability to regenerate any structure throughout its lifespan, including regenerating its head structures (mouth, tentacles, neurons, stinging cells) within about 72 hours. Migratory stem cells, known as interstitial cells ('i-cells'), typically reside in the body column of *Hydractinia* feeding polyps. Head regeneration is accomplished via the proliferation of these i-cells forming a blastema structure that gives rise to all head structures. In this study, we established a detailed timeline of head regeneration in *Hydractinia symbiolongicarpus*. To better understand this process at a cellular level, we performed a series of experiments including live imaging, immunohistochemistry, and cell proliferation assays over a time course of regeneration. Most polyps completely regenerated their head within ten days, with first tentacle buds occurring between 48 and 72 hours post dissection. Immunofluorescence staining showed wound closure within four hours, while nervous system regeneration and the appearance of stinging cells around the newly formed mouth and in the budding tentacles occurred between 48 and 72 hours after dissection. EdU staining and pulse-chase experiments revealed the essential contributions made by the pool of proliferating i-cells to all regenerated head structures. Our results confirm initial observations made in a sister species of *Hydractinia* and provide a more detailed understanding of the head regeneration process in *Hydractinia* that will be used as a basis for future studies of this highly regenerative species.

P1-72 WYND, BM*; MARTINEZ, RN; Virginia Tech, Blacksburg, USA, Museo de Ciencias Naturales, San Juan, Argentina; *bmwynd@vt.edu*

A review of vertebrate beak morphologies in the Late Triassic; a framework to phylogenetically place an enigmatic beak from the Ischigualasto Formation, San Juan, Argentina

The fossil record rarely preserves direct evidence of ecology (e.g., gut contents), but it does preserve many cases of convergent morphology, which suggests similar ecologies. A beak, which is an edentulous dietary modification present in vertebrates and invertebrates convergently evolves repeatedly throughout the Phanerozoic. Here, we focus on the earliest evolution of beaks in the reptile fossil record during the Triassic Period (252 - 201.5 million years ago). We divide Triassic beaks into three morphotypes: 1) triangular, beak tapers to a point anteriorly, thin lateral walls, sharp occlusally; 2) square, a beak squared off anteriorly, thin lateral walls; 3) predentary, triangular beak, rounded lateral walls, concave midline shelf. With this subdivision, we analyze the phylogenetic distribution of Triassic beaks and a unique fossil beak (PVSJ 427) from the Ischigualasto Formation, San Juan, Argentina. PVSJ 427 is a small hematite-encased fossil that is triangular with a concave midline shelf, rounded lateral walls, and an anterior point. No bone is currently recognizable on the surface of PVSJ 427, indicating that it could be a natural cast of a beak or it could be a rhamphotheca encased in hematite. The rounded walls and midline shelf most closely matches the predentary morphotype, which is restricted to ornithischian dinosaurs, though this specimen is ~3 times larger than the earliest known Jurassic ornithischian beak. Regardless of phylogenetic position, PVSJ 427 reflects the earliest-known evolution of the predentary-like morphotype in vertebrates and indicates that this animal was likely exploring similar feeding ecologies to later-known ornithischian dinosaurs.

P2-80 XIANG, A*; GAGLIO, A; PELLICANO, A; GARDYN, N; SHALOV, J; LYNCH, KS; Hofstra University; *angellx0607@gmail.com*

Comparison of candidate genes in hypothalamic brain regions in blackbirds with stark divergence in maternal care strategies

