

MAYA ZOOARCHAEOLOGY:

New Directions in Method and Theory

Edited by Kitty F. Emery



Monograph 51

Costen Institute of Archaeology, University of California, Los Angeles



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Preface

In the past three decades zooarchaeological research in Mesoamerica has intensified in tandem with an increasing sophistication of analytical techniques and a growing complexity and diversity of theoretical questions. The study of ancient animal use is now widely recognized in the field of Maya archaeology. Technical innovations in the physical and historical sciences are now often incorporated into the zooarchaeologist's methodological repertoire, and the integration of new methods both broadens the field of analysis and sharpens the quantitative focus of modern faunal studies. In turn, these technological advances encourage a new and wider perspective on the traditional zooarchaeological questions of the Mesoamerican region (Figure 1). Although faunal investigations in the Maya area continue to focus on the traditional reconstruction of ancient subsistence patterns, recent studies increasingly examine the environmental and social aspects of the relationship between the ancient Maya and their animal resources.

The 1997 Society for American Archaeology symposium, "Current Research in Maya Zooarchaeology," organized by Norbert Stanchly and myself, faced the challenge of drawing together the community of zooarchaeological researchers in the Maya area to build a common understanding of the breadth of Maya zooarchaeology. The participants highlighted current research and discussed the role of fauna in ancient Maya diet, feasting, trade, and ritual. The symposium met with unqualified enthusiasm, and the session provided an important forum for communication among the various generations of researchers interested in the role of animals in ancient Mesoamerica. This volume continues that forum and broadens the conversation to include a wider range of both participants and topics for discussion.

Although the 1997 symposium reviewed current and ongoing zooarchaeological projects,

and incorporated both final and preliminary analyses, this volume is a more comprehensive work, combining traditional zooarchaeological reports and various state-of-the-art summaries of methods and theoretical perspectives. This combination of detailed discussions of basic zooarchaeological data with reviews of important themes in Maya zooarchaeology emphasizes the central issues that guide our research from basic data collection through final comparative interpretation. The chapters emphasize the newest developments in technical methods, the most recent trends in the analysis of "social zooarchaeology," and the broadening perspectives provided by a new geographic range of investigations. The main focus of the volume remains on fostering cooperation among Mesoamerican zooarchaeologists at the levels of both preliminary analysis and final theoretical reconstruction.

In keeping with this goal *Maya Zooarchaeology: New Directions in Method and Theory* has been subdivided into six thematic categories, each tied to the overall emphasis on current theoretical directions of the science. In chapter 1, which serves as an introduction to these six thematic sections, I present a critical history of the science of zooarchaeology in the Maya realm and defines the volume's focus and themes.

Part 1, *Methods in Maya Zooarchaeology*, provides insights into the methods of zooarchaeology as they apply to the unique Mesoamerican environment and the complexities of ancient Maya culture. In chapter 2, the first chapter in this section, I review methodological issues in Maya zooarchaeology today, placing particular emphasis on those methods presented in this volume. In chapter 3 Norbert Stanchly presents a detailed discussion of the status of the important field of taphonomy in Mesoamerican zooarchaeology, and in chapter 4 Harriet Beaubien emphasizes the importance of excavation and

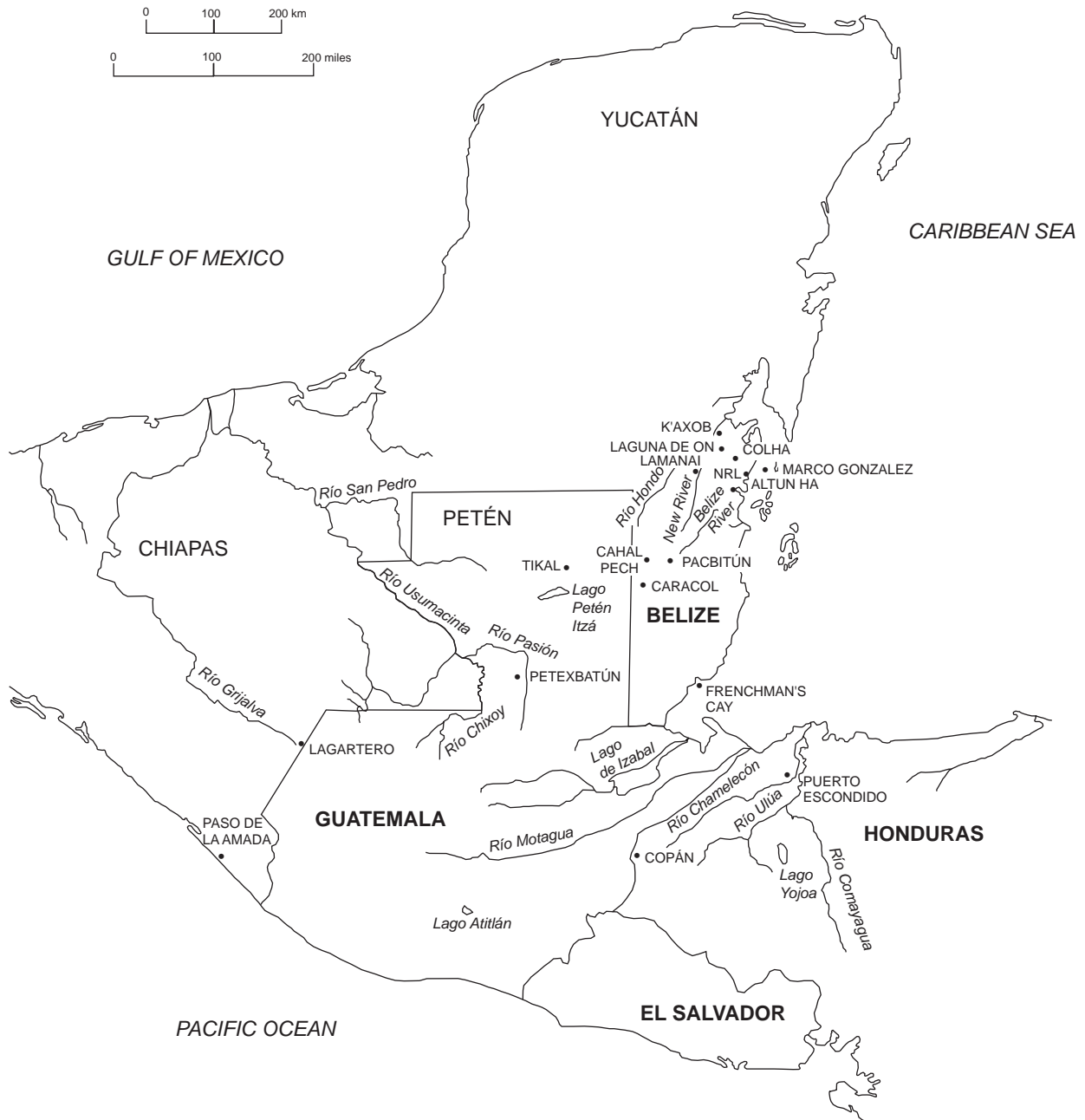


Figure 1. Map of main sites discussed in *Maya Zooarchaeology*.
Unless otherwise noted, all maps have been drawn by Kitty F. Emery.

recovery methods by describing the conservation of a unique invertebrate funerary assemblage.

In part 2, *Animal Remains and Environmental Reproductions*, chapter authors shift our attention to new techniques in environmental reconstruction. In chapter 5 Heather McKillop and Terance Winemiller apply new techniques in GIS technology to coastal archaeomalacology. Their discussion is followed in chapter 6 by my nontraditional use of bone chemistry and ecosystem fidelity analyses in reconstructing the Classic Maya environments. These analyses are complemented in chapter 7 by Marilyn Mason's discussion of subsistence and economic responses to changing habitats and resource availability. Together these chapters highlight intriguing perspectives on zooarchaeological methods of ancient environmental reconstruction.

Part 3, *New Interpretations of Ancient Species Significance*, presents three new techniques used in the evaluation of specific species use in the ancient Maya world: a nutritional and ecological assessment of a freshwater mollusc (Terry Powis, chapter 8), an isotope analysis of Maya animal management and domestication (Christine White et al., chapter 9), and a biomass analysis of marine fishes and their dietary importance at a coastal site (Kevin Seymour, chapter 10).

Modern zooarchaeological research recognizes the vital importance of animal resources as part of the political, religious, and economic life of the ancient Maya, and the volume's fourth section—*Maya Animals in Ritual, Politics, and Economics*—reflects this understanding in its two chapters: Wendy Giddens Teeter's center/periphery analysis of animal use at Caracol (chapter 11) and Hattula Moholy-Nagy's reconstruction of Classic period use of fauna in ritual deposits at Tikal (chapter 12).

In part 5, *Reconstructions from the Borders of the Maya World*, two chapters look at animal-use patterns from the peripheries of the Maya world. In chapter 13 Thomas Wake looks

to the north, and in chapter 14 John Henderson and Rosemary Joyce look south. Together Wake, Henderson, and Joyce broaden the geographic boundaries of the science of Maya zooarchaeology and present important comparative data.

In the final section, *New Perspectives on Maya Zooarchaeology*, two discussions tie together the diverse strands of today's Maya zooarchaeology. In chapter 15 David Pendergast takes an archaeological perspective, and Elizabeth Wing follows, in chapter 16, with a zooarchaeological perspective. These concluding chapters present models for a unified method and theory based on the themes presented in the earlier chapters.

We hope that this volume will be valuable as a review of the current status of zooarchaeology in the Maya world, as a foundation for understanding the implications of the important new directions of Maya zooarchaeology, and as a catalyst for the continued expansion of our methodological, theoretical, and geographic frontiers. In the face of the recent increase and diversification of researchers, methods, and theoretical inquiries, it is essential that such a volume be offered to a wide audience in order to promote communication among researchers and reunification of a zooarchaeological methodology and theoretical paradigm.

Acknowledgments. This volume could not have been accomplished without Norbert Stanchly's constant encouragement. The 1997 SAA session was his idea, and he was pivotal in getting this volume on the road. I would also like to thank Marilyn Beaudry-Corbett for her initial invitation, her enthusiastic support, and her unending patience with the inevitable glitches. This volume has also been substantially improved by commentary from our two reviewers. My very deepest gratitude goes to my scientific and editorial advisers, and to the publishers and editors of the *Cotsen Institute of Archaeology*.

Kitty F. Emery

Maya Zooarchaeology

Historical Perspectives on Current Research Directions

Kitty F. Emery

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The history of Maya zooarchaeology is closely tied to the developmental trajectories of the anthropological and ecological sciences and global changes in scientific paradigms. Environmental variables have always been part of archaeological research, but early zooarchaeological analyses in the Maya region were theoretically marginalized, having no place in either research design or contextual interpretation. Today Maya zooarchaeology searches for a new paradigm to both reunify the diverse areas of inquiry within the science and integrate environmental data into archaeological research at all levels. This brief introduction to the studies that make up this volume provides the basis for a definition of modern zooarchaeological research techniques and a unified theoretical perspective on ancient Maya animal use.

Zooarchaeology—the analysis of animal bone and shell assemblages from archaeological deposits for the purpose of elucidating past cultural and environmental patterns—is one of several environmental archaeology studies built on the foundations of the biological and geological sciences and molded by the theoretical trends of archaeological paradigms and research foci. The science was first introduced to Mesoamerican archaeological studies, particularly in the Maya region, in the early 1930s, but it has recently enjoyed a methodological resurgence in tandem with the increasing recognition of the complexity of cultural adaptations to the highly diverse and fragile environments of Middle America.

The Maya world can be geographically defined, on the basis of general cultural commonalities, as the region between the Gulf Coast to Isthmus of Tehuantepec “Intermediate Area” of southern Mexico, and the Ulúa and Comayagua river valley systems of Honduras (Figure 1.1). The environments of this area are remarkably varied and encompass ecosystems ranging from lowland and highland moist and

dry forests, to low brush swamps and savannas, to dry-desert interior and coastal valleys. Both Nearctic and Neotropical fauna roam the forests, deserts, and savannas of the Maya area, and the zoogeography of the region is one of the most complex in the world (see appendix for a list of zooarchaeologically recorded fauna of the Maya area mentioned in this text).

The Maya world, however, was only one part of a wider Mesoamerican interaction sphere from its very beginnings, and there is no doubt that the wider environmental and cultural sphere also had its effect throughout the history of the Maya (Figure 1.2). The first “Maya” complexes arise in direct association with the formative trends of the Gulf Coast, and there is considerable evidence for a continuity of Olmecoid iconographic elements, and particularly faunal complexes including the felids and reptiles, through Maya prehistory (Adams 1977; Coe 1977). Although the effects of early associations between the Maya world and northern Mexico during both the Early and Terminal Classic periods are the subject of considerable controversy, the link between these cultures is

