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In Search of the "Maya Diet": Is Regional Comparison Possible in the Maya Tropics?

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ABSTRACT: For years archaeologists have attempted to describe the ancient "Maya diet" and other pan-Maya patterns in the use of animals. We need such descriptions before we can understand what animal-use choices were defined by regional culture values rather than by local resource availability. But differences in archaeological methods and theoretical focus as well as biases imposed by variability in preservation and taphonomy, both between and within sites, obstruct our comparing data sets from various Maya sites, and thereby recognizing the ancient pan-Maya animal-use patterns. This paper compares data from archaeological sites across the Maya world, discussing the theoretical premises of the research and the biases in recovery methods and preservational conditions, to evaluate the utility of the data for regional comparison. The paper discusses the possibilities for a realistic interpretation of regional or pan-Maya animal-use patterns and presents suggestions for increasing sample comparability and regional interpretation.

KEYWORDS: MAYA, FORAGING ECOLOGY, ZOOARCHAEOLOGICAL METHODS, REGIONAL ZOOARCHAEOLOGY, ANIMAL-USE

RESUMEN: Durante muchos años los arqueólogos han intentado describir la antigua "dieta maya" y definir su variedad, tanto cronológica como regionalmente. Esta descripción resulta esencial antes de que podamos comprender que opciones de usos de animales fueron definidas por valoraciones culturales de carácter regional en vez de por las disponibilidades locales de recursos. Sin embargo, los diferentes métodos arqueológicos y enfoques teóricos al igual que los sesgos impuestos por la variabilidad en la preservación y tafonomía, tanto intra como intermuestrariamente, obstruyen nuestros intentos de comparar las distintas series de datos de los diferentes yacimientos mayas. Al hacerlo impiden que seamos capaces de reconocer los antiguos patrones de uso de animales a nivel global del mundo maya. Este trabajo compara datos de yacimientos arqueológicos de todo el mundo maya valorando las premisas teóricas de la investigación y los sesgos en los métodos de recuperación y en las condiciones de conservación, a fin de evaluar la utilidad de los datos de cara a análisis regionales. El trabajo valora las posibilidades en torno a una interpretación realista de los patrones de uso animal regionales o de la totalidad del mundo maya y avanza ideas para incrementar la comparabilidad de las muestras y las interpretaciones regionales de las mismas.

PALABRAS CLAVE: MAYA, ECOLOGÍA DE SUBSISTENCIA, MÉTODOS ZOOARQUEOLÓGICOS, ZOOARQUEOLOGÍA REGIONAL, USO DE ANIMALES

INTRODUCING THE QUESTIONS

The Maya world, stretching from the Yucatan of Mexico to central Honduras, encompasses a vast environmental diversity, from dry savanna to semideciduous tropical rainforest. Maya culture was similarly complex and variable; each community depended on local resources for subsistence and on broad Mesoamerican trade networks for economic gain. The social organization and the resulting local and regional uses of the Mesoamerican environment fluctuated constantly over the 2,000 years of Maya occupation of the area. Because of this cultural and environmental variability, it is difficult to characterize the ancient Maya diet, or any other patterns in ancient Maya environmental use. Zooarchaeologists working in the Maya world have been trying for the past 50 years to recreate the ancient animal-use patterns, but our success has been hindered by the complexity of the very cultural and environmental conditions that make Maya research so fascinating.

"What animals did the ancient Maya eat?" This must be one of the questions most often asked of any Maya zooarchaeologist. Do we yet know the answer? Can we, for example, separate localized animal-use patterns from culturally pan-Maya patterns? Can we distinguish which food-related practices reflect variations within the Maya pattern (based on subgroup ethnicity, status, or chronologically fluctuating styles)? Can we even distinguish which animal-use patterns are dietary, and which are not? I believe that we can distinguish only a very few of these patterns for the Maya world as a whole, although we may already have enough evidence to determine pattern causes for certain sites.

An understanding of ancient Maya animal use must be based on broad regional comparisons of animal-use activities at many sites in various environmental contexts, and from all time periods. Given the history of Maya zooarchaeology and the variable environmental and cultural conditions of the Maya world, can we create a strong enough regional comparison to provide robust answers to questions about pan-Maya patterns in animal use? A review of the status of Maya zooarchaeology, and of the variability in archaeological and zooarchaeological methods across the science, suggests that we do not yet have an appropriate basis for regional interpretation. However, many of the issues that confound a comparative or regional analysis are surmountable both in the short term, by a realistic assessment of their impact, and in the future, by a renewed attention to those zooarchaeological methods that are of specific importance to the Maya world.

Here, I briefly outline some of the obstacles to regional comparisons in our search for a real understanding of ancient Maya animal use: first, the lack of complete data, and second, the variability we encounter in the quality of the data we do have, in terms of both preservation and research methods. I then describe several studies that are possible given our current samples, as well as some analytical techniques for which we are not yet ready, and make some suggestions for improvement in our zooarchaeological techniques that would allow for more successful future studies.

DO WE HAVE ENOUGH INFORMATION?

Maya zooarchaeology is still nascent, and the database of information incomplete. Although the regional and chronological coverage of Maya zooarchaeology is better than might be expected considering the fairly limited attention to our science in the region, significant gaps do exist in terms of faunal samples from sites and occupation periods across the region. Even where zooarchaeological remains have been analyzed from all periods or sites in an area, sample sizes are often too small to be representative.

To evaluate the completeness of Maya zooarchaeology, I have compiled zooarchaeological data from 52 sites from the available published literature (Table 1). Based on this compilation, I review the total number of analyses performed over the past five decades (Figure 1), and the geographic (Table 2) and chronological coverage (Figure 2) of these analyses.

Zooarchaeology in the Maya area began in the 1930s with the integration of biological and archaeological surveys at sites like Uaxactun (Ricketson & Ricketson, 1937); these early studies, however, were generally done by zoologists who had little or no interest in the archaeological implications of their work. The impact of the "New Archaeology" in the 1960s, with its attention to environment and regional studies, is clear in the swell of zooarchaeological research reflected in Figure 1. During the early 1960s, Gordon Willey's Belize River Valley project (Willey *et al.*,

