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Zooarchaeological and Isotopic Perspectives on Ancient Maya Economy and Exchange



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Abstract

In 2006, FAMSI funds supported the first stages of zooarchaeological and strontium isotope analysis aimed at reconstructing how animal resources were incorporated in ancient Maya economic and exchange systems. Although research is on-going, the zooarchaeological results from the primary research sites of Trinidad de Nosotros and Cancuén demonstrate inter-site differences in animal use both within and between regions of the Maya lowlands. Moreover, initial comparisons of the faunal assemblages from the nearby sites of Trinidad de Nosotros and Motul de San José suggest intra-polity exchange of subsistence resources, possibly due to site specialization in subsistence activities, or elite demand for particular resources. The preliminary results of strontium isotope analysis indicate limited evidence for long-distance trade and acquisition of faunal resources. In addition to providing a novel means of identifying non-local resource acquisition, the isotopic results establish baseline data that can be used in future studies examining trade and human migration. Continuing research is exploring the methodological issues associated with using strontium isotopes to reconstruct how animal resources were moving across the landscape.

Resumen

En 2006 fondos de FAMSI sostuvieron las primeras etapas de análisis zooarqueológico y análisis de isótopo de estroncio con el fin de reconstruir como los recursos de animales se incorporaron a las redes económicas y de intercambio de los maya antiguos. Aunque todavía se están llevando a cabo investigaciones, los resultados zooarqueológicos de los sitios de investigaciones preliminares de Trinidad de Nosotros y Cancuén demuestran diferencias de inter-sitio en la utilización de animales tanto dentro de las regiones de las tierras bajas de los maya como entre ellas. Además, comparaciones iniciales de la colección fauna de los sitios cercanos Trinidad de Nosotros y Motul de San José sugieren intercambios entre estas unidades políticas de recursos de subsistencia, posiblemente debido a la especialización de cada sitio en las actividades de subsistencia, o por las exigencias del élite de recursos particulares. Los resultados preliminares de análisis de isótopo de estroncio indican pruebas de intercambio de larga distancia y la adquisición de recursos de animales. Además de proveer una manera novedosa de identificar la adquisición de recursos no locales, los resultados isotópicos establecen una línea base que se puede utilizar en investigaciones futuras para estudiar la migración humana y de intercambio. Las investigaciones que continúan examinan la metodología en cuanto a los asuntos vinculados con el uso de isótopos de estroncio para reconstruir la manera de mover los recursos de animales por el paisaje.

Introduction

In 2006, FAMSI funds supported the first stages of zooarchaeological and isotopic analysis aimed at exploring how faunal resources were integrated in the ancient Maya economy. Faunal remains from Trinidad de Nosotros and Cancuén, two primarily Late to Terminal Classic period sites (ca. 600-950 C.E.) located in Petén, Guatemala, were identified during the course of this study ([Figure 1](#)). These sites were chosen because they are both currently interpreted as prehistoric trading centers based on the presence of relatively high quantities of exotic ceramic and lithic artifacts, and the sites' strategic geographic locations between resource zones and along known trade routes (Demarest 1999, 2004; Kovacevich 2007; Moriarty in press; Moriarty, et al. 2004). Comparative zooarchaeological data is also available for the sites' known trading partners, which allows for regional and intra-polity analysis of ancient Maya animal use. The isotopic analysis component of the project incorporated faunal remains from the primary study sites in addition to samples from several other Maya archaeological sites located across the Maya lowlands of Belize, México and Guatemala ([Figure 1](#)). The strontium ($^{87}\text{Sr}/^{86}\text{Sr}$) isotope analysis is not yet complete, but the data will eventually be used to identify where faunal resources were being acquired, and how far they were moved across the landscape as part of long-distances exchange networks.

The results of this research are significant because animals and animal products are one important category of natural resources that has not yet been fully explored in terms of economic research. Despite the importance of faunal resources as both subsistence and prestige goods in ancient Maya society, researchers still disagree about the scale of faunal resource exchange, and whether trade functioned primarily as a means of establishing and maintaining elite power through the exchange of high status items, or as a more practical means of redistributing subsistence resources (Hirth 1992; McAnany 1992; Sluyter 1993). Addressing this issue requires us to move beyond basic single site descriptions, and start assessing how animal use patterns varied between sites at regional and inter-regional scales. Consideration of Maya animal use patterns across spatial boundaries can move us closer to understanding how faunal resources were integrated into the Maya economy through the reconstruction of production, distribution and exchange networks.

Towards this end, the current report presents preliminary zooarchaeological data from Cancuén and Trinidad de Nosotros (hereafter referred to as Trinidad). The sites are compared to address inter-regional variation in animal use. A more in-depth look at intra-polity animal use patterns is also presented through a comparison of Trinidad with the nearby major political center of Motul de San José. The strontium isotopes results, and plans for continuing research are presented at the end of the report. Research is currently on-going so all results presented here should be considered preliminary.



Figure 1. Location of primary study sites (indicated with stars) and additional sites included in the strontium isotope sample. Map adapted from Emery (2004).

Background: Animal Resources in Maya Economy and Exchange

Recent discussions of ancient Maya economy emphasize the existence of multiple systems of resource production and exchange (Graham 1987; McAnany 1993; Rice 1987). Within these discussions, researchers commonly distinguish between utilitarian and non-utilitarian, or prestige and subsistence economies (Brumfiel and Earle 1987). These distinctions are related to differences in how commodities are exchanged, assigned value, and distributed across social classes. In ancient Maya society, animal resources were integrated into *both* prestige and subsistence economies due to their utility as staple resources and their more symbolic use in Maya ritual and status definition.

The use of animal resources as prestige commodities is well-documented across Mesoamerica (Kunen, et al. 2002; Masson 1999; Pohl 1983). Faunal remains such as stingray tail spines, spondylus shells, jaguar canines, and modified deer and turkey bones are often recovered from elite ritual and funerary contexts throughout the Maya area. Not surprisingly, most evidence for long-distance trade in faunal resources also comes from high status and ritual deposits (McKillop 2004). Within the Maya area, long-distance trade in animal commodities has been identified between the coast and the interior, and between the highlands and lowlands (Beaubien 2004; Lujan 1994; Moholy-Nagy 2004). However, prestige items may also have been obtained locally or through intra-regional exchange. Exotic resources likely accrued value or status based on the labor input required to obtain them, but certain prestige goods were also in demand for their symbolic value regardless of whether they were local or exotic commodities (Graham 2002). For example, spondylus shells were commonly used to make jewelry and whole shells are frequently found in elite tombs. These marine shellfish represent long-distance trade items at inland sites such as Tikal and El Mirador, and local resources at sites along the Caribbean and Pacific coasts. The distinction between prestige goods as exotic or local commodities is significant to our understanding of regional variability in Maya animal use and exchange. If elite animal use is determined primarily by cultural norms, we would expect to see little variation in contemporary elite faunal assemblages across the Maya area and extensive trade in animal products. Conversely, if prestige commodities are defined more at the local or regional level, elite animal use should vary greatly across regional and ecological boundaries, and trade in prestige commodities should be less extensive.

Another key question that remains to be answered is the degree to which utilitarian or subsistence resources were incorporated into regional and long-distance exchange networks. Many economic models assume that subsistence plant and animal resources were acquired locally (Hirth 1992; McAnany 1993; Sanders 1976), but some researchers propose long-distance transport of staple resources such as marine fish (Lange 1971), maize (Sluyter 1993) and salt (McKillop 2002). Recent zooarchaeological evidence from the Maya lowlands has also identified regional exchange in deer, fish, and turtle meat for basic consumption (Carr 1996; Emery 1999; Hamblin 1985; Pohl 1990; Wing and Scudder 1991). The motivation behind regional and long-distance exchange in subsistence resources may be elite demand for favored or high status meats (Pohl and Feldman 1982; Shaw 1991), local scarcity of wildlife (McAnany 1992), or site specialization in subsistence activities (Carr 1986). The difficulty of identifying dietary versus non-dietary animal use may confound this issue, but more research is needed to determine whether Maya dietary patterns truly conform to local ecological conditions, or whether greater quantities of subsistence resources were being exchanged than previously thought. If Maya dietary patterns were shaped primarily by local resource availability, we would expect to see great dietary diversity between sites and little trade in subsistence resources. If, on the other hand, Maya meat consumption was determined by pan-Maya dietary norms, we would expect greater trade in subsistence resources and more dietary homogeneity between sites.