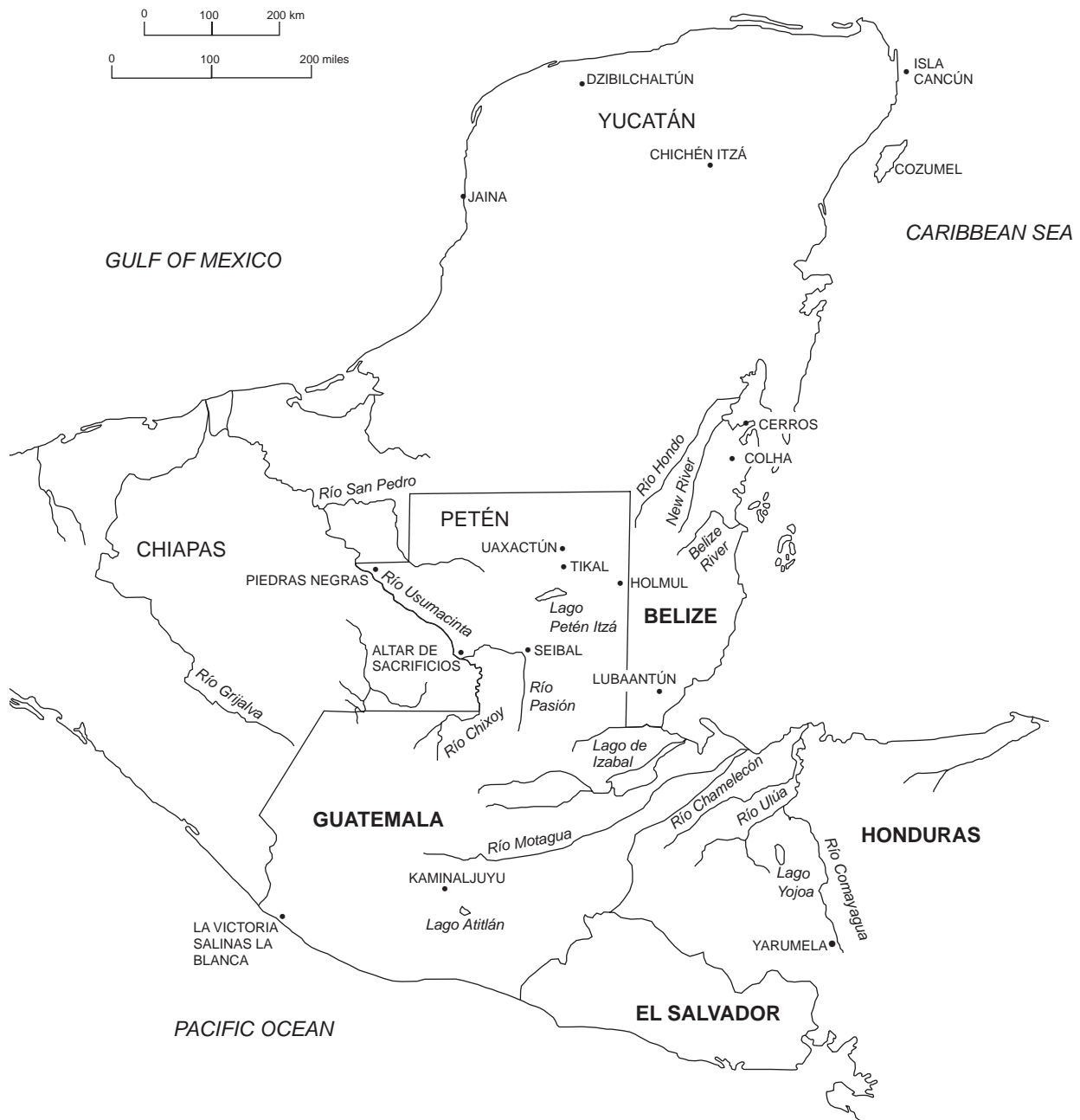


Figure 1.1. Map of Maya area.

undeniable. Evidence from the southern frontiers of Honduras also suggests an early and ongoing relationship between the Maya and the southern intermediate cultures (Henderson 1992). Through exchange and transfer of ideas the Maya had access to the fauna of all of Mesoamerica—an interchange highlighted by

the similar roles played by animals and their deified counterparts in all the Mesoamerican cultures. Small wonder, then, that attempts to define a “Maya diet” or any commonality in the use of fauna by the Maya have met with limited success.

1. HISTORY AND RESEARCH DIRECTIONS

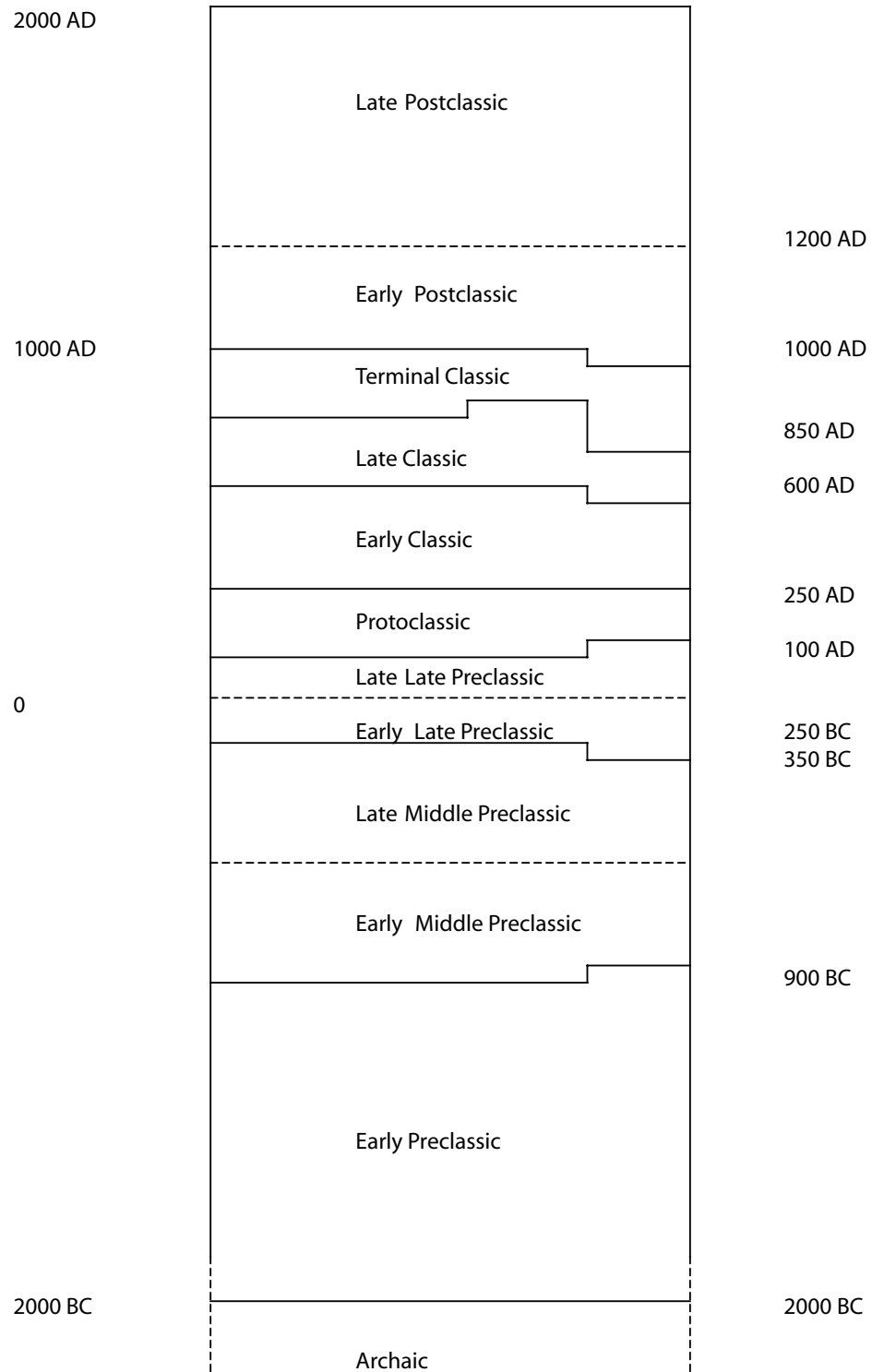


Figure 1.2. Chronology of the Maya realm.

This chapter reviews the complex history of zooarchaeological investigations in Mesoamerica and the Maya realm and traces the contiguous developmental trajectories of the archaeological and zooarchaeological sciences within the greater context of changing global anthropological paradigms. Although environmental variables have never been neglected in the archaeological sciences, early zooarchaeological analyses were both archaeologically marginalized and severely theoretically involuted, having no stated place in either archaeological research design or contextual interpretation. Within the last few decades, however, the zooarchaeological sciences have undergone rapid methodological and theoretical diversification. Today the science is in search of a theoretical paradigm that encompasses a reunification of the diverse areas of inquiry within the science, and the integration of environmental data into archaeological research.

EARLY DEVELOPMENTS: ZOOARCHAEOLOGY IN THE CONTEXT OF ENVIRONMENTAL ARCHAEOLOGY

Environmental archaeology is one of the oldest interdisciplinary studies in the archaeological sciences; until recently, however, it has been one of the most poorly articulated aspects of archaeological investigation. Despite the fact that environmental characteristics are generally accepted as important variables in archaeological research design, environmental data, whether geoarchaeological, archaeobotanical, or zooarchaeological, are often considered to be merely a body of static, descriptive background information. Thus, the various branches of environmental archaeology, and particularly of zooarchaeology, are often not recognized for their vital role in the study of dynamic factors affecting cultural patterning. Our most recent definitions of environmental archaeology and zooarchaeology emphasize the interdigitation of specialized techniques of environmental reconstruction with a theoretical paradigm that encompasses a contextual understanding of

human activity within the environmental milieu (Albarella 2001; Butzer 1982; Dincauze 2000; Evans and O'Connor 1999; Shackley 1981). Despite this recognition of the vital nature of the human/environment relationship, even today most environmental archaeology, and much of Mesoamerican zooarchaeology, is technical and methodological in nature.

All areas of Mesoamerican archaeology are linked to some degree with environmental archaeology, and the theoretical premises and methodological innovations of the environmental archaeology sciences have played a primary role throughout the development of Maya archaeology. As a result of this intertwining of the methods and theories of Maya archaeology with those of environmental archaeology, it is possible to trace the contiguous developmental trajectories of these sciences within the greater context of global archaeological theories.

CULTURE HISTORY AND ZOOARCHAEOLOGICAL STUDIES

As early as the 1840s Worsaae (1849) argued that archaeological finds had to be studied in relationship with their paleoenvironmental settings; and, certainly, as fascinated as the earliest explorers to the Central American jungles were by the ancient peoples, they were equally fascinated by the ability of those peoples to live in the tropical rainforests. Early cooperation among archaeologists, biologists, and geologists in the Old World stimulated the analysis of ancient environments and was an important impetus in the development of a functionalist view of the relationship between human societies and their environmental settings. This developmental relationship between archaeology and the environmental sciences in the Old World has been thoroughly explored by various authors and will not be covered in detail here (see, e.g., Evans and O'Connor 1999; Trigger 1989). Despite the long history of European zooarchaeology, the zooarchaeological tradition is relatively recent in the New World. Early interest in North American shell middens notwithstanding

(Jefferson 1797; Wyman 1868), the science of environmental archaeology began in the Americas within the boundaries of the Midwestern Taxonomic Method and was intrinsically tied to the development of trait lists in lifeway categories (Evans and O'Connor 1999; O'Connor 1996; Trigger 1989). Early studies in Mesoamerican archaeology constructed sequences to describe the development of cultures, but even when the goal was an evolutionary one (Spinden 1928), the studies were essentially descriptive rather than explanatory.

In the 1920s and 1930s biologists and archaeologists made their first scientific forays into the newly accessible forests of Belize and Guatemala, and beginning in 1930, the Carnegie Institution of Washington and the Museum of Zoology of the University of Michigan jointly sponsored biological and archaeological research in cooperation with A. V. Kidder, chairman of the Division of Historical Research at the Carnegie Institution. The age of biological classification was in full bloom, and new methods were rapidly brought to the study of tropical flora and fauna. Under the auspices of the Carnegie-Michigan projects, zoological collecting expeditions focused on mammals (Murie 1935), birds (van Tyne 1935), herpetofauna (Stuart 1935), fishes (Hubbs 1935), and molluscs (Goodrich and van der Schalie 1937), and their work contributed a wide range of information on vertebrate and invertebrate fauna. These zoological studies, complemented by equally detailed botanical (Bartlett 1935; Lundell 1937) and soil (Cooke 1931) data, were of immediate interest to archaeologists working in close collaboration with the biological scientists.

Revolutionary excavations at the site of Uaxactún (Ricketson and Ricketson 1937) and smaller projects at sites like Piedras Negras (Coe 1959) and Holmul (Merwin and Vaillant 1932) were the first to explicitly discuss the importance of animal populations to the early inhabitants of the Mesoamerican lowlands. At the same time, the Carnegie Institution was supporting similar studies in the Yucatán, at sites like Chichén Itzá, and in the highland

regions of Guatemala, at sites like Kaminaljuyu (Kidder, Jennings, and Shook 1946; Shook and Kidder 1952). Excavations funded by private sources quickly followed suit in their attempts to accumulate some biological data in association with the sites such as Zaculeu (Woodbury and Trik 1954), and early Mexican studies also began to comment on animal remains from archaeological sites such as Jaina (Moedano-Koer 1946; Pina-Chan 1968).

In many Mesoamerican sites, however, early analyses of animal remains were traditionally made by zoologists and were appended to site reports as incidental species lists (Kidder 1947; Pollock and Ray 1957; Ricketson 1937; Woodbury and Trik 1954). Perhaps because of the many zoologists working in the area, archaeologists often simply turned faunal remains over to the zoological specialists for identification and did not attempt to integrate the resultant species lists into their archaeological investigations. As well, these early analyses were generally restricted to faunal remains found in special deposits, like burials and caches, or to those that were artifactually modified. Nonartifactual animal remains from general refuse were often ignored.

These early zoological studies, for all their value as species listings, often showed more interest in modern animal populations than in ancient ones, and they certainly had very little interest in patterns of animal use in the past. Where zoological analyses were not possible, comparison with other sites easily replaced actual investigation: "I think that one can fairly conclude, however, that there is nothing at Uaxactún in bone that would be out of place at Piedras Negras, and vice-versa. A knowledge of the Uaxactún bone objects and attention to distributions would surely suffice to pin down the Piedras Negras collection as lowland Maya" (Coe 1959:68).

However, although this early period was a time of classification and data collection, the Carnegie researchers created more than a simple cultural and chronological framework of Maya history—they were instrumental in the

first interdisciplinary research efforts toward elucidating the environmental and ecological history of the region.

CULTURAL ECOLOGY AND TRANSITIONS IN ZOOARCHAEOLOGY

In 1940 Kluckhohn advocated the use of a "scientific approach" to address trends and uniformities in Mesoamerican cultural change (Kluckhohn 1940). Julian Steward's explicitly materialist use of the ecosystem approach in his early studies of change in subsistence economies and population distributions at this same time provided the most important impetus for the development of environmental archaeology in the Americas (Steward 1955). Despite the environmental determinism implied by many of the principles of cultural ecology, Steward's models provided a basis for moving beyond the simplistic trait lists of the previous generation. Together these influences stimulated major American research programs incorporating interdisciplinary teams interested in questions of land use. Similar movements were simultaneously afoot in European archaeology, as a developing interest in geochronology and environmental change (Zeuner 1952) met with the new field of "economic prehistory" (Clark 1989; Higgs 1972) to encourage research into the relationships between environmental resources and human populations.

In the Maya lowlands Gordon Willey brought techniques derived during his Virú Valley Project to the analysis of the Belize River Valley (Willey et al. 1965) and later to his studies in the Pasión Valley of Guatemala (Willey 1973, 1990). At the same time, other large settlement projects in both the southern lowlands at Tikal and the northern lowlands at Dzibilchaltún specifically integrated environmental variables into research strategies and data collection (Jones, Coe, and Haviland 1981; Kurjack 1974; Puleston 1974, 1983). In Mexico the Tehuacan Archaeological-Botanical Project, led by R. S. MacNeish (Flannery 1967; MacNeish 1972), combined archaeological, botanical, zoological,

and geological studies to delineate changes in subsistence economies. In the Chiapas region of Mexico various projects acknowledged the importance of animal resources in the development of Preclassic subsistence systems (Chavez-O 1969; Flannery 1969; Follett 1967; Green and Lowe 1967).