The external conditions that contributed to the evolution of avian obligate brood parasitism have been well-studied whereas the intrinsic mechanisms are less well understood. Our lab previously identified differentially expressed transcripts specific to the preoptic area (POA) in brood parasitic and a closely related non-parasitic species. We selected six maternal care-related candidate genes and compared their expression in additional hypothalamic regions in parasitic bronzed cowbirds (Molothrus aeneus) and non-parasitic red-winged blackbirds (Agelaius phoeniceus). We compared genes with neuromodulatory and structural functions including mesotocin (avian homolog of oxytocin), arginine vasotocin (homolog of vasopressin), galanin, prostaglandin synthase, stathmin and mesencephalic astrocyte derived neurotrophic factor (MANF). We compared expression patterns of these genes in a pooled sample that contained tissue punches from the lateral hypothalamus, tuberal nucleus, ventral medial hypothalamus, and posterior medial hypothalamus. Results reveal that differential expression of these genes between parasitic and non-parasitic blackbirds is not specific to the POA. We found significant differences between parasite and non-parasite species in all transcripts within these additional hypothalamic regions. These results suggest that the POA is likely not the only brain region that was targeted by evolution to produce this novel behavioral phenotype as additional hypothalamic regions exhibit similar gene expression differences between parasitic and non-parasitic species. Additional studies will examine brain regions within other social behavior-related regions to identify the full suite of neural architecture that may underlie the brood parasitic strategy.

P2-197 YOUNG, MG*; MCMAHON, TW; ANGELINI, DR; Colby College; *mgyoun21@colby.edu*

Bombus Microbiome Diversity and Pathogen Prevelence in the State of Maine

Bumblebees are critical, native pollinators, contributing to both local ecosystems and agriculture throughout North America. Similar to the honeybee, many *Bombus* species have faced decline over recent years due to multifaceted causes that work in conjunction to overwhelm the natural defenses of bees (Goulson et al. 2008; 2015). Currently, Maine's endemic populations are threatened by the use of agrochemicals, climate change, and various diseases and parasites. Through ecological genomic research, we have investigated both the range and diversity of the Maine bumblebee species and looked for correlations between microbiome composition and anthropogenic and environmental factors. This has been accomplished through 16s and 18s sequencing of field samples collected across the diverse biomes of the state during the summers of 2017 and 2018. Analysis of species distribution suggests that many of the coastal islands act as refuges for threatened bees due to their geographic isolation from the mainland. With our data, we have assessed the prevalence of known pathogens, such as *Crithidia, Nosema*, and *Apicystis*. Previous research indicates that bumblebees forage within a maximum range of 5 km (Goulson 2010; Stubbs & Drummond 2001; Dibble et al. 2017). We tested the hypothesis that islands outside of this daily foraging range are geographically isolated from the spread of both pathogenic and benign microbes by comparing island and mainland samples with differential abundance analysis of observed OTUs and the use of various diversity metrics. Taking into account both the microbiotic and metadata profile collected on each sample, we used statistical analysis to further examine for predictors of microbiome health and other correlations within our data.

P2-189 YOUNG, CM*; JEBB, KE; MORAN, CJ; GERRY, SP; Fairfield University, The Citadel; *carolineyoung072@gmail.com*

Effects of Muscle Acclimation to a Thermal Regime

Investigating the differences in muscle physiology between lab acclimated fish and those taken from the wild can help us understand the impacts of thermally acclimated fish in a laboratory. Additionally, these comparisons allow us to evaluate the inferences made on fish in the wild by laboratory studies. To address these topics we asked the question, does muscle physiology in wild cunner (*Tautogolabrus adspersus*) differ from cunner in the lab? We hypothesized that 20°C acclimated cunner would produce greater power output and muscle kinetics compared to 20°C natural cunner. Lab acclimated cunner (n=5) were collected from Long Island Sound and held for 4 weeks at 20°C. Similarly, the natural cunner were caught when ocean water reached 20°C. To address our hypothesis, we examined the effects on power output and muscle kinetics with cunner tested at 20, 10, and 5°C. The 20°C acclimated cunner had a greater twitch force per PCSA, as well as power output at 5, 10, and 20°C. Additionally, throughout each testing temperature, power output for lab acclimated cunner was greater at every frequency. However, the time to maximum twitch contraction and relaxation were relatively similar between acclimated and natural cunner at every testing temperature. The difference in power output and force PCSA could indicate that muscle in thermally acclimated fish underwent a change to produce greater results. Furthermore, this data could suggest that lab acclimated fish are not accurate comparisons to those in the wild.

