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The Origins of Early Colonial Cows at San Bernabé, Guatemala: Strontium Isotope Values at an Early Spanish Mission in the Petén Lakes Region of Northern Guatemala

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ABSTRACT

The earliest Spanish explorers in the 15th century brought ships stocked with European domesticated animals to the Americas. Yet for nearly two centuries, the Maya living in Guatemala's Petén Lakes region continued to rely on traditional wild animal species. A small number of cow, equid, and pig bones have been identified in Kowoj and Itza Maya Contact period contexts at Ixlú, Nixtun Ch'ich', Tayasal, and Zacpetén; however, significant changes in regional animal use are only visible after the Spanish began to build missions in the region during the early 1700s. We explore the introduction of European domesticates to the region at the San Bernabé mission near Tayasal using faunal, isotopic, and historic data. There were marked differences in mammal use, but a continued reliance on aquatic species such as turtles and snails. Animal acquisition strategies changed as well, with potentially significant impacts on local and regional land use and the daily lives of the Mayas.

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Colonialism in the Maya region

European colonialism brought great changes to indigenous cultures across the Americas, spreading rapidly in some places and taking decades or centuries to arrive in others. Northern Guatemala was the last part of the Maya region to come under Spanish rule in the early 18th century, nearly 200 years after initial recorded contact with Spanish in AD 1525 (Jones 1998). Despite nearly four decades of research on Postclassic (AD 900–1525) and Contact (AD 1525–1697) period history and archaeology, there is little published information on animal use in and around the region during those periods (but see Emery 1990; Pugh et al. 2016a; Thornton 2012).

Animal use provides particularly useful insight into the impact of contact and colonialism. Despite management and/or domestication of a limited number of species such as dog and turkey, animal acquisition among the Maya revolved around hunting and collecting fauna, and wild animal species figured prominently in Maya art and iconography (e.g. Miller 1999; Pohl 1981; Schlesinger 2001; Seler 1996). In the Petén Lakes region, Postclassic populations relied heavily on aquatic resources such as turtles and snails, along with large terrestrial ungulates deer and peccary. European domesticated species such as equid, cow, and pig remains are identified during the Contact period after AD 1525. However, they are exceedingly rare and generally found in non-utilitarian

contexts, such as the modified cow mandible associated with an altar and incensario fragments at Zacpetén (Pugh 2009b, 381).

It was only after Spanish missions were established around Lake Petén Itzá during the early 1700s that European domesticates appeared in significant quantities in the zooarchaeological record. Cow and pig remains partially replace those of large indigenous species such as peccary and deer. We analyse these changes using two methods: the first section uses traditional zooarchaeology to compare residential animal use at the Postclassic/Contact period sites Zacpetén, Nixtun Ch'ich', and Tayasal with the Colonial period Mission San Bernabé. The second section uses strontium isotopic assays to identify the origins of the introduced species and show that animals were brought to San Bernabé from southern Guatemala.

These findings are important on multiple levels. Animal husbandry requires significant changes in settlement layout and daily activities, as well as integration into the colonial economic system. Ideological changes are equally important. Spanish goods held both exotic appeal (Helms 1992; Pugh 2009a, 378) and threatened Maya culture, because appropriating Spanish goods to some extent meant accepting the Spanish. Cattle were a key part of Spanish efforts to establish settlements, and after nearly 200 years, served as an important tool to incorporate Petén Maya groups into the colonial system.

Animal use and Petén Lakes history during the Postclassic and Contact periods

During the Postclassic period, the Petén Lakes region was occupied by multiple ethnic groups, including Itza speakers who controlled territories and trade routes to the west and south of the lake, Kowoj Mayas occupying sites to the north and east, and other groups such as the Mopan with whom they competed and formed alliances (Caso Barrera 2002; Jones 1998; Pugh 2003, 2009a, 2009b; Pugh et al. 2016b; Rice and Rice 2005; Thompson 1977). Architectural, caching, and ceramic patterns, along with historic accounts, allow us to associate sites such as Zacpetén with the Kowoj Mayas, Nojpeten, Tayasal, and Nixtun Ch'ich' with Itza speaking groups, and use of Ixlú by both Maya groups at different times (Figure 1).

Several general trends characterise faunal use during the Postclassic period in the Maya region. Faunal assemblages have more small and medium-sized mammals, and more diverse species than before (Emery 1990). There is a statistically significant reduction in the use of deer and other large mammals that dominate Classic period faunal collections, especially in elite contexts (Emery 2007). A second trend is regional variability, which may be explained by differences in local ecosystems (Powis et al. 1999). Masson and Peraza Lope (2008) described a focus on iguana and turkey at Mayapan in Mexico, while Alexander (2005, 172) noted a focus on aquatic resources at Isla Civiltuk during the Late Postclassic, where 30% of the faunal remains come from turtles, fish, snails, or crocodiles.

Fauna use during the Postclassic also is characterised by specialisation at some sites, including Lamanai

and Laguna de On, Belize and Mayapan, specifically with turkey and certain fish species (Emery 1990; Masson 2004; Masson and Peraza Lope 2008). Another form of specialisation is the management of dogs and deer at Mayapan, observed by demographic profiles that show a focus on adolescent animals that had reached adult size but had incomplete fusion of bones (Masson and Peraza Lope 2008).

During the Contact period, remains of European animals provide material evidence for sporadic contact between Petén Maya groups and the Spanish, including visits by representatives of the Spanish crown and church described in 16th and 17th century historic documents (Caso Barrera 2002; Jones 1998, 29–32). Animals may have been acquired as gifts, through tribute or theft (Smith 1987, 122–124), or traded along with traditional products like cloth, cacao, achiote, copal, and vanilla, and new ones such as metal, sugar cane, citrus, or bananas (Caso Barrera 2002).

The Itza Mayas had close ties, including intermarriage, with eastern lowland sites like Tipu and long-standing connections with Yucatecan populations (Rice and Rice 2005). Perhaps more important were the small settlements scattered across the Petén, especially those of Mayas who fled Spanish-controlled regions and maintained connections with their former villages (Caso Barrera 2002, 138; Thompson 1977). These groups often fell under Itza rule, though some, such as the Lacandon, remained independent (Palka 2005a). These networks allowed both goods and ideas to flow from areas under Colonial control; however, there is very limited evidence of non-indigenous material culture in the Petén during the Contact period.