Despite this apparent integration of zooarchaeological data into broad questions of behavior and adaptation, however, zooarchaeological studies actually changed little at the beginning of this transitional period of theoretical investigations. Under the auspices of the University of Pennsylvania Tikal Project in the Guatemalan Petén, environmental studies continued with Stuart's (1958) work on herpetofauna, Smithe and Paynter's (1963) analysis of modern birds, Rick's (1968) classification of the Tikal mammals, and Olson's (1969) work on soils. But few early authors attempted to move beyond the limitations of the zoological list of subsistence species. The practice of including analyses of excavated faunal remains was still not widespread, and the emphasis throughout this early period of subsistence debate was firmly on the agricultural, botanical, and soil components of human interactions with their environments. Zooarchaeological remains were less well understood and less valued.

ZOOARCHAEOLOGY IN THE NEW ARCHAEOLOGY TRADITION

Following close on the heels of Caldwell's "The New American Archaeology" (Caldwell 1959), Binford outlined the "New Archaeology" (Binford 1962, 1965) in which he proposed an ecologically based, systemic model for the quantification of behavioral patterning. Influence from a developing branch of "new geography," which emphasized General Systems Theory, provided the framework in which much of the Binfordian ecological model of adaptive human behavior could be placed. One of the most influential systems-oriented analyses in the New World was Flannery's (1968) model of the development of early Mesoameri-

can agriculture. Similar models proposed for Old World agriculture and domestication incorporated earlier economic archaeology studies to define human processes of resource acquisition as active and adaptive strategies. Karl Butzer's research in both the Old and New Worlds provided a pivotal holistic "contextual" approach that emphasized the combination of environmental and cultural factors in any archaeological research (Butzer 1982). Increasing scientific rigor, demanded by the new arenas of investigation, introduced questions of sampling and recovery bias and the processes of taphonomy.

In contrast to the rapid rise in interest in zooarchaeology in the Old World that was fostered by the new economic and systems models of adaptation in resource procurement, studies of ancient animal remains in the New World, and particularly in Mesoamerica, did not keep pace. The studies of the process and economics of animal domestication in Europe, Asia, and Africa were pivotal to questions of changing societal complexity. As well, paleoanthropological research on early hominid behaviors added impetus to the search for a clear understanding of the processes by which bone is transformed under conditions of use and deposition (Shipman 1981).

Despite the lack of a similar impetus for zooarchaeological research in Mesoamerica, environmental archaeology as a whole developed quickly during this period. Under the influence of the New Archaeology and with the advent of increasingly complex methodological techniques of environmental analysis, settlement and subsistence questions raged in the Maya area. In the 1970s, as a result in part of an eroding general confidence in technological change, and spurred by publications like *Silent Spring* by Rachel Carson (1962), the ecology movement suggested that environmental mismanagement could lead to declining living standards or even to the collapse of civilization. At the same time, the first paleolimnological studies appeared in association with a burgeoning interest in the cause of the apparent end of Classic Maya civilization in the ninth century

A.D. (Cowgill 1961, 1962; Cowgill et al. 1966; Tsudaka and Deevey 1967). With these studies came the first use of molluscs as environmental indicators (Covich 1983; Covich and Stuiver 1974; Emery 1986; Feldman 1974a, 1974b, 1978; Willey et al. 1965). This provided an interesting complement to simultaneous studies of microfaunal variability in the drier northern regions of Mexico (e.g., Flannery 1986).

In this milieu zooarchaeologists were becoming accepted members of environmental and archaeological teams for the first time. Olsen provided basic descriptions of faunal remains from Altar de Sacrificios (Olsen 1972) and Seibal (Olsen 1978), and Willey attempted to incorporate these into the archaeological discussions (Willey 1973). Pohl joined forces with the ongoing Tikal Project (Pohl 1976), and Savage and Luther (Luther 1974; Pendergast 1971; Savage 1971, 1978) analyzed animal remains from Eduardo Quiroz and other caves in Belize. Hamblin joined the Cozumel Island Project (Hamblin 1984), Carr took on the Cerros assemblages (Carr 1986a, 1986b), Scott began the analysis of the Colha remains (Scott 1979, 1980), and Wing provided analyses and theoretical models for a variety of projects, including Dzibilchaltún (Wing and Steadman 1980) and Lubaantún (Wing 1975). In Mexico zooarchaeological analyses were included in investigations in Chiapas (Agrinier 1975; Voorhies 1976) and the Yucatán (Alvarez 1976; Barrera-Rubio 1977; Miller 1977); and Colby (1988) reviewed zooarchaeological remains from the Maya frontier at Yarumela. Most important, some archaeological projects began to integrate zooarchaeological analyses from the outset as one of the primary goals of analysis. Shell-midden analyses on Cancún (Andrews et al. 1974; Wing 1974) and Coe and Flannery's (Coe and Flannery 1967; Follett 1967) research at Salinas la Blanca on the Guatemalan coast both incorporated new research strategies and zooarchaeological methods.

Together these new reports traced an increasing interest in the diversity of aquatic and terrestrial resources that were now visible in the zooarchaeological record as a result of

more detailed archaeological excavation methods. While zooarchaeologists argued globally for the use of fine-screening for greater archaeological recovery, methods of faunal analysis also increased in sophistication with the advent of detailed methods of identification and quantification. New theories on archaeological fauna emphasized the use of strictly standardized bone counts, and these were quickly incorporated into Maya faunal reports. Maya zooarchaeologists were among the first to investigate the potential of such measures as biomass and bone weight and the value of osteometrics for both identification and analysis of dietary contribution (Wing 1976, 1977, 1978). A new ability to age and sex skeletal remains allowed the first measures of animal population statistics (Pohl 1976). An interest in species and skeletal element distributions through archaeological deposits from both site core and periphery allowed these researchers to delve into questions of differential resource distribution—questions of paramount importance under the paradigm of the New Archaeology.

The new zooarchaeological methods encouraged a wider range of investigations. Recovery of fish bones and mollusc remains through fine-screening spurred an interest in the use of lacustrine and riverine fauna (Moholy-Nagy 1978), the possibility of pisciculture in wetlands (Dahlin 1979; Lange 1971; Thompson 1974), and an enduring fascination with marine resources (Andrews 1969; Cobos 1989; Hamblin 1985; McKillop 1984, 1985; Moholy-Nagy 1963, 1985; Vail 1988). The use of these finer sampling methods in cave excavations allowed the first analysis of cave fauna and their depositional history (Savage 1978) and encouraged an early interest in ritual use of animals. Renewed study of the process of domestication in the Old World (Brothwell 1975; Collier and White 1976; Hecker 1978), in combination with animal population statistics generated through age and sex analyses in the Maya area, spurred interest in the possibility of animal domestication having occurred in the Maya world (Pohl and Feldman 1982; Wing

1978), which has been the subject of ongoing investigation (Clutton-Brock and Hammond 1994; Dillon 1988; Emery et al. 2000; White et al. 2001, this volume). It was also during these early years of the New Archaeology that the first works discussing fauna from a wider perspective appeared, indicating an interest in regional and comparative patterns of faunal resource use (Benson 1977; Stark and Voorhies, eds. 1978; Wing 1981). Wing's early work (Wing 1981) on the definition of a Maya "menu," using statistical analyses of dietary patterns, remains unsurpassed in today's literature and would be a valuable study to follow using the more extensive data available today.

TOWARD A SOCIAL ZOOARCHAEOLOGY

Three authors, however, have introduced the science to Mesoamerican archaeologists as both a comparative and a processual study. Mary Pohl's (1976, 1990) groundbreaking zooarchaeological study of five sites in the Guatemalan Petén and Elizabeth Wing's (1976, 1977, 1978, 1981) detailed comparative studies and innovative methods have broadened the recognized scope of zooarchaeology as a tool for Mesoamerican archaeologists. Finally, the publication of Nancy Hamblin's (Hamblin 1984) detailed analysis of Cozumel fauna indicates a true turning point in our understanding of the value of zooarchaeological studies to Maya archaeology.

By the early 1980s zooarchaeological remains were recognized by most archaeologists as being well suited to the analysis of both environmental change through time and associated dietary adaptation to environmental patterns. However, with a wider understanding of the versatility of zooarchaeology and its utility for the analysis of political, ritual, and economic systems, reports slowly began to reflect its use as a measure of processual change and societal adaptation. In keeping with the tone of the New Archaeology and the role of middle-range theory in the prediction and interpretation of social variability through archaeological

remains, many of these reports dealt with economics and social evolution (Carr 1985, 1989; Cobos 1989; Emery 1986; Hamblin 1985), as well as subsistence and environmental change (Bradley 1983; Cliff and Crane 1989; McKillop 1984, 1985).

The processual analyses of the New Archaeology rapidly made it clear that simple inventories of the available biotic communities of a given region were not sufficient to address questions about the relationship between environments and complex societies like those of the Maya (Wiseman 1983). Although locally available resources are important, with the development of elaborate exchange partnerships between communities from different environmental zones, the Maya resource base expanded to include exotic species. In association with other work at Cozumel, Hamblin (1985) introduced faunal assemblages as indicators of patterns of trade, not only of artifactually altered marine molluscs (Andrews 1969; Cobos 1989; Moholy-Nagy 1985) but also of animal resources for subsistence purposes. Carr and others followed suit with investigations into the transport and exchange of animal products (Carr 1989, 1996; Emery 1990, 1999; Mock 1994).

Even from an early date there had been considerable interest in the social, religious, and political information available from animal bones (Wing 1981), but current research emphasizes these aspects even more strongly. Few of the early authors went as far as Pohl in the investigation of the societal role of animals, particularly as indicators of changing patterns of ritual (Pohl 1981, 1983) and status (Pohl 1985b, 1990, 1994). Her work now, however, is tied to a more recent general trend toward the use of zooarchaeological remains as indicators of social differences and ritual behaviors that is associated with the newest archaeological paradigm: postprocessualism.

As a result of the failure of many archaeological studies to produce broad behavioral generalizations, and in response to the post-modernist intellectual movements of the period,

the late 1980s and early 1990s saw a rejection of deductive science as an appropriate methodology for the study of the past. As a direct challenge to the neoevolutionary concepts of uniformity and the ecological constraints to culture that characterized the New Archaeology, postprocessual archaeology argues that the reductionist approach masked the true internal diversity of a society as represented by its individuals. Cultural diversity and individual choice, along with an ongoing interest in the particularism of political and economic history, have once again become areas of interest for the archaeological community.

In fact these newest trends in archaeological attention seem to have changed the focus of Mesoamerican zooarchaeology only slightly. Most recent archaeological investigations in the Maya region now include zooarchaeological investigations (Alvarez 1982; Andrews 1986; Blanco-Padilla 1987; Carr 1986a, 1986b; Coggins 1992; Hopkins 1992; Hudson et al. 1989; Marrian 1986; Martinez-Muriel 1989; Morton 1987; Powis et al. 1999; Shaw 1991, 1995a; Stanchly 1995; Wing and Pohl 1990; Wing and Scudder 1991), but emphasis on postprocessual zooarchaeological analysis is less common in the modern literature. This trend is in many ways a reflection of the general stability of Maya research. History and the diversity caused by individual variation have always been themes in Mesoamerican archaeology as a result of the preservation of, and interest in, hieroglyphic texts and other identifiable family and place emblems (Sabloff 1992).

With this stability in mind, however, it is interesting to note that with intensified studies of the Mesoamerican landscape, recent environmental studies also stress the variability and heterogeneity of both the ancient ecology and responses to it (Fedick 1996). Some recent attempts have been made to define a "Maya menu" and to offer comparative analyses of chronological change in diets across the Maya landscape (Carr 1996; Cliff and Crane 1989; Pohl 1994; Polaco and Guzman 1997; Wing and Scudder 1991), but these are limited by the paucity of

published zooarchaeological reports. As well, the occasional regional study of specific species is appearing in the literature as authors attempt to search for patterns of single-species distribution across the Maya region (Baker 1992). Unfortunately, zooarchaeological studies are still nascent, and not enough information has yet been gathered or identified to allow analysis of either variability or generalities of animal use in the Maya world.

Lacking a database broad enough to allow inquiries of a postprocessual nature, Maya zooarchaeology appears to have diversified in both technique and theoretical perspective. Social themes are now paramount, and although subsistence (Miksicek 1991; Wing and Scudder 1991) and economic (Carr 1989; Cliff and Crane 1989; Cobos 1989, 1994; Hamblin 1985) questions continue to be of great interest, the variability of social systems, along with their effect on access to animal resources, is a common avenue of inquiry. In neighboring parts of the world attempts have been made to correlate dietary distinctions with social variables of group affiliation (Reitz 1985) and status (Brown 1996; Cusick 1993) in order to better define variability in cultural patterning. Today in the Maya area animals are often analyzed with an eye to their use by ancient peoples as both status (Chase et al. 1998; Emery 2002; Pyburn 1989; Shaw 1999) and ethnic markers (Emery 1999; Masson 1995a). The question of differential accessibility to resources is reflected in the variety of papers dealing with the domestication (and thereby control) of certain species (Clutton-Brock 1981) and with the distribution of both subsistence (Moholy-Nagy 1998) and trade goods (Moholy-Nagy 2003b) among different social levels in ancient Maya society.

Beyond subsistence, the role of animals in the ceremonial and ritual life of the ancient Maya is another common theme running through modern zooarchaeological analyses. Once again, this theme is not new to the zooarchaeological literature of the Maya area (Borhegi 1961; Hamblin 1981; Pohl 1983). However, ritual behavior of a localized nature, par-

ticularly with regard to feasting, is a topic of great current interest for both environmental and social archaeologists and is one for which zooarchaeological data seem almost uniquely qualified. Many of the most recent analyses emphasize the utility of faunal remains for distinguishing events such as feasts or period-ending ceremonies (Emery 1986; Masson 1995a; Pohl 1994; Shaw 1995b; Wharton and Stanchly 1998), and some of these discussions are central to arguments about the evolution of early complexity in the Maya region.

