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DEER SPECIALIST GROUP NEWS

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Editorial

Dear DSG members,

We are pleased to present the latest issue of the IUCN SSC Deer Specialist Group (DSG) newsletter. This edition features a variety of fascinating articles, most of them focused on Holarctic or Old World deer species.

Highlights include a study on spotted deer and the synanthropic predominance of hard-antlered males, as well as the use of camera traps to assess threats to the Bawean deer. We would also like to spotlight the contribution of young member Jhonnel Villegas, who, together with Dr. Ceacero, is working to conserve the Philippine brown deer through cultural engagement.

Another article emphasizes community participation in the co-production of knowledge for caribou conservation. We also feature a remarkable report of a long-distance dispersal event by a water deer and provide an update on the reintroduction project for the Persian fallow deer.

From the Neotropics, we include a valuable contribution on the physiological validation of an enzyme immunoassay for measuring faecal cortisol and corticosterone metabolites in brown brocket deer.

Dr. Khursheed Ahmad is organizing the **2nd International Conference on Hangul and Other Threatened Ungulates** and warmly invites all members to participate. More details and information are included in this issue.

We also extend a warm welcome to **Dr. Alolika Sinha**, who will be serving as the Red List Authority for Old World deer species. Please contact her if you can contribute to updating species assessments. All contributions and information are very valuable and welcomed. In addition, we are seeking volunteers to take on leadership roles and to help identify experts or members from other groups to support two key areas critical to the conservation of many endangered, vulnerable, or data-deficient deer species:

Climate Change Working Group: Gather and synthesize data on the known and potential impacts of global warming on cold-climate DSG species.

Human–Deer Conflict Mitigation: Develop protocols to reduce conflict in a diversity of habitats and regions, particularly in South American habitats such as the Pampas, Cerrado, and other open grasslands, but also in forested, and also in Old-World regions.

We encourage all members to get involved, share your expertise, and collaborate to achieve these goals.

Finally, we thank everyone who contributed to this edition. The deadline for **Issue 37** is **September 30**. We invite you to submit manuscripts for the next issue by contacting **Dr. Patricia Black** at *black.patricia@gmail.com*.

With our best wishes,

Susana and Noam

Susana González and Noam Werner,

Co-Chairs, IUCN/SSC Deer Specialist Group.

Predominance of hard-antlered males in synanthropic spotted deer

Rosella Daniels[1&2] and Sarangan Prabakaran[2]

[1] MCC Campus Matriculation Higher Secondary School, Chennai, India

[2] Marine Biology Regional Center, Zoological Survey of India, Chennai, India

Email: danielsrosella@gmail.com

Abstract

The Spotted Deer was presumably introduced in the erstwhile city of Madras by the British during the colonial era. Its distribution in the city was originally limited to the Guindy Deer Park. Over the years, small herds have dispersed out of the protected area and established local populations wherever conditions were suitable. Hard-antlered males can be frequently seen, roaming around, even in densely populated residential areas. Antler stages have been used to understand the breeding cycles of the deer. As a result, there have been studies both on captive deer and in wild populations throughout India. There are also a few studies of the antler stages of the core population that was found within the deer park in Madras during the 1990s. As there are no studies on the antler stages of the currently synanthropic and free-ranging deer in Madras, we undertook a study on how frequently the different antler stages were observed and the monthly variations in the numbers of males in different antler stages. In this short communication we present our observations of the antler stages of males during a 15-month period in 2024-25.

Resumen

El ciervo moteado fue presumiblemente introducido en la antigua ciudad de Madrás por los británicos durante la época colonial. Su distribución en la ciudad se limitó originalmente al Parque de Ciervos de Guindy. Con el paso de los años, pequeñas manadas se han dispersado fuera del área protegida y se han establecido poblaciones locales donde las condiciones lo permitían. Es frecuente observar machos de cornamenta dura vagando, incluso en zonas residenciales densamente pobladas. Los estadios de la cornamenta se han utilizado para comprender los ciclos reproductivos del ciervo. Como resultado, se han realizado estudios tanto en ciervos cautivos como en poblaciones silvestres en toda la India. También existen algunos estudios sobre los estadios de la cornamenta de la población principal que se encontró en el parque de ciervos de Madrás durante la década de 1990. Dado que no existen estudios sobre los estadios de la cornamenta de los ciervos actualmente sinantrópicos y en libertad en Madrás, realizamos un estudio sobre la frecuencia con la que se observaron los diferentes estadios de la cornamenta y las variaciones mensuales en el número de machos en diferentes estadios. En esta breve comunicación presentamos nuestras observaciones de los estadios de cornamenta de los machos durante un período de 15 meses en 2024-2025.

Key words: Spotted Deer, Guindy, Madras, Synanthropic, Antler

Introduction

The Spotted Deer (*Axis axis*) is a species of medium-sized deer endemic to South Asia (Schaller 1967). It was widely shipped and introduced abroad by Europeans during the colonial era (Campbell 2010). Available evidence points to the fact that it was introduced in the Andaman Islands (Thirumurugan et al. 2024) and also in the Guindy Park inside the erstwhile city of Madras (Krishnamurthy 1975). The exact time of introduction in Madras is however unclear, as some sources have reported with certainty that it was present in high densities inside the Guindy Park as early as 1900 (Savory 1900).

Madras came to be known as Chennai during the past 30 years, and the colonially established Guindy Park in the city became the Guindy Deer Park and subsequently the Guindy National Park in 1978 (Raman et al. 1996). During the years that followed, herds of the spotted deer have strayed outside the protected area and the species currently exists in the form of a meta-population with subpopulations in many localities (Daniels & Prabakaran 2024) and, with the majority of them being synanthropic (implies wild animals that are well-adapted to coexistence with human beings).

In a study that monitored the herd size of the free-ranging deer between 2006 and 2012 within a residential area of Chennai, it was found that 60% of the herds were not larger than three individuals (Daniels & Prabakaran 2024). It was also noticed that males that were straying were generally hard-antlered. It is for this reason that the present study was undertaken.

Materials and Methods

The study was undertaken inside the campus of a school in the city of Chennai during the years 2024 and 2025. The Madras Christian College (MCC), to which the school is annexed, reportedly has around 90 Spotted Deer (Raman 2023). Herds that strayed out of the college entered the premises of the MCC Campus Matriculation Higher Secondary School seeking food and water, especially during the dry season. These herds were regularly observed and counted. The specific method used was the vantage point method recommended by The Deer Initiative of UK (The Deer Initiative 2008). Since the deer had become synanthropic, they allowed close access and it was possible to observe and count them without disturbing them. Daily observations were made in all months, except May when the school was closed. The data was stored as an excel spreadsheet and analyzed.

Results and Discussion

The results of the study are presented in Table 1. A total of 1024 males were observed during the 15-month period. The number of males observed each month however varied between 32 and 114. At least sixty-five per cent of the males observed were in hard-antler stage during the first 9 months (January-September). The proportion of hard-antlered males started to decline during the wet and cooler monsoon months of October-December and the trend continued till April 2025. The decline in the proportion of hard-antlered males coincided with an increase in the proportion of other antler stages, especially velvet, indicating a clear cyclical pattern (Table 1).

Table 1: Monthly variations in the antler stages of males

Month	Shed (%)	Spike (%)	Velvet (%)	Hard Antler (%)	Total Males
January 2024	8.1	16.21	8.1	67.56	37
February 2024	0.0	20.68	0.0	79.31	58
March 2024	1.13	11.36	0.0	87.5	88
April 2024	0.0	9.8	0.0	90.19	51
June 2024	0.0	11.42	0.0	88.57	35
July 2024	0.0	17.14	0.0	82.85	70
August 2024	0.0	4.41	2.94	92.64	68
September 2024	5.47	8.21	1.36	84.93	73
October 2024	18.75	12.5	21.87	46.87	32
November 2024	4.9	31.37	27.45	36.27	114
December 2024	11.94	34.32	46.26	7.46	70
January 2025	0.0	17.71	73.96	8.33	96
February 2025	0.0	0.0	88.76	11.24	89
March 2025	1.20	3.61	56.63	38.55	83
April 2025	0.0	0.0	38.33	61.67	60

Antlers play an important role as weapons in intraspecific combats (Clutton-Brock 1982) (Figure 1). In the Spotted Deer, males with the longest hard antlers were the most successful in mating (Barrette 1987). Antler stages have been found to be convenient external signs of internal changes in the reproductive status of males (Ramesh et al. 2013). An annual shed-growth cycle is normally seen in all stages of antlers, with a few exceptions, and it does correspond with the breeding season in adults (Schaller 1967).

Figure 1. A five-year old male in hard antler (Courtesy Rosella Daniels).

According to M. Krishnan "lack of a season for antler shedding is perfectly in accord with the fact that breeding is not confined to any season but takes place throughout the year. This may be further proved (apart from the stags being in velvet or hard horn throughout the year) by the fact that young fawns may be seen at any time of the year" (Krishnan 1975). Acharjyo & Patnaik 1988, have reported the antler cycles in captive Spotted Deer in the Nandankanan Biological Park in Orissa. According to them, antlers were shed over a period of nine months between August and April. A summary of nine studies of Spotted Deer in India, Nepal and Texas presented in

Ramesh et al. 2013 suggests that the peak rutting season can vary locally but is largely confined to the March-October period.

Inside the Guindy National Park, 50% of the males were in hard antlers for 8 out of 12 months (Raman 1998). This is rather similar to what we have observed in 2024 in the MCC Campus Matriculation Higher Secondary School (Table 1). However, there are some differences in the months with the highest percentage of hard-antlered males between the two studies in Chennai. Raman 1998, has reported that 73-91% of males were in hard antlers during March-July inside the Guindy National Park. During the corresponding months, it was 82-90% inside the school according to the present study.

Eighty-seven per cent of males were in hard antlers in the Mudumalai Tiger Reserve (Western Ghats) in May-October (Ramesh et al. 2013). For the corresponding period in the school, it was more than 80%, except in May (no data available) and October (46.87%). In the Bandipur National Park, hard-antlered males were found throughout the year but were proportionately higher in June-August months (Sharatchandra & Gadgil 1975). During the same months in our study, it was from 82.85% to 92.64% Elsewhere in Rajasthan, 62.74% of males were in hard antlers during the monsoon season (mid-June to mid-October) (Rajawat 2018).

Based on our 15-month study, the following inferences can be drawn. The frequent sightings of males in hard antlers are an indication that the Spotted Deer breeds throughout the year even when synanthropic. This does not seem to be a unique adaptation. Food, especially grass and browse, is not available throughout the year. At the same time, there is very little predation-pressure. The more than 100 years of existence in a relatively predator-free environment has not changed the reproductive cycles of the Spotted Deer. The only predators are meso-predators such as stray dogs and, to a lesser extent, the Golden Jackal (Menon 1987, Rajashekhar 1993). Thus, it may be concluded that whether the deer lives in a protected area or in an institutional campus along with humans (and stray dogs), the inherent reproductive cycles (as inferred from the antler stages) has not changed significantly. The predominance of hard-antlered males in synanthropic Spotted Deer is a clear indication that it breeds year around. How this might affect future management of the deer and the urban ecosystem as a whole has to be carefully assessed. Further, data gaps, such as that corresponding to the month of May, should be filled in future studies.

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Assessing threats to the Bawean deer, a camera trap approach

Ariyanto Agus[1,2], Sunwong Hong[3], Joerg Mehnert[4], Drygala Frank[4*]

[1] Department of Ecology and Environmental System, Kyungpook National University (KNU), Sangju, Republic of Korea

[2] East Java Natural Resources Conservation Agency, Indonesia

[3] Department of Animal Science and Biotechnology, Kyungpook National University, Sangju, Republic of Korea.