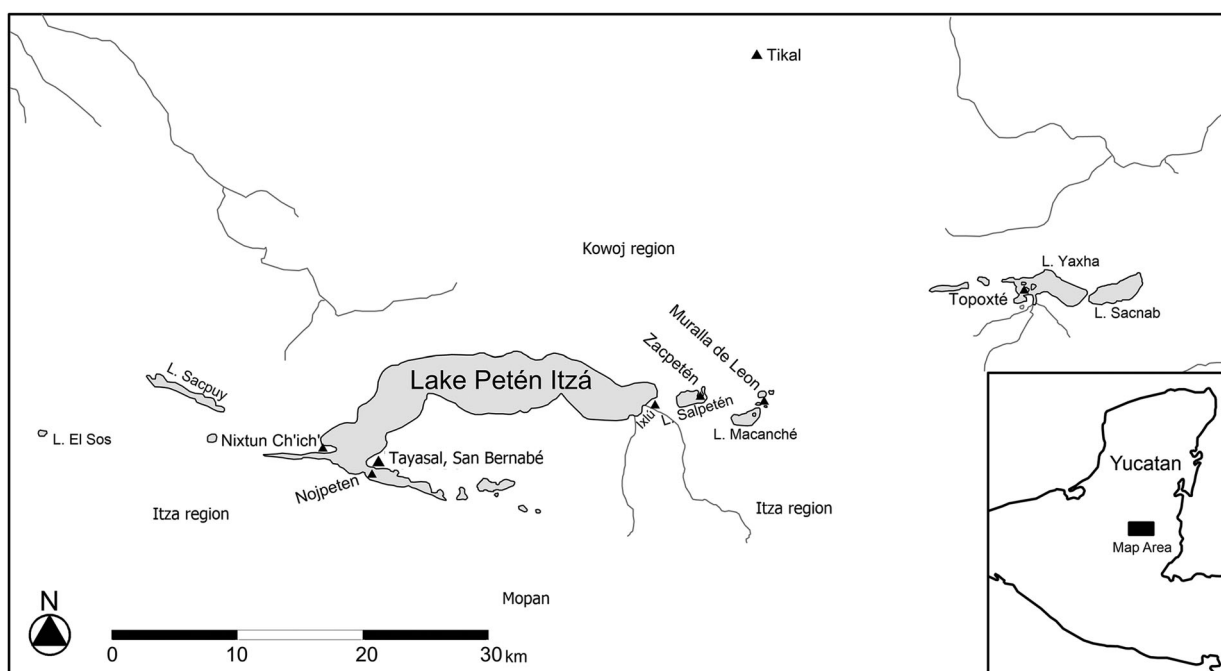


Figure 1. Maya groups in the Petén Lakes region (modified from Jones 1998).

The sites in this study offer an unusual opportunity to compare residential faunal assemblages from contemporaneous sites occupied by different Maya ethnic groups, and to compare them to a Spanish mission subsequently established near one of the residential groups. The faunal samples come from residential structures with associated ceremonial architecture that were occupied from the Late Postclassic into the Contact period. Most bones come from horizontal excavations that include middens screened through 1/8" hardware cloth, resulting in small-to-medium-sized faunal assemblages (see Pugh 2002, 354). It is more difficult to directly compare the status of the sites and the households within them, despite historic accounts of both Kowoj and Itza Mayas. Samples were selected for this study from nearly 50,000 bone and shell fragments that have been analysed to date, one of the largest faunal collections in the Maya region (Freiwald 2012, 2013; Pugh et al. 2016a), with the goal of characterising Postclassic/Contact period animal use: complete analyses will be presented elsewhere.

Zooarchaeology of the Kowoj and Itza Mayas

Zooarchaeological methods used in this study focus on species identification and quantification using the number of identified specimens (NISP). Tropical assemblages often have small MNIs, or estimates of the minimum number of individuals, and a great deal of species diversity that increases with the size of the collection (Emery 2004). Freiwald identified faunal specimens in the field laboratory in Flores, Petén, Guatemala and at the University of Wisconsin-Madison Zoological Museum using standard zooarchaeological methods (e.g. Reitz and Wing 1999; Russell 2011; Ziegler 1965), supplemented by skeletal collections at the University of Mississippi, photographic references from the Chicago Field Museum and Florida Museum of Natural History, and other guides (e.g. France 2008; Gilbert 1990; Gilbert, Martin, and Savage 1996; Gómez 2009; Merck 2015; Moholy-Nagy 1978; Post 2003, 2005; Powis 2004; Schmid 1972).

The faunal samples from Zacpetén, Tayasal, and Nixtun Ch'ich' show a reliance on aquatic resources that characterises Postclassic animal use in the region. Ixlú remains have not been extensively analysed so are not discussed in detail. Kowoj and Itza Maya groups also relied on deer and peccary, supplemented by smaller animals such as armadillos, opossums, agoutis, and pacas (Table 1). There is no evidence for reliance on domesticated animals (e.g. turkey) or those that might not be acquired by hunting or collecting.

Zacpetén is located on Lake Salpetén (Figure 1) and was occupied by Kowoj Mayas during the Late Postclassic–Contact period. Excavations by the Proyecto Maya Colonial (Pugh 2001; Rice 1988; Rice and Rice 2009; Rice, Rice, and Pugh 1998) resulted in more

than 50,000 bone and shell fragments associated with 26 buildings and nearby plazas. Zooarchaeological analysis completed to date includes nearly 83000 bone and shell fragments from seven structures. This discussion centres on Late Postclassic–Contact period fauna from Structure 719, a high status residential building in a group that also contained temple and shrine structures (Pugh 2002, 359).

Analysis of 3746 bone and shell fragments show a heavy reliance on aquatic resources such as lake dwelling apple snails (*Pomacea flagellata*) and ridged and smooth jute snails (*Pachychilus* spp.) from rivers and streams, along with turtles, crabs, and fish. Large and medium mammals make up approximately 25% of the sample, with a focus on deer (Figure 2). The single European domestic species is a cow mandible, which fossilised to a greater extent than any of the other bones (Figure 2). Its context near an altar and the distinct taphonomic processes that caused the fossilisation show its uniqueness in the Postclassic/Contact period faunal samples. No other non-native species have been identified at Zacpetén, although Pugh (2009a) has described other European material culture in ceremonial contexts.

Nixtun Ch'ich' is located on Lake Petén Itzá's western shores and was occupied from the Preclassic through the Contact periods. Pugh and colleagues (2016b; Rice 2009) have identified extensive Late Postclassic occupation, including on the Candelaria Peninsula, the location the Spanish may have used to launch an attack on Nojpeten that ushered in the Colonial period in the region (Jones 1998 in Rice 2009, 403).

Fauna from two residential structures with associated middens, ZZ1/1 and QQ2/1, shows how the Chakan Itza Mayas utilised lacustrine and terrestrial game resources. Mound ZZ1 is located on the easternmost tip of the Candelaria peninsula, and may include Contact period use by both the Spanish and residents of the Mission San Jerónimo (AD 1702–1734). Excavations revealed a number of 'Spanish' artefacts including Punta Rassa glass pendants, which were produced from ca. AD 1650 to 1700 (Pugh et al. 2016b; Rice 2009). Colonial period fauna from Mound ZZ comes from the upper levels of a trench placed vertically along the structure's axis as part of a salvage operation (Rice 2009), as well as excavations of a midden associated with a residence (Structure ZZ1/1). Fauna from ZZ1/1, one of two small Contact-Colonial period structures on the south side of the mound, came from 1 × 1 m units in a horizontal excavation.

Fauna have been analysed from Structure QQ2/1 and nine other structures, along with test pits and platforms that were excavated by Pugh and colleagues (2016b) in 2013, some of which had been explored previously by Don and Prudence Rice. Structure QQ2/1 is a Postclassic period residence located near the lake-shore 2.1 km west of Structure ZZ1/1. More than half

Table 1. Species identified to date at Petén Lakes sites in this study.