SITE NAME	FIGURE NUMBERS	SOURCE OF DATA USED IN CHARTS
Aguateca	1, 4, 2, 6, 9, 10, 12	(Emery, 1997), unpublished data
Actun Balam	1	(Savage, 1978)
Actun Polbilche	1	(Savage, 1978)
Alta Verapaz	1	(Ashmore, 1987)
Altar de Sacrificios	1, 2, 6, 9, 10, 12	(Pohl, 1976, 1990)
Altun Ha	1	(Pendergast, 1967)
Aquiles Serdan	1, 2, 6, 9, 10, 12	(Flannery & Mudar, 1991; Blake, Chisholm *et al.*, 1992)
Arroyo de Piedras	1, 4, 2, 6, 9, 10, 12	(Emery, 1997), unpublished data
Bayak	1, 4, 2, 6, 9, 10, 12	(Emery, 1997), unpublished data
Barton Ramie	1, 2, 6	(Willey, Bullard *et al.*, 1965a)
Cahal Pech	1, 2, 6, 9, 10, 12	(Stanchly, 1995)
Cancun	1, 2, 9, 10, 12	(Wing, 1974)
Caracol	1, 6, 9, 10, 12	(Teeter, 2001, in press), pers comm.
Cerros	1, 9, 10, 12	(Carr, 1986)
Chiapa de Corzo	1	Lee, 1969
Chichen Itza	1, 6	(Cobos, 1989; Hopkins, 1992)
Chitak Tzak	1, 4, 2, 6, 9, 10, 12	(Emery, 1996)
Colha	1, 6, 9, 10, 12	(Shaw, 1991; Shaw & Mangan, 1994)
Copan	1, 2, 6, 9, 10, 12	(Pohl, 1995; Collins, 2002)
Cozumel	1, 6, 9, 10, 12	(Hamblin, 1984)
Cuello	1, 9, 10, 12	(Wing & Scudder, 1991)
Dos Pilas	1, 4, 2, 6, 9, 10, 12	(Emery, 1997), unpublished data
Dzibilchaltun	1, 2, 9, 10, 12	(Wing & Steadman, 1980)
Eduardo Quiroz	1	(Savage, 1971)
Ek Luum	1	(Shaw, 1995a)
Flores	1, 2, 6, 9, 10, 12	(Pohl, 1976, 1990)
Itzan	1, 6	(Emery, 1991)
Kaminaljuyu	1, 4, 2, 6, 9, 10, 12	(Kidder, Jennings *et al.*, 1946; Emery, 1995, 2002)
La Blanca	1, 2, 9, 10, 12	(Wake & Harrington, 2002)
Laguna de On	1, 2, 9, 10, 12	(Masson, 1999)
Lamanai	1, 4, 2, 6, 9, 10, 12	(Emery, 1990, 1999), unpublished data
Lubaantun	1, 2, 9, 10, 12	(Wing, 1975)
Macanche	1, 2, 6, 9, 10, 12	(Pohl, 1976, 1990)
Marco Gonzalez	1, 6	(Seymour, 1991; Emery & Graham, 2003)
Mayapan	1, 2, 9, 10, 12	(Pollock & Ray, 1957)
Motul de San Jose	1, 4, 2, 6, 9, 10, 12	(Emery, in press-b), unpublished data
Naj Tunich	1	(Brady, 1989)
Nakbe	1, 6	Unpublished data
Pacbitun	1, 4, 2, 6, 9, 10, 12	(Emery & Baker, 1992)
Paso de la Amada	1	(Wake, in press)
Piedras Negras	1, 4, 2, 6, 9, 10, 12	(Emery, in press-a), unpublished data
Punta de Chimino	1, 4, 2, 6, 9, 10, 12	(Emery, 1997), unpublished data
Quim Chi Hilan	1, 4, 6	(Emery, 1997), unpublished data
Salinas La Blanca	1	(Coe & Flannery, 1967)
Seibal	1, 2, 6, 9, 10, 12	(Pohl 1976, 1990)
Tamarindito	1, 4, 2, 6, 9, 10, 12	(Emery, 1997), unpublished data
Tikal	1, 2, 6, 9, 10, 12	(Pohl, 1976, 1990; Moholy-Nagy, 1994)
Tipu	1, 4, 2, 6, 9, 10, 12	(Emery, 1989, 1990, 1999)
Uaxactun	1	(Ricketson, 1937)
Ujuxte	1	(Wake, 2000)
Urias	1, 4, 6	(Emery, 2002; Emery & Robinson, in prep)
Zaculeu	1, 2	(Woodbury & Trik, 1954)

TABLE 1

List of sites used in chart calculations, with analyst and publication from which data was derived. Note that this is not a complete list of zooarchaeological analyses in the Maya region, nor of all publications associated with each site or analysis.

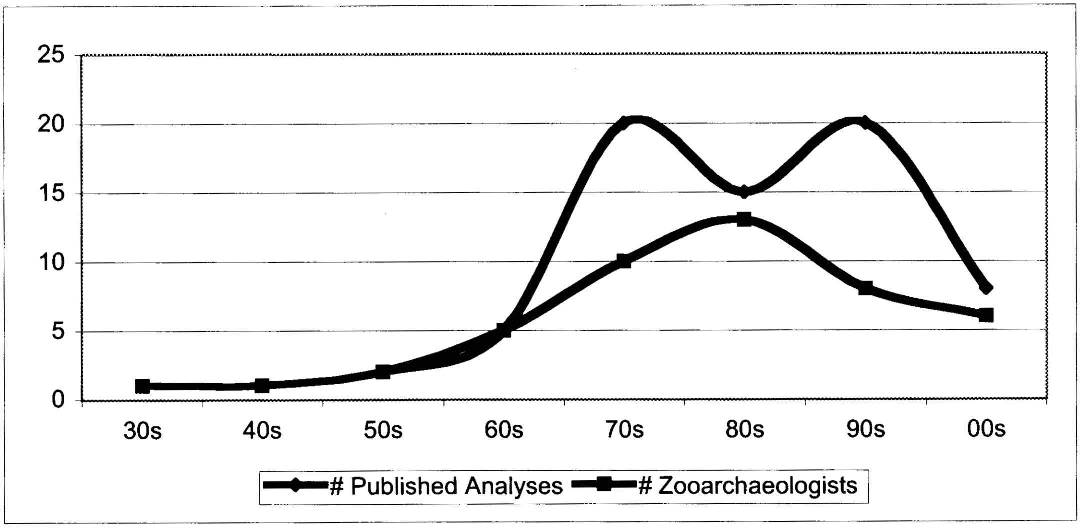


FIGURE 1

The history of Maya zooarchaeological research over the past 80 years charting by decade the number of zooarchaeological publications and the number of analysts.

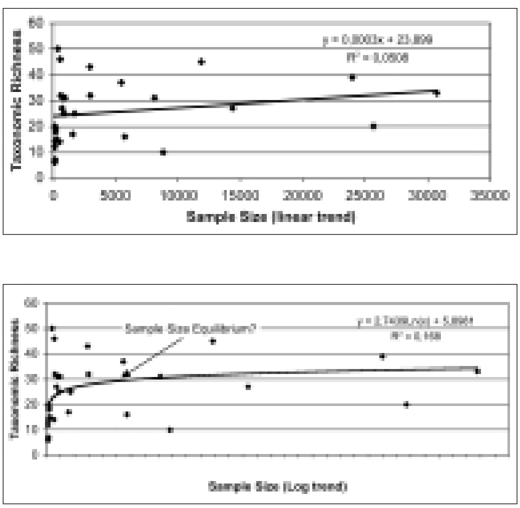


FIGURE 2

Correlations between sample size and taxonomic richness in 50 samples from the Maya world (based on published literature). (a) Correlation is presented as a linear model with significance of the association listed. (b) Correlation is presented as a log model to illustrate the point of diminishing return on taxonomic diversity as a hypothetical point of sample size representativeness.

1965b), and later the Pasión Valley project in Guatemala (Willey, 1973, 1990) as well as large settlement projects at Tikal and Dzibilchaltun (Stuart, 1958; Smithe & Paynter, 1963; Rick, 1968) specifically integrated environmental variables into research strategies and data collection.

In the next decade, Mary Pohl's pivotal work introduced the science of zooarchaeology to Maya archaeology with her dissertation research (Pohl, 1976). During the 1980s, more researchers actively pursued zooarchaeological studies at various sites – for example, Cozumel (Hamblin, 1984); Cerros (Carr, 1986); Colha (Shaw, 1991); Cuello (Wing & Scudder, 1991), and Dzibilchaltun (Wing & Steadman, 1980), among others.

In fact, more zooarchaeology was studied at that time than during any period since, despite the fact that fewer publications appeared at that point. The dramatic drop in zooarchaeological analyses during the 1990s may reflect simply a publication lag, but it is also possible that it reflects two trends. First, the effect of post-processualism and a return to cultural histories as a focus in Maya archaeology may have resulted in some loss of interest and funding for environmental research at major sites.