Associated with this recent interest in the role of animals in feasting and other ceremonial activities is an increasing interest in the symbolic role of the various species (e.g., Benson 1988a, 1988b, 1988c, 1989). This is also not a new focus, and Mesoamerican zooarchaeologists rely on our earliest historical documents and their interpretations (e.g., Tedlock 1985) although there is as yet no comprehensive work on animal symbolism from the codices to rival that by Tozzer and Allen (1910). However, the increasing knowledge gained through studies of epigraphy and iconography has certainly increased our understanding of this field. Research on the role of animals as spirit companions, as totems, and as sacrificial victims has been a part of even the earliest descriptions of the Maya and continues today (Brown 1996; Carr 1996; Pohl 1983; Pohl and Pohl 1983), but the use of zooarchaeological remains as a mechanism for defining the specific rituals that may have accompanied historic events is rapidly gaining favor (Henderson and Joyce this volume; Pohl 1981).

Simultaneous with the rapid diversification of themes in Maya zooarchaeology has been a much more dramatic methodological shift. Zooarchaeological methods have become more complex and exacting—rapidly becoming more diverse and technologically sophisticated. Along with a rising interest in the processes of taphonomy (Stanchly this volume) and archaeological recovery (Teeter this volume; Masson this volume) has come an increasing complexity of the techniques borrowed from the environ-

mental and material sciences. Many zooarchaeologists have continued to access the valuable paleoenvironmental and subsistence data provided by molluscan and microfaunal studies (Healy et al. 1990; McKillop and Wine-miller this volume; Miksicek 1991; Powis this volume), although studies that integrate bone chemistry (Coyston 1999; Emery et al. 2000; Tykot et al. 1996; van der Merwe et al. 2000; White et al. this volume) with population statistics such as harvest rates and mortality curves (Carr 1996; Emery 1986, 1989; Pohl 1990) and ecological community statistics (Emery this volume) are quickly becoming the norm.

The diversity of new methods is equaled by the diversity of basic zooarchaeological approaches. Archaeological sampling strategies produce zooarchaeological remains from a diversity of social and preservational situations that are often less than clearly defined for the zooarchaeologist. Animal remains are recovered using methods of variable precision, sometimes noted and sometimes not. Even within this volume the processes of identification and quantification vary among analysts as a result of the diversity of methods available and applicable to the various questions.

Although the chapters included here reflect the current diversity of subject material and methods, however, they also highlight a recent theoretical reunification. Maya zooarchaeology today continues to be interested primarily in the reconstruction of ancient environments, generally in an attempt to map the effects of this complex civilization on the tropical rainforest environment, as well as in the role of ancient animals in Maya society, as both a natural resource for subsistence and an important participant in Maya politics, economics, and religion.

CONCLUSIONS

This brief review of the evolution of zooarchaeology in context with the changing theoretical interests of environmental archaeology emphasizes two aspects of the zooarchaeological sciences: first, the overwhelming plethora of methodological and technological innovations that have appeared in the last 30 years; and second, the wide diversity of theoretical avenues that have become available to Maya zooarchaeologists as a result of both changing anthropological paradigms and changing archaeological methods.

Derived from a wide variety of other sciences (geology, zoology, botany, ecology, geographic philosophy, and mathematics, to name just a few), environmental archaeology seems in many ways a "goodie bag" from which techniques and analogies can be drawn apparently at random. Unfortunately, the very diversity of the methodological innovations of recent years has often made it impossible to compare the results of different studies, leading to a loss of the comparative aspect of much zooarchaeological research—an aspect very much needed to increase the database of information on ancient animal use in the Maya region. The primary arguments against most regional analyses complain of insufficient knowledge of the variability in the environments studied, the variability of archaeological and zooarchaeological methods used, and the lack of standardization in the quantified results. Short of including long and complicated methodological discussions in every zooarchaeological report, the solutions to the problem must include the production of standardized methods of analysis and the introduction of those standards at all levels of archaeological research design, implementation, and discussion.



PART 1

Methods in
Maya Zooarchaeology

2

In Search of Assemblage Comparability

Methods in Maya Zooarchaeology

Kitty F. Emery

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Maya zooarchaeologists work with a challenging data set that must be approached with interpretive care and sophistication. The diversity of the tropical life assemblage is among the highest in the world, and the preservational conditions affecting Mesoamerican zooarchaeological assemblages are among the worst. The complexity of ancient Maya society has resulted in an archaeological penchant for studies that disregard zooarchaeological data. This chapter details the methods that modern Maya zooarchaeologists have used to counteract these effects and to create strong, reproducible results to support theoretically flexible conclusions. The biggest hurdle is the requirement for comparable faunal data sets, and the most effective cure is the clear definition of methodological parameters at each step of the zooarchaeological research process.

Zooarchaeological research in a tropical environment requires an unusual methodological arsenal. In the Mesoamerican tropics, physical conditions combine with the interpretive difficulties inherent in studies of any complex society, and for Maya zooarchaeology the situation is further complicated by the theoretical and methodological foci of archaeologists working in the region. Maya zooarchaeologists have only recently begun to tackle the many obstacles that lie in their path, but they have already provided the archaeological world with evidence of the sophistication of the science in broaching complicated theoretical problems. Before we offer our conclusions to the academic world, however, we must be sure that our assumptions are robust and that our results are reproducible. The answer to the biases imposed by the Mesoamerican situation lies in working toward comparable zooarchaeological assemblages, the parameters of which are clearly defined to allow researchers to combine data sets to provide stronger and broader interpretations.

The faunal communities of Central America are among the most diverse of any in the world and are characterized by scattered and sparse populations and narrow behavioral adaptations to specific microzones. As a result of this pattern, the likelihood is high for the recovery of a wide diversity of animal species in any Mesoamerican zooarchaeological assemblage, and there is a coincident difficulty in the identification, interpretation, and statistical analysis of the remains recovered. Preservational conditions in the widely ranging climates of Central America are highly variable, and the dramatic seasonal fluctuation in precipitation means that preservation of bone is limited even in the drier regions. The recovery of any assemblage in the humid lowlands is indeed cause for celebration.

Mesoamerican cultures, and particularly the Maya themselves, are sophisticated and complex, with an incredible heterogeneity of cultural adaptations that provide elegant solutions to the difficulties of tropical life but offer unending puzzles to archaeologists in the area. Archaeological research in the Maya area has

traditionally focused on the elite, on the symbolic, and on the history of the nobility. The introduction of new theoretical considerations, such as settlement and household archaeology, and a coincident interest in regional patterns that encompass all status groups have been of great benefit to zooarchaeological research. But the reality of application of these new interests to archaeological research is less than we might hope, particularly in today's postprocessual milieu of emic and historical interpretations based on epigraphic interpretation.

Zooarchaeologists are a relatively recent arrival to the scene in the Maya world, are few in number, and are still experimenting with the application of zooarchaeological methods and techniques from nontropical worlds. As mentioned in chapter 1 of this volume, zooarchaeology as a true investigation of the sophisticated relationship between the ancient Mesoamericans and their animal neighbors is very young indeed. Those of us who continue to practice in the area are only slowly developing cadres of skilled students, and many of us have come to the region with a hazy understanding of the very real limitations of zooarchaeological research in the region.

These difficulties span the gamut of potential methodological pitfalls in zooarchaeology and create a research situation that is not conducive to accurate, quantitative, or comparative conclusions. Yet we soldier on: converting North American methods to Mesoamerican situations, applying a wide range of techniques to overcome the most obvious biases, and using common sense to dictate the distance that we are willing to reach with our conclusions. We have continued to incorporate new technological innovations from the ecological and physical sciences, and this broadening of our methods has increased the sophistication of our conclusions. However, the reality is that zooarchaeological methods are hard pressed in the Mesoamerican world. To provide accurate results, we need to have comparative data sets, and those require mutually comparable methods. We need detailed samples where these are available, and these samples must rely on

sophisticated archaeological research focused on households and interregional spaces and time-consuming collection methods oriented specifically toward the recovery of the greatest range of species. And we need theoretical support in an academic milieu that favors the big and the beautiful. In competition with the needs of a project ceramist or epigrapher, the zooarchaeologist is forced to negotiate for access to provenience records or a role in project planning, occasionally in return for turning a blind eye to the lack of proper detail in excavation procedures.

THE PROCESS OF ZOOARCHAEOLOGICAL ANALYSIS AS FRAMEWORK

Reitz and Wing (1999) suggest that, beyond the biological and anthropological correlates of the animal-human relationship, research on the methodological basis of our science is pivotal in current zooarchaeological studies worldwide. The need for methodological navel gazing in the zooarchaeological world results primarily from our increasing desire, first, to produce explanatory models instead of descriptive classifications and, then, to make those models applicable to more than single-site reconstructions of simple subsistence patterning. Zooarchaeology is clearly a strong technique for flexible, quantitative investigations. However, one argument against its use in theoretical modeling is the difficulty of cross-sample comparability. This is particularly true in Mesoamerican zooarchaeology. In many cases our faunal assemblages are small, and the methods used for their analysis are not clearly stated in published or field reports. Neither do we discuss the biases imposed by site-specific taphonomy, or the variability in archaeological and zooarchaeological recovery and treatment techniques. When samples from a variety of sites are combined (which they often are since each site yields a relatively depauperate collection), unless all the samples were studied by a single analyst, the basic methods used are unknown, and the samples are often not comparable.

Reitz and Wing (1999:28) go on from their first statement on the primary role of methodological studies in zooarchaeology to suggest that in a worldwide perspective the most common foci for methodological investigations are what they term "first-order changes," or taphonomy, and "second-order changes," or the effects of excavation and identification procedures. These foci are rarely discussed, however, in any Mesoamerican zooarchaeology literature, even as introductory comments to faunal reports (although see Stanchly this volume for an exception). It is vital that we also begin to gaze at our own navels and to create a database of analytical literature detailing the requirements for methodologies in Mesoamerican zooarchaeology.

Under the difficult conditions already described for zooarchaeological investigations in Mesoamerica, it is also clear that we need to consider methodological issues at every level of zooarchaeological analysis. We must begin our investigations with sufficient information at the biological and ecological level. We, as zooarchaeologists, must be aware of taxonomic classification debates, but we must also understand the dynamics of animal population change, the ecological significance of animal community interactions, and the complexity of total ecosystem interrelationships. At the level of cultural interpretation and archaeological methods we need to clearly recognize and describe the structure and function of the archaeological site, the likely range of human activity involved in the deposition of the zooarchaeological remains, the taphonomic history of the site, and the archaeological techniques that were used to provide the zooarchaeological sample. These requirements demand a more sophisticated relationship with the archaeologists whose work provides us with ours. Our laboratory methods must also be clearly articulated and must be appropriate to the research questions that have guided both the archaeological and zooarchaeological research. We must strive first and foremost to choose methods that do not skew or mask the evidence. Our interpretation

will inevitably be biased as a result of the combination of environmental, cultural, and methodological factors unique to Mesoamerica, but the bias can be significantly reduced through the use of multiple lines of evidence based on such interpretive aids as ethnographic analogy, experimental and ethnoarchaeological studies, and a careful comparison of cultural contexts. Each of the interpretive methods and frameworks must also be described and evaluated to allow comparative discussions based on the analyses provided. Finally, the use of mutually intelligible terminology at the taxonomic, archaeological, and zooarchaeological levels is an inherent need that underlies the requirement for comparative analyses.

A FRAMEWORK FOR ZOOARCHAEOLOGICAL COMPARABILITY

Any zooarchaeological assemblage of remains from a community of animals utilized by a human population passes along a continuum of behavioral and transformational processes before it reaches the zooarchaeologist (Andrews 1995; Davis 1987; Koch 1989; Lyman 1994b; Meadow 1980; Reitz and Wing 1999; Schiffer 1987). Each step along the continuum affects the resulting assemblage and the information that may be obtained from it. Following the terminology of Klein and Cruz-Urbe (1984:3) adapted on the basis of a taphonomic model created by Andrews and Cook (1985: 689), and presented in Emery (1990), it is possible to categorize the methods of zooarchaeological research and analysis into a coherent methodological hierarchy (Figure 2.1):

1. the life assemblage (the community of live animals in ecological equilibrium);
2. the death assemblage (the carcasses collected by people, carnivores, or other agents of bone accumulation);
3. the deposited assemblage (the carcasses or portions thereof that come to rest at a site);

4. the fossil assemblage (the animal parts that survive the effects of the geomorphological situation until excavation);
5. the excavated assemblage (the part of the fossil assemblage that is recovered through archaeological excavations);
6. the curated assemblage (the part of the excavated assemblage that is analyzed or examined by the zooarchaeologist).

It is on the basis of this type of hierarchy that we can define the pivotal methodological considerations for Mesoamerican zooarchaeol-

ogy and the variety of biases that must be considered before our assemblages can be used as comparable analytical units. Since no acquisition of archaeological data is without bias, truly comparable samples have been affected by the same processes throughout and are therefore biased in the same ways. But of course finding truly comparable samples is an impossibility. Therefore, analytically comparable samples are those for which the biases imposed by this continuum of change are clearly defined and for which the biases have been ameliorated to the best of the analysts' abilities.