[4] Association for Nature and Biodiversity, Germany / Indonesia

[*]Corresponding Author: fdrygala@anbio.org

Abstract

The Bawean deer (*Axis kuhlii*) is endemic to the small and isolated Indonesian island of Bawean (197 km^2) and is listed as Critically Endangered on the IUCN Red List. We set up a grid of 30 cells of 2.25 km^2 each, with one randomly distributed camera trap in each cell, in the protected areas (i.e., Bawean Island Nature Reserves and Wildlife Sanctuaries) to study the potential threat to the Bawean deer during 9 months (dry and wet seasons) in 2023. We detected *A. kuhlii* in 14 grid cells (13 in south-western part and one in north-eastern part of the island). We detected free-ranging dogs (*Canis familiaris)* in 7, poaching/hunting in 5 and other forms of human disturbance in 21 grid cells. In addition, it is likely that hunting of Bawean warty pigs (*Sus blouchi*) using dogs, nets and snares is a major threat to the Bawean deer. As the Bawean deer only occurs on one island and an estimated population of less than 300, it is at high risk of extinction due to loss of individuals through various potential threats.

Keywords: *Axis kuhlii*, Bawean island, endemic, dog predation, conservation measures

Resumen

El ciervo de Bawean (*Axis kuhlii*) es endémico de la pequeña y aislada isla indonesia de Bawean (197 km2) y está clasificado como En Peligro Crítico en la Lista Roja de la UICN. Establecimos una cuadrícula de 30 celdas de 1,5 km^2 cada una, con una cámara trampa distribuida aleatoriamente en cada celda, en las áreas protegidas (es decir, las Reservas Naturales de la Isla de Bawean y losSantuarios de Vida Silvestre) para estudiar la amenaza potencial para el ciervo de Bawean durante 9 meses (estaciones seca y húmeda) en 2023. Detectamos A. kuhlii en 14 cuadrículas (13 en el suroeste y una en el noreste de la isla). Detectamos perros en libertad (*Canis familiaris*) en 7, caza furtiva en 5 y perturbaciones humanas en 21 cuadrículas. Además, es probable que la caza

del cerdo verrugoso de Bawean (*Sus blouchi*) con perros, redes y lazos sea una amenaza importante para el ciervo de Bawean. Urge aplicar medidas de conservación sobre el terreno y sensibilizar a guardas, cazadores y agricultores sobre las principales amenazas para el ciervo de Bawean.

Palabras clave: *Axis kuhlii*, isla de Bawean, endemismo, depredación por perros, medidas de conservación.

Introduction

The Bawean deer (*Axis kuhlii*), endemic to the small and isolated Indonesian island of Bawean (197 km^2), is listed as Critically Endangered on the IUCN Red List of Threatened Species, and is protected under Indonesian law and listed in Appendix I of CITES. The last survey, based on camera trap data from 2017 to 2019, estimated 120-277 animals (Rahman et al. 2023). Only 4-5 deer have ever left Bawean. They were brought to Surabaya Zoo, Java, in the 1940s as the founders of all ex-situ populations. Since then, there has been no population management plan. Like most deer, *A. kuhlii* reproduces well in captivity. Today there are several ex-situ populations on Java (e.g. Surabaya Zoo, Maharani Zoo, Taman Safari Bogor/Prigen) and two populations (Zoo Poznan - Poland, Tierpark Berlin - Germany) in Europe. Moreover, since 2017 there has been a captive population on Bawean island itself (at Mombul village) which had 35 deer in January 2025 (Fig1).

Free-ranging dogs (*Canis familiaris*) can have a significant impact on wildlife through predation (Ritchie et al. 2013) and disturbance (Feldmann 1974, Zapata-Ríos & Branch 2016, Weng et al. 2022), potentially leading to local extinction of prey species (Borroto-Páez 2009). An earlier camera-trapping approach by Rahman et al. (2023) suggests that predation by free-ranging dogs could be a problem for the Bawean deer. Therefore, we quantitatively analysed our camera trap data, focusing on the occurrence of free-ranging dogs in the protected areas on Bawean (Fig. 2). We also aimed to document the distribution of human activities (collecting firewood, collecting leaves for livestock, collecting honey, felling trees) including poaching/hunting.

Material and Methods

We laid out a grid of 30 cells, each covering 2.25 km^2, in protected areas on Bawean, which comprise 46.6 km^2 of the centrally located Bawean Island Nature Reserve and other isolated wildlife sanctuaries in the west and east of the island (Fig. 2). Due to a random encountering modeling approach, we randomly distributed camera traps (CTs, i.e. 19 Zero Beam, Wild Boar Research Institute, Gangwon, South Korea; 5 SecaCam, ZEISS Company, Germany; 5 Bushnell, Bushnell Corp, USA; and 1 Cuddeback, American Blvd, USA) in each cell during four months of the rainy season (January 29 - May 31, 2,530 trap days) and five months of the dry season (June 1 - October 31, 2023,

Figure 1. *Axis kuhlii* from the captive breeding program on Bawean Island.

3,323 trap days), for a total of 5,829 trap days, to study the potential threats to the Bawean deer. The cameras were set to a 30-second video mode with a 30-second interval and were continuously active throughout the 24 hour cycle. All videos were time-stamped with date and time. We counted human activity per day at different CTs, if 2 different camera traps recorded the same activity in the same day, we calculated them as 2 (two) activities because of the different locations (*i.e.* grid cells).

Results

We recorded *A. kuhlii* in 13 grid cells in the south-western part of the island. Only one female was photographed in a camera trap in the north-eastern part of the island. We recorded free-ranging dogs in three grid cells with deer occurrence and in four without. In one case, we found a freshly dead deer that had partly been eaten by dogs, filmed by the camara traps, in the immediate vicinity. We also recorded 2-3 free-ranging dogs together on our camera traps. We have no records on the predation of fawns (Fig.2A, Tab. 1).

Table 1. Free-ranging dogs recorded on CTs (n=30) in the protected areas of Bawean

No. cell/CT	Camera trapping days with records of dogs	No. individual dogs
1	1	1
2	1	3
12	1	2
15	13	1-3
14	1	1
16	1	1
22	1	2

We also recorded human activity in 21 cells (70% of the 30 grid cells). We divided human activity into categories such as passing forest path, collecting firewood, collecting leaves for livestock, collecting honey, poaching/hunting, setting bird traps and goat grazing (Tab.2).

Table 2. Human activity recorded on CTs (n=30) in the protected areas of Bawean

Human Activity	CT days with human activity	No. grid cell / CT
Passing forest path	62	1,4,6,8,9,10,11,12,13,14,15,19,22,23,24,25,27,28
Collecting firewood	11	15
Collecting leaves for Livestock	19	1,6,9,12,15,23,24
Collecting honey	13	9,13,14,24,27
Poaching/hunting	11	15,25
Install birds' traps	4	9
Goat pasturing	2	6

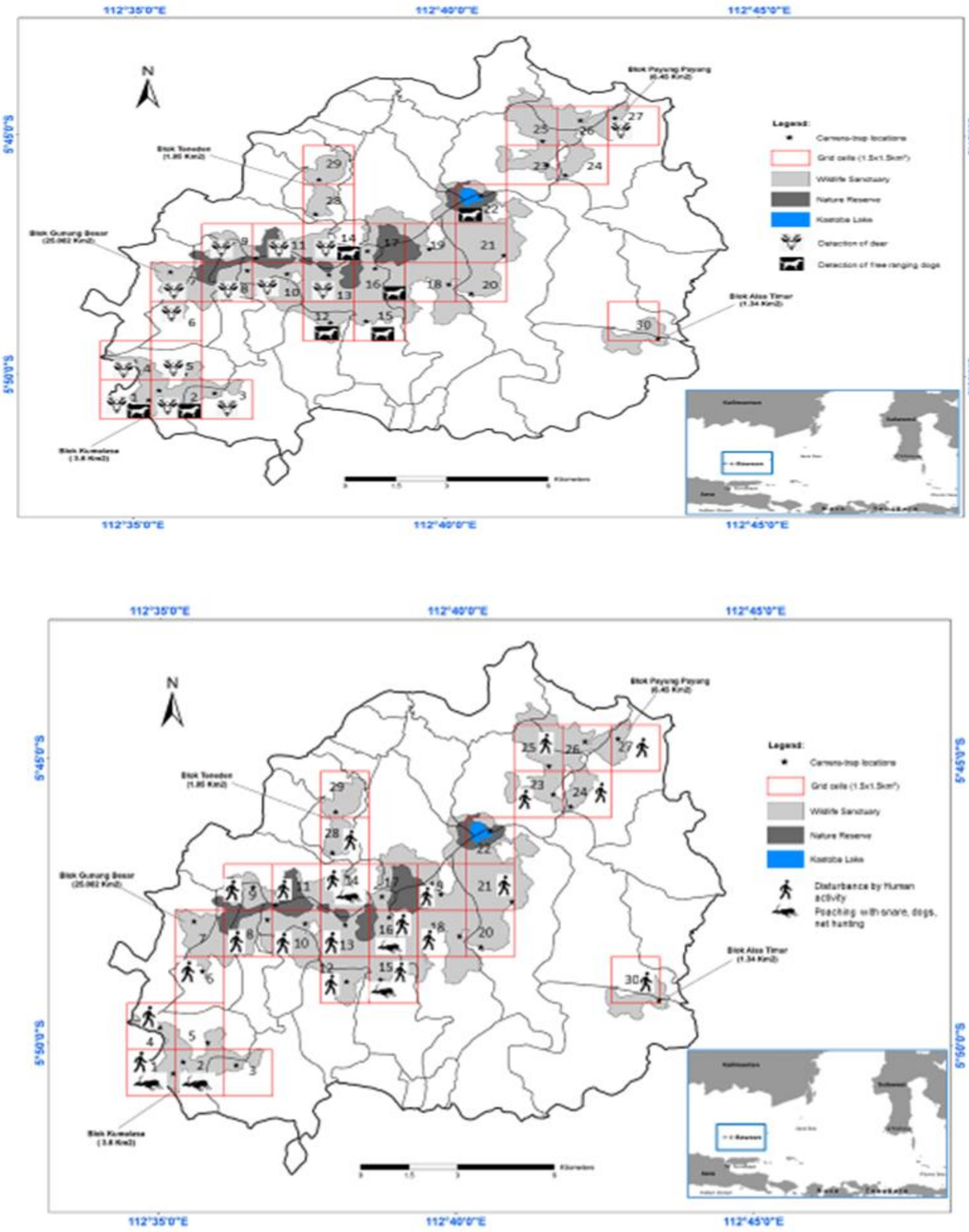

Figure 2. (A) Occurrence of A. kuhlii and free-ranging dogs in the Bawean Island Nature Reserve and Wildlife Sanctuaries; (B) Human activity (collecting firewood, collecting leaves for livestock, collecting honey, felling trees) and poaching/hunting.

Moreover, we recorded poaching/hunting in seven grid cells, with evidence of free-roaming dogs found in these seven grid cells. However, humans hunting with spears were observed in two grid cells, i.e. 15 and 25 (Fig. 2B).

Discussion

There are no *autochthonous* mammalian predators on Bawean and therefore *A. kuhlii* might not be adapted to predation by free-ranging dogs. Therefore, dogs might pose a significant threat to the deer population. Several incidents, in addition to the one captured by our camara traps, show that deer have been successfully hunted and partially eaten by dogs. However, there is no evidence that dogs live completely independently of humans or reproduce in remote areas on Bawean.

The local community generally has a positive attitude towards "their" deer and it has become the island's mascot. In 2016, there was an incident where a deer was chased by a free-ranging dog but was successfully rescued and released by the villagers. However, two freshly dead deer were found in 2017, followed by one in 2018 with flesh wounds caused by dogs, and two older carcasses in 2020, suggesting predation pressure from free-ranging dogs (Bawean Conservation Office, 2024 unpublished report). One suggestion for the motive behind the deer predations by free-ranging dogs, is the poor welfare and lack of adequate food available for these dogs. We have no information on predation by dogs on other wildlife. (*e.g.* rodents, snakes, monitor lizard) as this is difficult to record. The endemic Bawean warty pig (*Sus blouchi*) is probably too defensive for the dogs and the monkeys (Long-tailed Macaque *Macaca fascicularis*) are unreachable. Our findings are in line with a recent study on the reintroduction of the water deer (*Hydropotes inermis*), which found a significant negative impact of predation by free-ranging dogs (Tang et al. 2024).