Primary Site Descriptions

Trinidad is located approximately 2.6 km south of Motul de San José and is situated directly on the shores of Lago Petén Itzá ([Figure 2](#) and [Figure 3](#)). The site was excavated by Matt Moriarty (Ph.D. candidate, Tulane University) between 2003 and 2005 under the auspices of the larger Motul de San José project (directed by Dr. Antonia Foias and Dr. Kitty Emery). Based on the site's location, Moriarty has interpreted Trinidad as a Maya port, which likely participated in coastal-inland trade moving east to west across the lake, and further into the interior of the Petén. Dock facilities, as well as quantities of exotic goods including obsidian, marine shell, and non-local chert and ceramics, have been uncovered at Trinidad, thus supporting the site's interpretation as a trade port (Moriarty in press; Moriarty, et al. 2004).

The details of the political and economic ties within the Motul polity are still being explored. One area of particular interest is how Trinidad's possible role as a trade center influenced the site's overall status and access to exotic resources. Another important question is whether Trinidad and Motul de San José's other secondary centers served as specialized resource production or acquisition sites for the larger polity. For example, the residents of Trinidad had much greater access to aquatic resources such as fish and large turtles. It is therefore possible that Trinidad de Nosotros specialized in the extraction or modification of local aquatic resources for regional distribution.



Figure 2. View of Lago Petén Itza from the site of Trinidad de Nosotros.



Figure 3. Harbor area at Trinidad de Nosotros.

The Late/Terminal Classic period site of Cancuén is located near the Petexbatún region of the southern Petén. Based on its location, Cancuén is thought to have played a major role in highland-lowland trade and interaction (Demarest 1999a; Demarest and Barrientos 2003; Kovacevich, et al. 2000); (Demarest, personal communication). The site is only 8 kilometers from the Maya highlands along the Rio Pasión, a waterway that served as a major trade route connecting the volcanic highlands and lowland rainforests (Hammond 1972). Excavation of the site under the direction of Arthur Demarest and Tomás Barrientos has been ongoing since 1997, and preliminary ceramic and lithic analyses demonstrate long-distance trade interactions between Cancuén and sites in both the Maya highlands and northern lowlands (Demarest 1999). In addition to long-distance trade, Cancuén's economic prosperity was based on craft specialization in the production of chert and obsidian artifacts, possibly for intra-regional exchange (Demarest 2000; Kovacevich, et al. 2000). The extent to which faunal resources were integrated into the site's highland-lowland trade system will be investigated through the on-going research. Although not presented in this report, comparisons will also be drawn between the Cancuén faunal assemblage and those of its likely trading partners in the northern Petexbatún region of Guatemala.



Figure 4. Monuments at the site of Cancuén.

Methods: Zooarchaeological Sample Recovery and Analysis

Between January and August 2006, I conducted initial identification of the Trinidad and Cancuén faunal assemblages on-site in Guatemala. Specimens requiring additional analysis were exported to the Florida Museum of Natural History (FLMNH) Environmental Archaeology Laboratory for identification using the FLMNH modern comparative collections ([Figure 5](#)) (see <http://www.flmnh.ufl.edu/databases> for collection holdings). Dr. David Steadman and Dr. John Slapcinsky assisted with specialized identifications of avian and mollusk remains. Although a large portion of the zooarchaeological assemblages has been identified (>90%), the results presented here should be considered preliminary until all identifications have been confirmed.



Figure 5. Project PI working at the Florida Museum of Natural History with modern comparative specimens.

Not including intrusive species such as terrestrial snails and small rodents, I identified a total of 3120 zooarchaeological specimens from the site of Cancuén, and a total of 10,458 specimens from Trinidad. Only 3588 of the Trinidad remains were recovered during general excavation using 4mm mesh screen. The additional 6870 fragments were recovered through selective fine-screening of 110 bulk soil samples (5-10 liters each) collected by the site's archaeologists during excavation. Between 2004 and 2006, I water-screened soil samples through a series of nested 1, 2 and 4mm mesh screens, and then hand sorted the remaining matrix to recover zooarchaeological remains ([Figure 6](#) and [Figure 7](#)). Similar screening methods were employed at the site of Motul de San José, but have not yet been completed for Cancuén. Since recovery methods greatly affect zooarchaeological sample comparability (James 1997; Quitmyer 2004; Shaffer and Sanchez 1994), the fine screen remains have been excluded from this discussion except when specifically noted. Temporal control over the samples presented in this report is maintained by only including faunal remains from Late or Terminal Classic deposits.



Figure 6. Water-screening soil samples on the shores of Lago Petén Itza.

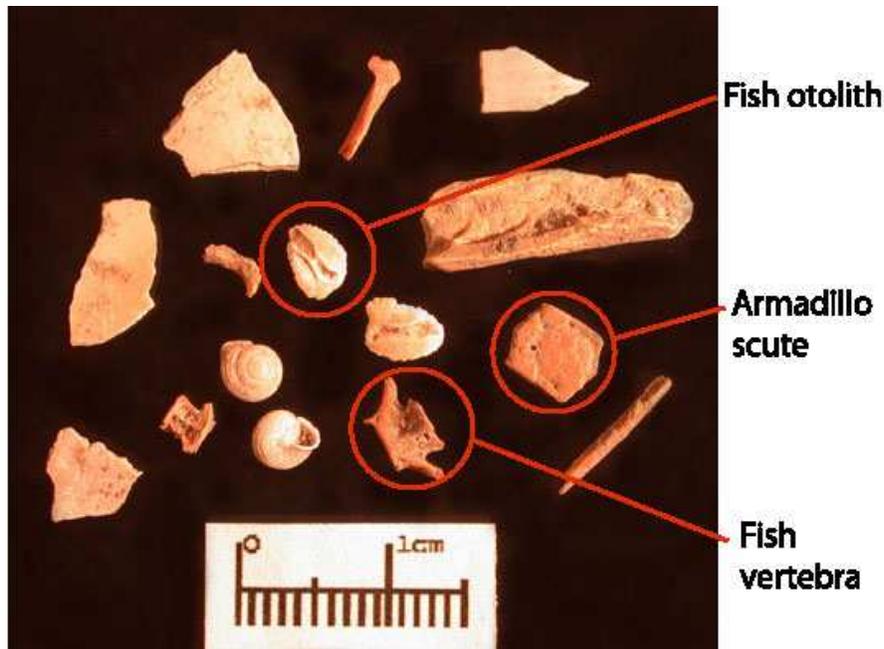


Figure 7. Examples of faunal remains recovered with 1mm mesh screen.

All zooarchaeological tallies are presented as the number of identified specimens (NISP). Although NISP tallies have the potential to overestimate the contribution of species with large numbers of identifiable skeletal elements such as turtles and armadillos, other derived quantification measures, such as the minimum number of individuals (MNI), tend to be adversely affected by small sample sizes (Grayson 1981; Grayson 1984). Since each assemblage contains less than 3600 fragments, NISP tallies avoid overestimating the contribution of rare species that are only represented by a single element.

Trinidad de Nosotros: Zooarchaeological Results and Intra-polity Comparisons

Similar to other inland Late/Terminal Classic Maya faunal assemblages, the most commonly identified species at Trinidad include turtles, large mammals such as white-tailed deer (*Odocoileus virginianus*), brocket deer (*Mazama* sp.) and peccaries (Tayassuidae), and freshwater mollusks including apple snails (*Pomacea flagellata*), jute (*Pachychilus* sp.), and large freshwater mussels (Unionidae). Deer are by far the most common mammals, but dogs (*Canis familiaris*), peccaries, armadillos (*Dasybus novemcinctus*), agoutis (*Dasyprocta punctata*), pacas (*Agouti paca*) and rabbits (*Sylvilagus* sp.) were also frequently encountered in the assemblage ([Table 1](#)).

A similar suite of species was identified by Dr. Kitty Emery¹ (Curator - Environmental Archaeology, Florida Museum of Natural History) in the faunal assemblage from the Motul polity capital, Motul de San José (hereafter referred to as Motul). Despite these general similarities, the nearby sites of Trinidad and Motul differ in their reliance on various categories of resources. Motul residents used mammals to a much greater extent, while the inhabitants of Trinidad employed a broader pattern of animal use, exploiting both mammals and freshwater molluscs in relatively equal quantities ([Figure 8](#)).