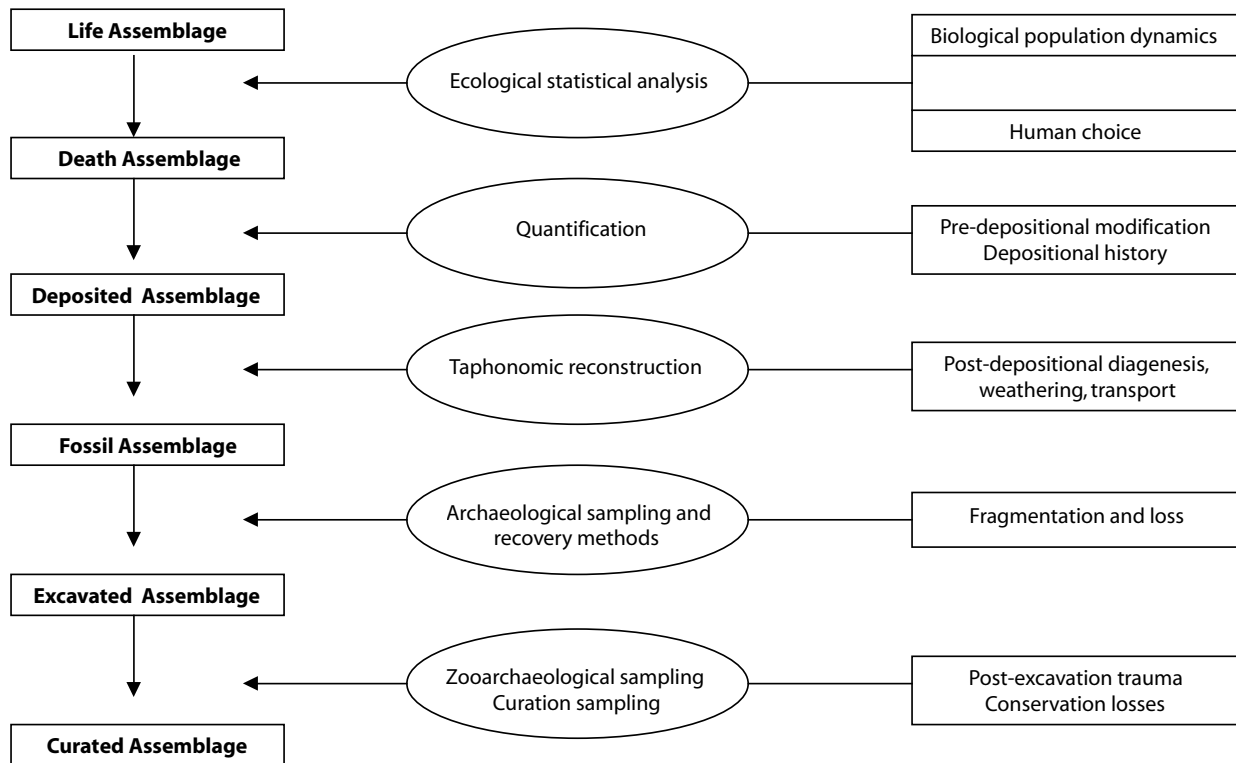


Figure 2.1. Developmental history of a zooarchaeological assemblage (modified from Lyman 1994b:31; Emery 1997:73).

The Curated Assemblage to the Excavated Assemblage (Bone Curation and Primary Zooarchaeological Data Gathering)

At the very foundation of this methodological hierarchy lie the potential pitfalls of our own zooarchaeological techniques. It is appropriate therefore to begin at this basic level of primary data acquisition, a stage that has been called both empirical (Reitz and Wing 1999) and replicable (Lyman 1994b) and is therefore relatively free of biasing agents. Unfortunately, the lack of a coherent methodological framework for zooarchaeological analysis means that our basic data gathering even at this stage is hardly empirical.

Basic identification of taxa. "After initial recovery from the field, all zooarchaeological remains were subjected to a standardized identification process" (Emery 1997:76). Statements of basic zooarchaeological identification methods are certainly more common now than they were 50 years ago (see Wake this volume for an example), but as we publish more sophisticated and theoretical conclusions from our zooarchaeological data, we have a tendency to give short shrift to the basic methodological details. There simply isn't room in most publications for a discussion of that "standardized identification process." However, there are certain variables within that process that must be defined before these primary data can be considered reproducible.

The process of identification always introduces bias through the culling of identifiable remains from those the analyst considers unidentifiable. "Contrary to the notion that there are no unidentifiable bones (Binford and Bertram 1977), specimens should be identified to a particular taxon only if they can be unquestionably assigned to it on the basis of morphological features found through comparison with reference specimens after all other possible identifications are excluded by the same procedure" (Reitz and Wing 1999:154). In my own zooarchaeological reports unidentifiable remains are

those that are so fragmentary or eroded that recognizable features are obscured or those for which no reference specimens are available. And this raises an important concern beyond the simple disparity between analysts and their personal level of skill: how accurate is our taxonomic information for the region we are studying?

Few of us have complete comparative collections that would include enough specimens to account for either individual variation or the overlaps in size and morphology that might be caused by environmental and habitat change. More important, none of us have the kind of detailed biological and taxonomic information on ancient species patterning that is available for many other regions of the world (although see Andrews 1969; Healy et al. 1990; McKillop 1985; Powis this volume). This simply isn't available in tropical Mesoamerica, where biologists are still hard at work defining basic taxonomic and habitat distinctions for most of the species (e.g., Emmons 1990; Henderson and Hoevers 1975).

Accurate taxonomic identifications are essential and, surprisingly, are not clear even for our most common species. Teeter (this volume), for example, suggests that zooarchaeologists may have been misidentifying two of our most familiar species: the dog and jaguar. Carr (1996) discusses the morphological and osteometric overlap among deer species—a difficulty that has often led me to define some specimens at the family level only (Cervidae) instead of at the species level (as either *Odocoileus virginianus* or *Mazama americana*). However, these differences are essential: separating the ocellated from common turkey (*Meleagris ocellata* and *M. gallopavo*) has allowed some researchers to define patterns of domestication and trade (Hamblin 1984), and a separation of peccaries (*Tayassu pecari* and *T. tajacu*) could provide clear distinctions in habitat availabilities because the two species are behaviorally very different (Emmons 1990). Osteometric analyses are often used by zooarchaeologists in other parts of the world (Driesch 1976) but are rarely seen in the Mesoamerican

literature, and this is not surprising given that these analyses are most effective when samples are replete with repetitive taxa and elements. However, osteometric analysis has been a useful analytical tool not only for distinguishing between closely related species in our area (Hamblin 1984) but also for the analysis of demographic patterning (Emery 1986; Miksicek 1991).

Beyond basic taxonomy we also need a clear understanding of the modern habitat preferences and behavioral habits of the species we are identifying, and often these are not available or are so changed from ancient patterns that it is difficult to use ancient species distributions to discuss evidence for procurement patterns, trade, or other socioeconomic variables (e.g., Baker 1992; McKillop and Winemiller this volume). This is particularly clear in our attempts to reconstruct environmental change (a topic I will discuss below). Feldman (1978, 1980), for example, has been important in discussions of Late Classic environmental degradation, citing as his evidence the differential frequencies of intrusive snail species with differing habitat preferences. However, to what extent does ground snail burrowing behavior affect the appearance of some species over others in various strata (Emery 2000)? Perhaps not at all, but these are certainly issues that need clarification before Feldman's methods can be applied in other situations.

Identification of skeletal elements. Our difficulties in basic identification procedures do not end at the taxonomic level. The identification of skeletal elements (usually the first stage before a taxonomic identification simply because elements are more easily recognized than are taxa) can also vary among analysts, and the procedures used for this stage should be clearly stated. For example, variability can be introduced by the fact that certain elements and element portions are simply more easily identified than others, and the effects of this differential "identifiability" must be realized, although they often cannot be removed from the assemblage analysis. The use of diagnostic elements or features for

efficient and accurate identification of large samples (Reitz and Wing 1999; Watson 1979) is not yet necessary in our region simply because for the most part our samples are too small and diverse to require the use of (or to have sufficient) diagnostic features. We do need, however, to clearly define those elements that are diagnostic and therefore more readily identified in our samples: catfish spines, armadillo scutes, and turtle carapace are just a few examples.

Finally, there are so many formats that can be used for recording the various and diverse types of data that can be gleaned from a single element that it is essential to define clearly which format we have used for our analyses. Consider this range of descriptors for element fragments: breakage units (Driver 1985), anatomical terms for diagnostic features (e.g., Morlan 1994), diagnostic zones (Munzel 1988), and element completeness (Klein and Cruz-Uribe 1984:108). Standardizing the information we gather on elements, or on the alterations caused by natural, animal, and human agents, would greatly increase the comparability of our samples for later analysis.

Secondary data: Aging and sexing Mesoamerican fauna. Information on age and sex is vital to any broad conclusions that we may wish to reach in our analyses. Carr (1996) clearly identifies the need for well-defined age and sex data for our deer remains in order to identify strategies of deer population management. She suggests that the accumulated evidence for a preponderance of mature deer in most collections could indicate low hunting pressure during the Classic period, but she cautions that immature bones may also decay more rapidly and that young deer may have been used for sacrifices or rituals, a proposition based on the recovery of predominantly immature or subadult individuals in caches and special deposits (Emery 1991; Masson 1996; Pohl 1990; Wing and Scudler 1991).

But can we assume that our age and sex data are realistically accurate? The most common age classification methods for animals with determinate growth patterns include age-

dependent characteristics like bone remodeling and reduction in bone porosity (Chaplin 1971), tooth eruption patterns and wear (Davis 1987; Hillson 1986), and epiphyseal fusion (Purdue 1983a). Sexing generally uses diagnostic elements or markers (e.g., pelvic shape [Purdue 1983b; Taber 1956; Uerpmann 1973]), or osteometrics and the analysis of bimodal size distributions (Purdue 1983b; Rasmussen et al. 1982). But these methods rely on detailed modern biological information. When we clearly don't have this information, how many of us are using North American characteristics for our determination of age classes? And if we are not using those data, then are we relying only on the most generalized age class patterns?

For species with indeterminate growth patterns (those that are continuous growers like molluscs, fishes, and some reptiles), a variety of allometric equations have been developed to allow the derivation of full-body size and therefore an estimate of age at death (Reitz et al. 1987; Reitz and Wing 1999). Rate of growth, however, is known to be affected by environmental conditions in all species, and this variable is often one that we are most unsure of in the Mesoamerican past.

Again we must question the applicability of the data we are using. To what extent can we use these types of features or equations in our zooarchaeological assemblages that are typically defined by single elements from single species? And even when we have relatively large skeletal collections, rarely do we have enough examples from any one species and element to allow for the interindividual comparisons that are essential for accurate age- or sex-class derivations. Comparative analyses like Carr's (1996) intriguing discussion of deer management techniques are based on age classes derived from a variety of methods by several independent researchers using a wide range of sample sizes of unknown preservational conditions. How realistic can we actually be when using this data? On the other hand, this type of study exemplifies the broad theoretical modeling that we are striving toward, so the onus lies on us as the zooarchaeological "technicians" to

clearly define our techniques to increase the probability that the interpretive work done by other researchers is accurate.

The Excavated to the Fossil Assemblage (Methods of Archaeological Sampling and Recovery)

As zooarchaeologists we are quick to criticize the methods of the field archaeologist, but the truth now is that many of us are both zooarchaeologists and field excavators, and many others work side by side during the planning and implementation of archaeological procedures. We are an intrinsic part of archaeological fieldwork and have therefore an added responsibility for the methods that are applied in the field, as well as those that are applied in our labs.

A host of excavational situations can add bias during the transition from fossil assemblage (the animal parts that survive the effects of the geomorphological situation until excavation) to excavated assemblage (the part of the fossil assemblage that is recovered through archaeological excavations). Archaeological sampling strategies can affect the relative proportions of the different culturally separate deposit types that are excavated. This in turn affects the proportionate representation of different status deposits, different functional deposits, different chronological periods, and deposits that have been exposed to different preservational conditions. Finally, archaeological sampling strategies can affect sample size, a variable that makes statistical and quantitative analysis difficult if not impossible in many cases.

Excavation and recovery methods. The effects of excavation strategy and recovery method have long been a subject for considerable dissension between archaeologists and the analysts who work with them. In the Maya region our excavation focus until relatively recently has been on the elite core and the elucidation of politics and religion. With the advent of settlement and household archaeology in the 1970s and 1980s, the focus shifted to subsistence and environment questions, and zooarchaeology really

came into its own. We have continued to cling to our role in Maya archaeology despite the postprocessual trend back toward the elite with the growing emphasis on historical genealogies as documented through epigraphy. These trends are discussed more fully in chapter 1 of this volume, but they are all reflected in, first, changing archaeological methodologies including more detailed excavation strategies focusing on between-settlement spaces, invisible architecture, and activity areas; and second, an attention to recovery methods applicable to these foci.

Along with the changing emphases also comes, however, a diversity of archaeological methods, as excavators adapt the traditional techniques to new research questions. Excavation techniques range from horizontal stripping and point plotting for activity-area analysis to shovel-test pitting and trenching for vertical and chronological analyses. Whereas horizontal stripping will provide contiguous unit samples that can illustrate activities in discrete areas by a single population during a defined time period, vertical test pitting provides information on a variety of activities by a variety of individuals generally over a considerable time depth. As a result the definition of excavation methods and the meaning of provenience designations is now more essential than ever. How were excavation units chosen and placed? Were levels arbitrary or natural? And how were lots or loci defined? These variables will significantly affect our aggregation units. Where these definitions are not available to us as active members of the excavation team, we must demand them from the excavators. When we have the information, it must be made clear in the published reports (as an example, see McKillop and Winemiller this volume).

Even more rampant is the ongoing discussion worldwide about methods of faunal recovery (Payne 1972, 1975), as it has become abundantly clear that the method of recovery used dramatically affects the composition of our faunal assemblage in terms of species, element, fragment size, and many other variables. Shaffer and Sanchez (1994) have argued that

our quantitative analyses depend on the equal opportunity for recovery of each and every specimen at a site. Research in many areas of the world has indicated that for optimal recovery the most effective method is flotation (Masson this volume; Reitz and Wing 1999:120), although the time consumed in this process prohibits its use in all situations. The use of 1/8" screen has been shown to be more effective than 1/4" screen (Cannon 1999; Shaffer 1992; Shaffer and Sanchez 1994; Wing and Brown 1979), but in my experience with clayey lowland soils this smaller mesh size only serves to increase fragmentation unless wet screening procedures are used. Although correction factors have been derived to increase the compatibility between samples screened at 1/8" and those screened at 1/4" (James 1997), these have been hotly debated (Cannon 1999; Shaffer and Baker 1999). As shown by the chapters in this volume, most excavators working closely with zooarchaeologists today do screen at least special deposits using a 1/4" mesh (Wing this volume).

Shaffer and Sanchez (1994) argue that recovery methods must be standardized for accuracy, but in reality, consistent tests of the validity of sample recovery methods in each situation (see Masson this volume) and a clear discussion of sample recovery variability would go far to ameliorate the problem.

In some special circumstances even these standard methods are not sufficient for recovery. Beaubien (this volume) describes the results of detailed excavation and conservation strategies in the recovery of a unique assemblage of marine fauna from a royal tomb at Copán and notes that although these remains were recovered by professional conservation teams, the recovery techniques are applicable to any excavation situation.

Post-excavation treatment and sampling. Once an assemblage has been recovered through archaeological excavation or surface reconnaissance, it is subjected to a variety of modifications (cleaning, transport, initial identification) that will bias the extent to which the remains enter the final curated assemblage and that can leave the

bone remains further fragmented or eroded. In many cases we are also faced with a basic, time-related quandary. Do we demand, for example, that all remains be washed by the excavators, halving (or better) the time that we spend in analysis, since the remains must be washed before we can examine them? Or do we discourage washing by excavators because we are all too well aware of the potential for erosion of important features (or even entire specimens in some cases) by the energetically applied toothbrush of the ceramic washer?