The Bawean warty pig was recorded in 28 of the 30 grid cells during this camera-trap survey. Although both species have their activity peaks at dusk and dawn, the peaks differ by about 2 hours. The pigs were more nocturnal than the deer, which may be due to a much more intense persecution due to crop raiding by the Bawean warty pig. However, we never recorded both species simultaneously on the CTs.

As the two species have long been sympatric on Bawean, we do not expect any negative effects on the *A. kuhlii* population through competition, predation, or other processes. It is legal to hunt wild pigs like the Bawean warty pig with dogs, nets, and snares in Indonesia, but not within protected areas. In this traditional dog/net hunt, a 50-100 m long net is set up in the forest. The dogs find the pigs, stand and bark. Then 20-30 hunters drive the pigs into the net. Then either the dogs or the hunters kill the pigs and leave them in the forest because they are not allowed to sell or eat them for religious reasons. There is a possibility that the deer are also trapped in these activities, and although we cannot prove it, we believe that the deer are then used illegally for consumption.

During our CT approach, we recorded a female deer only once in the north-eastern part of Bawean (i.e. Block Payung-Payung Fig. 2A). The last previous signs of deer in this area were recorded by Abdul Rahem (Ranger Forest Department Bawean) in 2019 through footprints, antler rubbing, foliage eaten by deer and faeces. There was a captive breeding programme in the Block Payung-Payung for four years (2011-2014). According to Nursamsyi (2025; Head of Forest department Bawean), the Payung-Payung enclosure started in 2011 with 25 Bawean deer. Due to a high mortality rate, 14 deer were left in 2014. When the owner died in the same year, there was not enough money left in the budget to feed the deer, so they were released. As there were no records of *A. kuhlii* in the north-eastern part in previous CT approaches (Rahman et al. 2016, Rode-Margono et al. 2020, Rahman et al. 2023), we strongly suspect that our record is from an offspring of the 14 deer released in 2014 and that the original population is extinct in the eastern part of the island. However, this record shows the long-term survival of the deer from a small founder population. Therefore, we propose to release more *A. kuhlii* from ex-situ populations in the northeast of Bawean.

A. kuhlii is already listed as Critically Endangered by the IUCN Red List of Threatened Species (Semiadi et al. 2015) and thus threatened with extinction. Based on our CT data and surveys, we conclude that the population could reach a demographic tipping point if no conservation measures are taken, *i.e*. the growth rate goes from positive to negative (De Silva and Leimgruber 2019), which would also lead to extinction in the short term. As the Bawean deer only occurs on one island and its population is estimated at fewer than 300 animals (Rahman et al. 2023), there is a significant risk of extinction to through various potential threats, including if individuals are lost to dog predation.

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Conserving the Philippine Brown Deer (Rusa marianna Desmarest, 1822) through Cultural Engagement

Lenilyn R. Pua[1], Jhonnel P. Villegas[1,2*], and Francisco Ceacero[2]

[1]Davao Oriental State University, City of Mati, Philippines

[2]Czech University of Life Sciences Prague, Praha, Czech Republic

*Corresponding author's email: jhonnel.villegas@dorsu.edu.ph

Abstract

The Philippine brown deer (*Rusa marianna* (Desmarest, 1822) is a wild species endemic to the Philippines, where it faces severe threats from poaching and habitat destruction. This study documents the relationships of the Mandaya Indigenous people (Davao Oriental, Philippines) with this endangered species, based on interviews. The Mandaya people have profound ecological knowledge of and a spiritual connection to the brown deer, viewing it as a sacred gift from the Supreme Being. Habitat loss and illegal hunting remain significant threats in the locality, despite the Mandaya's cultural ethos of sustainability and respect for nature. Community-based conservation strategies follow from the participants' responses to protect the brown deer.

Keywords: culture, Endangered species, Mandaya, Mindanao Island, Philippines, wildlife

Resumen

El sambar de Filipinas (*Rusa marianna* (Desmarest, 1822)) es una especie endémica a las Filipinas como especie silvestre que enfrenta graves amenazas debido a la caza furtiva y la destrucción de su hábitat. Este estudio documenta las relaciones del pueblo indígena Mandaya (Davao Oriental, Filipinas) con esta especie en peligro de extinción, basándose en entrevistas. El pueblo Mandaya posee un profundo conocimiento ecológico y una conexión espiritual con el sambar, al que consideran un regalo sagrado del Ser Supremo. Sin embargo, la pérdida de hábitat y la caza ilegal siguen siendo amenazas significativas en la región, a pesar del ethos cultural de sostenibilidad y respeto por la naturaleza del pueblo Mandaya.

Introduction

The Philippine brown deer (*Rusa marianna* (Desmarest, 1822)), locally known as "Sol'law na Osa", is a true deer species endemic (as a wild animal) to the Philippines, where it is threatened by poaching and habitat destruction. Listed as Vulnerable under the International Union for the Conservation of Nature (IUCN) Red List and as Endangered under the Philippine Red List, this species is one of the lesser-studied deer (MacKinnon et al. 2015, DENR-BMB 2020, Pineda 2024, Villegas et al. 2025).

The Mandaya are an ethnolinguistic group residing in Davao Oriental and nearby provinces. Their name originates from the words *"man"*, meaning *"people"*, and *"daya"* or *"ilaya"*, which refers to the upper portions of rivers. This Indigenous community has been documented to inhabit their ancestral lands since the 16th century (Nabayra 2014, Pawanka Fund 2019, Insigne 2023). The Mandaya people have deep ties to their ancestral lands and coexisted with the brown deer for centuries, although this interaction is currently undocumented in published literature.

This study is part of a larger project, "Ecology and Conservation of the Philippine Brown Deer (*Rusa marianna* (Desmarest, 1822))." This paper reveals a meaningful interconnection between the brown deer and the Mandaya people in Caraga, Davao Oriental, the Philippines, discusses local threats to the species, and proposes local conservation policies to aid in its protection.

Methodology

Using qualitative methods, the researchers gathered information through in-depth interviews (Bauyot et al. 2024, Johanson et al. 2024) with ten participants and community observations in an ancestral domain of the Mandaya people in Sitio Caliongan, Pichon, Caraga, Davao Oriental, the Philippines. The interviews were conducted using the Mandaya language, involving teachers, housewives, farmers, community elders, and leaders. The discussion focused on the participants' ecological perspectives, their perceptions of local conservation threats, and their policy recommendations. Each participant was allowed to share their insights, with follow-up questions encouraging deeper elaboration. The discussions were recorded and transcribed for subsequent use.

Results and Discussion

The Mandaya people possess extensive ecological knowledge about the brown deer. Their understanding reflects a deep spiritual and cultural connection to the deer, consequently influencing their hunting practices. They consider the brown deer to be *"Yatag ni Magbabaya"* or a gift from the Supreme Being, which means that the community must respectfully use this natural resource. Hunting is not conducted excessively, as respect for nature is a core value.

However, challenges such as habitat loss and illegal hunting still threaten ecological balance in their ancestral lands. With intensive logging activities in the past and agricultural expansion, brown deer habitats have been consistently reduced. Agriculture activities include copra production, small-scale vegetable plantation, abaca farming, and backyard animal raising, among others. The community also practices rotational swidden farming.

They noted that the brown deer, especially when its population was still abundant, was observed feeding on agricultural products.

Figure 1. Adult brown deer (*Rusa marianna* Desmarest, 1822) hunted for venison. The place and people involved are not disclose for ethical reasons.

Hunting has been a long-time tradition of the community. In most cases, they hunt the brown deer for subsistence, that is, to provide food for the families and communities. Poverty is a significant driver of subsistence hunting, as Indigenous households rely on brown deer meat for food and survival (Tanalgo 2017, Villegas et al. 2022). Deer hunting within the Mandaya culture is also interwoven with spiritual beliefs, part of a worldview that respects the interconnectedness of life. This cultural ethos emphasises sustainability and ecological balance. This is consistent with the findings of Villegas et al. (2022) with the Obu Manuvu Indigenous community in Davao del Sur, where they declared the brown deer a sacred animal.

Despite the respectful practices of the Mandaya, there has been a notable decrease in the brown deer population at present. Former hunters report that they could easily catch large brown deer individuals before, but such capture is now rare. Direct physical interactions with the deer have become rare, with some women and youth claiming they have not seen a brown deer despite their proximity to the forests.

The present study advocates for enhanced wildlife protection through culturally sensitive approaches. The following recommendations are based on participants' responses:

1. **Strengthening Wildlife Protection Law Implementations.** There is a need for strict law enforcement and wildlife protection efforts in close coordination between the Mandaya Indigenous community, the Department of Environment and Natural Resources (DENR), and the National Commission on Indigenous Peoples (NCIP).
2. **Implementing "No-Hunting" Zones.** Designating areas where hunting is prohibited can help protect vulnerable populations. These sacred grounds would allow the brown deer to repopulate, contributing to the wildlife conservation goals of the community.
3. **Banning indiscriminate hunting tools.** Prohibiting the use of snares and traps would safeguard the brown deer and other wildlife. Dogs need to be managed to prevent them from killing brown deer. The use of guns is less damaging to the species as it targets specific brown deer individuals.
4. **Promoting Stakeholder Engagement and Collaboration.** Discussing with the Mandaya community, by academic institutions, government agencies, and NGOs, should be conducted to align conservation efforts.
5. **Updating brown deer information.** Utilise modern technology, such as camera traps, drones, and GPS tracking, to enhance ecological data gathering and monitor brown deer populations and range.
6. **Prioritizing Community Education.** Conducting regular educational campaigns among the Mandaya people, including informational posters strategically placed throughout the community to enhance awareness and promote conservation efforts.

The holistic understanding of ecological balance of the Mandaya offers a regenerative model for conservation that aligns with both their cultural heritage and environmental practices. This Indigenous knowledge could improve community-based conservation programs for the brown deer. This also forms part of the broader regenerative futures agenda of Davao Oriental State University, aiming to promote regenerative agriculture, biodiversity, and culture (Ponce & Villegas 2022, Villegas & Ponce 2024).

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A Remarkable Dispersal Event by a Water Deer: Insights into Long-Distance Water-travel Potential

Min Chen[1,2,3*], Jingwei Zhang[4], Qiuting Chen[1,2,3]

[1] School of Ecological and Environmental Sciences, Institute of Eco-Chongming, East China Normal University, Shanghai 200241, China

[2] Ministry of Education & Shanghai Science and Technology Committee, Yangtze Delta Estuarine Wetland Ecosystem Observation and Research Station, Shanghai, China

[3] Hainan Institute of East China Normal University, Sanya 572025, Hainan, China

[4] School of Life Sciences, East China Normal University, Shanghai, China

* Corresponding Author: mchen@bio.ecnu.edu.cn

Abstract:

This study documents a notable dispersal event of the water deer (*Hydropotes inermis*), which involved an almost certainly aquatic journey of at least 30 kilometers from Shanghai Binjiang Forest Park to Hengsha Island, Shanghai. GPS telemetry data revealed this long-distance apparently aquatic movement in water deer. While the precise path taken during this movement could not be fully reconstructed due to sparse intermediate GPS data points, this finding suggests the species' unexpected capacity for cross-water dispersal across fragmented habitats. This discovery holds significant implications for comprehending the distribution and conservation of water deer populations along the Yangtze River, as well as for the global management of the species, encompassing the conservation of native populations and the potential mitigation of non-native populations in Europe

.**Keywords:** Water deer, swimming distance, GPS tracking, conservation, urban development

Resumen: Este estudio documenta un evento significativo de dispersión del ciervo chino de agua (*Hydropotes inermis*), que involucra una larga travesía acuática desde el Parque Forestal Binjiang de Shanghái hasta la Isla Hengsha, Shanghái, cubriendo una distancia total de menos 30 kilómetros kilómetros. El movimiento fue monitoreado mediante GPS, lo cual representa un cruce acuático de larga distancia sin precedentes. Aunque la trayectoria específica de este movimiento sigue siendo incierta debido a la limitada cantidad de datos GPS intermedios, el evento pone de manifiesto el potencial de dispersión extensa del ciervo chino de agua a través de hábitats fragmentados. Este hallazgo es crucial para comprender la distribución y la conservación de las poblaciones de ciervos chinos de agua a lo largo del río Yangtze, y tiene implicaciones globales en la gestión de

la especie, tanto en la conservación de las poblaciones nativas como en el control potencial de las poblaciones invasoras no nativas en Europa.