But a more frightening possibility is that perhaps Maya archaeologists accepted these early zooarchaeological data as sufficient evidence that ancient Maya patterns of animal use were already well enough understood. As a result, the archaeological push for Maya zooarchaeology may have lost its earlier impetus. Interestingly, Mary Pohl has noted that the authors of the three most substantial

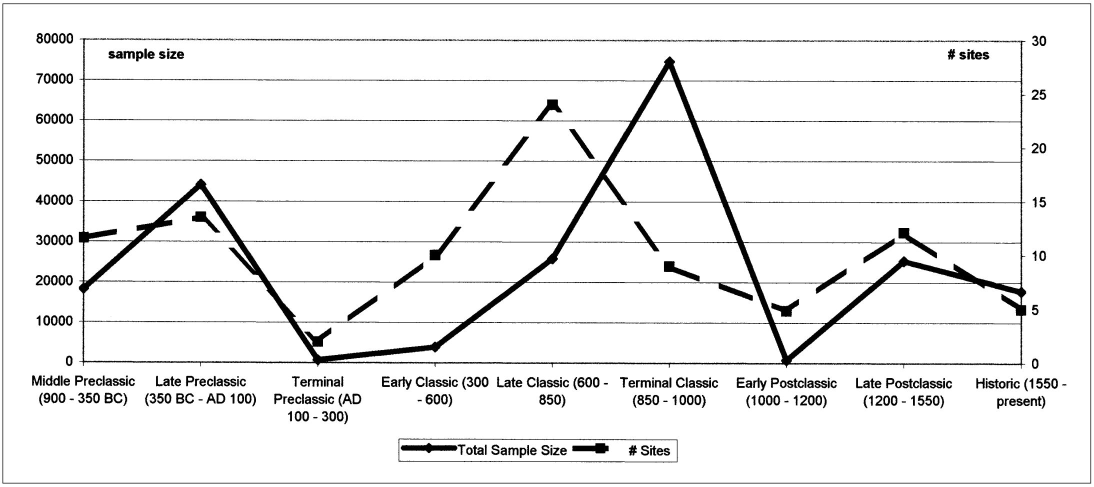


FIGURE 3

Chronological coverage of Maya zooarchaeological analyses charting for each period of Maya occupation both total number of sites analyzed (Y1 axis) and samples sizes (NISP, Y2 axis).

Ph.D. dissertations of the 1980s failed to find regular jobs in zooarchaeology. She suggests that later scholars may therefore also have been hesitant to specialize in zooarchaeological research (Pohl, personal communication, 2004).

Whatever the cause, the science of zooarchaeology has since been neglected as a specialty of particular value to the world of Maya archaeology as a whole.

Clearly then, although the number of sites for which zooarchaeological analyses have been published is fairly extensive, the geographic coverage is fairly uneven, and some regions are not well enough investigated. Furthermore, even where several sites have been investigated in some areas, the samples analyzed were too small to provide representative data on ancient animal use in these areas.

Chronological Coverage

Equally important to our review of zooarchaeological coverage over the Maya world is a clear picture of the time periods that have been studied. Again I have compiled data from 30 of the sites for which publications are available, this time charting the number of samples and number of specimens analyzed per chronological period throughout the Maya occupation (Figure 3, sites listed in Table 1). This analysis indicates that, although the Late Classic period has been well analyzed, severe gaps in our knowledge of animal use over time still exist. As a result of traditional biases in Maya archaeology, the Late Classic period is well covered both in terms of sample size and the number of sites studied. Coverage of the Preclassic is good overall. But the important transition period between the Late Preclassic and the Early Classic is not as well explored, nor is the period between the Terminal and the Late Postclassic periods. These are important transitionary periods, and pivotal for our understanding of culture change. Over the 3,000 years of occupation of the Maya world, we can expect animal-use patterns to have varied, so it is vital that we have complete data for all time periods. Again, the data I have compiled from the published literature make it clear that Maya zooarchaeologists still need to study samples from many of the important time periods.

CAN WE COMPARE SITE ASSEMBLAGES TO UNDERSTAND REGIONAL MAYA ANIMAL-USE PATTERNS?

To reconstruct any regional or pan-Maya animal-use patterns (the "Maya diet," for example) and distinguish these from the patterns that are unique to the various sites of the ancient Maya world, we not only need enough large samples, but we also need accurate and detailed data from

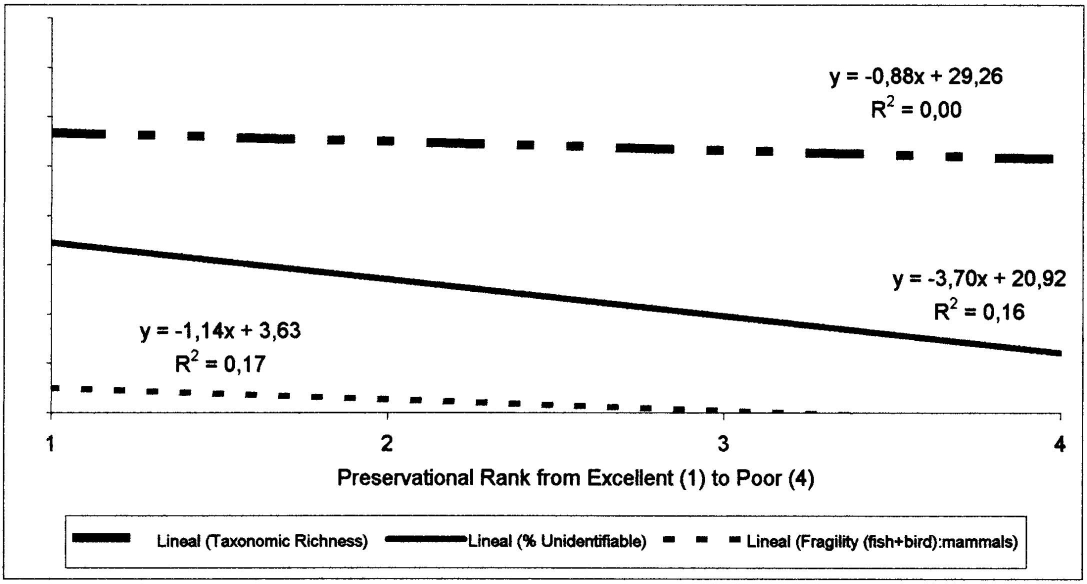


FIGURE 4

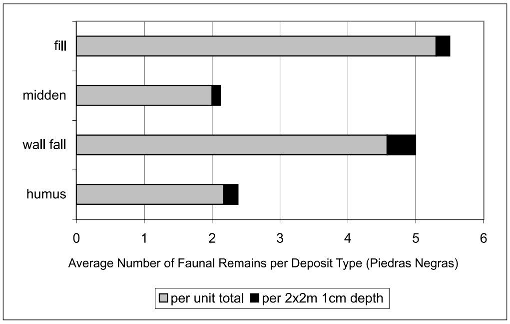
Effects of preservation on diversity, identifiability, and recovery. Linear trends for each measure track the correlation between diversity (# taxa), identifiability (% identifiable), and recovery (ratio of fragile : robust taxa and elements) and preservation rank as it drops from excellent (1) to poor (4).

those samples. The accuracy of our zooarchaeological data depends on our attention to four main issues: using appropriate methods of material recovery and analysis, understanding the potential bias in our samples that result from differential depositional and preservational factors, using sufficiently detailed comparative materials for our identifications, and paying attention to the accurate quantification of the identified faunal assemblage. These issues are even more important in the analysis of Maya faunal samples because of the heterogeneity of environmental conditions that exist between subregions. Before we can begin to compare our datasets to create pan-Maya analyses of either human or animal variation, we need samples that are directly comparable. Before we can have comparable samples, we need, first, to understand the archaeological context, especially variability in preservation, and then to be sure that our recovery and analysis methods are standardized.

Variability in Preservation

Preservation in any environment is affected by extremes of temperature and humidity, soil moisture content, and the rate of nutrient cycling and plant and animal activity in the area, among other things. In tropical regions, some of these characteristics are more pronounced. Typically, zooarchaeological samples from the Maya world are not as well preserved as they are in more temperate regions. But few published Maya zooarchaeology reports mention the specific factors that may have affected preservation, and to my knowledge there are no published discussions of relative preservation between sites for the Maya region.