At the same time, two levels of post-excavation sampling also occur after the point of initial retrieval—the inclusion of excavated remains in samples returned to the zooarchaeologist for analysis, and the inclusion by the zooarchaeologist of remains in samples for identification. Many of us have been faced with the difficulties of accurately analyzing assemblages that are missing all artifactual materials (often relegated to small-finds analysts without any preliminary zooarchaeological identification), or microfauna erroneously considered “intrusive and therefore unimportant” by archaeological investigators, or those species remains that appear in such bulk as to impede transport (turtle shell, freshwater gastropod remains). On the other hand, what do we do when the “small sample” delivered from the Guatemalan archives with a one-year identification time limit is in fact a sample of more than 10,000 identifiable remains? We, too, must sample our assemblages and, by so doing, add bias to the analysis. Our decisions can be based on the selection of random samples or samples from specialized loci (features, storage pits, house floors) or the rejection of samples with secondary contexts or evidence for mixing, as in structure fill. Regardless, the requirements for accurate sampling dictate that we must be involved in the decision making and that the subsample must be representative and appropriate to the research objectives.

Contextual comparability of zooarchaeological samples. Clearly, then, our biggest hurdle in zooarchaeological methods is the recognition of the basic contextual separation among our samples.

Our best analytical sample is one that comes from a single discrete deposit with evidence for functional continuity and approximate chronological contemporaneity of all remains (such as those analyzed by Seymour this volume; Shaw and Mangan 1994; Wake this volume; White et al. this volume at Lagartero). As Stahl’s (2000) research in Ecuador indicates, these discrete deposits offer clear contextual information on a specific event or temporally bounded behavioral activity.

In our search for broader patterns that would confirm the single-event markers, however, most zooarchaeologists are tempted by the wider analytical focus provided by comparative samples either on a community level (e.g., Teeter this volume; Shaw 1999) or on a regional level (Carr 1996; Emery 1997, 1999; Pohl 1990, 1994). To effectively compare time periods (and most of us do attempt to discuss change over time), we need clearly defined and chronologically distinct assemblages. Chronological comparisons appear to be the easiest to control, but how secure are we in the dating of fill assemblages or midden deposits? To compare behavioral patterns, we need functionally equivalent deposits, but certainly in the Maya region multiple functions before or during deposit creation may easily have been the norm (Shaw 1999). At the other end of the scale, one of our favorite comparisons is that of animal use between status groups, yet the accumulated difficulties inherent in this analysis cry out for caution (Pohl 1985b, 1995; Shaw 1991). Current debate rages as to the status differentiation within Maya society, the degree of overlap, and the manifestations of the class differences (Chase 1992). To effectively compare status groups, therefore, we must clearly define the archaeological markers used for the identification of the different levels, as well as the other variables that will affect the accuracy of our study. The number of qualifiers we need at this level may far outweigh the utility of the measure.

Rather than avoid comparison, however, it is vital to note the variability in assemblage contexts with regard to contemporaneity (as do most authors in this volume), deposit type and

function (Henderson and Joyce this volume; Shaw 1999; Stanchly this volume), and social value (Moholy-Nagy this volume; Teeter this volume; Pendergast this volume). As well, the distinctions between seemingly similar contexts need to be carefully defined. For example, Moholy-Nagy (this volume) and Teeter (this volume) both discuss the fine variations in cache and burial assemblages often lumped by other researchers as single ritual units.

From the Fossil Assemblage to the Deposited Assemblage (Preservation and Post-depositional Variability)

Once an animal carcass has been obtained and divided, its remains may be subject to a variety of uses or may be immediately discarded. It is this discard history that, in part, determines the next level of bias on the skeletal assemblage (Lyman 1994b). However, the post-depositional history or taphonomy of the remains has the greatest effect on their potential recovery, particularly in the Mesoamerican world (these are discussed in detail by Stanchly this volume). The effects of disturbances at the point of initial deposition (biostratinomic processes) combine with the effects of preservational variability in the different depositional environments (diagenetic conditions) to produce considerable flux in the proportionate representation of any one individual animal in the deposited faunal assemblage (terms from Reitz and Wing 1999:114).

These taphonomic variables are the source of most worldwide zooarchaeological squabbling at this point (e.g., Coard 1999; Higgins 1999; Nicholson 1993), and several of the arguments are of particular importance to our studies. For example, recent work by Bennett (1999), suggesting that subsurface faunal remains (to a depth of between 10 and 20 cm) can be morphologically altered by recent surface burning events, is vital where milpa agriculture is prevalent. Equally important are the observations by Tappen (1994) regarding the effects of bone weathering patterns in the humid tropics, and by Olsen (1989) who notes the natural wear patterns on deer antler and their remarkable similarity to culturally derived patterning.

However, as Stanchly (this volume) clearly points out, Mesoamerica may be the one area in the world that is not contributing to this discussion. Perhaps we are afraid to peer too closely at the effects of taphonomic processes on our assemblages for fear we will then be forced to discard all of our results as biased. I will not cover the taphonomic discussion here because Stanchly has done so in depth, but there are two issues that are peripheral to the discussion in general yet are of great importance to our Mesoamerican zooarchaeological analyses: discard behavior and quantification of preservational characteristics.

Discard behavior. A current argument in zooarchaeological studies worldwide is the question of interpretation of discard behavior. Discard behavior is the primary determinant of faunal distribution in most loci, yet it is a biasing agent that obscures other cultural patterning that might be more effective in discussion of animal use (Arnold 1990; Chase and Chase 2000; Gifford 1981; Hayden and Cannon 1983; Pendergast this volume).

It is clear that disposal behaviors will affect bone distributions: sweeping away bone and other detritus can result in size sorting (Schiffer 1983), disposal into pits or chultuns may selectively protect remains (Stanchly this volume), and collection for secondary use as fill or agricultural fertilizer will selectively bias the faunal assemblage (Pendergast this volume; Shaw 1999). It is also clear, however, that some disposal behaviors are linked to the use of the animals in the first place: rituals are accompanied by specific disposal behaviors (Brady 1997; Henderson and Joyce this volume; Masson 1996; Sandweiss and Wing 1997), bone tool manufacturing may be associated with the same "dangerous objects" discard behavior that characterizes lithic debitage discard (Hayden and Cannon 1983), and certainly the discard of "wet" dietary remains is likely to be governed by olfactory regulations that are not inherent in the discard of "dry" remains (Emery 2000; Teeter this volume). The difficulty lies, however, in a two-part question: can we distinguish the

relationship between debitage and the activities that produced it (Pendergast this volume), and can we separate disposal behaviors from the effects of other transformational processes (Stanchly this volume)?

Pendergast argues in this volume that faunal remains gathered from behind-structure middens may not be reflective of either the activities within those structures (because the middens may not be associated with the structures they abut) or normal activities in general (because the accumulation of midden garbage is often indicative of abandonment and not daily life).

Some authors (Lyman 1984; Rogers 2000a, 2000b) argue that we cannot distinguish between the human decisions to transport soft bones (those that are characterized generally by their greater food utility) and to discard dense bones (those that occur in parts of the carcass that are low in food utility but that are also the least susceptible to erosion). The situation is further complicated by the differential use of bones and shell for tool manufacture. Various suggestions have been made by North American researchers that it is possible to correlate part density and utility with element abundance in the zooarchaeological assemblage to allow a behavioral interpretation of all those noncorrelated patterns (Lyman 1984; Rogers 2000a). This type of quantitative analysis has not yet been attempted in our area.

Quantifying preservation. The variability in long-term preservational conditions such as natural geomorphological processes like erosion, or the effects of soil acidity and water movement, can be quite high, not only between deposits but also between sites and even residential units within sites. The route to sample comparability lies in the description and quantification of the post-depositional effects of animal alterations and weathering for each subassemblage of either chronological period or site. But how do we quantify these differentials in post-depositional taphonomy, particularly in situations where we are not part of the excavation team and cannot demand even simple measures like

pH testing? I have attempted (Emery 1997) to measure faunal preservation both through an analysis of absolute density of faunal remains through the deposits and residences of the region and by comparison of frequencies of identifiable to unidentifiable remains. But the reality is that the effects of intersample variability as a result of chronological, contextual, and discard differentials combine with strong variations imposed by preservational conditions to create incomparable samples. No matter how carefully we describe the differences and effects, we cannot make our samples quantifiably comparable.

This lack of compatibility among samples, then, brings up an important issue. If our samples are incomparable, can we compare absolute densities of bone to derive a measure of access to animal resources? Many authors have used differential bone frequencies as a measure either of status-related access differences (Pohl 1985b) or of the reduction of protein availability over time (Teeter this volume; Masson this volume). However, with all this evidence for sample variation, other authors argue that it is simply impossible to make this equation work (Pendergast this volume; Stanchly this volume). Pendergast (this volume) introduces, for example, the simple variable of time to show the reduction in apparent protein availability with a variation of 50 years in the length of time represented by a midden accumulation. This debate is ongoing but deserves careful consideration before we present our conclusions as references to support or deny archaeological interpretations of environmental change or anthropogenic effects on animal populations.

From the Deposited Assemblage to the Death Assemblage (Zooarchaeological Quantification)

The natural abundance and availability of animal resources are visible only through the screen of biases caused by human interaction with that natural population. The effects of species choice (itself governed by diverse economic, ritual, and taste issues) and hunting technology, of butchering and carcass transportation between kill site

and home site, and finally of carcass use as the result of food sharing and differential access within a community or household all bias the view of the original life assemblage. It is primarily in an effort to negate the effects of these cultural choices and activities, in combination with the effects of post-depositional preservational variability, that the various methods of zooarchaeological quantification have been developed and refined over the years. At this point in the continuum we are entering the realm of secondary data, or data that are derived from primary data by means of quantification.

The search for the most accurate means of quantifying faunal remains in the archaeological record has a long history (Gilmore 1949; White 1953; Wintenburg 1919). Recent arguments, however, examine aspects of appropriate quantitative units and procedures of analysis (Fieller and Turner 1985; Grayson 1984; Lyman 1994a; Pilgram and Marshall 1995; Ringrose 1993, 1995). Although numerous quantification units are available (see Reitz and Wing 1999 for an excellent review), and many of these have been used in Mesoamerican zooarchaeology, our two most common measures are the number of identified specimens (NISP) and the minimum number of individuals (MNI). Variability in the extent to which these measures are used, the format of their use, and their modification by the application of secondary dependent measures (such as allometric scaling) have introduced an important source of bias to our comparative analyses.

Basic counting units. Quantification measures as basic counting units first appeared in the Mesoamerican zooarchaeology literature in the 1950s but did not become common in published accounts until the 1970s. This lack of discussion of quantification was undoubtedly the result of the very descriptive nature of most zooarchaeological research until the seminal work by Pohl (1976) and Wing (Wing and Brown 1979) that first attempted to use the data for a purpose other than the creation of a broad species list for the region under study. It is noteworthy that

every author in this volume has either included basic counting units or has discussed their validity.

The number of identified specimens count (NISP) is a simple count of bone fragments per taxon calculated as a ratio of bone fragments per taxon to total bone fragments and represented as a relative frequency. For many years the NISP ratio was considered an accurate representation of exploitation, despite early recognition that the size of the species under examination could directly affect its representation at a site because of both the differential recovery of very small remains and the differential removal of certain elements from a kill site (White 1953). It is also now clear that the microstructure and chemical composition of the bone itself can also produce varying effects (Hare 1980; Lyman 1994b; Rogers 2000a; Stanchly this volume) and that the differential identifiability of certain elements, and their differential representation in the skeletal series of certain species, can also have dramatic effects on the relevance of the measure for intertaxa comparisons (Ringrose 1993).

Despite these drawbacks NISP measurements (as empirical and unmodified counts) do have the advantage of referring directly back to the original archaeological faunal assemblage. If determination procedures are made explicit in the literature, these measurements can be used very effectively to compare disparate sites and cultural practices. Such NISP measures are practically ubiquitous in Mesoamerican zooarchaeological literature, particularly in discussions that present primary results.

A variety of other basic counting units have been used in the Mesoamerican zooarchaeology literature, and two of these deserve further discussion. Although I have only rarely seen the use of ubiquity measures for our area (Carr 1986b; Henderson and Joyce this volume; McKillop and Winemiller this volume), these are particularly important for discussions of comparability. Ubiquity (comparison of the number of samples within which a taxon occurs) is often used in other paleoenvironmental sciences such as palynology, where relative frequency is

irrelevant because of the dramatically disparate species counts found in any one sample. This measure overrides variability in skeletal element representation or sample size, and for a rapid and realistic comparison between collections that are otherwise not comparable, this measure appears to hold considerable potential.

Recording the weight of remains from various taxa has also become standard practice in Mesoamerican zooarchaeology. Often this weight measurement is invaluable because our research time is sometimes limited to a few days at best, with a sample that must then be returned to local institutions for "warehousing" with no chance of export to North American laboratories. With such limitations on our time and access, the best we can hope to do when confronted with a large assemblage is to divide the collection by basic identification criteria and then to weigh the taxonomic groups. This method has been used particularly by researchers confronted with large numbers of turtle or molluscan remains (Masson this volume; McKillop and Winemiller this volume; Pendergast 1981a). Similar methods, however, are currently under direct attack in California, where opponents suggest that the weight method does not take into account species variability in element density or size, particularly where this is correlated with environmental conditions, and that the identification of fragments instead of non-repetitive elements (or diagnostic features only) decreases the accuracy of analysis (Mason et al. 1998, 2000). However, as McKillop and Winemiller (this volume) correctly point out, in the absence of a more direct measure, the fact remains that larger elements do tend to have larger meat packets, and this provides a significant increase in the information that can be gleaned from analysis.

Corrected counting units. Minimum number of individuals, or the MNI measure, has gained popularity among archaeologists, but it has a long history of use by paleontologists, beginning in the early nineteenth century (Grayson 1984). In its simplest form the MNI consists of

matching the paired elements of any taxon in an assemblage based on side, size, age, and weathering (Ringrose 1993). The matched pairs are counted, and to this count is added the number of unmatched elements that remain. However, a variety of formulae have been proposed for the MNI measure, some of which are more conservative than others (Reitz and Wing 1999).