	San Bernabé, Tayasal Strs. T29, T35 *unless noted	Tayasal Group 23 Strs. T52, T53	Zacpetén Str. 719 *unless noted	Nixtun Ch' ich' ZZ1/1 and Str. QQ 2/1 *unless noted	Ixlú Str. 2023
Cow (<i>Bos taurus</i>)				ZZ1	
Pig (<i>Sus scrofa</i>)				ZZ1	
Equid (<i>Equus</i> sp.)	T31				
Jaguar (<i>Panthera onca</i>)				ZZ1	
Tapir (<i>Tapirus bairdii</i>)			732		
Whitetail deer (<i>Odocoileus virginianus</i>)					
Brocket deer (<i>Mazama</i> sp.)					
Peccary (Tayassuidae)					
Dog (<i>Canis lupus familiaris</i>)				ZZ1	
Virginia Opossum, Grey Four-Eyed Opossum (<i>Didelphis virginianus</i> , <i>Philander opossum</i>)	T34				
Anteater (<i>Tamandua mexicana</i>)					
Monkey (Atelidae)					
Paca (<i>Cuniculus paca</i>)				ZZ1	
Agouti (<i>Dasyprocta punctata</i>)				ZZ1	
Giant Pocket Gopher (<i>Orthogeomys grandis</i>)	T31				
Coati (<i>Nasua narica</i>)					
Southern Spotted Skunk (<i>Spilogale angustifrons</i>)					
Rabbit (<i>Sylvilagus</i> sp.)					
Yucatecan Squirrel (<i>Sciurus yucatanensis</i>)	T31				
Hispid Cotton Rat (<i>Sigmodon hispidus</i>)					
Central American River Turtle (<i>Dermatemys mawii</i>)					N/A
Pond slider (<i>Trachemys scripta</i>)					N/A
Mexican/Northern Giant Musk Turtle (<i>Staurotypus triporcatus</i>)					N/A
Mud turtle (<i>Kinosternon</i> sp.)			732, 765		N/A
Furrowed Wood Turtle (<i>Rhinoclemmys areolata</i>)					
Narrow Bridge Musk Turtle (<i>Claudius angustatus</i>)					
Iguana (<i>Iguana iguana</i>)			732		
Crocodile (<i>Crocodylus</i> sp.)					
Fish (not identified)					
Bird (not identified)					
Turkey (<i>Meleagris</i> sp.)				ZZ1	
Toad (<i>Bufo</i> sp.)					
Marine shell					
Apple snail (<i>Pomacea flagellata</i>)					
Jute (<i>Pachychilus indiorum</i> and <i>P. glaphyrus</i>)					
Coral					
Clam (<i>Nephronaias</i> sp.)				ZZ1	
Crab (Decapoda)				ZZ1	
Vertebrate					

of the fauna in QQ2/1 come from large deposits of *Pomacea* snail shells ($n = 470$), some in possible dedicatory caches (see Pugh et al. 2016b, 11). Similar caches

were not reported for ZZ1/1, but analysis of the snail and marine shell is incomplete. In all, more than 5000 bone and shell fragments have been analysed

**Zacpetén
Structure 719
Postclassic/Contact
period fauna
 $n = 3,746$**

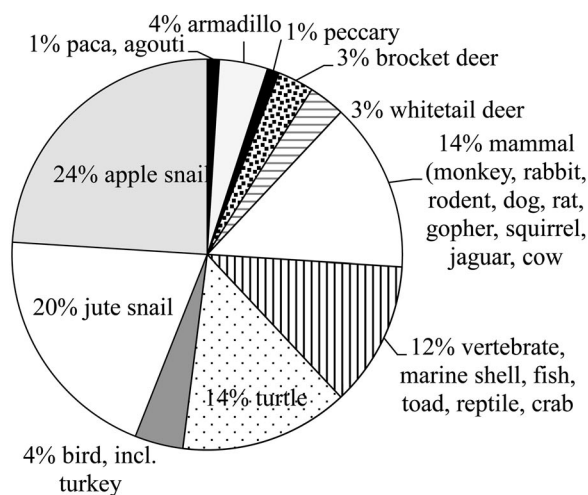


Figure 2. Summary of Zacpetén Structure 719 fauna (insert: cow mandible).

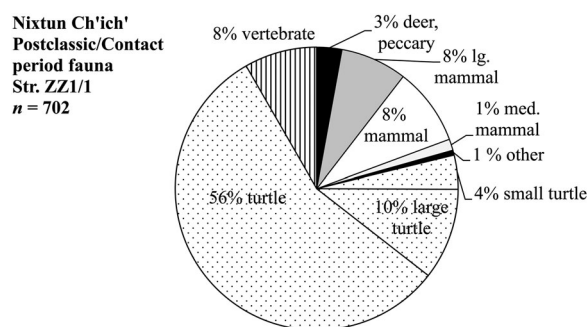


Figure 3. Summary of Nixtun Ch'ich' ZZ1/1, excluding snail shells.

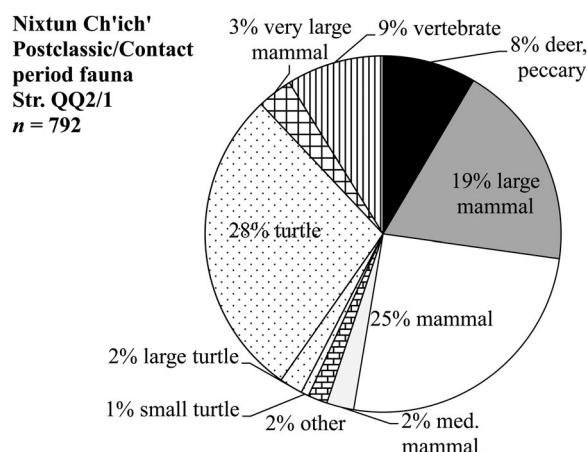


Figure 4. Summary of Nixtun Ch'ich' QQ2/1 fauna, excluding snail shells.

from Nixtun Ch'ich'. Figures 3 and 4 (excluding aquatic snail shells) show a focus on aquatic species and large mammals.

Most turtle were large ones, including the Central American river turtle, northern or Mexican giant musk turtle, and the pond slider, but smaller turtle species include the furrowed wood turtle, mud turtles, and the narrow-bridged musk turtle (see Table 1). Deer and peccary were the most common terrestrial fauna, along with a variety of smaller animals such as coati, armadillo, and agouti. Unusual species are included in the 'other' category, including crocodile, marine shell, bird, and fish, and a small number of cow and pig remains. Similar fauna were found at QQ2/1 and ZZ1/1 but in different quantities. Analysis of more ZZ1/1 and QQ residential fauna will show whether this is a real difference or a product of the small sample sizes.

Tayasal is located on a peninsula across Lake Petén Itzá from Nixtun Ch'ich' as well as from the Itza capital Nojpeten in the area occupied by the Itza Mayas (Figure 1). Yuko Shiratori investigated Late Postclassic–Contact period occupation in Group 23, which contained residential structures T52 and T53 as well as ceremonial structures (Shiratori 2012). The faunal sample of 4291 specimens is drawn from more than

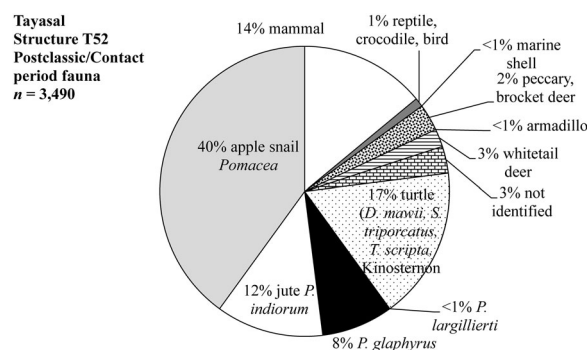


Figure 5. Summary of Tayasal Structure T52 fauna.

26,000 bone and shell fragments analysed to date. This dataset provides the most direct comparison of Precolonial and Colonial animal use because Group 23 is in close proximity to the Mission San Bernabé.

Figures 5 and 6 show a marked aquatic focus. Seventy-five percent of the remains were snail and turtle shell fragments, with nearly all snails representing an individual animal and turtle remains portions of carapace or plastron. Most mammals in the sample are large species, such as deer and peccaries (Table 1). Imported species such as marine shell were uncommon, as were birds and iguanas, and fish, which is perplexing given the proximity to the lakes. A single domestic animal was identified: an equid tarsal in a Contact period context (Shiratori, Freiwald, and Pugh 2014) that clearly was deposited after Cortés passed through the region in AD 1525 and reported leaving a horse in the care of the Itza (Jones 1998).