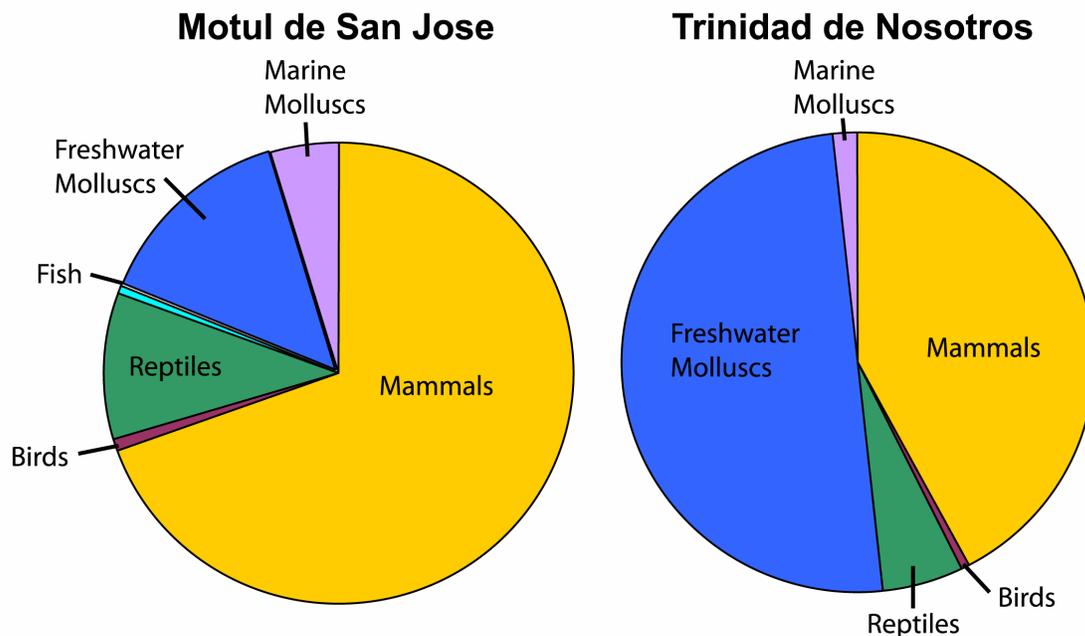


Figure 8. Taxonomic composition of the Trinidad and Motul faunal assemblages by class.

¹ The Motul de San José faunal assemblage was identified by Dr. Kitty Emery with assistance from various undergraduate and graduate students from the University of Florida, Gainesville.

Table 1. Taxa identified in the Trinidad de Nosotros and Cancuén zooarchaeological assemblages

Scientific Name	Common Name	TRINIDAD		CANCUEN	
		NISP	NISP%	NISP	NISP%
Vertebrata	Vertebrates (unidentified)	410	13.7	65	2.1
Mammalia	mammal	33	1.1	155	5.1
Mammalia (large)	mammal (e.g. deer)	514	17.1	715	23.5
Mammalia (medium/large)	mammal (e.g. deer, dog)	110	3.7	61	2.0
Mammalia (medium)	mammal (e.g. dog)	59	2.0	50	1.6
Mammalia (small/medium)	mammal (e.g. dog, rabbit)	63	2.1	8	0.3
Didelphidae	opossum	1	0.0	2	0.1
<i>Didelphis</i> sp.	opossum	-	-	4	0.1
<i>Dasyus novemcinctus</i>	nine-lined armadillo	147	4.9	2	0.1
<i>Sylvilagus</i> sp.	rabbit	5	0.2	2	0.1
<i>Agouti paca</i>	paca	2	0.1	9	0.3
<i>Dasyprocta punctata</i>	agouti	3	0.1	4	0.1
Carnivora (cf. <i>Eira barbara</i>)	carnivore (cf. tayra)	1	0.0	1	0.0
<i>Canis familiaris</i>	domestic dog	10	0.3	45	1.5
<i>Urocyon cinereoargenteus</i>	grey fox	1	0.0	3	0.1
<i>Bassariscus sumichrasti</i>	cacomistle	2	0.1	-	-
cf. <i>Poto flavus</i>	cf. kinkajou	-	-	1	0.0
Felidae (large)	cat (e.g. puma, jaguar)	-	-	2	0.1
cf. <i>Panthera onca</i>	cf. jaguar	-	-	2	0.1
<i>Puma concolor</i>	puma	2	0.1	-	-
<i>Leopardus pardalis</i>	ocelot	-	-	2	0.1
Artiodactyla	artiodactyl (deer/peccary)	2	0.1	4	0.1
Tayassuidae	peccary	3	0.1	55	1.8
<i>Tayassu tajacu</i>	collared peccary	-	-	7	0.2
Cervidae	cervid (deer)	8	0.3	9	0.3
<i>Mazama</i> sp.	brocket deer	16	0.5	15	0.5
<i>Odocoileus virginianus</i>	white-tailed deer	78	2.6	304	10.0
<i>Tapirus bairdii</i>	tapir	-	-	6	0.2
Aves (large)	bird (e.g. turkey)	11	0.4	-	-
Aves (medium/large)	bird (e.g. turkey, cormorant)	4	0.1	4	0.1
<i>Meleagris</i> sp.	turkey	3	0.1	3	0.1
<i>Crocodylus</i> sp.	crocodile	-	-	42	1.4
Testudines	turtle	40	1.3	174	5.7
Testudines (medium/large)	turtle (medium/large)	45	1.5	-	-
Testudines (small/medium)	turtle (small/medium)	4	0.1	-	-
<i>Kinosternon</i> sp.	musk turtle	10	0.3	7	0.2
<i>Kinosternon</i> cf. <i>acutum</i>	musk turtle	1	0.0	2	0.1
<i>Kinosternon leucostomum</i>	white-lipped musk turtle	1	0.0	1	0.0
<i>Staurotypus triporcatus</i>	giant musk turtle	9	0.3	1	0.0
<i>Dermatemys mawii</i>	giant river turtle	9	0.3	122	4.0
Emydidae	slider turtle	2	0.1	-	-
<i>Rhinoclemmys areolata</i>	furrowed wood turtle	1	0.0	1	0.0
<i>Trachemys scripta</i>	slider turtle	10	0.3	8	0.3
Iguanidae	iguana	1	0.0	1	0.0
Serpentes	snake	1	0.0	3	0.1
Anura	frog/toad	-	-	1	0.0
Osteichthyes	fish	1	0.0	-	0.0
<i>Atracosteus tropicus</i>	tropical gar	-	-	1	0.0
Decapoda	crab	1	0.0	-	-
Mollusca	mollusc	-	-	12	0.4
Gastropoda	gastropoda	2	0.1	10	0.3

Scientific Name	Common Name	TRINIDAD		CANCUN	
		NISP	NISP%	NISP	NISP%
<i>Pachychilus</i> sp.	jute	3	0.1	8	0.3
<i>Pachychilus glaphyrus</i>	jute	9	0.3	-	-
<i>Pachychilus indiorum</i>	jute	215	7.2	2	0.1
<i>Pachychilus pleuristriatus</i>	jute	-	-	22	0.7
<i>Pomacea flagellata</i>	apple snail	942	31.4	11	0.4
Bivalvia	bivalve	5	0.2	79	2.6
Unionidae	freshwater mussel	142	4.7	231	7.6
<i>Lampsilis</i> sp.	freshwater mussel	8	0.3	3	0.1
<i>Nephronaias</i> sp.	freshwater mussel	-	-	3	0.1
<i>Nephronaias</i> cf. <i>yzabalensis</i>	freshwater mussel	-	-	1	0.0
<i>Psoroniaias</i> sp.	freshwater mussel	2	0.1	145	4.8
<i>Psoroniaias semigranosus</i>	freshwater mussel	5	0.2	153	5.0
Mollusca (marine)	marine mollusc	6	0.2	36	1.2
Dentaliidae	tusk shell	1	0.0	2	0.1
Gastropoda (marine)	marine gastropod	4	0.1	3	0.1
<i>Strombus</i> sp.	conch	13	0.4	160	5.3
<i>Strombus gigas</i>	queen conch	-	-	2	0.1
<i>Strombus</i> cf. <i>pugilis</i>	queen conch	1	0.0	3	0.1
<i>Oliva</i> sp.	olive shell	12	0.4	8	0.3
<i>Oliva sayana</i>	lettered olive	2	0.1	9	0.3
<i>Prunum</i> sp.	marginella	1	0.0	3	0.1
<i>Trivia</i> sp.	trivia shell	-	-	2	0.1
<i>Trivia pediculus</i>	coffeebean trivia	-	-	2	0.1
<i>Cypraea</i> cf. <i>cervus</i>	Atlantic deer cowrie	-	-	1	0.0
<i>Cypraea</i> cf. <i>zebra</i>	zebra cowrie	-	-	1	0.0
<i>Columbella mercatoria</i>	common dove shell	1	0.0	-	-
<i>Melongena melongena</i>	West Indian crown conch	-	-	1	0.0
cf. <i>Asaphis deflorata</i>	cf. gaudy sanguin	1	0.0	-	-
<i>Spondylus</i> sp.	spondylus	1	0.0	222	7.3
<i>Codakia</i> sp.	lucine	-	-	1	0.0
cf. <i>Dinocardium robustum</i>	cf. cockle	1	0.0	-	-
cf. = compares well with	TOTAL =	3001	100.0	3040	100.0

Although the results do not show up in the analysis of general excavation remains, the sites also differ in their use of freshwater fish. When the results of selective fine screen (1 and 2mm mesh) tests are added to the sample, fish make up approximately 14% of the identifiable remains in the Trinidad assemblage and less than 1% of the Motul assemblage. This finding is not surprising considering Trinidad's lakeside location, and the recovery of numerous fishing weights during excavation (Moriarty, et al. 2004). It is also interesting to note that most of the fish remains recovered at Trinidad represent very small individuals that were likely prepared as soup. In contrast, the few fish remains recovered from Motul all came from high elite deposits and represent larger individuals that could have been filleted or smoked. This suggests preferential distribution of large fish carcasses to the Motul elite. Elite residents of Motul also enjoyed greater or exclusive access to other preferred meat resources and ritual species including deer, peccaries, crocodiles (*Crocodylus* sp.), marine mollusks, the large Central American river turtle (*Dermatemys mawii*), and felids (e.g. jaguar, puma and ocelot) (*Panthera onca*, *Puma concolor* and *Leopardus pardalis*).