Palabras clave: *Hydropotes inermis*, distancia de nado, seguimiento por GPS, conservación, desarrollo urbano

Introduction

Some animals possess the ability to move across multiple terrains, such as aerial flight, terrestrial locomotion, and the transition between land and aquatic environments. This adaptability not only broadens their foraging and resting habitats but also serves as a strategy to evade predators and natural disasters. Several deer species are known for their swimming proficiency, notably the milu (*Elaphurus davidianus*)(Li et al., 2023), the White-tailed Deer (*Odocoileus virginianus*) (Sweeney et al., 1971), the Sika (*Cervus nippon*) (Niwa, 2021), and the Caribou (*Rangifer tarandus*) (Webber et al., 2021).

Among deer family, the water deer (*Hydropotes inermis*) was known to swim to escape floods in Jishan Island, Jiangxi Province, and Yancheng, Jiangsu Province, China, as well as utilizing water bodies to evade predators. Moreover, populations of water deer residing in the Zhoushan Islands, Zhejiang Province, exhibit inter-island migration patterns via swimming (Sheng and Lu,1984). Following its local extinction in Shanghai, the species was successfully reintroduced to Shanghai in 2007 and has since been observed in Binjiang Forest Park (Chen et al., 2015). To monitor the water deer in this area, we employed GPS telemetry—a proven method for quantifying habitat use and movement patterns, aligning with contemporary wildlife tracking practices aimed at informing conservation strategies.

Methods

We utilized advanced GPS collar technology (Global Messenger Co., Ltd., HQAN40S) to track the real-time locations of selected water deer in Binjiang Forest Park, Shanghai, China.

To accurately assess the movement of the water deer in aquatic environments, we conducted geospatial analyses using the ArcGIS software (10.8). Key procedures included: (1) Minimum Displacement Calculation: Measured straight-line distances between consecutive GPS points. (2) Path Simulation: Reconstructed probable movement trajectories (Figure 2, red lines) accounting for the hydrological barrier.

Observations

On 16 October 2024 (00:00–08:00), a GPS-tracked water deer (*Hydropotes inermis*) initiated an unprecedented apparently aquatic dispersal from Binjiang Forest Park, Shanghai to the coastal waters near Hengsha Island, where it was rescued by local fishermen (Figure 1). This event represents the first documented long-distance apparently aquatic movement (at least 30 km) of water deer in a tidal estuary or indeed in any sort of water-body.

Figure 1. The water deer that was rescued after a long apparently aquatic journey (photo from Finance.Sina.com.cn, 2024)

The deer evidently traversed the Yangtze River's South Branch-Nangang Waterway (mean depth: 7 m), drifting downstream with tidal currents averaging 0.5–2 m/s (peak: 1–2 m/s; Shanghai Water Authority, 2024; Zhang et al., 2022). Key trajectory features show temporal consistency, matching the 8-hour travel period with tidal currents and GPS-recorded departure/arrival times. The water deer likely drifted past Changxing Island due to a lack of viable landing points. Changxing Island, formed by the natural evolution and artificial land reclamation of multiple sandbars, features a water system of primarily artificial canals and rivers for drainage and navigation. These local waterways lack interconnected large waterways that traverse the island. Thus, it's improbable that the water deer swam through any waterways on Changxing Island， probably preventing the deer from accessing the land and forcing it to continue drifting northward between Changxing and Hengsha Islands. The absence of GPS transmissions throughout suggests the deer stayed submerged or in water contact, blocking signal transmission. We have simulated a water route (Figure 2). Furthermore, the deer was incapable of making land where it was found and had to be rescued from the water.

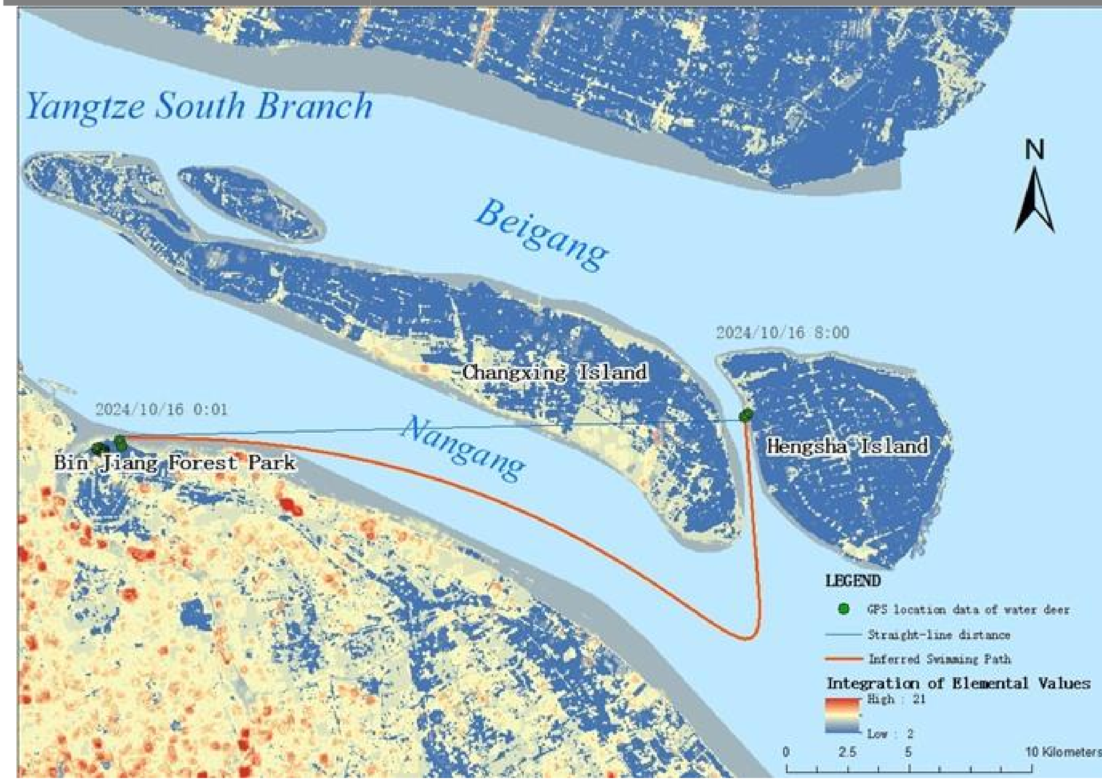

Figure 2. Minimum-distance aquatic movement route of the water deer.

Considering that there is no established water deer population on the island and that the deer was alone, it was deemed more beneficial for the animal to live in a relatively suitable habitat. Therefore, the deer was transported back to Binjiang Forest Park.

Discussion

Why did the water deer choose to go into the water and drift so far? Considering the knowledge of water deer behavior, its entry into the Yangtze River likely represents an escape response rather than intentional long-distance dispersal. Prior studies indicate that water deer frequently enter water bodies to evade predators (e.g., stray dogs) or anthropogenic disturbances (Tang et al., 2024). This hypothesis aligns with the GPS data: the deer's abrupt departure from Binjiang Forest Park at midnight (00:00)—a period of low human activity—suggests it was flushed into the river by non-human stressors. The hardened embankments and anti-intrusion barriers along the park's perimeter further support that accidental entry, rather than deliberate crossing, initiated this event.

How far did the deer swim and drift? The calculated straight-line displacement (~30 km) and simulated trajectory (~36 km) provide the first empirical albeit circumstantial evidence of water deer swimming ⩾30 km in tidal estuaries. While precise path reconstruction is hindered by sparse mid-journey GPS data. The limited data aligns with the deer being in the water for most of the time, as the absence of GPS transmissions throughout the duration strongly suggests the deer remained submerged or in water contact, preventing signal transmission. These estimates indicate the species' capacity for extensive aquatic movement—a trait previously anecdotally reported in Zhoushan Archipelago populations migrating across inter-island channels. In the Zhoushan Archipelago, water deer used to appear, disappear, and appear (Guo & Zhang, 2002), and people witnessed water deer swimming, which determined that it migrated between islands. Five islands are within 3 km of Zhoushan Island, of which the closest, Changshi Island, is only 0.35 km away from Zhoushan Island, and the farthest, Putuo Mountain, is 3 km away. Water deer are found in all of them(Guo & Zhang, 2002). According to this record, water deer can apparently move between islands up to at least 30 kilometers apart. In China, water deer are mainly distributed along the middle and lower reaches of the Yangtze River, (Wang, 1998; Xu et al, 1998). The water deer's ability to swim long distances and its propensity for island hopping are crucial for its distribution along the Yangtze River.

The record of a water deer swimming and drifting a distance of at least 30 kilometers offers a new perspective on the species' locomotive capabilities and provides significant clues regarding its migratory behavior. This information is likely to be useful for the conservation of water deer populations and for understanding their ecological adaptability within fragmented habitats. If there is a need to control the rising non-native populations in Europe, such information on dispersal possibilities is vital.

GPS tracking was critical to this discovery because it enabled real-time monitoring of a behavior that would otherwise remain undetected. Future studies should prioritize deploying accelerometers or motion sensors to distinguish active swimming from passive drifting, thereby uncovering more detailed behavioral patterns.

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Ethical Statement

The study was conducted in compliance with the ethical guidelines for wildlife research. The GPS tracking was performed with minimal disturbance to the deer, and the rescued individual was safely transported back to its original habitat.

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The practicalities of co-production of knowledge in conserving caribou

Anna Brose[1*], Anne Gunn[2], Ophélie Couriot[1], Megan Perra[1], Chloe Beaupre[1], Elie Gurarie[1]

[1]State University of New York College of Environmental Science and Forestry, Syracuse, USA
[2]CircumArctic Rangifer Monitoring and Assessment Network, Canada
*albrose@esf.edu

Abstract:

Steep declines in the Bathurst and Bluenose East Caribou Herds in Canada have highlighted the need for co-production of knowledge to understand a complex ecological-societal system. Our research group of non-Indigenous scientists has found success by applying our technical skills to address questions of greatest concern to Indigenous partners. These successes have not been without challenges, and we are learning to check our own biases, to better plan for the time and funding required for meaningful exchanges of knowledge, and to communicate early and often with our partners about how best to support their capacity to affect change in caribou co-management. We share some lessons learned and encourage fellow researchers to embrace co-production of knowledge to address the many complex issues facing deer conservation worldwide.

Keywords: Caribou, co-production, Indigenous knowledge, *Rangifer tarandus*

Resumen

Las marcadas disminuciones en las manadas de caribúes Bathurst y Bluenose East en Canadá han puesto de manifiesto la necesidad de una coproducción de conocimiento para comprender un sistema ecológico-social complejo. Nuestro grupo de investigación, conformado por científicos no indígenas, ha tenido éxito al aplicar nuestras habilidades técnicas para abordar las preguntas de mayor preocupación para nuestros socios indígenas. Estos logros no han estado exentos de desafíos, y estamos aprendiendo a reconocer nuestros propios sesgos, a planificar mejor el tiempo y los recursos necesarios para intercambios significativos de conocimiento, y a comunicarnos de forma temprana y frecuente con nuestros socios sobre cómo apoyar mejor su capacidad para generar cambios en la cogestión del caribú. Compartimos algunas lecciones aprendidas y alentamos a otros investigadores a adoptar la coproducción de conocimiento para abordar los numerosos problemas complejos que enfrenta la conservación de los cérvidos en todo el mundo.

Introduction

The Bathurst and Bluenose East Herds of barren-ground caribou (*Rangifer tarandus groenlandicus*) have experienced severe declines in abundance. The Bathurst Herd has declined by more than 98% since 1986, leading to harvest restrictions and changes in their range (Fig. 1; Mennell 2021, Gunn and Russell 2022, Gurarie et al. 2024). The extent of the decline has caused heartbreak, deprived Indigenous people of meat and other essentials including hides and sinews and threatened their cultural identity.