Now a common corrected counting unit, MNI is used in most Mesoamerican faunal reports and is certainly one of the measures most frequently presented by the authors of this volume. It does have several advantages over the basic counting units such as NISP. The MNI is independent of the number of parts in the skeleton of a species, the number of skeletal parts that are regularly introduced to the site by the bone accumulator, or the degree of fragmentation of the skeletal parts (Grayson 1984; Nichol and Wild 1984). The calculation has been criticized, though, on several fronts, only a few of which can be mentioned here. Without careful evaluation of context, size, sex, and age of the elements, the MNI is not representative of the total utilized population. It does not allow the interpretation of skeletal element frequencies and distributions (Marshall and Pilgram 1993). As well, the MNI is not equally accurate for every sample size. It is related to the total sample of the taxon under consideration by a negative hyperbolic regression statistic (Casteel 1977; Masson this volume; Turner 1980) and is therefore less accurate with very small or very large samples (those at either end of the hyperbola). Grayson (1984) also notes that in any sample, MNI exaggerates the importance of rarer taxa because the presence of a single specimen of a species will be weighted as heavily as several specimens of a more common species. Finally, there is no consensus on how the MNI should be calculated beyond the evaluation of matched pairs of elements, and samples calculated by different analysts may not be comparable in terms of sample aggregation or the MNI formula used.

Many of these disadvantages are of particular importance in Mesoamerican zooarchaeology:

we consistently deal with small assemblages and with high species diversity, so our calculations are unlikely to be statistically valid. Our theoretical focus is generally on complex civilizations; therefore, we must be particularly vigilant in the study of skeletal element representation and body-part use—just those factors that are impossible to study using the MNI.

One particularly important difficulty is the derivation of culturally valid units for MNI calculation or the use of any other corrected counting unit. We do not have a complete understanding of ancient Maya sharing behavior, particularly for animal foods. Pohl's (1977) investigation suggests that the sharing takes place even between unrelated village members, but in most cases ethnographic analysis has shown that both hunting and other large-scale economic and subsistence practices are often shared among household members and that the exchange of subsistence goods takes place primarily at the household level (Wilk 1991). Recent settlement analyses in the Maya region have shown, though, that Maya households were not residentially limited to single structures. In fact there is considerable evidence that, in lower-status groups particularly, coresidentiality is implied by spatial juxtaposition of the structures (Inomata 1997) and that food-sharing behavior undoubtedly took place between structures. How, then, should we calculate the MNI of an animal that has been shared undoubtedly among family members, probably among residences, and possibly among unrelated social groups of different status? In each analysis it is vital that the cultural unit used for MNI calculation be carefully defined.

There are many other derived or corrected counts that might prove useful for Mesoamerican zooarchaeologists. As an example, the calculation of species representation through the analysis of body-part or skeletal-element representation overcomes many of the difficulties inherent in the MNI analysis, particularly if the two methods are used simultaneously to allow comparison between sample representation. The MNE (minimum number of elements) is es-

entially an MNI of each element in that the various segments and fragments from each element are matched and counted, providing an estimate of the actual number of elements that are represented by the various fragmented parts (Binford 1981; Stiner 1994). This measure is intuitively the first stage of an MNI calculation (Marean et al. 2001), yet it is rarely defined in Mesoamerican zooarchaeology reports. Dividing MNE frequencies by the expected skeletal element frequencies for each species provides the MAU (minimum animal units) measure (Binford 1981; Ringrose 1993). These methods are most useful in the analysis of repetitive species assemblages, such as those containing domestic species, or in some cases at coastal sites where species diversity is particularly low. They have much less applicability for the analysis of tropical fauna assemblages in regions where preservation is poor, because the chance of species repetition is much less. However, Pohl (1990) has used a variant of this measure to provide observed-to-expected ratios of element-use data for deer, and her research proves the effectiveness of this type of detailed element analysis.

Derived measures. In North American zooarchaeology secondary counts are occasionally plotted against sets of derived "utility indices," or measures of proportionate utility of the various species and body parts. These derived measures allow comparison of relative "value" or "utility" of the zooarchaeological assemblages beyond a simple count of specimens or individuals or species represented. Utility indices are based on detailed modern analogies and actualistic observation and in many cases provide very accurate measures of the value of each body portion. The FUI (food utility index), for example, is equally applicable to any species (allowing a great deal of interspecific comparability) and makes no assumptions about cultural choice in food use. In this measure the food utility is expressed as the gross weight of the part (weight of bone, meat, marrow, grease, etc.) minus the dry bone weight (Metcalf and Jones 1988; Reitz and Wing 1999). The FUI has the disadvantage, though, of

ignoring all the nonfood-related cultural uses of animal parts. These are particularly important in Mesoamerican studies or any other research that examines complex cultures (Crabtree 1990). Binford's (1981) study of the Nunimiut provided him with sufficient analogy to determine element "worth" in terms of all potential uses, a utility index he called the MGUI (modified general utility index). Although this type of measure does indeed provide the most effective comparative index of utility, it is completely impossible to create for any of the ancient cultures of Mesoamerica.

Mesoamerican zooarchaeologists have, however, used some derived utility measures to compare the value of different taxa and body parts. Calculations of biomass representation are consistent with these analyses of utility because they suggest the relative productivity represented by the individuals or elements in the zooarchaeological assemblage (Casteel 1978). Various methods have been used to calculate biomass or dietary representation, and each provides the analyst with a set of advantages, some decided disadvantages, and a series of assumptions that underlie the calculation and the interpretations.

Perhaps the most unbiased weight-based biomass calculations use skeletal elements as the variables for testing (Prange et al. 1979). Carr's (1986a) work at Cerros is an excellent example of this measure in action. In this analysis statistically derived formulae are applied to weights for each element for each taxa to calculate biomass representation per element. The major advantage of this method for use in Mesoamerican collections is the fact that this measure does not assume the use of an entire individual based on the recovery of a single element. Food sharing, trade, and tribute in a complex civilization will inevitably involve differential animal portion distribution, and this is corrected using the element biomass calculation. A second clear advantage of this method is the lack of assumptions about portion utility. This biomass measure is not equivalent to a meat measure and does not make assumptions about the uses to

which the portion has been put. Finally, because this measure is based on element weight, it does not require the calculation of MNE for an accurate assessment of the count of the elements represented.

Various disadvantages to this method are of particular importance in this region, however. Preservational conditions (including leaching and mineralization) will affect the bone weight, differential element preservation will affect the representative nature of the sample, and the basic formulae that are used in the calculation are generally based on nonrepresentative fauna (from North America or other locations) and are not entirely accurate (Casteel 1978; Prange et al. 1979; Reitz and Cordier 1983; Reitz et al. 1987; Reitz and Wing 1999; Wing and Brown 1979).

Other biomass measures are based on MNI calculations instead of sample weight and are derived using average whole-body or usable meat weights in animals of determinate growth. These are much more commonly used, and the information from which body weights are derived is generally drawn from the biological literature (McKillop 1984; Wing 1980). Whole-body biomass calculations are a very effective and rapid comparative measure that take into account the variable food utility of molluscs vs. deer, but again, the arguments against any utility measure include the inaccuracies of our "value" assumptions. A *Spondylus* valve is indeed much lighter in biomass (even whole-body biomass) than an *Agouti paca*, but the simple fact remains that its value lies not in biomass but in symbol and prestige.

In animals of indeterminate growth another calculation of significant utility is the derivation of body weight (or meat weight) by allometric scaling relative to skeletal-element size (Seymour this volume; Wing 1980). These measures are based on the allometric relationship between the dimensions of single skeletal elements or features and whole-body size (Reitz and Cordier 1983; Reitz et al. 1987). However, this type of analysis is based on the statistical validity of the allometric relationship (Reitz and

Wing 1999), and it therefore assumes the use again of an appropriate comparative sample for its derivation. Seymour (this volume), for example, provides live and usable weight values for various common marine fish families by calculating individual fish sizes from regressions on archaeological specimens as opposed to estimated average live weights from modern specimens. His work has shown that species-specific derivations provide lower and more variable weight values than those approximated in earlier literature (Wing 1980).

Once again, the plethora of options and correlating constraints should not hinder the use of basic, secondary, or derived counts. Instead, caution should be taken to provide clear definitions of the measures used and their underlying assumptions.

From the Death Assemblage to the Life Assemblage (Secondary Zooarchaeological Analyses)

The most difficult task for the zooarchaeologist is identifying the original life assemblage, the naturally occurring community of animals coexisting in an ecological equilibrium that can be affected by environmental fluctuations and interaction with humans. This is a fundamental step toward the final goal of reconstruction of the behavior patterns of the cultural group as it affects and is affected by the animal community. But recognition of the life assemblage behind a death assemblage is complicated by the fact that the death assemblage is affected by human activities and choices—which species were preferred, to what extent they were transported back to the site, how and when the skeletal remains were discarded, if they were reused, and a host of other variables. At the other end of the continuum, those species that are neither chosen by people nor attracted to human habitation never appear in the archaeological record. Our analyses, therefore, are limited in their ability to distinguish the absence of a taxon as a result of food taboos or other cultural avoidance or those that result from a true absence from the environment. Despite these

difficulties it is an important goal for Mesoamerican faunal analyses to describe the death assemblage and from it to reconstruct both these highly variable human activities and the original life assemblage or animal community on which the human choices acted. It is in this final stage of interpretation of zooarchaeological remains that we find the clearest evidence of bias and loss of comparability, but it is also here that we find many of our most valuable results. As zooarchaeologists we can provide a wealth of information for archaeological modeling and theoretical analysis: everything from middle-range or actualistic data to tests of predictive hypotheses generated through other archaeological avenues. But if we are unable to trust the results that are generated at this all-important juncture of our research, then the results are unimportant.

Environmental reconstructions. Zooarchaeological studies rely on environment-based theoretical models, such as cultural ecology, which emphasize the importance of processual systems and the adaptive relationship between humans and the environment (Bates and Lees 1996; Butzer 1982). Mesoamerican zooarchaeologists must therefore strive toward accurate reconstructions of the ancient Mesoamerican environment. Without these environmental reconstructions our cultural conclusions are inaccurate and, as discussed above, irrelevant. We must understand local and regional biotic communities in order to detail the animal populations and their relationship with ancient cultures in the region. Borrowing generally from ecological methods, zooarchaeology attempts to reconstruct environmental variables using both population and community ecology measures.

At the population level zooarchaeologists examine the relationships among individual animals of the same taxonomic group, and generally our analyses are restricted to those that are in a single breeding population (implying, then, a regional restriction). At this level the focus of study is generally on the analysis of life

history strategies or the paleodemography of a given taxon. Discussions of population growth and regulation have regularly been used in Mesoamerican zooarchaeology to suggest cultural and environmental factors that might affect population stability. For example, harvest pressure has often been cited as causal for morphological and osteometric changes seen in molluscan populations (Emery 1986; Miksicek 1991), and the same factor has been suggested as a possible explanation for age patterns among deer populations in the lowlands (Carr 1996; Pohl 1990).

Reitz and Wing (1999:179) note that alterations in well-established population demographics may also indicate a more dramatic change in animal management techniques—the introduction of domestication practices. The discussion of animal domestication in the Maya area is particularly intense as zooarchaeologists debate the extent of ancient control over certain species (Carr 1996; Wing this volume). The Mesoamericans are known to have had only two domestic animal species, the dog (*Canis familiaris*) and the common turkey (*Meleagris gallopavo*). However, ethnographic analogy and ethnohistoric documents suggest that the Maya may have domesticated the white-tailed deer as well (Pohl 1990; Pohl and Feldman 1982). Unfortunately, the only evidence for animal management has come from the archaeological remains of possible animal pens (Hamblin 1984; Rice 1993), and zooarchaeological attempts to document changes in deer morphology, demography, or use patterns that would be indicative of domestication have failed (Carr 1996; Pohl 1990), although see Hamblin (1984) for age-class evidence for coati and turkey raising on Cozumel. However, the recent addition of bone isotopic methods to the zooarchaeological arsenal has provided new data to support at least the selective husbandry of certain individuals in preparation for ritual sacrifice or feasting (Tykot et al. 1996; White et al. this volume). This suggestion is strongly supported by zooarchaeological evidence for specialized animal treatment and management in ceremonial situations.

It is vital to note, however, that analyses of population demographics provide information on all density-dependent factors that might have affected population structure, including the relative availability of food and habitat (tied to environmental conditions) and the abundance of predators (tied to community ecology). Although many zooarchaeological analyses use the presence/absence of single species as indicators of environmental patterning, the potential effects of trade patterns or population management strategies may interfere with the validity of the ancient species as true markers of past habitats. A detailed description of community distributions is a more effective method for the analysis of ancient environments.

At the level of community organization we are interested in the reconstruction of the relationships between taxa or groups of populations that co-reside in a single ecosystem (Odum 1971; Ricklefs 1973). Mesoamerican zooarchaeology methods at this level, therefore, have included the analysis of such issues as zoogeography and ecosystem structure, and we sometimes turn to specific measures of habitat fidelity, community diversity, and similarity.

Ancient environments in the Maya area have been reconstructed in a variety of ways. One of the most common is the use of taxonomic habitat preferences. However, these analyses are often based on the arbitrary assignment of species to single ecosystems in a way that does not necessarily reflect the ecological reality of environmental distributions. The fidelity, or degree of preference, of a species for any specific ecological community type is highly variable. Species with low fidelity occur in a number of different communities and those with high fidelity in only a few. Some authors have used a “fidelity measure” that more accurately reflects the environmental characteristics represented by the zooarchaeological remains recovered (Emery 1997, chapter 6 this volume; Pohl 1976). The most effective environmental reconstructions are those done using microfaunal communities in undisturbed sediments. Microfauna respond quickly to environmental

changes and can reflect those changes either morphologically within species or genetically between species (Covich 1983; Flannery 1986). Recording variability of either type provides clear evidence of habitat changes without many of the biases involved in the study of macrofaunal assemblages that have been affected by cultural activities. Biases exist, however, even in the analysis of microfaunal populations; primary among these are the effects of predator preferences on microfaunal death assemblages and taphonomy on both natural and cultural deposits where microfauna are found (Andrews 1990; Andrews and Nesbit Evans 1983; Dodson and Wexlar 1979; Flannery 1986; Saavedra et al. 1998).