Contact period contexts at these sites cannot be clearly separated from Late Postclassic occupation, but the limited numbers of non-native species fit the general pattern of specialised use of European material culture (Pugh 2009a; Pugh 2007). The Precolonial non-native animals do not suggest adoption of Spanish culture; instead, the Maya reinterpreted foreign objects without accepting the Spanish and maintained traditional subsistence patterns for nearly 200 years after initial contact with the Spanish.

Animal use during the early Colonial period

In Petén, colonialism arrived only after AD 1697, when the Itza capital Nojpeten fell to Martín de Ursúa and his indigenous collaborators, and the Spanish began to establish missions in the region and 'reduce' settlements to better control indigenous populations (Caso Barrera 2002; Jones 1998). They constructed a church at Nojpeten, Nuestra Señora de los Remedios, also referred to as The Presidio, and began to establish missions around the lake in the same location as many modern towns. They also began to import cattle, a crucial component to establishing rule in the region (Pugh et al. 2016a; Schwartz 1990). The "sale of livestock to

**Tayasal
Structure T53
Postclassic/Contact
period fauna
n = 801**

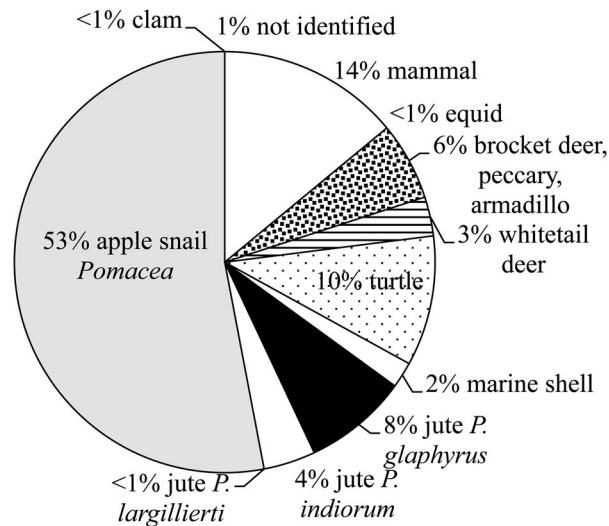


Figure 6. Summary of Tayasal Structure T53 fauna (inset: equid tarsal).

Yucatan” became the primary economic product of Petén from just after the conquest to 1840 (Schwartz 1990:41).

Colonial faunal use may have varied as much as Postclassic subsistence strategies did (de France and Hanson 2008). Cows, pigs, horses, and chickens are identified across the Maya region, but were differentially incorporated into Maya diet and economy. For example, Gasco (2005) describes a hybrid culture in Chiapas, with Christian-influenced burials similar to those at San Bernabé (Pugh et al. 2016a), limited European goods during the Contact period, and eventual husbandry of chickens. Emery (1990) identified a limited number of cow and pig remains at Tipu and Lamanai in Belize, but attributed changes in animal use to Postclassic trends rather than Colonial ones.

In Yucatan, wills and tribute requirements from AD 1646–1835 provide evidence that cows, and to a lesser extent horses, pigs, chickens, and turkeys, were used by some Maya communities (Restall 1997, 365). Cattle were the most commonly owned property near Merida by the late 17th century (Patch 1993, 183). Horses were listed as property earlier (AD 1661) in Tekanto, with cattle commonly described in the late 18th century (Thompson 1999). Merida Mayas infrequently owned birds, but archaeological evidence for husbandry of pigs and poultry were identified in Yaxcabá communities (Alexander 2004; Patch 1993). Domesticated animals were reported as community property, but may not have been consumed frequently (Farriss 1984).

Incorporation of cows, pigs, and equids into Petén economies for the first time comes from species identifications and analysis of butchery patterns at San Bernabé residential structures. The mission was established sometime before AD 1712 near Tayasal and the Mission San Miguel, which was formed earlier in AD 1702. The exact location was rediscovered in 2010, when excavations revealed the remains of a

church with Colonial period burials and other contemporaneous structures built over earlier Maya settlement (Pugh and Sánchez Pólo 2012; Pugh et al. 2016a; Pugh, Sánchez, and Shiratori 2012).

The mission likely was settled by related groups of Itza Mayas, based on material culture and Miller Wolf’s analysis of skeletal remains (Miller 2012; Pugh et al. 2016a). This analysis focuses on fauna associated with two residential structures, T29 and T35, located to the south of the church (Figure 7). Ixkamik pottery, a locally produced hybrid ware with European attributes, and Spanish *reales* were associated with both structures (Pugh et al. 2016a, 62; Pugh and Sánchez Góngora 2014, 8; Pugh, Sánchez, and Shiratori 2012).

Animal use changed, but not completely. San Bernabé abutted the lake, and lacustrine resources remained important (Figures 8 and 9). The same types of large turtles were collected, along with jute and apple snails, but even these resources show some important differences. Where residents of Tayasal Structures T52 and T53 consumed both smooth (*P. indiorum*) and ridged (*P. glaphyrus*) jute (Figures 5 and 6), mission structures show a focus on one type of jute snail, either ridged or smooth. Jute species generally are collected in distinct locales (e.g. Halperin et al. 2003; Healy, Emery, and Wright 1990), so this suggests use of different catchments. If residents of San Bernabé came from nearby settlements, they may have retained rights to the same fields (Alexander 2005); however, their ability to hunt and collect in traditional areas may have been restricted.

The main finding for this analysis is the relative abundance of cow and pig remains. Cow remains were associated with 12 structures at San Bernabé (Structures T29, T30, T30A, T30C, T31, T32/111, T33, T34, T35, T112, T145, and T1121), while pig remains were found in association with seven

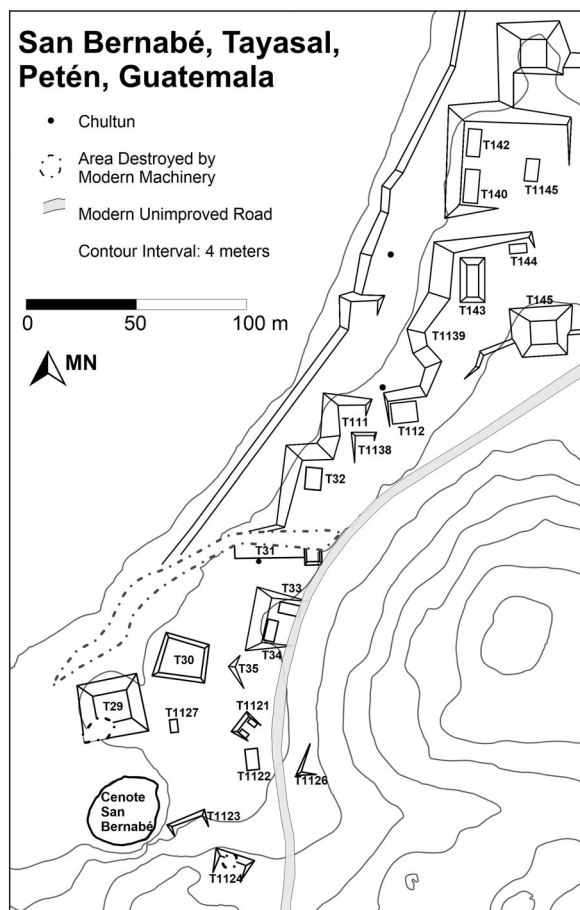


Figure 7. San Bernabé map, from Pugh et al. (2016a, 54, Figure 4).