Approximately 10% of the Motul faunal remains and 4% of the Trinidad remains show evidence of artifactual modification. When we look at the types of modified remains at each site, the aquatic/terrestrial division between Motul and Trinidad stays consistent. Worked bone elements are much more common at Motul, while worked shell remains are present in greater frequency at Trinidad. If we divide the worked remains according to production stage (e.g. finished artifacts versus debitage), we see that Motul has more finished artifacts, and that the majority of these artifacts are made from bone rather than shell, while the opposite is true for Trinidad. Similar patterns emerge when we compare the sites' bone and shell debitage. Although sample sizes are small, these observations suggest that both sites were involved in craft production primarily for on-site consumption, rather than regional trade. For example, Trinidad is not producing excess quantities of modified freshwater or marine shell artifacts for exchange with Motul since the ratios between shell debitage and finished artifacts are similar at both sites. (Figure 9)

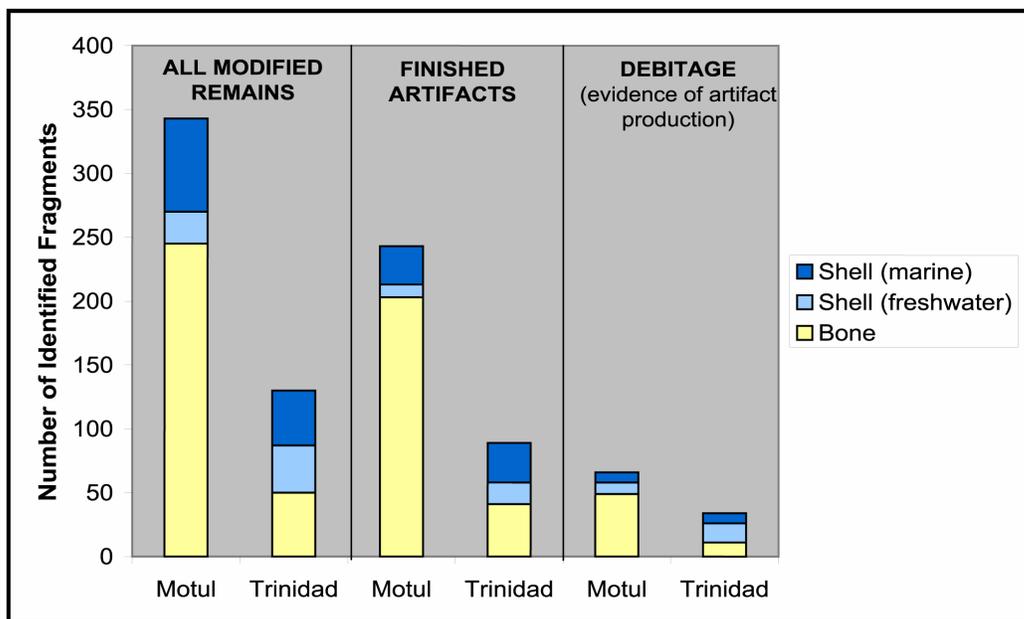


Figure 9. Raw material and production stage of artifactually modified remains from Trinidad de Nosotros and Motul de San José.

Based on the differences just outlined, we can form preliminary hypotheses about the function of Maya trade, and the degree of elite control over natural resource acquisition. Within the Motul polity, it is unknown whether the various sites used only local resources or also resources from the region as a whole. Trinidad and Motul are a good test of this question because Trinidad is the only site in the Motul polity located near a significant body of water. Therefore, Trinidad may have served as the primary aquatic resource acquisition site for Motul, which could have obtained its aquatic resources from Trinidad through systems of trade or taxation. It is also unknown whether non-local animal resources were imported for dietary or non-dietary purposes, and who had access to the imported goods. For example, if we look at aquatic resource distribution at Motul according to social class, we see that a large proportion of the turtle, fish, and freshwater shell remains come from elite residential groups within the site's core. This suggests that the Motul elites exerted some control over the access to faunal resources acquired outside the site's immediate area. The aquatic resources exchanged at the intra-polity level were primarily used for subsistence rather than artifact production purposes. Only a small portion (5%) of the aquatic remains from elite contexts is artifactually modified. Moreover, a large portion of the freshwater gastropods shows evidence of butchery.

Evidence for long distance exchange in faunal resources within the Motul polity comes primarily from the presence of modified and unmodified marine shell ([Figure 10](#)). Similar to other inland sites, access to these exotic resources was the exclusive right of the elites at both Motul and Trinidad. The sites' distance from the coast precludes the use of these commodities as dietary resources, and in fact, a large proportion of the marine shells (56-97%) show evidence of artifactual modification. There is limited evidence for marine shell working at both sites, but the majority of marine shells were imported from coastal locations as finished artifacts.

Based on Motul's greater size and architectural elaboration, it is not surprising that the site shows greater access to preferred meat resources and ritual and exotic commodities. In comparison, Trinidad's proposed role as a trade port and involvement in long distance exchange did not elevate its access to exotic faunal resources such as marine shell and stingray tail spines. However, this conclusion needs to be further assessed through a comparison of Trinidad with other inland trade ports, and sites of similar size and status.

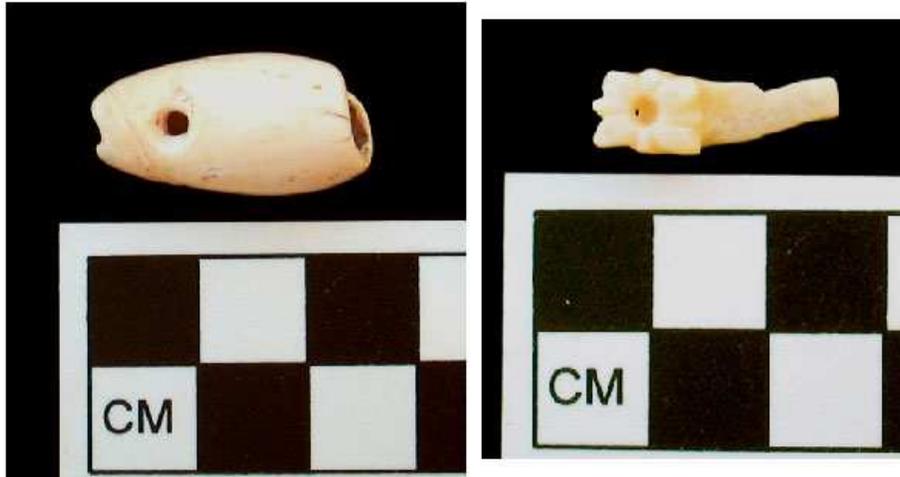


Figure 10. Examples of a marine shell tinkler (left) and ear adornment (right) from Trinidad de Nosotros.

Cancuén: Zooarchaeological Results and Comparisons

The most commonly identified taxa in the Cancuén faunal assemblage are deer, peccaries, dogs, crocodiles, large river turtles, freshwater mussels and jute (see [Table 1](#)). Although the full range of species identified at Cancuén is similar to that found at Trinidad, the assemblages differ in several ways. Large terrestrial mammals, such as deer and peccaries, are more common at Cancuén, while freshwater mollusks (especially jute and apple snails) are more common at Trinidad. The residents of Cancuén also used aquatic taxa such as crocodiles, large Central American river turtles, and freshwater mussels to a greater extent.