P3-87 ZAHOR, DL*; GLYNN, KJ; CHIPARUS, SL; CORNELIUS, JM; Eastern Michigan University; *dzahor@emich.edu*

Species, age and foraging-niche variation in blood lead levels in urban and rural songbirds

Anthropogenic metal pollutants emitted into the environment have the potential to harm organisms residing in the polluted ecosystem. Urban birds spend much of their time in human-dominated landscapes and could serve as bioindicators of metal pollution as well as possibly reflect human exposure. Lead is a persistent heavy metal in the environment that can act as a neurotoxin when it reaches high levels within an organism. Diets vary widely in songbirds and species that forage on soil-dwelling organisms may be more prone to lead exposure. Similarly, if young are fed preferred items there may be differences in exposure between adults and juveniles. Finally, species that associate strongly with human structures may differ in exposure to lead. In this preliminary study, we describe blood lead levels in four species of urban songbirds: two omnivores that forage frequently for soil-dwelling organisms and two granivores, including an invasive and native species of each. We will discuss the influence of diet, age and ecological niche on lead levels in these urban songbirds. Understanding factors that increase a species sensitivity to pollution can better guide conservation efforts and raise public awareness surrounding pollution risks to wildlife.

P3-36 ZALASKUS, KA; BARTOL, SM*; BARTOL, IK; Old Dominion University, Norfolk, VA, Virginia Wesleyan University, Virginia Beach, VA; *kjaco001@odu.edu*

Swimming Kinematics of Loggerhead Sea Turtles during Early Ontogeny

Sea turtles embark on extensive transoceanic migrations during early ontogeny, often moving into and out of prevailing currents in search of target food sources. Although efficient swimming is essential to a turtle's survival, surprisingly little is known about sea turtle swimming capabilities during the critical first year of life. In this study, we examined swimming kinematics of loggerhead sea turtles *Caretta caretta* through their first year of life, with an emphasis on documenting sustained swimming speed capacity, stability, and flipper motions. Each of four post-hatchling loggerhead sea turtles was placed in a 1000-gallon water tunnel at 3, 4, 5, and 6 months of age and subjected to a stepwise increase in current speed while three high-speed digital video cameras simultaneously recorded their swimming motions. Critical swimming speed ranged from 13 to 20 cm/s for turtles 3-6 months of age. Turtles achieved higher swimming speeds by increasing the frequency, vertical arc angle, and horizontal amplitude of their foreflipper strokes. Body pitch angle decreased with increased swimming speed, but body roll and yaw did not change significantly with increased swimming speed. Recoil motions decreased with ontogeny, suggesting that sea turtles improve their swimming proficiency with age and/or with experience swimming in the water tunnel. No abrupt kinematic shifts indicative of gait transitions were observed across the speed range tested. Our results suggest that young turtles are capable of making gradual adjustments to their flipper motions and body positioning to achieve higher swimming speeds.

P3-174 ZAMACONA GONZALEZ, R.*; WILCOXEN, T.E.; ZIMMERMAN, L.M.; Millikin University; *rzamaconagonzalez@millikin.edu*

Isotype switching and spleen development in Rana catesbeiana

Compared to immunity in adult frogs, little is known about immunity in tadpoles. It has been demonstrated that *Rana catesbeiana* tadpoles can isotype switch from IgM to IgY three weeks after exposure to an antigen. However, the exact timing of this has not been determined. The time period of isotype switching in *Rana catesbeiana* was studied in 90 tadpoles, in addition to the development of their spleens. We divided the tadpoles into two different groups, the control group and the immunized group. Control tadpoles received 10 µL of a 50/50 of phosphate buffer solution (PBS) and alum. Immunized tadpoles received 10 µL of 50/50 solution of 10 µg/µL of keyhole limpet hemocyanin in PBS and alum. Two tadpoles from the control group and four from the immunize group were selected randomly to be sampled every three days. We discovered that the immunized group had a larger spleen than the control group. The antibody levels to KLH will be measured using an ELISA. These results help us in determining the period of time it takes the tadpoles take to isotype switch from IgM to IgY. This information could be used in future research to investigate factors such as stress levels, change in temperature, and change in resource availability could affect the length of time that *Rana catesbeiana* takes to respond to novel antigens.