To examine the effects of preservational variability between sites, I have compiled data on three factors: taxonomic richness, the percentage of remains that were unidentifiable ("% unidentifiable"), and the ratio of fragile to robust taxa. For this comparison I have drawn data from 15 sites for which I was the primary analyst and for which I could therefore rank relative preservational condition of the remains (Figure 4, sites listed in Table 1). Taxonomic richness in this case is a simple count of non-overlapping taxonomic categories (that is, *Odocoileus*, *Mazama*, but not Cervidae). The % unidentifiable count does not include remains that were left unidentified for other reasons; it includes just those that were not identifiable to the level of class or better. The ratio of frag-



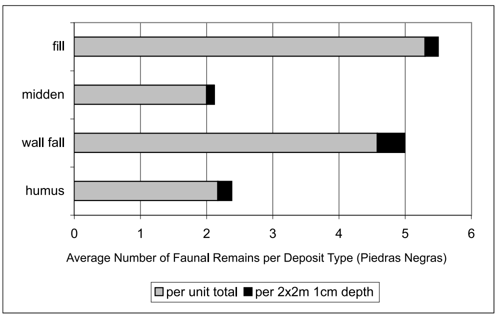


FIGURE 5

Differential recovery between deposit types comparing rate of recovery (per deposit and per unit of soil) for each of the most common deposits at the sites of Piedras Negras and Dos Pilas, Guatemala.

ile to robust for this study is calculated as [(sum of all fish) + (sum of all birds): (sum of all mammals)]. As Figure 4 shows, all three factors drop as preservation decreases. The most dramatically affected is the % unidentifiable count. However, the correlation is statistically significant between falling preservation and all three factors studied: taxonomic richness, the percentage of remains that were unidentifiable, and the ratio of fragile to robust taxa recovered.

Preservational conditions are also not constant over any one site – a fact that is emphasized by two calculations using samples I analyzed from the sites of Piedras Negras and Dos Pilas in the southern lowland Petén (Figure 5). Here I have quantified the number of remains both per deposit excavated and per unit of soil excavated. I based these analyses on estimates from established field practices described by the excavators (at Piedras Negras), or on numeric data provided by the excavators (at Dos Pilas). The formulae for these are therefore (# deposits/deposit type : # remains recovered) and (# soil units/deposit type : # remains recovered).

One archaeological assumption often made is that middens contain the most animal remains of any deposit type at a Maya site. This assumption is not supported at either of these two sites however. In fact, here, midden deposits contain considerably fewer remains than do other deposit types. A second common assumption is that at Classic Maya sites the preservational conditions of fill deposits (capped by limestone rubble and generally enclosed by plaster) encourage the greatest recovery of remains. This is true at Piedras Negras, but it is not true at Dos Pilas. A third assumption might be that the worst preservational conditions and the lowest deposition rate would be found in the humus level because of weathering and nutrient cycling. Again, although this is somewhat supported by the Piedras Negras analysis, it is not true at Dos Pilas.

Clearly the combination of depositional behavior and preservational conditions is much more complex than we understand. Any comparative discussion that does not take these factors into account will be hampered. And yet, many zooarchaeological reports do not describe or consider the different deposit types from which the remains have come.

VARIABILITY INTRODUCED BY DIFFERENTIAL RECOVERY METHODS

It is clear that the method of recovery used dramatically affects the composition of faunal assemblages. Quantitative analyses depend on the equal opportunity for recovery of each and every specimen at a site (Shaffer & Sanchez, 1994). Zooarchaeologists worldwide agree that at least a 1/4-inch (6.35 mm) screen is required for the collection of representative samples (Davis, 1987; Shaffer & Sanchez, 1994; James, 1997; Cannon, 1999). Research in many areas has indicated that for optimal recovery the most effective screen size is 1/16-inch (1.58 mm) (Wing & Quitmyer, 1992; Reitz & Wing, 1999: 120), and the use of 1/8-inch screen has been shown to be more effective than 1/4-inch (Wing & Brown, 1979; Shaffer, 1992; Shaffer & Sanchez, 1994; Cannon, Schwarcz *et al.*, 1999). Despite this research, recovery methods used at Maya sites are highly variable, often not noted in zooarchaeological reports, and frequently inappropriate to the recovery of a full taxonomic assemblage (most deposits are not

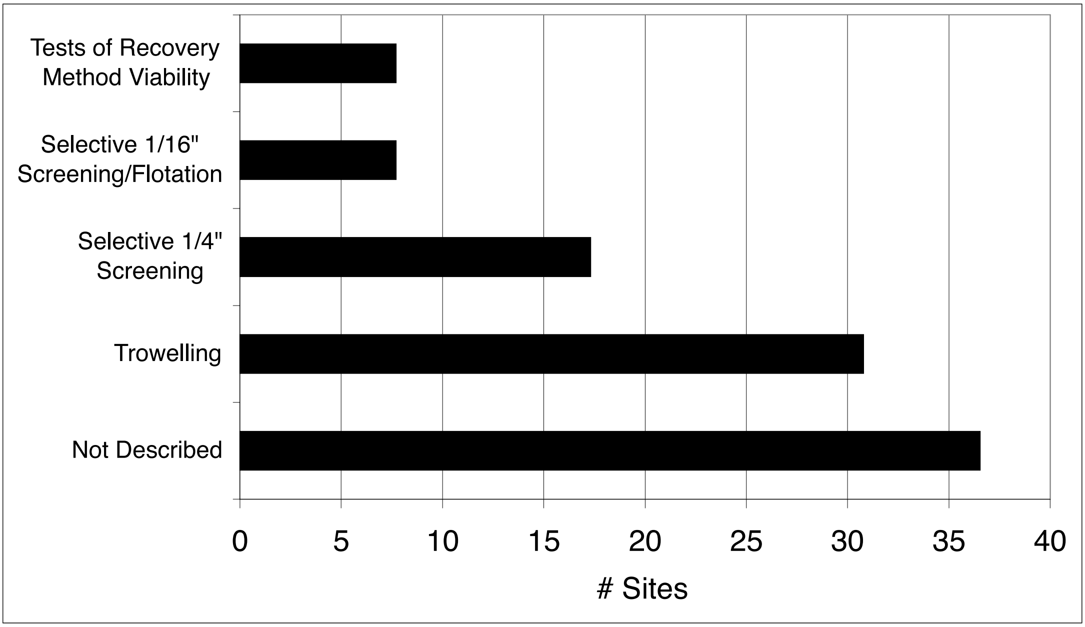


FIGURE 6

Recovery methods used at Maya sites charted as number of reported sites employing each recovery method or reporting a test of recovery method viability.

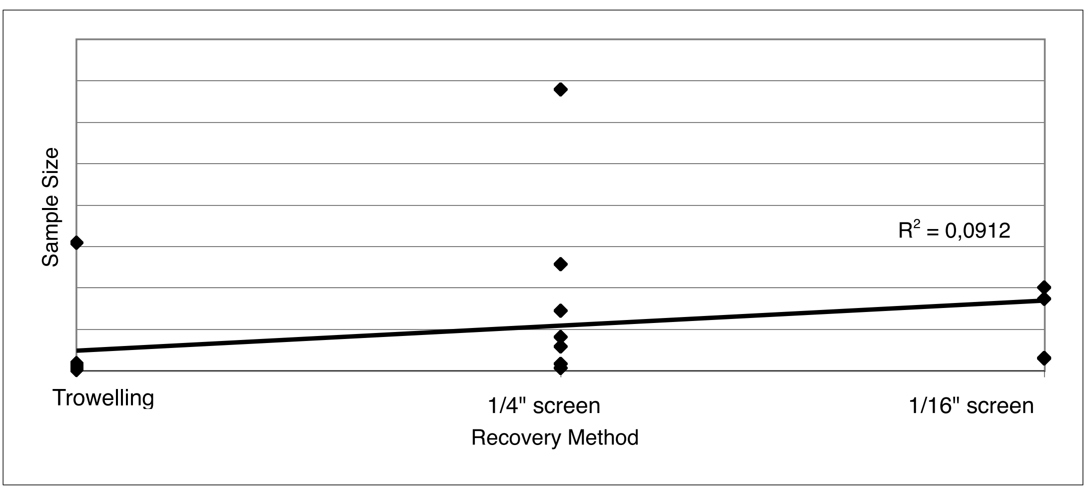


FIGURE 7

Effects of recovery method on sample size at various sites indicating the correlation between improved quality of recovery method used and increasing sample size.

screened although most special deposits receive special attention, and many archaeologists now consistently screen or float occupational and midden debris).