Some of this variation may be explained by differences in the local ecology surrounding each site. Trinidad is located in a lacustrine environment at the edge of Lake Petén Itzá, while Cancuén is located in a riverine environment along the upper reaches of the Pasión River. Apple snails prefer the slow-moving, low turbidity aquatic habitats found in lakes, swamps and wetland environments (Goodrich and van der Schalie 1937; Moholy-Nagy 1978), and would therefore be present in larger quantities near Trinidad. In contrast, species that prefer fast-moving aquatic habitats such as large river turtles and freshwater mussels (Goodrich and van der Schalie 1937; Powis 2004) would be more common in the local habitats surrounding Cancuén. Jute also prefer shallow, fast-moving water (Healy, et al. 1990), so it is unclear why these are present in much greater quantities at Trinidad, especially since large numbers of jute are present in cave deposits located in the area surrounding Cancuén (Brent Woodfill, personal communication). It is possible that jute are under-represented in the Cancuén assemblage due to their preferential use in cave-associated rituals.

In comparison to both Trinidad and Motul de San José, the site of Cancuén had greater access to various non-local species of marine mollusks. Large quantities of conch (Strombidae, Melongenidae) and spondylus (*Spondylus* sp.) shell were recovered along with smaller numbers of olive (Olividae), marginella (*Prunum* sp.), cowrie (Cypraeidae), trivia (*Trivia* sp.) and lucine (Codakia sp.) shells. The burial of Cancuén's final ruler, Kan Maax, alone contained 224 fragments of marine shell ([Figure 11](#)). Although some of the shells were interred in whole, unmodified form, most of the fragments are geometrically-shaped mosaic pieces that may have been adhered to a perishable background made of cloth or animal skin. Significantly, even when we remove these remains from the site's faunal assemblage, Cancuén still appears to have had considerable access to non-local marine resources. Although many of the Cancuén marine shells are too highly modified to identify to the species level, all of the unmodified shells were identified as Atlantic coast species. Pacific coast shells therefore do not appear to have been moved in large quantities across the highlands and into the lowlands via major highland-lowland trade routes, despite their presence in small quantities at sites as far away as El Mirador, Tikal and Copán (Emery 2005; Moholy-Nagy 1985; Thornton in prep). Additional species-level identifications may be possible, however, as research continues.



Photo provided by Tomas Barrientos

Figure 11. Marine shell mosaic pieces and large spondylus shell under cranium (far left in photo) from Kan Maax burial at Cancuén.



Figure 12. Carved shell artifacts in the form of a fish and water lily from Kan Maax burial at Cancuén.

Comparative analysis of Cancuén's faunal assemblage with those of its likely trading partners in the northern Petexbatún region is not yet complete. As data from this part of the project emerges, the results will be used to define intra-regional exchange networks, and to determine the degree to which faunal resources were incorporated into the specialized craft production systems already identified at the site for other artifact classes. Faunal assemblages previously identified by Dr. Kitty Emery from the sites of Aguateca, Dos Pilas, Arroyo de Piedra, Tamarindito, and Punta de Chimino are being used for the intra-regional comparison.

Methods: Strontium Isotope Analysis

Methodological Background and Sample Selection

Although traditional zooarchaeological methods may be used to define resource catchment zones and faunal exchange networks, these methods cannot identify all non-local resources. For example, species with large geographic ranges or broad habitat requirements, such as white-tailed deer, are often assumed to be local resources, but this assumption is questioned by ethnographic accounts of trade in deer haunches (Tozzer 1941) and suggestions of specialized hunting in less populated lowland areas such as the Maya Mountains of Belize (McAnany 1989). Highly modified bone or tooth artifacts are also difficult to classify as local versus non-local resources since these specimens often cannot be identified below the level of taxonomic class.

One potential methodological advance towards reconstructing prehistoric trade and acquisition patterns is the application of strontium isotope analysis to zooarchaeological remains. This method has been used previously to identify prehistoric human migration in Mesoamerica (Buikstra, et al. 2003; Price, et al. 2000; Wright 2005, 2005). Movement of people and faunal resources may be tracked with strontium isotope analysis because strontium isotope ratios ($^{87}\text{Sr}/^{86}\text{Sr}$) vary across the landscape according to a region's underlying bedrock. As an animal feeds and drinks, the local strontium signature is recorded in its skeletal tissues. Since distinct isotopic regions have already been identified in the Maya cultural area based on the characterization of strontium isotope ratios in soil, water, bedrock and vegetation (Hodell, et al. 2004), we can use these signatures to identify non-local animal resources ([Figure 13](#)).

I selected zooarchaeological samples for strontium isotope analysis from the following sites: Dzibilchaltún, Colha, Lamanai, Tipú, Caracol, Lubaantun, El Mirador, Motul de San José, Trinidad de Nosotros, Piedras Negras, Dos Pilas, Cancuén, Aguateca, and Copán. Additional samples from sites in Yucatán state, México were not included because formal permission to export the specimens was denied. Species sampled for analysis include white-tailed deer, brocket deer, peccary, tapir (*Tapirus bairdii*), jaguar and puma. Samples of tooth enamel were used whenever possible due to its greater resistance to diagenetic contamination than bone (Koch, et al. 1997; Nelson, et al. 1986; Sealy, et al. 1991; Sillen and Kavanagh 1982).

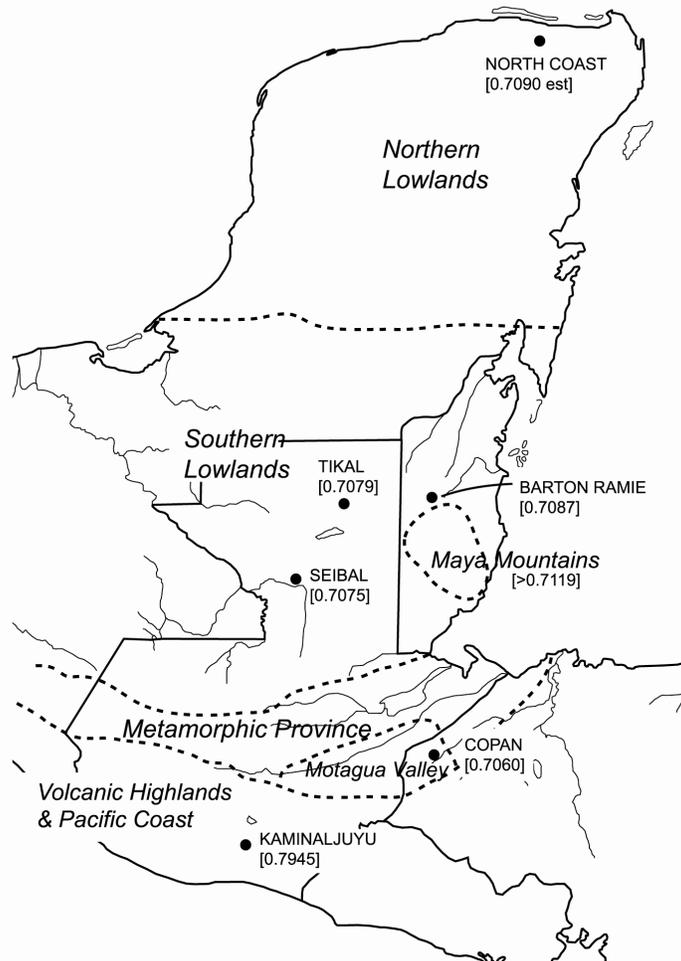


Figure 13. Map showing local strontium isotope ratios ($^{87}\text{Sr}/^{86}\text{Sr}$) at select Maya sites based on previous research on human skeletal remains (Buikstra, et al. 2004; Price, et al. 2000). Dashed lines delineate major strontium isotope regions as defined by Hodell, et al. (2004).

Laboratory Methods

Enamel samples were manually cleaned to remove all visible dirt and debris, and then mechanically cleaned under 10x magnification with a fine dental drill (170 taper fissure carbide drill bit) to remove discolored surface enamel ([Figure 14](#) and [Figure 15](#)). After cleaning exterior surfaces, a small enamel sample (30-60mg) was removed from each tooth with a dental drill and further abraded to remove any adhering dentine. Drill bits were changed between each sample to reduce the possibility of cross-sample contamination. Sample drilling equipment was provided by the Department of Anthropology Stable Isotope Laboratory at the University of Florida (Dr. John Krigbaum, supervisor).



Figure 14. Sample cleaning under 10x magnification with a fine dental drill.



Figure 15. Close-up of a peccary tooth being cleaned with a dental drill.

Sample pretreatment and strontium isolation was done in a class 1000 clean lab owned by the University of Florida Department of Geological Sciences (Dr. Ann Heatherington, supervisor). Clean enamel pieces were pretreated for 30 minutes in a 5% acetic acid solution to remove post-depositional contaminants, and rinsed to neutral with 4x distilled water. The samples were then transferred to sterile Teflon beakers and hot-digested in 3ml of 50% HNO₃ (optima). Once digested, the samples were uncapped and left overnight in a sterile laminar flow fumehood to evaporate.