P2-78 ZAMORE, SA*; SOCHA, JJ; Virginia Tech; *zamore@vt.edu*

Development of a virtual reality arena to study vision in flying snakes

Virtual reality is widely-used tool for exploring perception and decision-making in animals such as cockroaches, mice, fruit flies, bees, moths, and hummingbirds. By placing animals in a closed-loop environment, researchers can manipulate feedback (by temporally offsetting the response from a behavior, for example) such that requisites for locomotion or perception are revealed. Here, we demonstrate a new virtual reality environment, which we are developing to explore how flying snakes (*Chrysopelea*) visually perceive the environment during locomotion. The virtual arena consists of a 3-ft cube lined with PVC fabric, upon which images are back-projected (Epson VS350 XGA projectors). The system tracks the snake's head and body position using infrared (IR) reflective markers, commercial gesture sensors (Leap Motion), and custom computer vision scripts. The virtual world imagery, created using Unity software, is updated continuously using the tracked the head positions. To observe the snake's undulatory movement without translation, we designed air table that provides a zero friction surface. This new closed-loop virtual reality system will enable us to gain insight into how snakes use vision to move through their environment, and to react to specific visual features (such as looming and retreating objects). Supported by NSF 1351322 and 1402558.

P1-199 ZAPFE, KL*; FRéDéRICH, B; SANTINI, F; FEDERMAN, S; FIELD, D; DORNBURG, A; Clemson University, University of Liège, Associazione Italiana per lo studio della Biodiversita, Yale University, University of Bath, North Carolina Museum of Natural Sciences; *kzapfe@clemson.edu*

Collapsing Hotspots, Extinction, and Recovery: The Evolutionary History of Herbivorous Reef Fishes

Herbivorous reef fishes have evolved to occupy a central role in controlling both the distribution of algae and the flow of energy in coral reef food webs. Today, these fauna and the ecosystems they maintain have become increasingly threatened by anthropogenic stressors. Developing an understanding of how the diversification dynamics of these lineages responded to historic climatic shifts provides critical insight into the expectations of herbivorous fish diversity under current models of climatic change. We combined molecular, paleontological, and morphological data to assess the diversification dynamics of rabbitfishes (Siganidae) and surgeonfishes (Acanthuridae), two major clades of herbivorous fishes that have been of central ecological importance over the past 50 million years. By combining landmark-based geometric morphometric data of 396 extant and fossil species images with a time-calibrated phylogeny, we found diversification of both clades reflected the expectations of an extinction recovery model following the collapse of the West Tethys Sea. The two groups however exhibit differing tempos of speciation as well as extant morphospace occupancies relative to Eocene species. Our results indicate the viability of multiple evolutionary pathways leading to lineage persistence in the wake of environmental change. However, given modern-day trends in habitat degradation, they also forewarn of future patterns of diversity not dissimilar to those of the post Tethyian collapse favoring fewer, more generalized herbivores on reefs unlike those of the present.

P1-177 ZHANG, X*; RONALD, KL; HURLEY, LM; Indiana University, Bloomington; *xinzzhan@iu.edu*

Multimodal Female Stimuli Influence Vocal and Nonvocal Behaviors of Male House Mice (Mus musculus)

House mice use multimodal signals (e.g., auditory and olfactory) intersexual communication. However, more studies have been done on how females respond to signals from males than how males respond to signals from females. This is important because males and females can both send and receive signals during communication. Moreover, most studies tend to study nonvocal and vocal response behaviors separately instead of looking into the relationships between them; nevertheless, this relationship may give us new insights about the functions of multimodal signals. We presented female ultrasonic vocalizations (USVs), squeaks, and urine as unimodal signals and USVs+urine and squeaks+urine as multimodal signals to test male behavioral responses. We used the numbers of ultrasonic vocalizations as vocal behaviors and the duration of investigation, digging and rearing as nonvocal behaviors. We studied the correlations between each nonvocal and vocal behavior. We predicted that the correlations between male behaviors would only exist under multimodal conditions because increased information about females might cause males to produce vocal and nonvocal behaviors. .Our results supported our predictions, in that behavioral correlations only occurred during multimodal conditions. Specifically, the correlation between male investigation and USVs existed under female squeaks+urine condition and the correlation between male digging and USVs existed under female USVs+urine condition. Our results suggested that multimodal signals are more salient than unimodal signals. At the same time, correlations may have emerged because multimodal signals elicit the highest male response rate, creating a range in which individual variation can be observed.