(T29, T30, T31, T35, T97, T112, and T1105). The remains consist of easily identified cranial and lower limb elements, as well as fragments of thick cow and pig-sized limb bones classified as very large mammal remains. The proportion of identified deer and peccary is reduced to 1% or less of the sample.

The MNI estimates for all species are low, but also reflect the shift from native large mammal species to very large introduced ones. Tayasal Structure T52 had a minimum of two peccaries, three brocket deer, and three adult and subadult whitetail deer based on duplicate postcranial elements. The Structure T53 faunal sample includes just one of each animal (with an additional five left whitetail deer metatarsal bones left

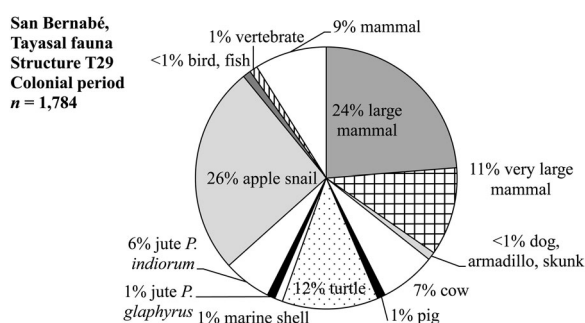


Figure 8. Summary of San Bernabé Structure T29 fauna.

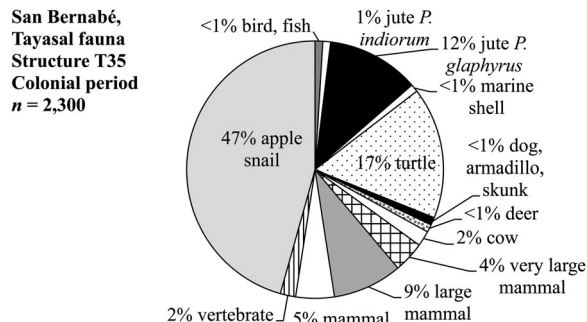


Figure 9. Summary of San Bernabé Structure T35 fauna.

as an offering in a burial). San Bernabé Structures 29 and 35 each had just one whitetail deer, brocket deer, and peccary represented as well, but a total of six cows and three pigs based on duplicate tooth elements (see next section).

Very large mammals also were processed differently. Some cows and pigs appear to have been butchered on site, while wild game either was processed or bones were deposited elsewhere (e.g. Brown and Emery 2008). For example, there is little difference between Postclassic and Colonial artiodactyl remains. Postclassic Structure T52 ($n = 263$, $\bar{x} = 3.6$ g) and Colonial Structure T29 ($n = 29$, $\bar{x} = 3.8$ g) deer and peccary fragments are of similar size and consist mainly of lower limb elements such as metapodials, tarsals, and phalanges. In contrast, Structure T29 cow remains include cranial elements, especially teeth, the most diagnostic element for cows and pigs.

Fragmentation of the large and very large animal bones was similar. Limb elements of very large mammals (5 to >12 mm cortical bone thickness) were compared to those of large mammals (2 to 4-mm-thick cortical bone), taking into account bone size and variability in thickness of bone elements in the classification of each fragment. Artiodactyl and large mammal bones in Colonial Structure T29 ($n = 405$, $\bar{x} = 1.62$ g) and Postclassic Structure T52 ($n = 538$, $\bar{x} = 1.23$ g) were similar to very large mammal bones in Structure T29, even though the fragments were larger due to the bone size and weight ($n = 122$, $\bar{x} = 4.93$ g).

However, Postclassic Structure T52 has significantly more burned bones (5.9%), ranging from browned to calcined, than Structure T29 (<1%) (Two-tailed Fisher's Exact Test $p < 0.0001$). Cut and chop marks differed for the very large mammal class as well. Structure T29 very large mammals (cows or pigs) are more likely to have cut or chop marks than large mammals (deer or peccaries) in the same structure (Structure T29 Two-tailed Fisher's Exact Test $p < 0.227$) and in Structure T52 (two-tailed Fisher's Exact Test $p < 0.0035$). Further analysis might show that the chop marks on very large mammal bone demonstrate the use of metal tools versus the stone tools traditionally used by the Mayas (e.g. Chase 2005).

Cattle often were used as communally-owned property that could be sold to pay for masses or other community needs, and bone fragments distributed across the site at San Bernabé, including in association with the mission church, support the idea that most residents used the animals. They also were raised to trade with Yucatán, moving north at the end of the rainy season, or to Tabasco in the form of salted meat (Caso Barrera 2002, 342; Schwartz 1990). Cattle worth 24–30 *reales* apiece would be useful in trade for local items as well, and coins at the mission show that the community participated in monetary exchange (Pugh et al. 2016a, 62). It is unlikely that milk or cheese production was important in a population not adapted to digesting lactose. Nor is there evidence that the San Bernabé Mayas used the cow or pig bones to make needles or other bone tools. Awls and worked antler associated with Colonial structures were made from the bones of large mammals, likely indigenous species.

The shift from hunting and collecting game to farming cattle would have been a large one. Field, forest, and fences were now needed for cattle, which along with pigs, damage plants and disrupt hunting of animals that were attracted to fields. Provisioning domesticated animals during the dry season also was a new task, and rearing young animals would require a new body of knowledge about diseases, appropriate fodder, and medical intervention that could only be acquired through ongoing contact with the Spaniards. These were only part of a suite of changes that presented additional challenges to Mayas living in the region, including disruption of communities as families slowly were resettled or fled to the forests, and death and illness as people were exposed to new diseases, including through livestock (Dobyns 1983; Thompson 1977).

Cattle were a key part of Spanish efforts to establish settlements (Bishko 1952; Farriss 1984, 321–322; Schwartz 1990, 41), as well as to provide food for soldiers in the Presidio across the lake. During the early 1700s, cattle were reported at the Presidio, and the royal *estancia* was located to the southeast of the lake. Structures with both fences and turnstiles are shown on a 1740s map of the region (Pugh, Sánchez, and Shiratori 2012, 5, Figure 3). It is likely that San Bernabé bovids were part of the effort to gain control over indigenous populations and incorporate them into the Colonial economy (see Schwartz 1990, 41–53). The next section turns to where these animals came from and what that may tell us about changes in food procurement and trade.

Strontium isotopes and cow, pig, and equid samples

The second section explores these changes in animal use by using strontium isotope assays to identify the origins of 14 of the introduced domesticated animals. European species were originally imported from

Spain and Africa, but more likely by the 18th century would have been brought to the Petén from other colonial centres in Yucatan and southern Guatemala.

Tooth samples

We processed tooth enamel of 14 animals found at three locations: San Bernabé and Tayasal, Zacpetén, and Ixlú (Figure 1). The isotope values come from duplicate lower molars for six cows, and teeth from pigs of different ages. The equid teeth come from Ixlú and are ‘caps,’ or deciduous teeth, from a young animal likely less than three years of age (Figure 10). Horses shed premolar deciduous teeth between 2½ and 4½ years of age. However, the age represented by the isotope sample is perinatal, as these teeth begin to erupt during the first 2 weeks of life, with the enamel developing *in utero* (Evans, Jack, and Jones 2006).

No bit marks are visible, but William Taylor (personal communication, March 2016) identified a rostral hook and uneven wear, which might have resulted in painful malocclusion of the teeth than can cause behavioural and eating problems. The teeth were found in Postclassic and Contact period lots (both in level 2) associated with Structure 2023.