In a review of the recovery methods used at 31 sites across the Maya world (Figure 6, sites listed in Table 1) I have classified recovery by (1) simple hand recovery (generally by troweling although often by pickaxe); (2) selective screening (1/4-inch screen) of occupational surfaces, special contexts, and middens; (3) selective 1/16-inch screening or flotation with a 1/16-inch basal mesh or better for heavy fraction recovery; (4) or any test of the efficacy of different recovery methods. At the Petexbatún sites for example, 1/4-inch screens were used on selected deposits. Samples were floated from those same deposits, and the heavy fraction for each was reviewed. Few or no remains were found in any of the heavy fraction subsamples, suggesting that further decreasing the gauge of screens used at this site would not recover significantly larger or more representative samples. Preservation was so poor at those sites that most deposits yielded no fragile or small remains. This can be considered an appropriate test of the efficacy of the recovery methods used, but even those tests must be reported in the literature to ensure that the sample can be recognized as complete.

Most Maya zooarchaeological reports do not mention the method of recovery (Figure 6). Over 30% of all samples were recovered only by hand troweling, and only 7% were recovered using the more detailed methods that the rest of the zooarchaeological world considers essential for the recovery of a full complement of zooarchaeological remains. The effects of these different methods on the samples recovered are not surprising (Figure 7). In this sample, a positive correlation between sample size and detail of recovery method was statistically significant ($R^2 = 0.0912$). As the sample methods are refined, the sample size increases.

Further, I compare the effects of flotation or 1/16-inch screening at the Postclassic/Historic Belizean site of Tipu and at the Classic period site of Piedras Negras in the Guatemalan Petén (both samples from my own research) with those from the Preclassic site of Colha in northern Belize (Shaw, 1991) (Figure 8). This comparison clearly illustrates better than 50% improvement in the quality of the remains recovered at these sites with the use of fine-gauge screening (1/16-inch). Here the total taxonomic diversity for each assemblage was subdivided to illustrate the portion recovered from trowel-excavated deposits versus fine-screened deposits. Anywhere from 60% to 90% of the small taxa in these assemblages has come from

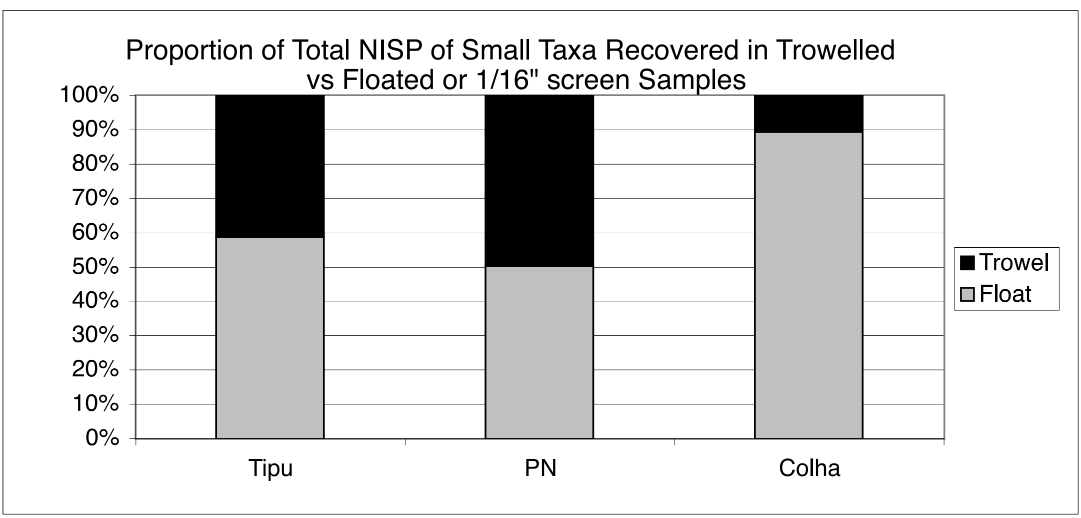


FIGURE 8

Effects of recovery method on recovery of small taxa charting the proportion of total NISP of small taxa recovered in troweled versus floated or 1/16" screened samples.

fine-screened or floated samples; these would have been missed had the deposits not been screened.

CAN WE ANSWER ANY QUESTIONS ABOUT REGIONAL OR PAN-MAYA PATTERNS IN ANIMAL USE?

Despite all these problems in our investigation of ancient Maya animal use, Maya zooarchaeology has had considerable success in reconstructing regional patterns. The zooarchaeological data from the Maya world promise great potential as long as we recognize and ameliorate the obstacles to inter-site comparison before we attempt any discussion of regional variability or pan-regional patterns. Needless to say, we are a long way from pinpointing the real complexity of ancient animal use. Nevertheless I would like to present some examples of what is already possible in regional comparisons, and what might be possible in the near future.

Patterns of Ancient Maya Dog Use

Despite the variabilities in preservation and recovery, dog remains are among the more substantial zooarchaeological finds. They are both easily recovered without screening and generally easily recognized by analysts. As the only true Maya domesticate before the Late Postclassic introduction of the turkey, the dog has been the subject of considerable discussion; its pattern of use was both as a steady source of meat for many communities (Wing, 1978) and as an important component of ritualized feasting (Shaw, 1991, 1999). Research at sites like Colha and Cerros (Carr, 1986) suggests that dogs were particularly important as food during the Preclassic period. The historic literature also suggests that dogs were a valuable ritual and tribute food during the Historic period (Pohl & Feldman, 1982; Shaw, 1999). This evidence raises questions, however: What role did dogs play during the Classic period? And is the evidence for Preclassic and Historic period dog use borne out in a regional perspective?

Here I have calculated the ratio of dogs to all mammals (including dogs) for 20 Maya sites of var-