Dried samples were re-dissolved in 3.5N HNO₃ the following day and loaded into cation exchange columns packed with strontium-selective crown ether resin to isolate strontium from other ions ([Figure 16](#)). Dissolved samples (200µl each) were added to each column and rinsed through four times with 100µl of 3.5N HNO₃. After a final rinse with 1ml HNO₃, the isolated strontium was collected in 1.5ml 4x distilled H₂O and dried down overnight.

Sample ⁸⁷Sr/⁸⁶Sr was measured with at Micromass Sector 54 thermal ionization mass spectrometer (TIMS) housed in the University of Florida, Gainesville Department of Geological Sciences. Multiple samples of the strontium standard NBS-987 were run to confirm instrument accuracy. External precision of analysis was ± 0.00002 (2 sigma absolute) based on 314 analyses of NBS-987.



Figure 16. Loading samples into cation exchange columns packed with strontium resin.

Strontium Isotope Results

To date, strontium isotope ratios have been measured on a total of 47 tooth enamel samples. The enamel samples are primarily from white-tailed deer, brocket deer, peccary and tapir molars. Several of the samples (n=10) did not yield usable results on the initial run. [Table 2](#) lists the strontium isotope ratios for the 37 zooarchaeological enamel samples from ten sites across the Maya lowlands. Average $^{87}\text{Sr}/^{86}\text{Sr}$ values are presented for each site in [Table 3](#). The baseline signature for each site still needs to be refined, but the preliminary data presented here may be compared to regional clusters defined by Hodell et al. (2004). Based on this comparison, the vast majority of samples represent faunal resources that were acquired locally rather than through long-distance exchange. One exception is a white-tailed deer from Copán, which has a strontium signature (0.7088936) consistent with an origin outside of the Motagua Valley (range 0.70417-0.70725) (Hodell, et al. 2004). Based on its isotopic signature the animal was likely brought into the site from another area of the metamorphic province located between the volcanic highlands and southern lowlands. This geological region has the most variable $^{87}\text{Sr}/^{86}\text{Sr}$ values within the Maya cultural area ranging from 0.70417 to 0.72017 (ibid.). However, it is also possible that the deer could have been imported from the northern Maya lowlands, which has isotopic signatures ranging from 0.70775 to 0.70921. The other white-tailed deer sampled from Copán has a strontium signature consistent with the site's local $^{87}\text{Sr}/^{86}\text{Sr}$ value (0.70644±0.00044) (Hodell, et al. 2004).

Table 2. $^{87}\text{Sr}/^{86}\text{Sr}$ results from Mesamerican zooarchaeological samples

Sample #	Site	Taxa (scientific name)	Element	$^{87}\text{Sr}/^{86}\text{Sr}$	Precision (1 sigma, permil)
DZ3	Dzibilchaltun	<i>Tapirus bairdii</i>	upper molar	0.7088917	0.0009
DZ4	Dzibilchaltun	<i>Tayassu</i> sp.	upper PM4 (left)	0.7088948	0.0009
CL2	Colha	<i>Odocoileus virginianus</i>	lower M3 (left)	0.7083423	0.0008
TP1	Tipu	<i>Odocoileus virginianus</i>	lower M1/2 (left)	0.7083962	0.0011
TP2	Tipu	<i>Tayassu pecari</i>	upper M2 (left)	0.7117084	0.0016
TP4	Tipu	<i>Mazama</i> sp.	lower M2 (leftO)	0.7087796	0.001
TP6	Tipu	<i>Tayassu tajacu</i>	lower M3 (left)	0.7084593	0.0012
TP7	Tipu	<i>Mazama</i> sp.	upper M1 (right)	0.7282004	0.0009
TP8	Tipu	<i>Odocoileus virginianus</i>	lower PM4 (right)	0.7201608	0.0008
TP9	Tipu	<i>Tapirus bairdii</i>	lower molar	0.7099302	0.0009
TP10	Tipu	<i>Tapirus bairdii</i>	lower molar	0.7094685	0.0021
TP11	Tipu	<i>Tayassu tajacu</i>	upper M3 (right)	0.7316242	0.0009
LU1	Lubaantun	<i>Odocoileus virginianus</i>	upper M2 (left)	0.7074043	0.0008
LU2	Lubaantun	<i>Odocoileus virginianus</i>	lower M3 (right)	0.707624	0.0009
LU3	Lubaantun	<i>Odocoileus virginianus</i>	lower M2 (right)	0.7078252	0.001
LU4	Lubaantun	<i>Mazama</i> sp.	lower M1 (left)	0.7073658	0.0013
TRI1	Trinidad de Nosotros	<i>Odocoileus virginianus</i>	lower M1 (left)	0.7074239	0.0009
TRI2	Trinidad de Nosotros	<i>Odocoileus virginianus</i>	upper M3 (left)	0.7069364	0.0009
TRI3	Trinidad de Nosotros	<i>Odocoileus virginianus</i>	decid. PM4 (left)	0.7073288	0.0011
TRI4	Trinidad de Nosotros	<i>Tayassu</i> sp.	lower M3 (right)	0.7075442	0.0009
MSJ4	Motul de San Jose	<i>Odocoileus virginianus</i>	upper M1 (right)	0.7071851	0.0009
MSJ5	Motul de San Jose	<i>Odocoileus virginianus</i>	lower M1 (right)	0.7072766	0.0008
MSJ6	Motul de San Jose	<i>Tayassu</i> sp.	lower I1	0.7074859	0.0008
CAN2	Cancuen	<i>Odocoileus virginianus</i>	lower M3 (left)	0.7076137	0.0007
CAN3	Cancuen	<i>Odocoileus virginianus</i>	lower M2 (right)	0.7074850	0.0009
CAN4	Cancuen	<i>Odocoileus virginianus</i>	lower M3 (left)	0.7074805	0.0008
CAN5	Cancuen	<i>Odocoileus virginianus</i>	lower M3 (left)	0.7073183	0.0008
CAN6	Cancuen	<i>Odocoileus virginianus</i>	lower M3 (right)	0.7076262	0.0008
CAN7	Cancuen	<i>Mazama</i> sp.	lower M1 (left)	0.7073266	0.0009
CAN9	Cancuen	<i>Tayassu tajacu</i>	upper M2 (left)	0.7073663	0.0008
CAN10	Cancuen	<i>Odocoileus virginianus</i>	lower M3 (right)	0.707435	0.0011
CAN12	Cancuen	<i>Tayassu tajacu</i>	upper M3 (right)	0.7074016	0.0008
CAN1A	Cancuen	<i>Odocoileus virginianus</i>	lower M2 (left)	0.7073001	0.0012
DP1	Dos Pilas	<i>Odocoileus virginianus</i>	upper M2 (right)	0.7066175	0.0008
AG1	Aguateca	<i>Odocoileus virginianus</i>	lower M1 (left)	0.7074084	0.0008
CO1	Copan	<i>Odocoileus virginianus</i>	upper M3 (right)	0.7066792	0.0008
CO2	Copan	<i>Odocoileus virginianus</i>	upper M2 (left)	0.7088936	0.0013

Table 3. Summary statistics for $^{87}\text{Sr}/^{86}\text{Sr}$ results from Mesamerican zooarchaeological samples

Site	N	Mean ($^{87}\text{Sr}/^{86}\text{Sr}$)	Std. Dev.
Dzibichaltun	2	0.7089	0.0000
Colha	1	0.7083	-
Tipu	9	0.7152	0.0091
Lubaantun	4	0.7076	0.0002
Trinidad de Nosotros	4	0.7073	0.0003
Motul de San Jose	3	0.7073	0.0002
Cancuen	10	0.7074	0.0001
Dos Pilas	1	0.7066	-
Aguateca	1	0.7074	-
Copan	2	0.7078	0.0016

Additional evidence for long-distance exchange or acquisition comes from a white-tailed deer sampled from Dos Pilas. This animal has a $^{87}\text{Sr}/^{86}\text{Sr}$ value (0.7066175) more similar to the distant metamorphic province and Motagua valley than that local southern Maya lowlands. A single deer from Trinidad de Nosotros also has a slightly lower strontium isotope ratio (0.70693) than the other fauna tested within the region ($\bar{x} = 0.7073$). This animal (or skeletal element) could have been acquired or imported from somewhere outside the local area. However, the lowest strontium value observed at Trinidad still falls within the entire range of $^{87}\text{Sr}/^{86}\text{Sr}$ results reported from bedrock, soil and vegetation samples within the southern Maya lowlands (0.70693-0.7845) (Hodell et al. 2004: 591 Table 2). It is interesting to note that as a whole, the samples from both Trinidad de Nosotros and Motul de Jose fall slightly below the average $^{87}\text{Sr}/^{86}\text{Sr}$ values for the local region as defined by modern fauna (0.70779-0.70790) (Wright 2005) and samples of soil, water and bedrock ($\bar{x} = 0.70770 \pm 0.00052 [2\sigma]$) (Hodell, et al. 2004; Wright 2005). Additional baseline samples will be run from each site to help explain the observed variation.