For years, local Indigenous knowledge holders have warned that the mines and associated roads are harming caribou (Parlee et al. 2018), interrupting movement patterns and generating dust that impacts forage quality (Legat et al. 2014). Other compounding factors (e.g., increased insect harassment and changes in forage availability due to climate change) have also been implicated in the decline of caribou along with predation, parasites and harvesting (GNWT 2018). The causes of the decline can, then, be characterized as “wicked”, in the sense that they are complex, involve conflicting viewpoints, and do not have straightforward technical solutions. While there are diverse views about using the term “wicked” (Lönngren & van Poeck 2021), the term draws attention to the paradigm that relying on classical reductionist science and linear problem-solving does not effectively address complex socio-ecological problems.

Bundled in a parka, snowpants, and down mittens, Dr. Ophélie Couriot gazed through her binoculars at barren-ground caribou (*Rangifer tarandus groenlandicus*; Fig. 1) feeding and resting by a seasonal ice road in Canada’s Northwest Territories. Ophélie, a post-doc based in New York, USA, was working with the North Slave Métis Alliance (NSMA) Caribou Guardians, who annually monitor caribou and traffic on the ice road, which is typically open for 8-10 weeks to supply several diamond mines (Smith 2022); up to four large haul trucks, weighing up to 42 tons, are dispatched every 20 minutes (JVTC Winter Road 2024 a, b). The NSMA and other Indigenous groups are concerned about impacts of the trucks on caribou, who have been using the area surrounding the ice road during winter for as long as elders can remember. Orna Phelan, wildlife biologist for NSMA, says, "The primary goal of the NSMA Winter Road Caribou Monitoring Project is to collect vital data to better understand the impact of the ice road on migratory barren-ground caribou [and] strengthen the connection of NSMA members to the land, fostering a deeper sense of stewardship over their Traditional Territory. By empowering Guardians to

Figure 1. Barren-ground caribou (*Rangifer tarandus groenlandicus*) are in steep decline in some portions of their range. Photo by Anne Gunn.

lead the on-the-ground efforts, we aim to ensure that Indigenous knowledge and modern science work together to protect both wildlife and cultural heritage."

The caribou Ophélie was watching were from the Bathurst and Bluenose East Caribou Herds, which have experienced severe declines in abundance. The Bathurst Herd has declined by more than 98% since 1986, leading to harvest restrictions and changes in their range (Fig. 2; Mennell 2021, Gunn and Russell 2022, Gurarie et al. 2024). The extent of the decline has caused heartbreak and deprived Indigenous people of meat and other essentials including hides and sinews.

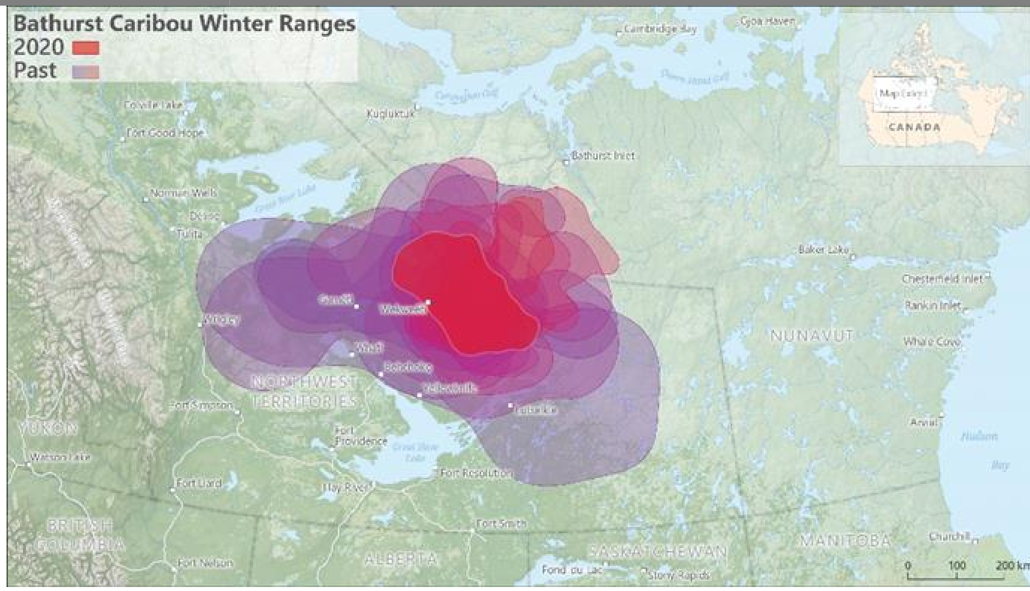

Figure 2. The winter range of the Bathurst Caribou Herd in northern Canada has shrunk as the population has declined by 98% since 1986. Map by Ian Freeman, Wyoming Migration Initiative.

For years, local Indigenous knowledge holders have warned that the mines and associated roads are harming caribou (Parlee et al. 2018), interrupting movement patterns and generating dust that impacts forage quality (Legat et al. 2014). Other compounding factors (e.g., increased insect harassment and changes in forage availability due to climate change) have also been implicated in the decline of caribou along with predation, parasites and harvesting (GNWT 2018). The causes of the decline can, then, be characterized as “wicked”, in the sense that they are complex, involve conflicting viewpoints, and do not have straightforward technical solutions. While there are diverse views about using the term “wicked” (Lönngren & van Poeck 2021), the term draws attention to the paradigm that relying on classical reductionist science and linear problem-solving does not effectively address complex societal and environmental problems.

The Bluenose East and Bathurst Caribou Herd ranges overlap the traditional use areas of three Indigenous Peoples who have settled land claim agreements with the territorial and federal governments in Canada (Sahtú, Nunavut, and Tłı̨chǫ), and three Peoples whose land claims are underway (Yellow Knives Dene First Nation, North Slave Métis, and Łutselk’e Dene First Nation). These land claim agreements have shifted stewardship of caribou in northern Canada from centralized territorial government management to the formation of co-management boards and advisory committees such as the Bathurst Caribou Advisory Committee (GNWT).

Indigenous Peoples bring their unique experiences, traditions, and knowledge to the table, and add necessary and nuanced perspectives to the complex issues facing caribou.

The complexities of the decline of Bathurst caribou have highlighted the need for the co-production[1] of knowledge and the previous shortcomings in our approach as research scientists working on the declines, which have far-reaching impacts on Indigenous communities. Even a brief survey of worldwide deer literature, such as in South America (Weber and Gonzalez 2003), suggests that complex threats to deer are common, and that co-production of knowledge could be highly effective in guiding conservation decisions. The call for co-production of knowledge is echoed elsewhere for globally vulnerable or threatened deer. Eld's deer (*Rucervus eldii*), a tropical Asian deer which was once widespread but now restricted to scattered populations. A recent review acknowledged the need to "make use of all existing knowledge and experience to devise effective conservation strategies" (Wong et al. 2021). Similarly, both academic research and involvement of local people were seen as two strategies to support the conservation of the Javan deer (*Rusa timorensis*), which IUCN rates as vulnerable (Firdaus et al. 2023).

One recent catalyst in sharing knowledge on the ranges of the Bathurst and Bluenose East Herds is the international and inter-disciplinary Fate of the Caribou Project (FotC), working from four universities across the United States (fateofthecaribou.esf.edu). We at FotC recognize that bridging Indigenous knowledge and "Western" academic science is an increasingly widespread theme in global conservation (Wheeler and Root-Bernstein 2020), but know, too, that misuse and misappropriation of Indigenous knowledge can cause significant harm (Parlee et al 2018, Pristupa et al. 2018). We hope our experience as non-Indigenous researchers learning to participate in co-production of knowledge is helpful to the Deer Specialist Group as we all work toward a sustainable future for deer and the people who rely on them.

Fate of the Caribou is a multi-disciplinary research group funded by the United States National Science Foundation (NSF) Navigating the New Arctic initiative (NSF 2018). Like many research programs that have sought to incorporate Traditional Ecological Knowledge and different ways of knowing into their research in recent years, we have experienced successes and challenges to doing so in a way that builds trust and doesn't take advantage of Indigenous communities.

[1]We use 'co-production' in the sense of drawing on collective indigenous knowledge and experience (Bandola-Gill et al. 2023).

At FotC, we specialize in movement and behavior analysis, remote sensing of vegetation changes, demographic modeling, geographic and synthetic population modeling, and graphic design and science communication. Our goal is to leverage our technical expertise to answer questions of greatest concern to communities living with caribou – for example, "How does the winter road impact Bathurst caribou?" (Canada) and "Why is the Western Arctic Caribou Herd not migrating near our village anymore?" (Alaska) – and to provide meaningful tools that amplify the voices of community-based caribou stewards. First, we built on existing relationships between team members and Indigenous communities in Alaska and Canada to listen to their most pressing concerns. We collaborate with Indigenous governments, Indigenous Government Organizations (IGOs), co-management boards, and communities (e.g., Wek'èezhìı Renewable Resources Board [WRRB], Tłı̨chǫ Government [TG], Western Arctic Caribou Herd Working Group, NSMA).

Recently, FotC members O. Couriot, M. Perra, and C. Beaupré travelled to Yellowknife, Canada to have collaborative focus groups with members of NSMA, the Kugluktuk Angoniatit Association (KAA), and Dechinta Centre for Research and Learning to introduce our project and hear their concerns about caribou. While in early stages, these discussions have provided depth and context for behaviors and range shifts that we only glimpse from data like GPS collar locations. For example, NSMA members shared that the changes in caribou survival we documented may be related to warmer winter weather causing more freeze-thaw cycles, creating ice that makes it hard for caribou to forage lichen (NMSA Pers. Comm. 2024).

Additionally, we are collaborating with the NMSA for sound monitoring along the NWT mine supply ice road, including processing their acoustic data using our access to contemporary acoustic analysis tools that were built for Arctic sound monitoring (Çoban et al. 2022) and supercomputing resources from the US National Center for Atmospheric Research. The ability to process big data has allowed us to forge a similar relationship with the KAA and Government of Nunavut (GN), processing data from a 2021 acoustic and camera trap monitoring project on the Bathurst calving grounds. Leveraging our resources and skills in this way has allowed us to support existing community-led monitoring efforts.

Similarly, post-doc Benjamin Larue at the University of Montana is analyzing the camera trap data from the 2021 project on the Bathurst calving grounds, which was designed by the KAA, GN, and Government of Northwest Territories (GNWT). The study was in response to community concerns about grizzly predation on the calving grounds and directly supports Inuit knowledge and observations. Recently, B. Larue received funding to use the remote cameras on the calving grounds of the Bluenose East Herd in collaboration with the KAA.

One key to working with communities is collaborative and innovative communication. Last year, we published a multimedia essay in partnership with the WRRB, TG, and others, demonstrating a shift in the winter range of the Bathurst Herd, and increased spatial overlap with the neighboring Bluenose East and Beverly Herds (Brose et al. 2024a). This shift was quantified and analyzed by our team (Gurarie et al. 2024) but originally observed by local hunters and biologists. The essay incorporated both the scientific findings of the range shift and the insights and impacts experienced by local communities, to bring awareness to the real-life consequences of the Bathurst Herd's decline. We also designed graphical summary posters highlighting the winter range overlap between the three herds (Brose et al. 2024b). With support from the WRRB, we had the summary translated into Tłı̨chǫ, making it more accessible to Tłı̨chǫ hunters and community members. We are currently developing an animation of Bathurst caribou movements around the ice road at the request of TG to showcase what they already observe on the land: that caribou seldom cross the road when mining traffic is active. These projects, while outside the normal "comfort zone" of academic publications, have greatly increased our positive and long-term contributions to caribou co-management by making findings accessible and demonstrable to a wide audience.

These projects and others we are working on would not be possible without the support and diligence of our research partners, and the extraordinary effort by the post-docs and graduate students on our project. Our team members have traveled to Yellowknife and other northern communities repeatedly to meet with people, participate in research activities, and immerse themselves in the communities most affected by the declines in caribou. The value of on-the-ground collaboration and learning cannot be overstated. While we budgeted for travel and honoraria in our funding proposals, we perhaps underestimated the need for and cost of frequent travel to remote areas of Canada and Alaska. When in doubt, we advise budgeting more than you think you need when planning co-production of knowledge initiatives.