Pig remains were identified at four sites: Ixlú, Zacpetén, Nixtun Ch’ich’, and Mission San Bernabé, Tayasal. All three *Sus* teeth sampled are from San Bernabé lots excavated in Structure (T29) and the ruins of the mission church (T31) (Pugh et al. 2016a). We sampled enamel that forms during the first 12 months in first



Figure 10. Ixlú equid teeth.

and third molars. One animal (Lot 90165) died just as the roots began to form in the third molar, at ~12 months. A second animal (Lot 70149) exhibited wear on the first and second molars (age class 8; age class 8–9 in Lemoine et al. 2014) that suggest it died after 52 months of age. Animal three (Lot 73596) died between the age of 30 and 52 months (age class ‘7’ in Lemoine et al. 2014; also see Bivin and Mc Clure 1976; Bull and Payne 1982; Grant 1982; Legge 2013; Lemoine et al. 2014; Oroian et al. 2010; Rolett and Chiu 1994; Simonds 1854).

A small number of cow bones were identified at Nixtun Ch’ich’ and Zacpetén, but most remains were found at the Mission San Bernabé, Tayasal. Samples come from residential structures T29 and T35 and include six lower right second molars and three deciduous second premolars. Enamel from the M₂ forms during the first 18 months, but most teeth were found with third molars that show an age at death of more than 3 years. Enamel of deciduous teeth begins forming during gestation, and these animals likely died between 2½ and 3 years of age (Jones and Sadler 2012a, 2012b; Simonds 1854).

Strontium isotope analysis

Strontium is incorporated into body tissues along with calcium and other elements, and researchers measure it

in tooth enamel, bone, and other body tissues to understand mobility at different stages of life. Enamel forms in utero, and bones remodel throughout life, providing a snapshot of residence from birth to burial. Variability in strontium is based on geologic differences in the ratio of two isotopes ($^{87}\text{Sr}/^{86}\text{Sr}$), where high values generally are present in igneous and metamorphic rock formations, and lower ones in marine limestones and volcanic bedrock. No measureable fractionation is present in biological samples from the same catchment: fodder for cattle, forage for whitetail deer, and meat from both animals that was consumed by humans will have similar values (Bentley 2006; Ericson 1985; Price et al. 2008, 2010, 2015).

Figure 11 shows a sample of published biogenic strontium isotope values that demonstrate measureable differences among populations living in the Maya region (Buikstra et al. 2004; Freiwald 2011a, 2011b; Freiwald et al. 2014; Hodell et al. 2004; Hoggarth et al. in review; Miller 2015; Mitchell 2006; Novotny 2015; Price et al. 2008, 2010, 2014; Somerville, Fauvelle, and Froehle 2013; Sosa et al. 2014; Spotts 2013; Sutinen 2014; Thornton 2011a; Trask, Wright, and Prufer 2012; Wright 2005a, 2005b, 2007, 2012; Wright et al. 2010; Wright and Bachand 2009; Wrobel, Helmke, and Freiwald 2014, 2017). Most studies focus on human mobility, but a number of isotope studies focus on trade and exchange of animals (Sharpe et al. 2016; Thornton

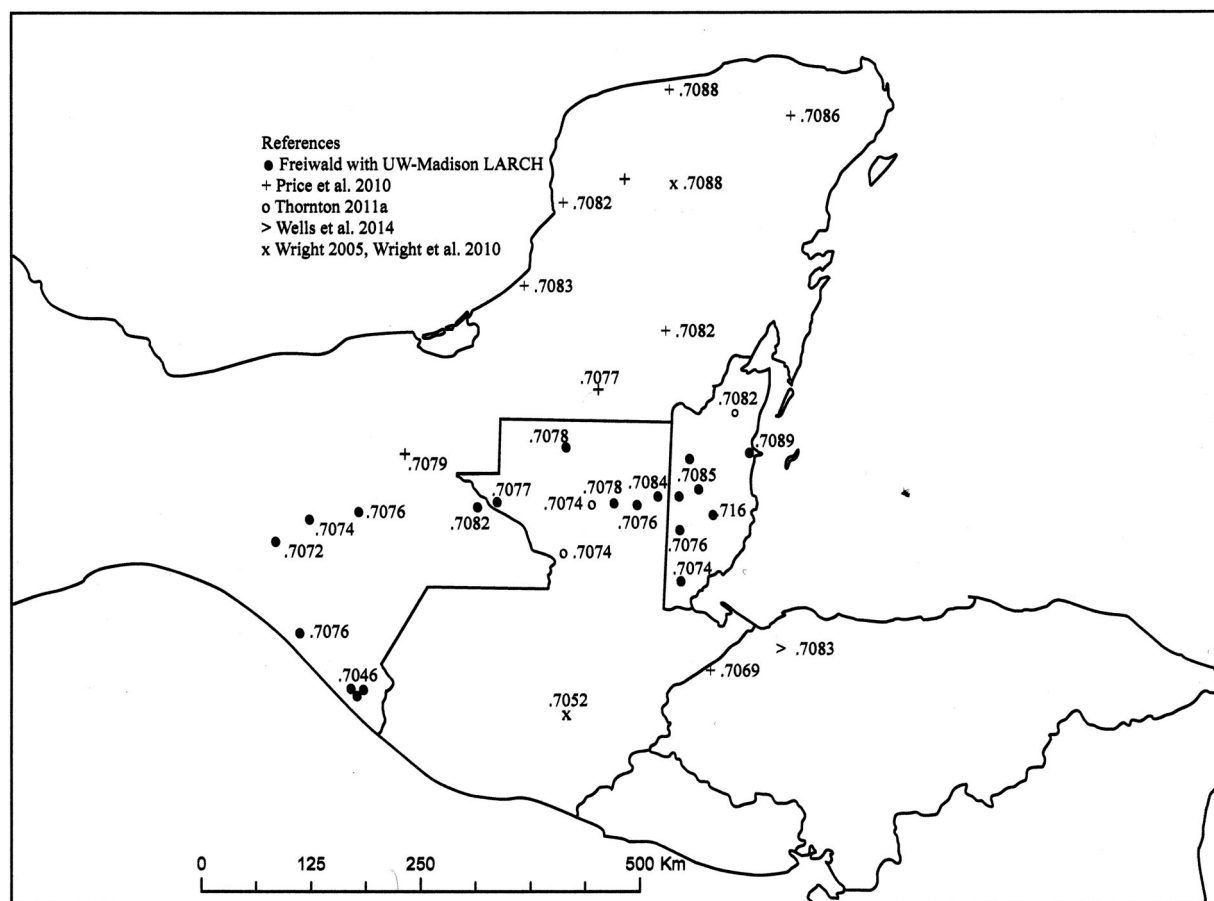


Figure 11. Strontium isotope values in biological faunal samples (including human) in and around the Maya region.

2011a, 2011b; Thornton and Emery 2016; Yaeger and Freiwald 2009; also see Laffoon et al. 2014).

Each tooth was measured (Von den Driesch 1976) and photographed using a DinoLite digital microscope AM4013T, and then was mechanically cleaned using a Microlab variable speed dental drill equipped with a diamond bur to remove surface contamination (Freiwald 2011a). Five milligrams of clean tooth enamel were processed at the UNC at Chapel Hill Geochronology and Geochemistry Laboratory using a VG Sector 54 thermal ionisation mass spectrometer (TIMS). Strontium was isolated using Sr-Spec ion exchange resin manufactured by Eichrom Industries in micro columns (~35 µL resin bed volume). Samples were loaded in single rhenium filaments in phosphoric acid and tantalum chloride solution and analysed in

triple dynamic multicollector mode with $88\text{Sr} = 0.1194$, which assumes exponential fractionation behaviour. Analytic uncertainty is estimated using the long term reproducibility of the NBS-987 strontium standard ($^{87}\text{Sr}/^{86}\text{Sr} = 0.710268 \pm 0.000020$, 2σ ; $n = 134$). Standard error for analyses generally exceeds 0.000011 , 2σ .