P2-230 ZIMMERMAN, MK*; WOODRING, AK; LANDBERG, T; Arcadia University; *mzimmerman_01@arcadia.edu*

Carry-over Effects of Larval Density and Hydroperiod on American Toad Morphology and Jumping Performance

Small slow-moving animals such as the American Toad often experience high mortality during dispersal and can be prevented from populating suitable habitats in urban areas due to roads and established predators. Our goal was to introduce marked toads to an urban park with a man-made pond and test to see if there were carryover effects of larval environment on adult translocation success. We manipulated tadpole density (10 or 29 tadpoles/tank) and hydroperiod (60, 75 or 90 days) in the lab to increase phenotypic variation and maximize introduction success. We predicted that toads raised in relatively low density would have larger body sizes. Relatively short hydroperiod was predicted to produce metamorphosis sooner, resulting in reduced body size and jumping performance, however it produced larger snout-vent (SVL) and tibiofibula (leg) lengths. As expected, lower density toads had higher mass relative to SVL (ANOVA, $p>.0001$). Leg length was significantly affected by hydroperiod (ANOVA, $p=.02$), density (ANOVA, $p<.0001$), and their interaction (ANOVA, $p=.14$). Jump distance was significantly affected by leg length (ANOVA, $p=.013$), hydroperiod (ANOVA, $p=.04$), density (ANOVA, $p<.0001$), but not in their interaction (ANOVA, $p=.20$). Age at metamorphosis decreased jumping distance (ANOVA, $p=.04$). Manipulating larval environments may increase the range of phenotypic variation that selection can act on during translocation. However this is a high risk and high effort strategy when coupled with experimental research because it results in low survival in degraded habitats. Despite initially low survival of translocated toads, we hope this strategy to understand the phenotype-environment relationship will eventually help conservation efforts in urbanized environments.

P1-192 ZIEMBA, JL*; LANCE, SL; CAPPS, KA; University of Georgia; *julie.ziemba25@uga.edu*

Investigating Potential Ranavirus Reservoirs

Ranavirus is a global pathogen of ectothermic vertebrates that can cause the mass-mortality of entire amphibian communities. However, asymptomatic amphibians have also tested positive for ranavirus in the field. In ephemeral wetland systems, it has been hypothesized that reservoir species retain sublethal infections from year-to-year between pond-filling events and subsequently reintroduce ranavirus to the community. Yet, our understanding of sublethal infection prevalence and the ways in which sublethally-infected individuals impact disease transmission is poor. Our objectives were to 1) explore disease susceptibility at low doses of ranavirus exposure and 2) examine the potential for chronic sublethal ranavirus infection. We conducted a series of laboratory dose-response experiments using *Pseudacris ornata*, *Lithobates capito*, and *Ambystoma talpoideum*. For each species, larvae were assigned to one of four doses ranging from 0 to 10^3 plaque-forming units of a local strain of ranavirus. Between one to two months after exposure, we sacrificed the survivors and dissected liver tissue for DNA extraction and qPCR. We found interspecific variability in susceptibility to low doses of ranavirus. Across doses, only *P. ornata* and *L. capito* larvae showed symptoms of ranavirus (hemorrhaging and acute death). Exposure to 10^2 plaque-forming units of ranavirus or fewer resulted in only 7% survival of *P. ornata*, but ~77% survival of *L. capito* and 100% survival of *A. talpoideum*. Ranavirus was not detected in the liver tissue of any surviving individuals, regardless of dose or species, suggesting resistance to infection, or the ability to clear the pathogen following infection. Although we found no evidence for chronic sublethal ranavirus infection, the growing documentation of apparently healthy, ranavirus-positive amphibians warrants further investigation of amphibian ranavirus reservoirs.