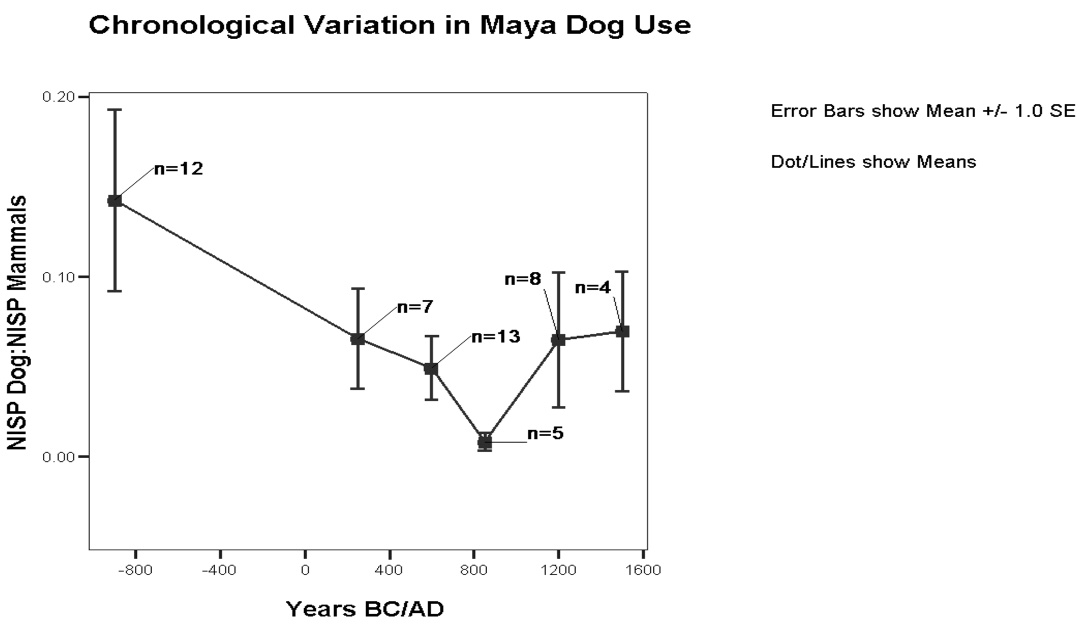


FIGURE 9

Variations in Maya dog use over time at Maya sites (calculated as a ratio of dog remains to the remains of all mammals per site) (N = number of sites per time period).

Northern Lowlands	Southern Lowlands – Inland:Guatemala	Southern Lowlands – (Belize/Honduras)	Southern Lowlands – Carib. Coast	Southern Lowlands – Pacific Coast	Southern Highlands – Inland
Isla Cancun	Tikal	Copan	Ek Luum	Ujuxte	Kaminaljuyu
Cozumel (5)	Altar de Sacrificios	Puerto Escondido	Marco Gonzalez	La Victoria	Urias
Dzibilchaltun	Ceibal	Pacbitun	Moho Caye	La Blanca	Chitak T'zak
Chichen Itza	Motul de San Jose	Barton Ramie	S. Belize coast	Paso de la Amada	
Mayapan	Uaxactun	Caracol	Cuello	Aquiles Serdán	
	Petexbatun (6)	Laguna de On	Cerros		
	Petén Lakes (3)	New River Lagoon	Colha		
		Lamanai	S. Belize Cayes		
		Belize caves (3)	Nohmul		
		Lubaantun	Altun Ha		
		Albion Island			
		Cahal Pech			
		Tipu			
		K'axob			

NISP:100-1000
NISP:1000-10,000
NISP:>10,000

TABLE 2
Regional Coverage of Zooarchaeological Analyses for the Maya World (based on published reports).

ious time periods (Figure 9). In this and all the following analyses, I have used the dependent variable as an index only against mammals and not against all taxa. This is to counteract the variable recovery of more fragile or smaller taxa, as well as the fact that some of these analyses exclude invertebrates from the overall specimen count. Here the dog index is plotted as mean values over the periods (N = the number of samples in each chronological period).

It does appear that, even in this regional overview, dogs were most important in the Maya diet during the Preclassic period, with a resurgence in the frequency of their remains in deposits from the early Postclassic period following a consistent decline over time in the intervening periods. A chi-square test shows that this variation over time is significant ($P = 0.000$), and an independent samples t-test cut at the Early Classic period shows that the greatest difference lies between the earliest periods of occupation and the Late Classic. But one intriguing and unexplained puzzle is the reappearance of dogs during the Terminal Classic period (significant separation found by Mann-Whitney U [$P = 0.02$] between the Late Classic and Terminal Classic periods). To explore the possible reasons for this reappearance of dog use on a regional basis, I turn to another animal group.

Patterns of Ancient Maya Bird Use

As part of an answer to the puzzle raised by the regional patterning in dog use, I turn to a discussion of bird use in the Maya world. I have calculated the ratio of bird to mammal NISPs for a total of 20 sites (Figure 10). Birds are generally one of the "fragile" categories and therefore their remains are less often collected and preserved, so this study should be approached with caution. However, I have also calculated the ratio of turkey to mammal remains. Even without screening, most large bird remains will be collected by hand, and they are well preserved even in terrible conditions.

The pattern is dramatic. Over time we see increases in the proportion of overall birds to mammals (around 800 AD, or the Terminal Classic period), and of turkeys to mammals (shortly thereafter). These patterns are again confirmed by statistical analysis. Chi-square tests show both are significant variations (birds, $P = 0.005$; turkeys, $P = 0.000$), and an independent samples t-test cut at the Terminal Classic indicates that the periods before and after 800 AD are significantly different (birds, $P = 0.007$; turkeys, $P = 0.000$).

What do these results indicate? One intriguing possibility is the introduction of a new hunting technology. Pendergast (1990) has shown that at Lamanai the Postclassic period is associated with the arrival of a new lithic technology characterized by small side-notched arrowheads, suggesting the integration of the Mexican bow-and-arrow technology into traditional Maya hunting techniques. Today the Lacandon Maya use similar small side-notched arrowheads to hunt both birds and fish (Nations & Clark, 1983).