Strontium isotope results

Eleven values range from 0.70709 to 0.70795 $^{87}\text{Sr}/^{86}\text{Sr}$ (Table 2). Three additional samples did not produce successful results. All but one of the values are consistent with $^{87}\text{Sr}/^{86}\text{Sr}$ ratios found in northern Guatemala at sites such as Zacpetén, Muralla de Leon, Topoxte (Table 2), and other sites in the region (Table 3). The

Table 2. Strontium isotope values and sample information.

Species	$^{87}\text{Sr}/^{86}\text{Sr}$	Site and provenance	Tooth	Sample number
Pig (<i>Sus scrofa</i>)	0.707694	San Bernabé Structure T29 lot 70149, level 2	RM ₁	UM71
Pig (<i>Sus scrofa</i>)	0.707583	San Bernabé Structure T31 lot 73596, level 2	RM ³	UM72
Cow (<i>Bos taurus</i>)	Pending	Zacpetén Structure 719 lot 18067	RM ₂	UM73
Pig (<i>Sus scrofa</i>)	0.707607	San Bernabé Structure T29 lot 90165, level 2	RM ³	UM74
Equid (<i>Equus</i> sp.)	0.707565	Ixlú Structure 2023 lot 20363	dp ²	UM75
Equid (<i>Equus</i> sp.)	0.707553	Ixlú Structure 2023 lot 20185	dp ³⁷	UM76
Cow (<i>Bos taurus</i>)	0.707444	San Bernabé Structure T35 lot 82592 level 2	ldp ₂	UM80
Cow (<i>Bos taurus</i>)	Pending	San Bernabé Structure T35 lot 83757 level 1a	ldp ₂	UM81
Cow (<i>Bos taurus</i>)	0.707882	San Bernabé Structure T35 lot 83765 level 1B	RM ₂	UM82
Cow (<i>Bos taurus</i>)	0.707626	San Bernabé Structure T29 lot 90592 level 1	RM ₂	UM83
Cow (<i>Bos taurus</i>)	0.707444	San Bernabé Structure T35 lot 82591 level 2	RM ₂	UM84
Cow (<i>Bos taurus</i>)	0.707093	San Bernabé Structure T29 lot 90629 level 1	RM ₂	UM85
Cow (<i>Bos taurus</i>)	0.707949	San Bernabé Structure T29 lot 70261 level 2	RM ₂	UM87
Cow (<i>Bos taurus</i>)	Pending	San Bernabé Structure T35 lot 82572 level 1	ldp ₂	UM88
Terrestrial snail (<i>Orthalicus princeps</i>)	0.707618	Zacpetén, Lake Salpetén	Shell	F10014
Terrestrial snail (<i>Euglandina cylindracea</i>)	0.707740	Yaxha, Lake Yaxha	Shell	F10015
Terrestrial snail (<i>Neocyclotus dysoni</i>)	0.707837	Topoxté, Lake Yaxha	Shell	F10016
Modern snail	0.707590	Muralla de Leon, Lake Macanché	Shell	F10045

RM₁: lower right first molar; RM₂: lower right second molar; RM³: upper right third molar; dp²: deciduous upper second premolar; dp³⁷: deciduous upper third premolar?; ldp₂: lower left deciduous second premolar.

F numbers denote samples prepared at the UW-Madison T. Douglas Price Laboratory for Archaeological Chemistry (LARCH). UM numbers were prepared at the University of Mississippi. Bold values are statistical outliers (>2 SD from the mean).

single low value ($0.707093^{87}\text{Sr}/^{86}\text{Sr}$) is a statistical outlier from the dataset; this animal was not reared in northern Guatemala (Figure 12). The mean of the remaining 10 animals ($0.70763 \pm 0.00017^{87}\text{Sr}/^{86}\text{Sr}$) is similar to that of the 21 individuals sampled from the church cemetery ($0.707673^{87}\text{Sr}/^{86}\text{Sr}$) and to average values from other studies in the central Petén (Table 3).

The low value of the San Bernabé cow ($0.707093^{87}\text{Sr}/^{86}\text{Sr}$) is similar to values found in the metamorphic geology in southern Guatemala (Hodell et al. 2004). This is the closest known area with values in this range, and Thornton (2011a, 211) interpreted animals with similar values at Dos Pilas and Aguateca as markers of long distance exchange. Isotope values in the volcanic soils near Santiago de Guatemala are even lower ($0.704\text{--}0.705^{87}\text{Sr}/^{86}\text{Sr}$ in Hodell et al. 2004; Wright et al. 2010), but are too low to be the place of birth for this animal.

Nor do these data show importation of Spanish, African, or Caribbean cattle. The earliest breed of cows reported in the New World, likely *criollos* or *Corrientes* (Rouse 1977), sailed with Columbus from southern Spain. Most published strontium isotope values in Spain are higher than those found in the Maya region, with the exception of Maya Mountain values (Table 3; Freiwald 2011a). Values similar to those in the Petén ($0.70757^{87}\text{Sr}/^{86}\text{Sr}$) are reported in La Cova limestones in northeastern Spain (in Boix

et al. 2011); however, values of Spanish fauna and burials reported by Price and colleagues (2006) are consistently higher.

Cattle also were brought from Africa and the Canary Islands as part of the slave trade (Ginja et al. 2010; Speller et al. 2013), and may have come to the mainland from early populations in the Caribbean. Isotope values in Africa are variable; for example, low values in volcanic geology are reported ($0.7025\text{--}0.7032^{87}\text{Sr}/^{86}\text{Sr}$ in Grant, Rex, and Freeth 1972) as are mid-range ones ($0.70889^{87}\text{Sr}/^{86}\text{Sr}$ in Viers et al. 2000, 217). However, values exceeding $0.712^{87}\text{Sr}/^{86}\text{Sr}$ more commonly serve as markers of Africans in Campeche, West Barbados, and the African burial ground in New York (in Price, Tiesler, and Burton 2006), bolstered by other biological and archaeological evidence.

Average $^{87}\text{Sr}/^{86}\text{Sr}$ values in the Caribbean also should exceed those in the central lowlands of Guatemala, although there is overlap in the range of values. Fauna sampled by Freiwald in the Dominican Republic average $0.70836^{87}\text{Sr}/^{86}\text{Sr}$ (Table 3), similar to values reported in Cuba (Laffoon et al. 2012; Laffoon and Hoogland 2011; Price et al. in preparation). The royal estancia in northern Guatemala is one likely source for all but one cow, which has a value consistent with those found near Colonial centres to the south, a pattern that differed from precolonial trade and exchange routes to the north and east.

Table 3. Strontium isotope values for northern Guatemala, with a sample of values in Spain, west Africa, and the Caribbeans.