Our successes have not been without setbacks and complications, and we are far from being experts on co-production of knowledge. We therefore share some "lessons learned" with open minds and acknowledge our own bias as a team of North American and non-Indigenous researchers. Our biggest constraint thus far, besides our own learning curve, has been the time it takes to build trusting and meaningful relationships with communities. Understandably, many Indigenous communities are wary of research scientists who come from afar proclaiming good intentions. It takes repeated visits, reliable on-the-ground effort, and consistent follow-up to build trust and engage respectfully with communities. While we entered this project with previously-established relationships and team members who are trusted in many of the communities we work with, it has still taken several years to strengthen those relationships and build new ones. Researchers and funding entities should keep this in mind when planning and budgeting for new projects. Similarly, it has taken longer to develop good, culturally-appropriate, and relevant communication products than we anticipated. This, too, should be accounted for in project planning and budgets, including budgeting to pay translators who can translate products into relevant local languages.

More broadly, our whole team is continuously learning how to better engage in co-production by checking our own preconceived hypotheses, adjusting our communications, and rethinking the potential benefits and drawbacks of research approaches. For example, we learned early on that the use of GPS collars on caribou was considered disrespectful by some Indigenous people. Indeed, the capture and instrumenting of caribou is invasive, requiring helicopter pursuit, net-gunning, restraint, blood sampling, and other biological measurements. While GPS collars are valuable for tracking movements of free-ranging animals, there are recurrent concerns that collars change caribou behavior, that caribou don’t like being watched so closely, and that release (after capture) is disrespectful because it spurns the gift that the caribou themselves have given when they allow themselves to be harvested or caught (Legat 2012). Younger generations are decidedly more open to collaring, but many community members have stressed that we must clearly communicate why collaring is necessary and how it may be useful in addressing their concerns about caribou.

These perspectives have shifted our own views of using GPS collar data. First, we feel it places an onus on us to learn as much as possible from GPS collar data and to address questions of direct and immediate concern to our community partners. Thus, we are returning the power of those data to those communities, to the best of our ability. Our second response to these concerns is to further develop and improve methods for collecting and analyzing data with respectful, non-invasive methods, i.e., acoustic and camera trap monitoring.

As we enter the last 1-2 years of our NSF Navigating the New Arctic funding cycle, we find ourselves asking, “What is the legacy of our project?” and “How we can best serve our partner communities beyond the lifetime of our funding?” One answer may be our Knowledge of the Caribou database initiative – building search tools to catalog existing compilations of Indigenous knowledge documented in the minutes and transcripts of co-management meetings and public hearings. Early in the FotC project, we had to respect that people in the communities are busy with their own lives and we had to fit in with their timetables. Just as importantly, they had often already shared their knowledge in other forums. Our focus is now on making it more efficient to find by compiling the Indigenous knowledge available in the large amount of the ‘gray literature’, i.e., co-management and environmental assessment board public registries and other online sources.

The most meaningful FotC legacy will be the lasting impact of contributing to real change in caribou co-management and policy. We have developed analytical tools (e.g., Couriot et al.'s 2022 TuktuTools R package for analyzing movements, Berner et al.'s 2024 Arctic Aboveground Plant Biomass Synthesis Dataset) and scientific papers which answer questions initiated by Arctic communities. Through our partnerships and communications, we are developing research products that can be used by our collaborators to support their capacity to speak up on development projects and management changes.

Ultimately, we hope the relationships and trust we have built with partner communities will encourage other researchers to embrace the necessary work of co-production of knowledge, to communicate early and often with partners about what kinds of outputs are most useful, and to leave sufficient time and funding to develop those products. Co-production of knowledge is essential to shape a just and sustainable future for human and non-human kin. At FotC, we have found success by bringing together a multi-talented team and network of partners to address the "wicked" problem of caribou declines from many angles; simultaneously, we have had to learn and adjust while our funding clock continues to tick, with our partners patiently guiding us. As we have learned, co-production of knowledge must be undertaken with care, forethought, and a plan for long-term impacts that will outlive ephemeral funding and personnel. Co-production of knowledge cannot and should never be an "add-on" to a traditional scientific study; it must be "baked in" from a project's conception. The words that us FotC members heard when meeting with our collaborators in the communities still resonate with us: "Be friendly, open; remember whose land your research is on; begin consultation with communities before the research even starts; show up; have local people facilitate discussions; [practice] reciprocity; respect for community, respect for animals."

As Ophélie watched the caribou near the ice road, she reflected on her experience with NSMA: "As researchers, we spend most of our time behind our computer screen, analyzing data. This experience with NSMA taught me that we can learn a lot by spending time in the field, with the people who live there. I am convinced that the research we are producing together will be more powerful than research done alone."

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Physiological validation of an enzyme immunoassay for measuring fecal cortisol and corticosterone metabolites in brown brocket deer (Subulo gouazoubira)

Laís Jaqueline de Souza[1,2,*], Cláudia Maria Herédias-Ribas[1,2], Mariana Torres Abramo[1,2,3], José Maurício Barbanti Duarte[2]

[1] Veterinary Science Postgraduate Program, School of Agricultural and Veterinary Studies (FCAV), São Paulo State University (UNESP), Jaboticabal-SP, Brazil.

[2] Deer Research and Conservation Center (NUPECCE), Jaboticabal-SP, Brazil.

[3] Tropical Sustainability Institute (TSI), Carapicuíba-SP, Brazil.

[*] Corresponding author: lais.jaqueline@unesp.br

The first two authors contributed equally to this work.

Abstract

This study aimed to physiologically validate an enzyme immunoassay (EIA) to quantify fecal cortisol and corticosterone metabolites (FCMs) in brown brocket deer (*Subulo gouazoubira*) through exogenous ACTH administration. The experiment demonstrated a significant increase in serum cortisol and corticosterone (SC) levels shortly after ACTH administration, with peaks observed at 15 minutes for cortisol and 45 minutes for corticosterone in the male, and at 15 minutes for both hormones in the female. FCM levels peaked at approximately 19-30 hours for cortisol and 21-26 hours for corticosterone after ACTH administration, aligning with the characteristic metabolic transit time of ruminants. The baseline values and the observed increases in FCM levels confirmed the specificity and sensitivity of the EIAs, effectively reflecting the induced physiological changes. This study highlights the importance of non-invasive methods for monitoring stress in sensitive and elusive species, such as the brown brocket deer. These methods contribute to research aimed at understanding the physiological responses of populations in environments impacted by human activities, while also providing a valuable tool for research on stress physiology and conservation efforts.

Keywords: Cervidae, stress, fecal hormone metabolites, glucocorticoids, ACTH challenge.

Resumen

Este estudio tuvo como objetivo validar fisiológicamente un inmunoensayo enzimático (EIA) para cuantificar los metabolitos fecales de cortisol y corticosterona (FCMs) en el venado gris (*Subulo gouazoubira*) mediante la administración exógena de ACTH. El experimento demostró un aumento significativo en los niveles séricos de cortisol y corticosterona (SC) poco después de la administración de ACTH, con picos observados a los 15 minutos para el cortisol y a los 45 minutos para la corticosterona en el macho, y a los 15 minutos para ambas hormonas en la hembra. Los niveles de FCMs alcanzaron su punto máximo aproximadamente entre 19 y 30 horas para el cortisol y entre 21 y 26 horas para la corticosterona tras de la administración de ACTH, en concordancia con el tiempo de tránsito metabólico característico de los rumiantes. Los valores iniciales y los aumentos observados en los niveles de FCMs confirmaron la especificidad y la sensibilidad de los EIAs, lo que refleja de manera efectiva los cambios fisiológicos inducidos. Este estudio resalta la importancia de los métodos no invasivos para monitorear el estrés en especies sensibles y esquivas, como el venado gris. Estos métodos contribuyen a la investigación destinada a comprender las respuestas fisiológicas de las poblaciones en entornos impactados por actividades humanas, al tiempo que proporcionan una herramienta valiosa para el estudio de la fisiología del estrés y los esfuerzos de conservación.

Palabras clave: Cervidae, estrés, metabolitos hormonales fecales, glucocorticoides, prueba de ACTH.

Introduction

The environment is dynamic and constantly changing, compelling animals to adapt to diverse modifications and stimuli for survival (Candolin & Wong 2012). This adaptive capacity is largely supported by the stress response, a complex physiological and behavioral reaction triggered by stressors—chemical, physical, or emotional agents that challenge homeostasis (Möstl & Palme 2002). The study of stress, its associated hormones, and the mechanisms by which animals manage social and non-social challenges has gained increasing prominence, with significant implications for understanding health, reproduction, and animal welfare (Touma & Palme 2005).

The stress response is mediated by the hypothalamic-pituitary-adrenal (HPA) axis, which orchestrates the release of glucocorticoids from the adrenal cortex (Tilbrook et al. 2000). This process begins with the hypothalamic secretion of corticotropin-releasing hormone (CRH), which stimulates the anterior pituitary to release adrenocorticotropic hormone (ACTH). In turn, ACTH triggers the adrenal cortex to produce glucocorticoids, such as cortisol and corticosterone, within minutes of stressor exposure (Möstl & Palme 2002, Touma & Palme 2005). Glucocorticoids serve several vital functions, including energy mobilization, modulation of immune responses, and facilitation of behavioral adaptations (Raynaert et al. 1976, Bahr et al. 1998). These hormones are also involved in activities related to emotional arousal, such as courtship and reproductive behaviors, underscoring the complexity of their role in animal physiology (Sapolsky et al. 2000, Romero 2004, Touma & Palme 2005).

While glucocorticoids play a crucial role in responding to acute stress, their prolonged elevation can have detrimental effects. Persistent stimulation of the adrenal cortex, even without increased ACTH levels, results in glucocorticoid hypersecretion, which can suppress immune function, cause tissue atrophy, and impair reproductive performance (Munck et al. 1984, Dobson & Smith 1995). Understanding the delicate balance between adaptive and maladaptive stress responses is critical for advancing animal health and welfare, particularly for species subjected to anthropogenic stressors or those with reactive temperaments, such as deer (Duarte 2010).

The assessment of glucocorticoid levels provides valuable insights into the physiological state of animals, but traditional methods, such as blood sampling, present significant challenges. Blood collection often requires physical restraint, which can induce stress and confound result interpretation (Palme et al. 1996, Touma & Palme 2005, Brown 2006). In contrast, non-invasive methods, like the analysis of fecal glucocorticoid metabolites, provide the advantage of repeated measurements that reflect long-term hormone secretion without disturbing the animal, thus minimizing feedback effects on the HPA axis (Touma & Palme 2005). However, it is important to highlight that the metabolism and excretion processes of steroid hormones make their measurement in feces complex (Engelking 2010). Glucocorticoids undergo hepatic metabolism and conjugation before being excreted via urine and/or bile into the gastrointestinal tract, where metabolites may either be reabsorbed through enterohepatic circulation or excreted in feces (Wasser et al. 2002, Heistermann 2010). The time lag between steroid detection in blood plasma and their metabolites in feces is species-specific, influenced by intestinal transit time and diet composition (Wasser et al. 1993, Stevens & Hume 1995, Palme et al. 2005, Pereira & Polegato 2010, de Souza et al. 2022). In ruminants, this process can take 24 to 48 hours (Palme et al. 1996, Schwarzenberger et al. 1996, Morrow & Monfort 1998, Grotta-Neto et al. 2024).

Enzyme immunoassays (EIAs) are widely used to quantify fecal glucocorticoid metabolites in domestic and wild species, aiding in hormone-behavior studies, environmental stress assessments, and animal welfare strategies (Touma & Palme 2005). However, species-specific validation is essential, as EIAs rely on antibodies whose cross-reactivity with excreted metabolites varies across species (Brown et al. 2004, Ludwig et al. 2013, Palme 2019). Physiological validation ensures that the assay reliably detects biologically relevant hormone changes, and for glucocorticoids, the primary methods include correlating hormonal patterns with stress indicators or administering exogenous ACTH to induce glucocorticoid increases in feces (Brown et al. 2004, Palme 2019).