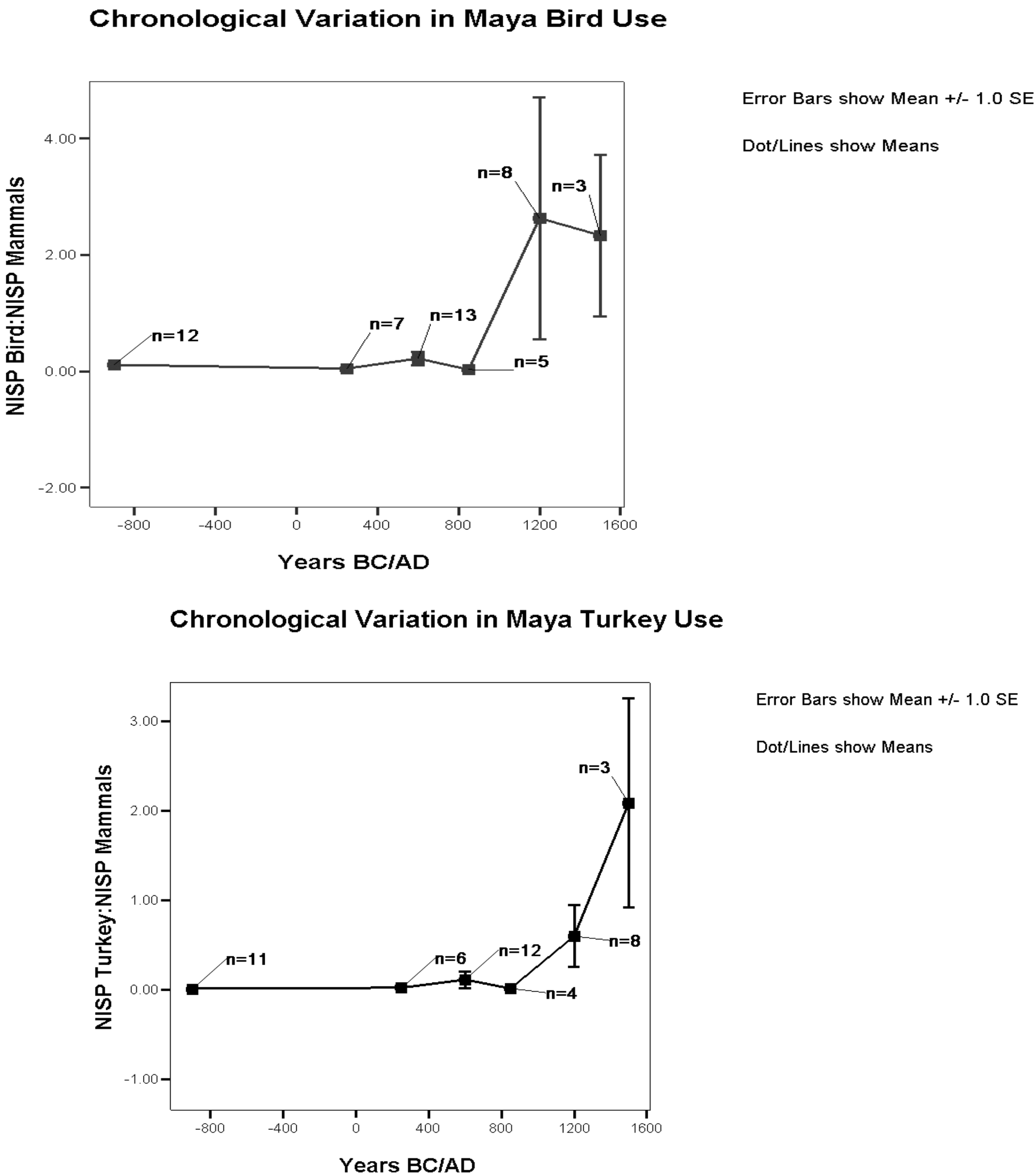


FIGURE 10

Variations in Maya bird use over time at Maya sites (calculated as a ratio of bird remains to the remains of all mammals per site) (N = number of sites per time period).

Another possibility could be the increase at this time of the use of turkeys as a standard commodity for ritual feasting. It was also during the Postclassic transition (a period of considerable population migration and transfer of both goods and ideas) that other new animal-use patterns (Emery, 1999), including possibly the idea of domesticated turkeys, may have been exchanged with northern Mexico (Hamblin & Rea, 1985; Shaw, 1995b). Certainly the ethnohistoric literature again points to a significant role for the turkey in ritual feasting during these late periods (Pohl & Feldman, 1982;

Pendergast & Jones, 1992). The arrival of the first domestic turkeys during the Postclassic is suggested by zooarchaeological analyses at Cozumel and elsewhere (Hamblin, 1984); however, zooarchaeologists have yet to carefully examine all finds of turkeys to verify the date of the first Maya use of these domestic birds.

Is there any link between the evidence for dog and bird distribution? Is it possible that the periods of increased use of dogs and turkeys are also periods of increased ritual and social feasting activities? Or are the two distributions explained best by the more functional evidence for, in the first place, the requirement for a stable and controllable meat source during the period of developing social complexity in the Preclassic, and, in the second place, a simple transition in hunting technology during the Postclassic?

Patterns of Ancient Maya Hunting and Resource Depression

Of all the questions surrounding cultural patterning, one of the biggest, for Maya zooarchaeologists today, is whether the Maya had enough meat – and linked to this question, whether they hunted out all their prey and therefore succumbed to eventual protein deficiency during the later periods of their occupation. These questions of resource use can be approached in various ways, two of which I discuss here.

1) *Quantifying Density and "Amount of Meat"*: The first approach is, I suspect (for all the reasons I introduced above) inappropriate to the research question (despite its having been used in several publications): This method is an attempt to quantify total meat from total bone or shell counts.

In what seems like a logical approach to the question of "amount of meat," some authors have suggested quantifying the relative densities of animal remains found in deposits over time. If we assume (albeit a dangerous assumption) that most sites will have approximately the same mix of deposit types, and the same concentration of samples from urban versus rural areas, and residential versus ritual structures, and if we assume that internally consistent recovery methods have been used, we could attempt to consider site density as a whole (Figure 11). For this method, I have compiled data on the relative density of remains in different time periods at Tikal (Moholy-Nagy, 1994), Tipu, the Petexbatún (samples drawn from my research), and Laguna de On (Masson, 1999). The density measure varies – in some cases being listed by the original authors as NISP per lot and in some cases as NISP per unit volume of soil. Although the results as charted on Figure 11 may suggest site-specific density shifts over time, they are more likely to indicate differences in excavation focus, recovery method, or preservation at the several sites than actual differences in meat in the ancient diet through time. As every zooarchaeologist knows, this method is fraught with potential difficulties introduced by variability in deposition, preservation, and recovery.

2) *Foraging Models and Large Game Depletion*: I believe that a more effective way to approach the question of Maya meat eating is through the use of foraging models. Research based on ecological models of predator/prey interaction (Griffiths, 1975; Schoener, 1979; Stephens & Krebs, 1986) suggests that foraging follows a predictable pattern that leads to "resource depression" – that is, the reduction in essential resources within a territory or "patch." These models have been used by Broughton and others (Broughton & Grayson, 1993; Madsen, 1993; Broughton, 2001) in concert with ethnographic analogies to suggest two separate patterns of hunting by high-order predators like humans. As human predators forage, they target large-body prey that provide the most efficient return on hunting time and effort. As those large-body prey are selectively hunted out, there is a reduction in foraging efficiency as the hunters are forced to include smaller body prey (which is less efficient in nutrient return). This also has the effect of increasing resource diversity, as more individuals of a wider range of taxa are included in the diet.

These patterns should be evident in the Maya zooarchaeological record, and I believe that we are ready to use the available data to tackle this issue from one of the two possible angles. As the analyses of preservational and recovery variability on sample size and taxonomic richness have shown, we cannot, unfortunately, measure relative diversity over the Maya area. Our recovery methods and depositional characteristics are simply too variable to ensure that our samples are comparable in terms of taxa recovered.

Even without refined recovery methods, however, all excavators regularly recover large mammals. They are well preserved even in poor conditions and can still be identified. Although they may

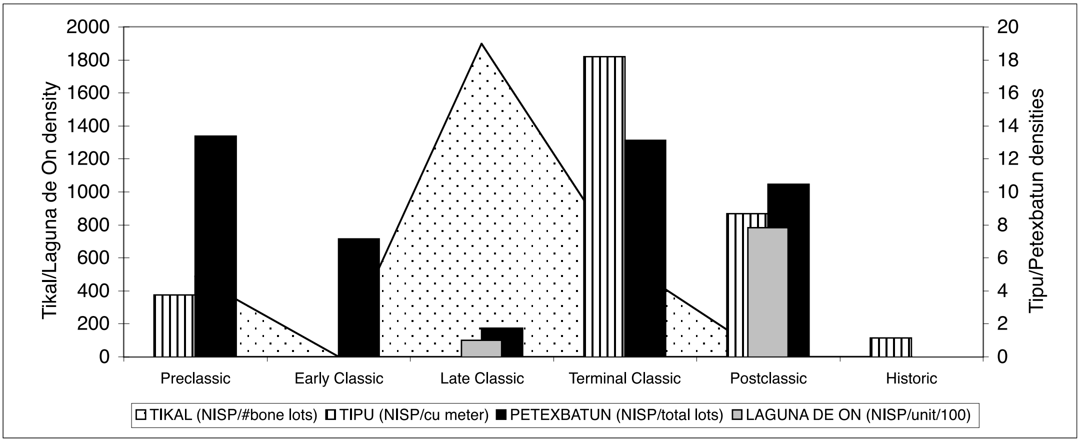


FIGURE 11

Density of animal remains in Maya deposits at Tikal and Laguna de On (Y1 axis) and Tipu and Petexbatún (Y2 axis). Variable density measures are listed as reported by the original authors.