Location	$^{87}\text{Sr}/^{86}\text{Sr}$ range	Reference
Petén, Guatemala	0.70744–0.70753	Hodell et al. (2004, 596–597, Appendix A)
18 water, 2 rock, 1 plant sample	0.707483 ± 0.00005	
Petén, Guatemala	0.70779–0.70794	Wright (2005a, 561, Table 2)
7 mammal bone and shell fragments	0.707857 ± 0.00006	
Petén, Guatemala	0.7072–0.7079	Thornton (2011a, 232–233, Table 6.4)
23 mammal bone and shell fragments	0.707552 ± 0.00189 (outliers removed: 0.7069, 0.7069, 0.7081)	
Southwest Spain	0.70845–0.70882	Valladares et al. (2006)
SW of Salamanca geologic samples		
Southeast Spain	0.7136–0.7158	Powell and Bell (1970)
Jumilla geologic samples		
Southeast Spain	0.70791–0.71541	DePaolo et al. (1983)
Caravaca geologic samples	($\bar{x} = 0.70996$)	
Central Spain	0.71544–0.71944	Galindo et al. (1994)
Sierra de Guadarrama geologic samples		
Central Spain	>0.7091	Chiquet et al. (1999)
Toledo Mountains, Galvez geologic samples		
Southwest Iberian Peninsula	>0.727	Priem et al. (1978)
deep mine samples geologic samples		
Northeast Spain	0.70795–0.70944	Soler et al. (2002)
Lobregat River water	0.70844–0.71352	
Lobregat River sediment		
Northeast Spain (Catalonia)	0.70940–0.70167	Canals and Cardellach (1993)
coastal mountains geologic samples		
Northeast Spain	0.70734–0.710	Boix et al. (2011)
Pyrenees Mountains geologic samples		
Andalucía, Spain fauna	$\bar{x} = 0.7091$	Price, Tiesler, and Burton (2006, 411)
Cádiz, Spain San Juan de Dios ossuary human remains	0.70871–0.71592	Price, Tiesler, and Burton (2006, 409, Table 3)
Seville, Spain fauna	0.7085–0.7138	Price, Tiesler, and Burton (2006, 411)
Northeast Nigeria	0.7025–0.7129	Grant, Rex, and Freeth (1972)
Nyong Basin, Cameroon	0.70889–0.71931	Viers et al. (2000, 217)
El Chorro de Maíta, Cuba	0.708–0.709	Laffoon and Hoogland (2011)
Burials from archaeological site		
Dominican Republic	$\bar{x} = 0.708179 \pm 0.0008$	Price et al. (in preparation)
10 plants and non-human fauna		

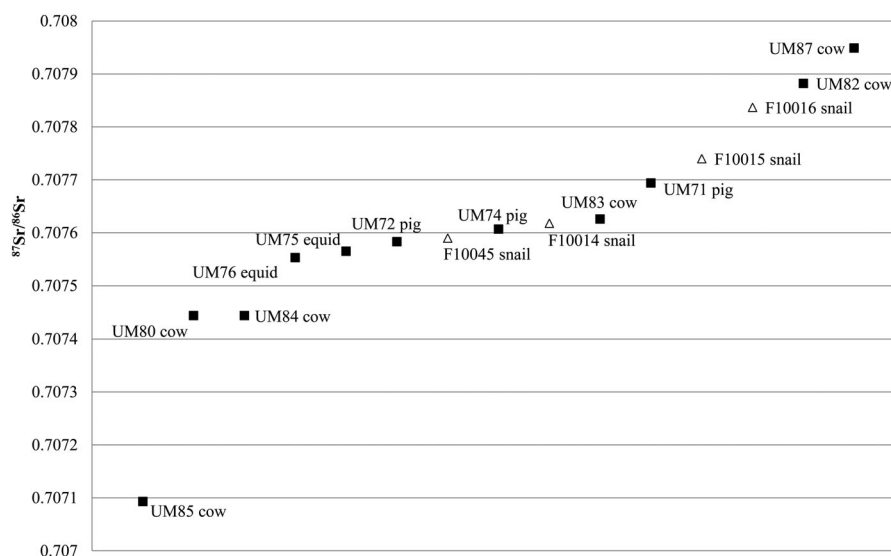


Figure 12. Strontium isotope values in fauna from San Bernabé.

How did the animals get there?

The non-local animal was probably brought from the south on the Camino Real, possibly from missions near Dolores, the Rio Dulce, or ranches in the Mopan area near Santa Ana and San Francisco (Schwartz 1990, 53). Although Ursúa brought more than 1200 ‘head of cattle and horses’ to establish ranches in 1699 (Villagutierre Soto-Mayor 1983, 363) and the Presidio had an initial supply of 15 horses and 51 cattle (Caso Barrera 2002, 311), historic accounts also show repeated requests for provisions by the Presidio from Santiago de Guatemala. However, roads were difficult to maintain and provisions along the way were scarce, which may explain the lack of imported animals (Caso Barrera 2002).

No animals in this sample had origins in northern or eastern Spanish centres such as Merida or Tipu, regions with isotope values exceeding 0.7082 $^{87}\text{Sr}/^{86}\text{Sr}$ (Freiwald 2011a, 2011b; Price et al. 2008). Instead, the Mayas acquired domesticated species from sources in the Petén during the first decades of Colonial control, and perhaps even earlier, as evidenced by the Contact period cow mandible encountered at Zacpetén.

Conclusions

The Mission San Bernabé faunal assemblage is the first to demonstrate the use of adopted non-native animal species, including cow, pig, and equid, in the Petén Lakes region. Cattle were a critical aspect of the Spanish Colonial system, necessary to sustain settlements and forming the basis of the colonial economic system (Bishko 1952; Farriss 1984; Jones 1998; Schwartz 1990). Cattle may have been payment for work, but some communities were obliged to raise the domesticated animals to meet tribute requirements, or even

were pressured or forced to purchase these animal species (Patch 1993). It is notable that sheep, goats, and chickens, animal species that arrived as early as Columbus did (Deagan and Cruxent 2002), were not identified.

Some Postclassic trends in animal use continued, including the heavy reliance upon aquatic resources. However, changes in species used during the Colonial period suggest a lack of access to former catchments, or perhaps a change in the microenvironments of the catchments themselves. Isotopic data show that although some domesticated species initially may have been imported from southern Guatemala, San Bernabé residents raised or acquired Petén-born animals and the taphonomy and distribution of the bones show that residents butchered the cows and pigs to consume or trade the meat.

However, the Maya continued to rely on wild game species into the Historic period, and still do today (Brown 2004; Freiwald 2007; Palka 2005a, 2005b; Thornton and Ng Cackler 2014). In the end, the San Bernabé mission, like many settlements the Spanish created in the region, was short-lived. By AD 1766, only 36 residents were reported in the census and the mission does not appear in 19th-century censuses (Pugh et al. 2016a, 52).

The use of new animal species documents a particularly important change. Rejection of European material culture is often interpreted as resistance to Spanish rule, and the Itza Maya actively maintained buffer zones between their territory and areas controlled by the Spanish (Jones 1998). Moreover, European goods found at Contact period sites usually were manipulated and used in Maya contexts (Oland and Masson 2005; Pugh 2009a, 378). The San Bernabé faunal sample shows a different perception of the Spanish, one that to some extent accepted Spanish material culture and the new lifestyle it required.

However, these results generate a new set of questions. DNA analyses might discern admixture of African cattle into Petén stock, and isotopic analyses of Postclassic fauna would allow for a more in-depth understanding of catchment use and animal exchange, and how it changed under colonialism, including diet of both wild and domestic game. We also need to address questions of plant use and look specifically for landscape changes such as fences, pens, or stone corrals (e.g. Alexander 2003). Butchering practices also need more attention in the Maya area, as does differential use of animals by different ethnic groups during the Postclassic and subsequent periods. The changes at San Bernabé will be better understood as research continues.

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