For Neotropical deer, many of which are highly susceptible to stress (Duarte 2010), validating non-invasive endocrine assessment methods is crucial, as 59% of the 17 species are threatened and 12% are classified as "Data Deficient" according to the 2019 IUCN Red List. Using high-performance liquid chromatography, Polegato (2004) confirmed that cortisol and corticosterone can be quantified in the feces of these species. Additionally, Christofoletti et al. (2010) physiologically validated the measurement of fecal cortisol metabolites via EIA in brown brocket deer and marsh deer (*Blastocerus dichotomus)*, using a polyclonal cortisol antibody (R4866, C. Munro, University of California, CA, Davis, USA). However, these authors conducted hormone measurements exclusively in fecal samples, without demonstrating cortisol fluctuations in blood. Therefore, the present study aimed to physiologically validate an enzyme immunoassay for measuring fecal cortisol and corticosterone metabolites (FCMs) in brown brocket deer (*Subulo gouazoubira*, Fig. 1), including the quantification of these hormones in blood samples. Cortisol assessment served as a "control" for validating the corticosterone EIA, as the physiological validation of the cortisol antibody R4866 had already been performed for fecal samples in this species (Christofoletti et al., 2010). By demonstrating the reliability of this method, we contribute to the growing body of research on non-invasive hormone monitoring and provide a valuable tool for studying the stress physiology of deer species.

Figure 1. Male (A) and female (B) specimen of brown brocket deer (*Subulo gouazoubira*). Photos kindly provided by Mariana Torres Abramo (A) and Bianca Ferrari (B).

Material and Methods

This study was carried out at Deer Research and Conservation Center (NUPECCE) facilities at São Paulo State University (UNESP/Jaboticabal Campus). We used a male and a female brown brocket deer housed individually in enclosed stalls of 12 m² at NUPECCE. The animals had *ad libitum* access to water and were fed a diet consisting of equine feed (Purina Co., Paulínia, Brazil) and approximately 1 kg/animal/day of alfalfa (*Medicago sativa*), perennial soybean (*Neonotonia wightii*), or fresh mulberry branches (*Morus alba*).

The validation of FCM assays was performed through the exogenous administration of adrenocorticotropic hormone (ACTH), responsible for stimulating glucocorticoid production (Brown et al. 2004). For this purpose, the animals were subjected to general anesthesia. Initially, chemical restraint was performed using an intramuscular combination of 1 mg/kg xylazine and 7 mg/kg ketamine. Once unconscious, the animals were intubated with appropriately sized orotracheal tubes and connected to an inhalation anesthesia machine for induction and maintenance of anesthesia. Induction was performed with isoflurane at a concentration of 3% (v/v) in 100% oxygen at a flow rate of 60 mL/kg/min. The vaporizer was then adjusted to maintain a surgical plane of anesthesia, ensuring immobility and loss of protective reflexes. The cephalic vein was catheterized for fluid therapy using 0.9% NaCl solution (10 mL/kg/h) and for blood collection. Upon loss of consciousness, an initial blood sample was collected and 0.5 mL of ACTH (Synacthen 0.25 mg/ml, Novartis, Linz, Austria) was administered via the jugular vein. The animals were maintained under anesthesia for two hours, enabling serial blood sampling: one pre-ACTH application sample, followed by samples collected every 15 minutes (at 15, 30, 45, 60, 75, 90, 105, and 120 minutes) post-administration. Blood samples were centrifuged, and serum was stored at -20 °C until hormone assays were performed, with no requirement for prior hormone extraction. During the experimental period, the animal's enclosures were inspected every two hours for fecal samples. This monitoring began 24 hours prior to ACTH administration and continued for 72 hours post-administration. Fecal samples were identified with the animal's identification number, collection date and time, and stored at -20 °C.

Prior to hormone extraction, the fecal samples were dried in an oven (Model 320-SE®Fanem® Ltd.; São Paulo, Brazil) at 56 °C for approximately 72 hours, then pulverized and manually homogenized. The metabolites extraction was performed following the method described by Graham et al. (2001). Approximately 0.5 g (±0.001 g) of dried and pulverized feces was mixed with 5 mL of 80% methanol. The mixture was vortexed at maximum speed for 30 seconds and then homogenized overnight (±14 hours) using a vertical shaker (Model AP22, Phoenix Ltda, Araraquara, Brazil). After an additional vortexing step at maximum speed for 30 seconds, the mixture was centrifuged at 400 × g for 15 minutes. The supernatant (fecal extract) was collected and stored at -20 °C for subsequent analysis.

Cortisol and corticosterone levels in feces (expressed in ng/g of dry matter) and in blood (ng/mL) were measured via enzyme immunoassay (EIA) in the Endocrinology Laboratory at NUPECCE. Assays were performed in duplicate following the protocol described by Brown et al. (2004). The EIA utilized the polyclonal antibodies anti-cortisol R4866 and anti-corticosterone CJM006 (C. Munro, University of California, CA, Davis, USA), with the following cross-reactivity for cortisol: cortisol 100.0%; prednisolone 9.9%; prednisone 6.3%; cortisone 5.0%; corticosterone 0.7%; others metabolic <0.5%; and for corticosterone: 100% corticosterone; 14.25% deoxycorticosterone; 0.90% tetrahydrocorticosterone; 0.03% 11-deoxycortisol; <0.01% prednisone; 0.07% prednisolone; 0.23% cortisol; <0.01% cortisone; 2.65% progesterone; 0.64% testosterone; and <0.01% 17β estradiol. For each animal and assay, we established a FCM baseline through an iterative process, calculated by excluding points greater than a certain threshold (mean + 2 SD) until no points fell above threshold (Brown et al. 1994; Curry et al. 2012; Palme 2019). To determine the baseline serum cortisol and corticosterone (SC) profiles, as we collected only one blood sample from each animal before ACTH administration, we considered this value as the "baseline". We observed a parallel arrangement between the standard curve and the curve formed by the pool of fecal extracts prepared by serial dilution for cortisol ($y = -0.4343x + 2.3668$, $R^2 = 0.9963$; $y = -0.0367x + 3.2723$, $R^2 = 0.9615$; respectively) and corticosterone ($y = -0.3159x + 2.2898$, $R^2 = 0.9719$; $y = -0.2257x + 2.1215$, $R^2 = 0.8621$; respectively). Furthermore, we also observed a parallel arrangement between the standard curve and the curve formed by the pool of serum samples prepared by serial dilution for cortisol ($y = -0.3829x + 2.3566$, $R^2 = 0.9933$; $y = -0.4503x + 2.3514$, $R^2 = 0.9991$; respectively) and corticosterone ($y = -0.2945x + 2.2561$, $R^2 = 0.9947$; $y = -0.261x + 2.3217$, $R^2 = 0.9839$; respectively). For both assays, we confirmed the parallel arrangement by Student's t-test comparing the slopes of both curves ($p > 0.05$), and inter-assay CV for low and high-value quality controls and the intra-assay CV was < 10%.

Results and Discussion

Researchers have been investigating stress in wildlife for an extended period to gain deeper insights into the physiological effects of environmental factors and the potential management implications of stress. Although stress has typically been assessed through behavioral observations and mortality rates, quantitative stress measures offer a more objective and comparable approach (Von der Ohe & Servheen 2002). The validation of non-invasive methods is crucial to ensure that fluctuations in hormonal metabolites accurately reflect physiological events in the species of interest (Brown et al. 2004). Consistent with prior studies, we demonstrated that ACTH challenges can effectively assess the suitability of a hormone assay for monitoring adrenocortical activity. Furthermore, this study represents the first effort to evaluate the applicability of this corticosterone EIA for fecal monitoring of adrenocortical activity in brown brocket deer.

Figure 2 illustrates the SC profiles of the male (Fig. 2A) and female (Fig. 2B) brown brocket deer. In both animals and assays, a marked increase in cortisol and corticosterone levels was observed within the first 15 minutes following ACTH administration. In the male, the highest peak of corticosterone occurred 45 minutes post-ACTH, whereas in the female, for cortisol and corticosterone, it was detected at 15 minutes. After these peaks, corticosterone concentrations declined, fluctuating near the baseline levels until the end of the anesthetic procedure. The fluctuation in serum cortisol concentration of the female was similar to that found for the corticosterone assay. However, for the male, there was a sudden drop in cortisol concentration between 15-30 minutes after ACTH application. The levels then began to rise again at 30 minutes, remaining above the baseline at 60 minutes, then falling and returning to values below the baseline.

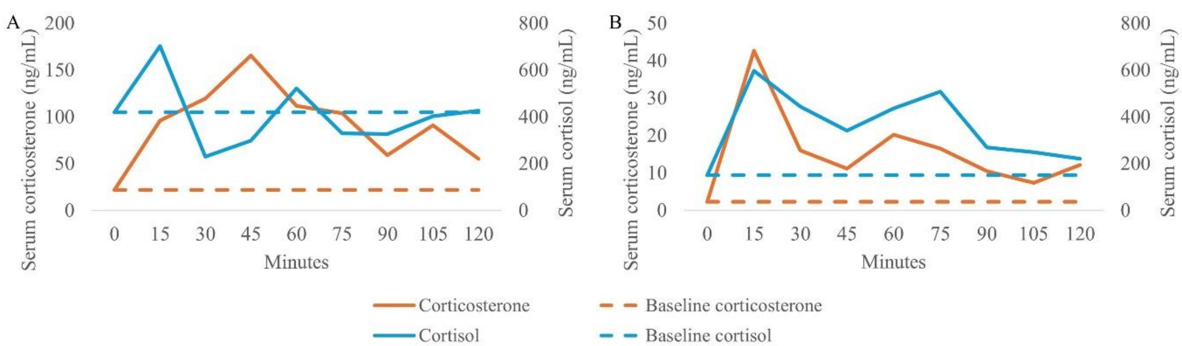

Figure 2. Profiles of serum cortisol and corticosterone of male (A) and female (B) brown brocket deer, obtained on the day the animals underwent general anesthesia. Minute 0 indicates the time of ACTH administration. The dashed line represents the hormonal baseline, defined as the hormonal concentration detected in the sample collected prior to ACTH administration.

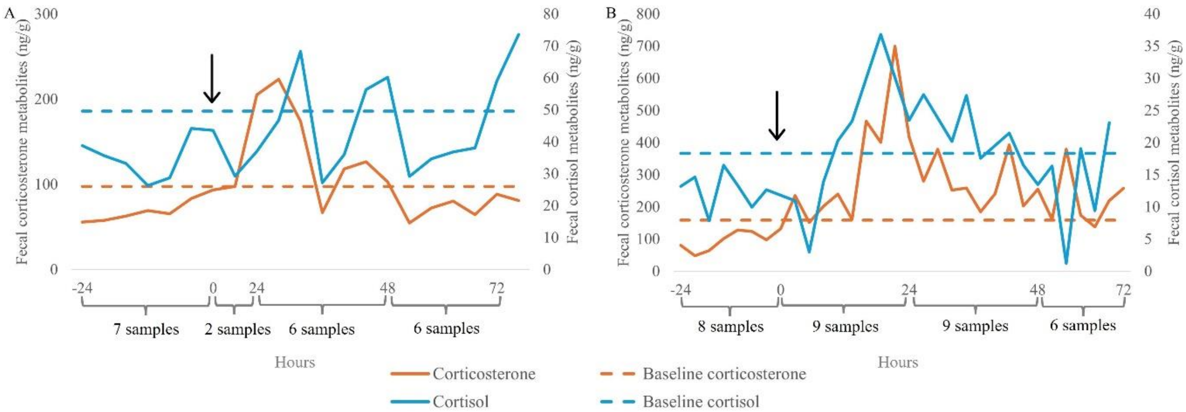

Figure 3. Profiles of fecal cortisol and corticosterone metabolites for the male (A) and female (B) brown brocket deer. The arrow indicates the time of ACTH administration, and the horizontal axis represents the hours before and after ACTH administration. Each point on the graph represents the hormonal concentration of an individual fecal sample, with 21 samples collected from the male and 32 from the female. Enclosures were inspected every two hours to check for the presence of feces. The dashed line indicates the hormonal baseline (mean + 2 SD) calculated from pre-ACTH values.