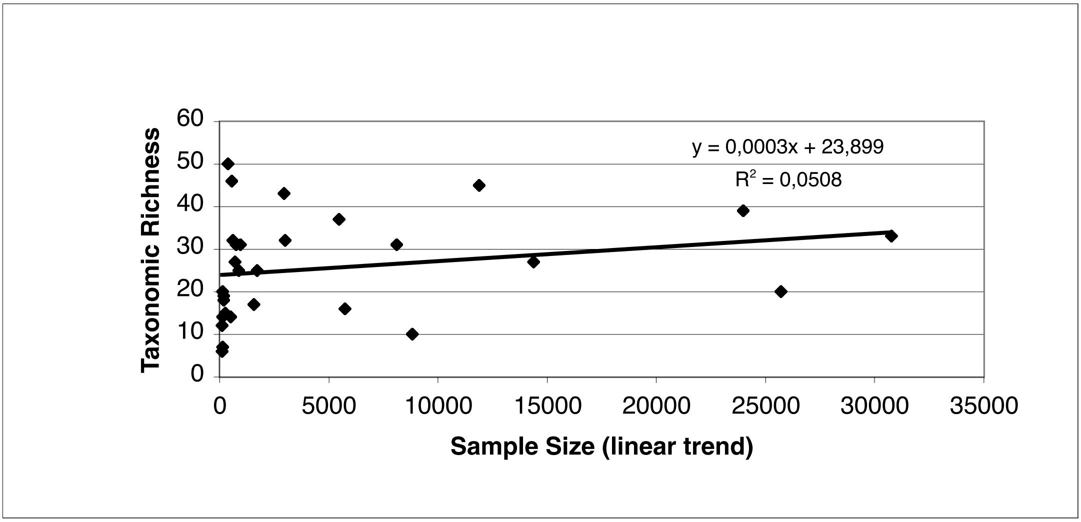
be differentially distributed through deposits and across sites, they will likely be distributed in much the same way over the entire range of sites examined.

Given that mammals present a fairly comparable taxonomic group across sites in the Maya world because they are better recovered, preserved, and identified than other taxa, I have calculated various ratios using mammal remains from 33 sites to test the foraging model of resource depression (Figure 12). This model suggests that if the Maya had been overhunting their environs, we should see a reduction in the largest meat-bearing fauna and particularly in the favorite species. The favored species for the ancient Maya was the white-tailed deer; it is ubiquitous across the landscape, is the largest meat package attracted to gardens, and is easily accessible. Other large mammals included in the Maya diet were the large peccaries, the reclusive tapir, and the smaller brocket deer.

Over time we can see a gradual decline in deer as a proportion of all mammals into the Postclassic period. After that period and into the historic years (when human settlement was not as dense in the region), deer rise again in relative abundance. Large mammals (all artiodactyls and the tapirs) are similarly affected by a reduction in relative frequency over time, in this case following a rise in the frequency of large mammals in the Early Classic. Presumably as these larger, more favored prey were hunted out, they were replaced by small prey, as the hunters attempted to supply the required proteins. Interestingly, the rebound in large game overall is more rapid, beginning during the Postclassic period and taking very few years.

Unfortunately the samples for these analyses are much more variable than they were for the bird and dog analyses, with the result that the statistical analyses are less compelling. Although an independent samples t-test cut at the Terminal Classic for the deer is significant at $P = 0.024$, it is not significant for the large mammals as a whole. Neither the deer nor the large-mammal assemblages comparisons are significant in chi-square analyses, likely indicating that foraging responses are localized as some sites reach the point of being hunted out more rapidly than others. However, with the addition of a greater sample set and a more detailed look at specific sites, I hope to refine this analysis and create a strong argument for the effects of Maya hunting on deer and large mammals on a regional and chronological scale.

The role of overhunting in animal species abundances has been suggested as a major factor in the "collapse" of the ancient Maya (Santley *et al.*, 1986; Culbert, 1988; Pohl, 1990), although without giving significant support for the model. Perhaps, with time, we may be able to address this model and other questions about the environmental sustainability of Maya hunting practices. We might be able to reveal such overhunting by analyzing body size reduction and changing age distributions over time among the various animal



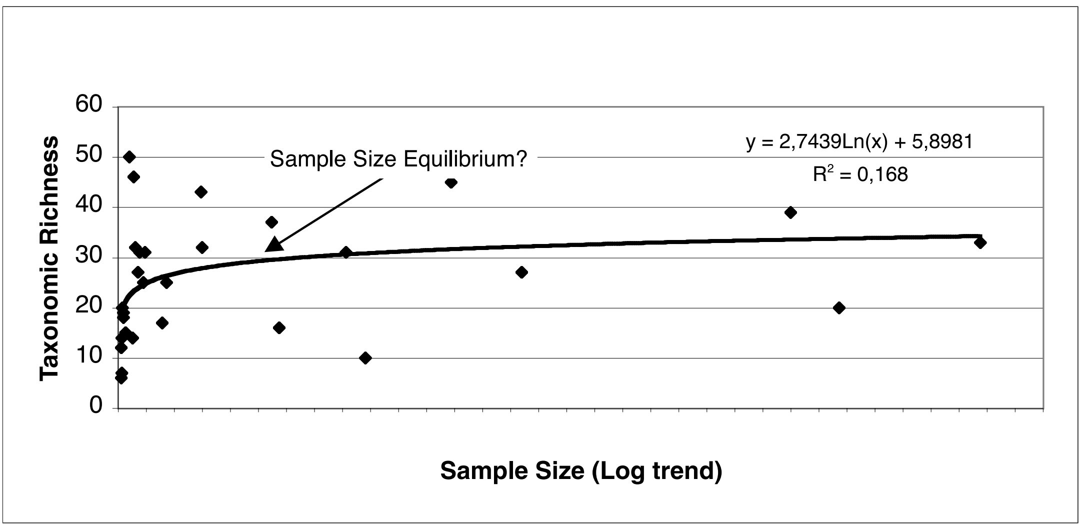


FIGURE 12

“Resource depression” or changing use of large game over time. These charts indicate measures of variation over time in frequency (NISP) of (a) large mammal remains to all mammal remains and (b) white-tailed deer to all mammal remains at various Maya sites (N = number of sites per time period).

populations. These studies remain to be tackled by Maya zooarchaeologists (although see Carr’s [1996] excellent discussion of deer management strategies among the Maya).

SUGGESTIONS FOR CREATING A REGIONALLY COMPARABLE DATASET

This paper discusses the limitations to regional comparison in the Maya world, and the possibilities that already exist for answering some substantial dietary questions. It focuses on the problems introduced by the twin issues of variability in the preservation of remains and variability in recovery techniques, and mentions briefly several other issues (the effects of archaeological bias in the recovery of remains from urban areas versus the periphery, from occupational versus ritual behaviors, and from different status and occupation groups, and as well, the effects of bias introduced by multiple researchers), which are nevertheless important and need further investigation.

From the analysis of preservation and recovery, it is clear that we should pay greater attention to the preservational characteristics of the sites for which we do zooarchaeological analyses. What are the general preservational characteristics? What are the variations between deposit types? And what proportions of our remains come from each possible preservational environment? We should also consider a quantifiable ranking system for the preservational condition of the remains themselves. When a zooarchaeological report notes an "excellent" or "poor" condition, what does that mean on a relative scale?

As well, we must consider the variability introduced by recovery methods. Obviously 1/16-inch screening creates larger, more complete, and more representative samples in many cases. Yet such detailed sampling methods may not be appropriate for all situations (Vale & Gargett, 2002, although also see Wake, this volume). At the very least, archaeologists in the Maya world should be encouraged to test the efficacy of the various recovery methods by selective recovery tests in each different deposit type they encounter at the site.

It also seems clear, though this paper does not discuss it in depth, that we need to keep in mind the effects of researcher bias. I have wondered for example, to what extent the apparent diversity of our assemblages might correlate with the taxonomic diversity of the type collection used (see Wake, this volume). There are many questions of this nature that deserve further exploration.

But I still believe that, even with the remains we currently have available, we can make some interesting comments on the "Maya diet" and other culturally linked animal-use patterns in the Maya world. If we are careful with our comparative analyses, we might be able to find chronological patterning that is characteristic of the Maya area as a whole, and that therefore reflects broad societal changes or cultural patterns and not simply the availability of local resources.

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