Strontium ratios also vary at the site of Tipú in central Belize. The site has an ideal location for studying animal acquisition patterns through strontium isotopes because it is located near a geological boundary between the southern Maya lowlands and the Maya Mountains. These regions do not overlap in strontium isotope ratios so it should be possible to distinguish between animals acquired within the Maya Mountains, and those acquired from the surrounding lowland areas. Based on the isotopic results from Tipú, two deer and two peccaries were obtained in the Maya Mountains, while two deer, one peccary and two tapirs were

obtained within lowland areas. Both of these geological regions are within the local resource catchment area of the site. The presence of animals from both lowland and Maya Mountain environments is therefore more informative regarding habitat use at Tipú than long distance exchange. Since the Maya Mountains were less suitable for agriculture, additional strontium testing will be used to explore whether the majority of animals were obtained through lowland garden hunting or more specialized highland hunting expeditions.

Preliminary Interpretations

Although much work remains to be done, preliminary conclusions may be drawn from the research completed to-date. Intra-polity comparisons between Trinidad de Nosotros and Motul de San José show that Trinidad exploited local aquatic resources in great quantities, possibly for exchange within the Motul polity. Preferred commodities such as large fish, large river turtles and jute may have been extracted from Trinidad by the Motul elite. The primary motivation behind the intra-polity exchange of faunal resources was likely to supply the Motul elite with preferred subsistence resources, since most of the aquatic remains were deposited in midden contexts and show evidence of butchery. However, highly nacreous freshwater shells may also have been obtained for artifact production purposes.

Trinidad's proposed role as a Maya trade port involved in long-distance exchange moving east-to-west across the Petén Lakes region did not increase the resident's access to non-local faunal resources such as marine shells and stingray tail spines. This is somewhat surprising based on Trinidad's high concentrations of other non-local resources such as obsidian (Moriarty in press). In contrast, the site of Cancuén appears to have obtained greater access to long-distance resources through its role as trade center. The marine shell identified at the Cancuén is mostly Atlantic in origin. It is possible that marine shell artifacts were moving south and west into the site and being exchanged for highland products such as jade and obsidian, which were moving north and east through the Pasión river system.

Preliminary results from the strontium isotope analysis of zooarchaeological remains confirm that most faunal resources were acquired locally. However, isotopic outliers at the sites of Copán, Dos Pilas and Trinidad de Nosotros indicate that regional and long-distance exchange of faunal resources may have occurred. The results from Tipú also show that the method may be useful for determining habitat use and resource catchment zones for sites located along distinct isotopic boundaries such as the interface between the Maya Mountains and the southern lowlands. As a whole, the dataset contributes to the rapidly growing database of strontium isotope data available for the Maya area. This will inform future studies of human migration in Mesoamerica, by establishing the biological strontium signature of known dietary commodities.

Continuing Research

The zooarchaeological and isotopic research outlined in this report is still in progress. Although a large portion of the faunal assemblages from Trinidad de Nosotros and Cancuén has been identified, the taxonomic identifications still need to be integrated with the provenience information and other artifact data available for each site. Much of this information is just starting to become available as ceramic, lithic and architectural studies are completed by the sites' archaeologists. Inter-site comparisons between faunal assemblages within the larger Motul and Petexbatún polities are also on-going. Issues of sample comparability must be addressed before discrete comparisons are conducted. Sample comparability will be assessed through a consideration of archaeological recovery methods (e.g. screening techniques), and variation in the chronology, status level and types of contexts (e.g. burial, fill, midden) sampled at each site (Emery 2004).

Strontium isotope research will also continue through December 2007. Additional zooarchaeological enamel samples from the sites of Caracol, Piedras Negras, Lamanai, El Mirador and Aguateca will be analyzed. In addition, strontium ratios in modern land snails from all of the sites included in the project will be measured to confirm local baseline $^{87}\text{Sr}/^{86}\text{Sr}$ values. The potential for using strontium isotopes to identify and source non-local samples of archaeological bone will also be evaluated. This will be done by comparing strontium ratios in samples of enamel and cortical bone taken from the same mandible. By sampling from the same skeletal element, it is possible to control for differences in the depositional environment and just address differential preservation between skeletal tissues (bone vs. enamel). If time and funds allow, heavy earth elements will also be measured in a subset of archaeological bones and bone tools as a proxy for diagenesis.

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Sources Cited

Beaubien, H.

2004 Excavation and recovery of a funerary offering of marine materials from Copán. In *Maya Zooarchaeology: New Directions in Method and Theory*, edited by K. F. Emery, pp. 45-54. Institute of Archaeology, UCLA Press, Los Angeles.

Brumfiel, E. M. and T. K. Earle (editors)

1987 *Specialization, Exchange, and Complex Societies*. Cambridge University Press, New York.

Buikstra, J. D., T. D. Price, J. H. Burton and L. E. Wright

2003 Tombs from the Copán acropolis: a life history approach. In *Understanding Early Classic Copán*, edited by E. Bell, M. Canuto and R. J. Sharer, pp. 185-206. University of Museum Publications, University of Pennsylvania, Philadelphia.

Carr, H. S.

1986 *Faunal utilization in a late Preclassic Maya community at Cerros, Belize*. Ph.D. dissertation, Tulane University.

1996 Precolumbian Maya exploitation and management of deer populations. In *The Managed Mosaic: Ancient Maya Agriculture and Resource Use*, edited by S. Fedick, pp. 251-261. University of Utah Press, Salt Lake City.

Demarest, A. A.

1999 Investigaciones arqueológicas y reconocimiento en la zona del sitio Cancuén. In *XIII Simposio de Investigaciones Arqueológicas en Guatemala*. Museo Nacional de Arqueología y Etnología.

1999 Proyecto Arqueológico Cancuén. Informe Preliminar No. 1, Temporada 1999. Preliminary report submitted to the Guatemala Institute of Anthropology and History.

- 2000 [Cancuén Archaeological Project](#). Report submitted to the Foundation for the Advancement of Mesoamerican Studies, Inc. (FAMSI).
- 2004 Proyecto arqueológico Cancuén, temporada 2003: introducción y antecedentes. In *Proyecto Cancuén: Informe preliminar no. 5 - quinto temporada*, edited by A. A. Demarest and T. Barrientos. Report submitted to the Instituto de Antropología e Historia de Guatemala, Guatemala City.
- Emery, K. F.
- 1999 Continuity and variability in Postclassic and Colonial animal use at Lamanai and Tipú, Belize. In *Reconstructing Ancient Maya Diet*, edited by C. D. White, pp. 61-82. University of Utah Press, Salt Lake City.
- 2004 In search of assemblage comparability: methods in Maya zooarchaeology. In *Maya Zooarchaeology: New Directions in Method and Theory*, edited by K. F. Emery, pp. 15-34. Institute of Archaeology, UCLA Press, Los Angeles.
- 2005 [Animals and Ritual in the Copán Acropolis: Zooarchaeology of Special Deposits](#). Report submitted to the Foundation for the Advancement of Mesoamerican Studies, Inc. (FAMSI).
- Goodrich, C. and H. van der Schalie
- 1937 *Mollusca of Petén and North Alta Vera Paz, Guatemala*. University of Michigan Museum of Zoology Miscellaneous Publications, No. 34. University of Michigan Press, Ann Arbor.
- Graham, E.
- 1987 Resource diversity in Belize and its implications for models of lowland trade. *American Antiquity* 52:753-767.
- 2002 Perspectives on economy and theory. In *Ancient Maya Political Economies*, edited by M. A. Masson and D. A. Freidel, pp. 398-418. AltaMira Press, New York.
- Grayson, D. K.
- 1981 The effects of sample size on some derived measures in vertebrate faunal analysis. *Journal of Archaeological Science* 8(1):77-88.
- 1984 *Quantitative Zooarchaeology: Topics in the Analysis of Archaeological Faunas*. Academic Press, Orlando, FL.
- Hamblin, N. L.
- 1985 The role of marine resources in the Maya economy: a case study from Cozumel, México. In *Prehistoric Lowland Maya Environment and Subsistence Economy*, edited by M. Pohl, pp. 159-174. Peabody Museum of Archaeology and Ethnology, Harvard University, Cambridge, MA.