Figure 3 presents the FCM profiles of the animals. The enclosures were inspected every two hours for feces collection, resulting in 21 samples from the male and 32 from the female. Both animals exhibited a distinct peak approximately 19-30 hours for cortisol and 21-26 hours for corticosterone after ACTH administration. For the assay using a corticosterone antibody, we observed that intravenous administration of ACTH resulted in a 2.3-fold increase in the male (Baseline: 97.56 ng/g; Peak: 223.23 ng/g) and a 4.4-fold increase in the female levels (Baseline: 158.54 ng/g; Peak: 699.50 ng/g), whereas for the assay using the cortisol antibody, the increase was 1.38-fold for the male (Baseline: 49.59 ng/g; Peak: 68.27 ng/g) and 2.00-fold for the female (Baseline: 18.35 ng/g; Peak: 36.89 ng/g). The male's highest peak occurred at 29 hours for cortisol and 26 hours for corticosterone post-ACTH, while the female's occurred at 19 hours for cortisol and 22 hours for corticosterone. This result aligns with findings from various authors who report that the process of secretion into the bloodstream and subsequent excretion into feces in ruminants typically takes 24 to 48 hours (Palme et al. 1996, Schwarzenberger et al. 1996, Morrow & Monfort 1998, Wielebnowski & Watters 2007). Thus, we emphasize the importance of accounting for this time lag to ensure the accurate interpretation of fecal data related to acute stress events in field or *in situ* studies.

In the study conducted by Christofoletti et al. (2010), a single intramuscular injection of ACTH in brown brocket deer triggered adrenocortical activation, leading to a 4.00-fold increase in fecal cortisol metabolites levels (cortisol antibody R4866) within 24–28 hours. Baseline concentrations averaged 199±24 ng/g in the male and 164±24 ng/g in the female, rising to peak values of 864 ng/g and 677 ng/g, respectively. Both the fecal cortisol profile and the peak timing observed by Christofoletti et al. (2010) were similar to those identified in the present study.

According to Micheletti et al. (2014), among various animal groups such as Amphibians, birds, Reptiles, Rodentia and Scandentia, corticosterone is typically the primary glucocorticoid produced in stress response. In contrast, non-rodent mammals primarily produce cortisol as their main glucocorticoid. Notably, exceptions can occur: while some lagomorphs, such as *Sylvilagus floridanus*, predominantly secrete cortisol, other species, like *Oryctolagus cuniculus*, exhibit higher corticosterone level (Micheletti et al. 2014).

In ruminants, Palme et al. (1999) reported that 11,17-dioxoandrostanes (11,17-DOA), a group of cortisol metabolites, are reliable indicators of glucocorticoid activity. Using HPLC, Polegato (2004) demonstrated that both cortisol and corticosterone can be quantified in Neotropical deer feces, highlighting the potential of these biomarkers in non-invasive stress assessment. As emphasized in the review by Cook (2012), minimally invasive approaches have become increasingly relevant in stress research, particularly for species that are difficult to sample invasively. Here, we show that, in brown brocket deer, serum and fecal profiles of both cortisol and corticosterone accurately reflected pre- and post-ACTH administration phases. This finding highlights that corticosterone, alongside cortisol, represents a valid and informative measure of stress response in brown brocket deer. The validation of this assay further strengthens the use of non-invasive methods to monitor welfare and environmental impacts in wild and captive deer populations, offering a valuable tool for improving management and conservation strategies. Finally, we suggest that future studies expand this validation to a larger sample size of males and females to explore potential variations in glucocorticoid excretion patterns related to age or sex.

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Reintroduction of the Persian Fallow Deer in Iran: Increasing Public Awareness and Project Progression

Farshad Eskandari

Shirdal Wildlife Conservation

Tehran, Iran

Email: far.eskandari@gmail.com

In February 2020, a group consisting of 6 male and 3 female Persian fallow deer (*Dama mesopotamica*) was translocated from the Manesht and Ghelarang breeding centers in Ilam Province to Dez National Park, located in the southwest of Iran(Fig 1). This park, situated near Dezful County in Khuzestan Province, spans an area of 17,895 hectares and provides a vital habitat for the Persian fallow deer. With its dense vegetation and abundant food and water resources, Dez National Park is a key site for the conservation of this endangered species. A comprehensive report on the transfer and release of the deer was published in the Deer Specialist Group Newsletter N°32 (2021).

Figure 1 .A male Persian Fallow Deer

Following the reintroduction, a monitoring program was established by park rangers to assess the health and survival of the deer. The monitoring strategy included local reports, direct observations, and tracking signs and traces left by the animals. From these observations, it became evident that engaging and empowering local communities was crucial in mitigating potential threats to the deer. Despite the fact that Dez National Park is a protected area, enforcement of national park regulations in this region remains inconsistent. The presence of domestic livestock, dogs, human activities, and the proximity of agricultural lands present significant risks to the reintroduced deer. Therefore, increasing local awareness about the species and its conservation needs was identified as a key strategy for reducing these threats and ensuring the long-term survival of the species.

In 2021, a public awareness program was developed by Shirdal Wildlife Conservation, a non-governmental organization dedicated to the protection of endangered species and habitats in Iran. This initiative was submitted to the GEF Small Grants Programme (SGP) for funding support. After extensive discussions with the SGP office in Iran, the program was approved and implemented in collaboration with the Department of Environment of Khuzestan Province. The project, which was executed over a two-year period, aimed to educate the public on the importance of Persian fallow deer conservation.

In alignment with the strategic management plan for the species, additional deer were introduced to the region in two separate phases in 2022 and 2023 to bolster the population. In November 2022, 11 males and 6 females were reintroduced to Dez National Park

These deer were captured from the same breeding centers in Ilam Province and transported to Khuzestan. The capture process involved darting and anesthetizing the deer on-site, followed by their transfer in transport boxes to the release location (Fig.2). Upon arrival, the deer were temporarily held in a small enclosure (100 square meters) for 3-4 days before being released into the wild. This release was carried out in four stages. Notably, the involvement of the local community in the process, along with their positive response to the presence of the deer near their villages, was a significant outcome of the educational efforts.

Figure 2. Release of the deer from boxes

Subsequent monitoring, using the same methods as before, showed an increase in the number of reported deer sightings, thanks to heightened local awareness. These reports were mapped to help identify areas with frequent deer activity (Fig 3).

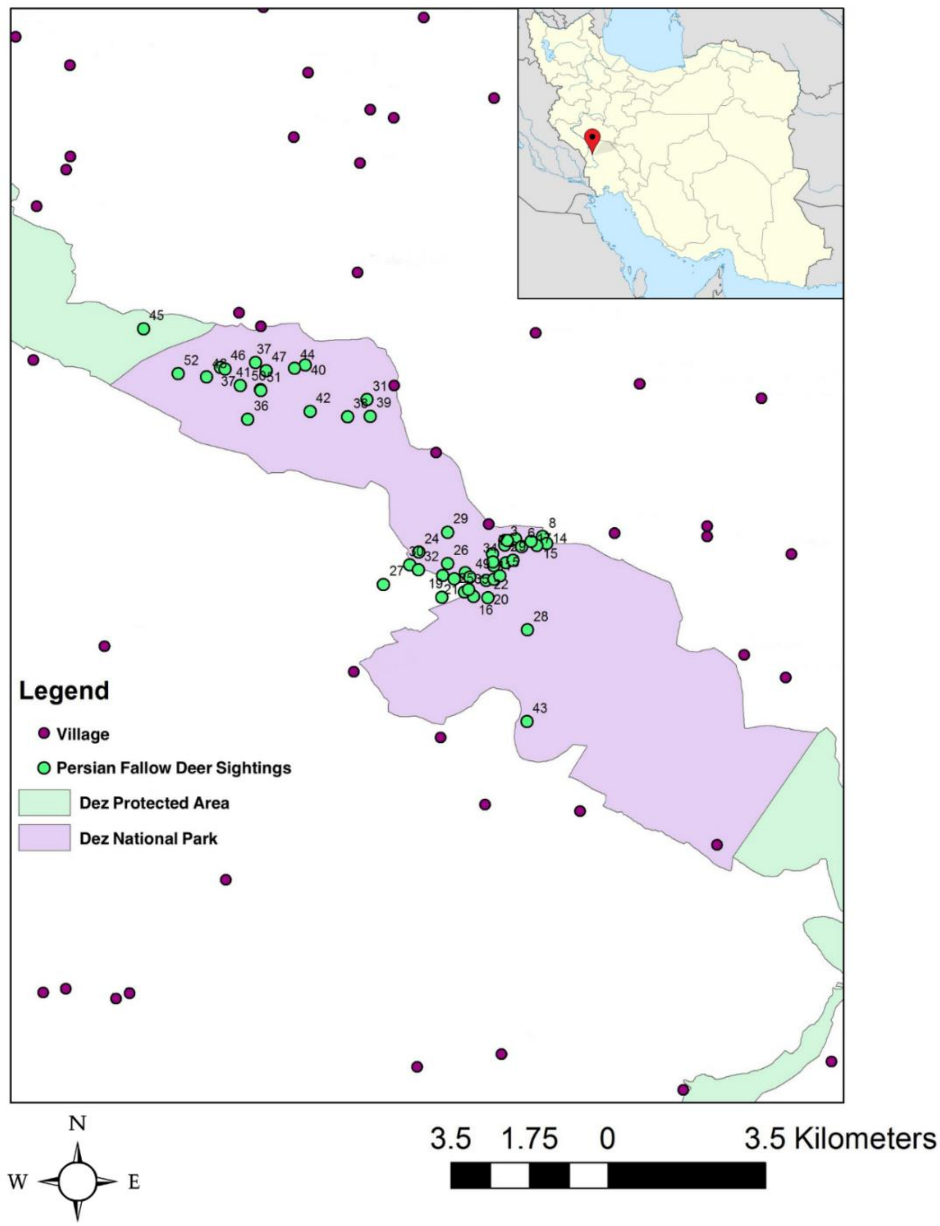

Figure 3. Map of Dez National Park showing deer sightings

A potential threat to the deer was the road running through the park, as the animals were occasionally observed near it. Although this road serves primarily local traffic, the risk of road accidents was mitigated by installing warning signs and lighting along the 8-kilometer stretch of the road. Another challenge was the deer's tendency to graze in surrounding agricultural fields, particularly at night. To address this, educational workshops for local communities and farmers were conducted as part of the ongoing awareness program.

In February 2024, a further reintroduction phase took place, during which 8 females and 2 males were released into the region. These deer were captured from the Persian fallow deer breeding center in Arsanjan, Fars Province, and transported to Khuzestan. The Arsanjan center, located 5 kilometers east of Arsanjan County, covers 300 hectares and currently houses 90 Persian fallow deer, according to the latest census. The capture method at this site involved using baited fodder to guide the deer into a small enclosure, followed by darting and anesthesia, before they were transported to Khuzestan for release. This phase marked a shift in the release site, which was moved approximately 7 kilometers north of the previous location. The deer were directly released into the wild by opening the transport boxes.

Post-release monitoring continued with the use of camera traps. Despite challenges posed by dense vegetation and limited resources, the camera traps yielded valuable images of the deer. In May 2024, a camera trap recorded sighting of a fawn with its mother, providing promising evidence for the species' continued survival in its historical range in Iran.

Currently, efforts are underway for additional reintroductions of Persian fallow deer to both Dez National Park and Karkheh National Park, which lies further to the west. In addition, plans are in place to deploy GPS collars on the released deer to enhance monitoring and support future conservation initiatives.

2nd International Conference on Hangul and Other Threatened Ungulates (2IHUC-25)

This conference is an unparalleled opportunity to address the critical conservation needs of the Critically Endangered Hangul deer and its close relatives, such as the Bukhara/Bactrian deer and the Yarkand/Tarim deer, as well as other threatened ungulates.

Building upon the success of the 2009 International Conference on Management & Conservation of Endangered Deer Species, this event aims to bring together the world's foremost experts to focus on vital topics, including:

* Population and movement ecology
* Habitat restoration
* Behaviour and genetics
* Health and disease management
* Climate change adaptation
* Sustainable conservation policy development

This conference promises to be a milestone in global conservation efforts. I am confident that, together, we can achieve far-reaching outcomes for conserving Hangul deer and other threatened ungulates.

Dr. Khursheed Ahmad
Professor -
Division of Wildlife Sciences
Faculty of Forestry
Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir
India.khursheed47@gmail.com