- Hammond, N.
1972 Obsidian trade routes in the Mayan area. *Science* 178:1092-1093.
- Healy, P. F., K. F. Emery and L. E. Wright
1990 Ancient and modern Maya exploitation of the jute snail (*Pachychilus*). *Latin American Antiquity* 1:170-183.
- Hirth, K.
1992 Interregional exchange as elite behavior: an evolutionary perspective. In *Mesoamerican Elites: an archaeological assessment*, edited by D. Z. Chase and A. F. Chase, pp. 18-29. University of Oklahoma Press, Norman.
- Hodell, D. A., R. L. Quinn, M. Brenner and G. Kamenov
2004 Spatial variation of strontium isotopes ($^{87}\text{Sr}/^{86}\text{Sr}$) in the Maya region: a tool for tracking ancient human migration. *Journal of Archaeological Science* 31:586-601.
- James, S. R.
1997 Methodological issues concerning screen size recovery rates and their effects on archaeofaunal interpretations. *Journal of Archaeological Science* 24:385-397.
- Koch, P. L., N. Tuross and M. L. Fogel
1997 The effects of sample treatment and diagenesis on the isotopic integrity of carbonate in biogenic hydroxylapatite. *Journal of Archaeological Science* 24:417-429.
- Kovacevich, B.
2007 Ritual, crafting and agency at the Classic Maya kingdom of Cancuén. In *Mesoamerican Ritual Economy: Archaeological and Ethnological Perspectives*, edited by E. C. Wells and K. L. Davis-Salazar, pp. 67-114. University of Colorado Press, Boulder.
- Kovacevich, B., T. Barrientos, A. Demarest, M. Callahan, C. Bill, E. Sears and L. Moran
2000 Producción e intercambio en el reinado de Cancuén. In XIV Simposio de Investigaciones Arqueológicas en Guatemala. Instituto de Antropología e Historia de Guatemala; Asociación Tikal, Guatemala, pp. 589-609.
- Kunen, J. L., M. J. Galindo and E. Chase
2002 Pits and bones: identifying Maya ritual behavior in the archaeological record. *Ancient Mesoamerica* 13:197-211.

- Lange, F. W.
1971 Marine resources: a viable subsistence alternative for the prehistoric lowland Maya. *American Anthropologist* 73:619-639.
- Lujan, L. L.
1994 *The Offerings of the Templo Mayor of Tenochtitlán*. University Press of Colorado, Niwot.
- Masson, M. A.
1999 Animal resource manipulation in ritual and domestic contexts at Postclassic Maya communities. *World Archaeology* 31:93-120.
- McAnany, P. A.
1989 Economic foundations of prehistoric Maya society: paradigms and concepts. In *Prehistoric Maya Economies of Belize*, edited by P. A. McAnany and B. L. Isaac, pp. 347-372. JAI Press, Greenwich, CT.
1992 Resources, specialization, and exchange in the Maya Lowlands. In *The American Southwest and Mesoamerica: Systems of Prehistoric Exchange*, edited by J. E. Ericson and T. G. Baugh, pp. 213-245. Plenum Press, New York.
1993 The economics of social power and wealth among eighth-century Maya households. In *Lowland Maya Civilization in the Eighth Century A.D.*, edited by J. A. Sabloff and J. S. Henderson, pp. 65-89. Dumbarton Oaks Research Library Collection, Washington, D.C.
- McKillop, H.
2002 *Salt: White Gold of the Ancient Maya*. University Press of Florida, Gainesville.
2004 *The Ancient Maya: New Perspectives*. ABC-CLIO, Santa Barbara, CA.
- Moholy-Nagy, H.
1978 The utilization of Pomacea snail at Tikal, Guatemala. *American Antiquity* 43:65-73.
1985 The social and ceremonial uses of marine molluscs at Tikal. In *Prehistoric Lowland Maya Environment*, edited by M. D. Pohl, pp. 147-158. Harvard University Press, Cambridge, MA.
2004 Vertebrates in Tikal burials and caches. In *Maya Zooarchaeology: New Directions in Method and Theory*, edited by K. F. Emery, pp. 193-205. Institute of Archaeology, UCLA Press, Los Angeles.

- Moriarty, M. D.
in press Trinidad de Nosotros: recent investigations at an inland Maya port on Lake Petén-Itza. *Mexicon*.
- Moriarty, M. D., A. E. Foias and J. Castellanos (editors)
2004 *Proyecto Arqueológico Motul de San José Informe #6: Temporada de Campo 2003*. Report submitted to IDAEH, Guatemala.
- Nelson, B. K., M. J. DeNiro, M. J. Schoeninger and D. J. De Paolo
1986 Effects of diagenesis on strontium, carbon, nitrogen and oxygen concentration and isotopic composition of bone. *Geochimica et Cosmochimica Acta* 50:1941-1949.
- Pohl, M.
1983 Maya ritual faunas: vertebrate remains from burials, caches, caves and cenotes in the Maya lowlands. In *Civilization in the Ancient Americas: Essays in Honor of Gordon R. Willey*, edited by R. M. Leventhal and A. L. Kolata, pp. 55-103. University of New Mexico Press and Peabody Museum of Archaeology and Ethnology, Harvard University, Cambridge, MA.
- 1990 The ethnozoology of the Maya: faunal remains from five sites in the Petén, Guatemala. In *Excavations at Seibal, Guatemala*, edited by G. R. Willey, pp. 144-174. vol. Volume 18, number 3. Peabody Museum Monographs, Cambridge, MA: Harvard University.
- Pohl, M. D. and L. H. Feldman
1982 The traditional role of women and animals in the lowland Maya economy. In *Maya Subsistence: Studies in Memory of Dennis E. Puleston*, edited by K. V. Flannery, pp. 295-311. Academic Press, New York.
- Powis, T. G.
2004 Ancient lowland Maya utilization of freshwater pearly mussels (*Nephronaias* spp.). In *Maya Zooarchaeology: New Directions in Method and Theory*, edited by K. F. Emery, pp. 125-140. Institute of Archaeology, UCLA Press, Los Angeles.
- Price, D. T., L. Manzanilla and W. D. Middleton
2000 Immigration and the ancient city of Teotihuacán in México: a study using strontium isotope ratios in human bone and teeth. *Journal of Archaeological Science* 27:903-913.
- Quitmyer, I. R.
2004 What kind of data are in the backdirt? An experiment on the influence of screen size on optimal recovery. *Archaeofauna* 13:109-129.

- Rice, P. M.
 1987 Economic change in the lowland Maya Late Classic period. In *Specialization, Exchange, and Complex Societies*, edited by E. M. Brumfiel and T. K. Earle, pp. 76-85. Cambridge University Press, New York.
- Sanders, W. T.
 1976 The population of the central Mexican symbiotic region, the Basin of México, and the Teotihuacán Valley in the 16th century. In *The Native Population of the Americas*, edited by W. M. Denevan, pp. 85-150. University of Wisconsin Press, Madison.
- Sealy, J. C., N. J. van der Merwe, A. Sillen, F. J. Kruger and H. W. Krueger
 1991 $^{87}\text{Sr}/^{86}\text{Sr}$ as a dietary indicator in modern and archaeological bone. *Journal of Archaeological Science* 18:399-416.
- Shaffer, B. S. and J. L. J. Sanchez
 1994 Comparison of 1/8"- and 1/4"-mesh recovery of controlled samples of small-to-medium-sized mammals. *American Antiquity* 59:525-530.
- Shaw, L. C.
 1991 *The Articulation of Social Inequality and Faunal Resource Use in the Preclassic Community of Colha, Northern Belize*. Ph.D. dissertation, University of Massachusetts.
- Sillen, A. and M. Kavanagh
 1982 Strontium and paleodietary research: a review. *Yearbook of Physical Anthropology* 25:67-90.
- Sluyter, A.
 1993 Long-distance staple transport in western Mesoamerica: insights through quantitative modeling. *Ancient Mesoamerica* 4:193-199.
- Thornton, E. K.
 in prep Patterns of ancient animal use at El Mirador: evidence for subsistence, ceremony and exchange. In *Introduction to Investigations at El Mirador, Petén, Guatemala. El Mirador Series, Part I*, edited by R. T. Matheny and D. G. Matheny. Papers of the New World Archaeological Foundation Number 59.
- Tozzer, A. M.
 1941 *Landa's Relaciones de las cosas de Yucatán*. Papers of the Peabody Museum of Archaeology and Ethnology, Harvard University, vol. 18, Cambridge.

Wing, E. S. and S. J. Scudder

1991 The exploitation of animals. In *Cuello: An Early Maya Community in Belize*, edited by N. Hammond, pp. 84-97. Cambridge University Press, Cambridge.

Wright, L. E.

2005 Identifying immigrants to Tikal, Guatemala: defining local variability in strontium isotope ratios of human tooth enamel. *Journal of Archaeological Science* 32:555-566.

2005 In search of Yax Nuun Ayiin I: revisiting the Tikal Project's Burial 10. *Ancient Mesoamerica* 16:89-100.