Ecological community statistics are most commonly used to quantify the distribution of, and the relationships between, living taxa in a natural ecosystem. As analytical tools they are valuable additions to the techniques of faunal analysis because they provide more detailed information on changing temporal and spatial patterns of resource utilization than is generally available through the simple analysis of taxarecovery frequencies and discussions of emic values of utilized species. One commonly used community statistic is species diversity (or heterogeneity), a measure that combines two distinct components: species richness, or the number of taxa present in a collection containing a specified number of individuals; and species evenness, calculated as the similarity in abundance of several taxa in a sample. The distinctions between these measures allow consideration of the different properties of the structure of the ecological community. There has been considerable debate as to the effectiveness of the various measures of diversity in archaeological studies because of the biasing factors of sample size (Cruz-Uribe 1988; Leonard and Jones 1989). When sample sizes are proven to be independent from the measure, however, this can be an effective method for examining dietary breadth and access to resources (Broughton and Grayson 1993; Emery 1999; Madsen 1993).

Community similarity measures are also occasionally used as a statistical technique for

quantifying differences among assemblages, although most often in North America (for Mesoamerican examples, see Emery 1997; Flannery 1967; Hardy 1996). These must be used with some care, however, as they are also subject to sample-size dependency issues and are sometimes entirely unsuited for the analysis of nonparametric zooarchaeological data.

Reconstructing cultural patterns. All of the chapters in this volume present reconstructions of cultural patterns—this is, after all, our final goal in the analysis of zooarchaeological patterning. To leave this chapter with some semblance of an optimistic view of our methodological capabilities, I cannot overemphasize the very real utility of our analyses at this level.

Our earliest and most enduring interpretive attempts have been in the reconstruction of ancient Mesoamerican diets. Subsistence studies continue to be the mainstay of zooarchaeological analyses, despite the arguments that have ensued as a result of quantification variability. Our zooarchaeological methods provide a strong basis for dietary analyses of single species (Healy et al. 1990; Powis this volume) or comparative studies (Pohl 1990) that combine archaeological use and distribution with ecological information on habitats, ethnographic data on procurement, and nutritional analyses. Our methods also support the effective application of theoretical models of subsistence behavior in presentations like that of McKillop and Winemiller (this volume), which uses an optimal foraging model based on cost efficiency to estimate dietary contributions. However, most authors feel that optimality (Winterhalder 1981), prey choice (Lyman 1985b), and other predictive models are difficult to apply in the context of a complex civilization, particularly in view of the indications that these are not yet even equal to explaining hunting patterns in noncomplex societies (Porcasi and Fujita 2000).

It is clear, however, that if we deal effectively with the internal issues of sample comparability, our zooarchaeological methods are strong enough to deal even with broader theoretical issues such as economic patterning in

trade (Carr 1985, 1986a; Shaw 1999) and craft production (Emery 2001; Trubitt 2000; Wake 1999); the politics of social status (Emery 2002; Teeter this volume; Pohl 1985b, 1995) and ethnic identity (Emery 1999; Scott 1996); and the construction of symbolic relationships on a social or ritual level (Moholy-Nagy this volume; Pohl 1983; Pohl and Pohl 1983).

It is our responsibility as analysts and often excavators to ensure that the conclusions we provide to the archaeological world are based on securely comparable samples and robust middle-range assumptions.

CONCLUSIONS

This volume presents several avenues toward solutions for the basic difficulties that zooarchaeologists must face: primarily the need for comparable samples for accurate site and regional analyses; and the inherent need, therefore, for a direct and confrontational attitude toward the biases created by the continuum of behavioral, transformational, and analytic processes through which any zooarchaeological assemblage passes. We are certainly not alone in facing these broad issues; however, as zooarchaeologists working in tropical environments and with the remains of complex civilizations, we do have a special set of hurdles to overcome. We must be particularly aware of the effects of biological diversity and the variability in preservational conditions among disparate environments within the region. We must also pay strict attention to the complexities introduced by social patterning in ancient Maya society and to the assumptions that underlie our conclusions about the patterns we believe we are revealing through our analyses. Although we have begun to approach the second set of issues, it is only very recently that we have begun to specifically test the first issues, the basic biological and taphonomic parameters of our science. The need for comparable samples is essential, and

although no two assemblages will ever be identical, with an appropriate level of clarity in the published literature we can create analytical comparability.

The work presented in *Maya Zooarchaeology* exemplifies some of the most important recommendations made in this chapter. Our basic identification procedures and the processes we use for secondary data classification (age and sex) must be clearly stated and must be based on taxonomically correct biological information (see Wake; Powis for examples). We must take an active and intrinsic role in archaeological planning, and we must demand the use of appropriate sampling and recovery methods based on verification tests to define site-specific methodology (see Masson; Beaubien for examples). Our contextual and provenience information must be detailed enough to identify deposit characteristics ranging from those that would affect preservation to those that would affect original disposal behavior (see Henderson and Joyce; Moholy-Nagy; Teeter). Taphonomic variables of specific interest to each situation should be defined and the resulting bias ameliorated with appropriate measures where this is possible (see Stanchly). Quantification should be approached cautiously on the one hand, and all field reports should contain basic counting data; but we should also begin to brave the new frontiers of possible tertiary and statistical methods in an attempt to provide quantitative comparability for our analyses (McKillop and Wine-miller; Seymour). Finally, we have been very successful in the incorporation of new techniques and methods from other sciences in the reconstruction of ancient environments and life-ways, and this trend should continue (Emery; White et al.). With a new attention to assemblage comparability and methodological reproducibility our reconstructions will gain further strength and our conclusions will find a clearer niche in the theoretical world of archaeological model building and testing.

Picks and Stones May Break My Bones

Taphonomy and Maya Zooarchaeology

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Taphonomy is increasingly recognized as an important field of inquiry in zooarchaeological method and theory. Taphonomic studies, including actualistic research, are now commonly employed as interpretive tools in various areas where zooarchaeology is practiced, most notably in early hominid research. Unfortunately, few studies in Maya zooarchaeology have provided explicit discussions of taphonomic agents that may affect the representativeness of faunal assemblages.

This chapter discusses the contribution that taphonomy can make to Maya zooarchaeology. Following a discussion of the goals and history of taphonomic research in the Maya lowlands, I will identify and discuss some of the natural and cultural taphonomic agents that may affect bias in the zooarchaeological record of the Maya. Finally, the essay will discuss some issues of taphonomy that may arguably be unique to the zooarchaeology of complex societies such as the Maya.

As zooarchaeologists we are interested in understanding and elucidating the interaction between humans and their animal communities from an anthropological and environmental perspective. The investigation of this interaction takes place on many levels, among them the reconstruction of subsistence strategies (paleodiet and paleonutrition), paleoeconomies, and paleoenvironments. The validity of our interpretations via the analysis of archaeofaunas is dependent on our assessment of the integrity or “representativeness” (Drennan 1996:85–86, Lyman 1994b:4) of a given faunal assemblage.¹

Most, if not all, archaeologically recovered animal assemblages are biased to some degree (Lyman 1994b:1; Marean 1991:677; Reitz and Wing 1999:110–113). Bias is introduced when “some non-human-related processes have affected the condition or frequencies of biological remains” (Lyman 1994b:1). Animal remains recovered from archaeological deposits have been subjected to various cultural and natural

processes from the time of the procurement of an animal to its subsequent deposition and the recovery of its skeletal remains by archaeologists. Identifying and reconstructing pre-depositional and post-depositional processes that affect bone survivorship is at the core of taphonomic research.² The representativeness of a sample is thus affected by its taphonomic history (Lyman 1994b:5).

The word *taphonomy* was coined by Efremov (1940) to denote a subfield of paleontology that sought to understand this “transition . . . of organics from the biosphere into the lithosphere or geological record” (Lyman 1994b:1). Archaeologists have adopted the term and modified its definition to varying extents. Lyman (1994b:1) provides a simple definition (based on Efremov’s original meaning): “Taphonomy is the science of the laws of embedding or burial.” Behrensmeyer and Kidwell (1985:105) refer to taphonomy as “the study of processes of preservation,” and Reitz and Wing (1999:110) define taphonomy as the “study of the changes that

affect a deposit.” Koch (1989:2) defines taphonomy as “the study of the processes of preservation and modification, and how they affect geological, biological, and cultural information in the geological [*or archaeological*] record” (emphasis mine).

To trace the taphonomic history of faunal assemblages, we seek to identify the taphonomic processes that act on them by recognizing their taphonomic effects or traces in the archaeological record (Gifford 1981). It is important to remember that taphonomic processes (particularly pre-depositional processes) can also affect the depositional history of an assemblage or the formation of a deposit. In this regard taphonomy is related to Schiffer’s (1987) “site formation processes.” This is important to realize because taphonomic inquiry has the potential to help clarify the formation history of problematic deposits.

The taphonomic history of an assemblage seeks to reconstruct those variables that act on faunal remains as they pass through the various stages from life to death and, finally, retrieval. Zooarchaeologists have referred to these stages as “assemblages” (Andrews and Cook 1985:689; Emery 1997:73; Klein and Cruz-Urbe 1984:3; Lyman 1994a:31; Reitz and Wing 1999:110, 111). Variably included among the list of assemblages are the life assemblage, death assemblage, deposited assemblage, fossil assemblage, excavated assemblage, and the curated assemblage. Although I do not intend to discuss these here, their importance lies in the fact that different taphonomic processes can affect each assemblage stage.

Taphonomic inquiry in zooarchaeology has intensified over the past two decades (Lyman 1994a:12–13). Understanding the processes that can introduce bias is essential to presenting valid interpretations of past animal resource use. As a subdiscipline of zooarchaeology, taphonomy has played an increasingly important, and in some cases primary, role as an interpretive tool (see Blumenshine 1986; Brain 1981; Bunn 1981). Unfortunately, although taphonomic inquiry is now regularly incorporated in

zooarchaeological methods in many regions, the Maya area has seen limited and cursory attention to taphonomic detail.

This chapter discusses the relevance of taphonomy to Maya zooarchaeology. I begin by tracing the history of taphonomic research in Maya archaeology. I then discuss the relevance of taphonomy to the zooarchaeology of complex societies and follow this with a brief review of those processes that have the potential to introduce bias in Maya archaeofaunas. This chapter is by no means an exhaustive review of the subject. It is presented to illustrate why Maya zooarchaeologists should pay more attention to this field of inquiry and to provide a stimulus for further research in taphonomy.

TRACING THE HISTORY OF TAPHONOMY IN MAYA ZOOARCHAEOLOGY

Published reports on ancient Maya animal use are few, and published papers dealing specifically with the taphonomy of Maya archaeofaunas are nonexistent. Although faunal remains from Maya sites have received attention from archaeologists and zoologists for the better part of this century (see Emery, chapter 1, this volume for a thorough overview of the history of the discipline), much of the interest in ancient Maya animal use can be described as secondary and descriptive. A great deal of what has been written on the subject of Maya animal use is in the form of short monographs included as appendices in larger excavation reports (Kidder 1947; Ricketson 1937; Wing 1974, 1975) or as papers in edited volumes (see Pohl, ed. 1985). To date only one full-length book dealing specifically with animal use by the Maya has been published (Hamblin 1984). One edited volume on Maya subsistence (Flannery 1982) has only a single chapter (Pohl and Feldman 1982) in fourteen that deals with the subject of animal resource utilization. In none of these publications is taphonomy addressed as a biasing factor in the interpretation of animal resource exploitation.

The lack of published zooarchaeological and taphonomic data can perhaps be attributed to two primary factors. First, the importance of animal proteins to ancient Maya subsistence is of secondary concern to archaeologists when compared to the importance of maize agriculture to the evolution and development of Maya civilization. Second, there is an implicit acceptance among Maya archaeologists that animal remains do not survive well in tropical environments and that this accounts for the paucity of bone recovered during excavations. This lack of faunal data has reinforced the idea that animal proteins were of secondary concern to the ancient Maya in comparison to agricultural staples (see also Shaw 1991:52). In other words, the lack of recovered bone is simply attributed to the poor preservation of organic remains in harsh tropical environments. Although it is true that organic preservation in the tropics is poor, there are a number of natural and cultural taphonomic processes acting on bone deposits that can diminish the structural integrity of bone and lead to "poor preservation."

Rather than investigating these taphonomic factors, many zooarchaeologists and archaeologists continue to use this "preservationally biased" lack of bones as an indicator of a lack of animal proteins. For example, some researchers have implied that a lack of faunal material from Classic period contexts indicates that meat was in short supply (see Dillon 1988; Masson 1993a: 99–100, 1999a:98; Pohl 1976; Sanders and Price 1968:92). Moreover, the absence of animal remains is cited as an indication of heavy deforestation and environmental degradation during the Classic (Masson 1993a:261, 1999a:98, 99).

Among published works Nancy Hamblin's (1984:17) monograph on Cozumel animal exploitation devotes only two pages to the subject. Masson (1999a:99) dismisses taphonomic variables as an explanation for the lack of recovered faunal material from Classic period contexts. She cites as evidence the apparent greater frequency of bone recovered from Preclassic

and Postclassic contexts and assumes that taphonomic processes were uniform throughout Maya prehistory. Therefore, the lack of faunal material from Classic contexts cannot be attributed to taphonomic variables. I would caution that in the light of inadequate research on the subject of taphonomic "uniformity" such conclusions are premature.

Mary Pohl (1976:67–81) provides the most extensive review of taphonomy in her unpublished doctoral dissertation, now almost three decades old. Pohl's treatment of taphonomy is extensive although mainly descriptive. To her credit she does provide some data on experimental research conducted with modern animal remains by Maya hunters in Belize. Moreover, Pohl's inclusion of a detailed review of taphonomic agents in the Maya region came at a time when the discipline was still developing within zooarchaeology as a whole. Unfortunately, although taphonomic inquiry has received increasingly specific attention from zooarchaeologists working in other regions of the world, Maya zooarchaeologists have not followed Pohl's lead.

Emery (1997:72–92) discusses the taphonomic history of faunal material from several Petexbatún sites with reference to the various stages through which the animal remains passed. This is a particularly insightful discussion in that she reviews biases that can be introduced by archaeologists, biases such as sampling techniques, processing of faunal material, and measurement error. Shaw (1991:243–249) provides a brief review of taphonomic agents at work on the Preclassic faunal assemblage at Colha.

The conclusions cited above demonstrate the urgency for resolving matters of differential preservation on a broad scale. These conclusions are premised on the effects of differential bone preservation and recovery without reference to detailed taphonomic inquiry. This research must be conducted before conclusions such as these can be substantiated.

TAPHONOMY AND COMPLEX SOCIETIES

An examination of the enormous amount of published taphonomic literature indicates that the majority relates to archaeofaunas of non-complex societies or hunter-forager bands. The development and application of taphonomic techniques in zooarchaeology is rooted in debates strongly aimed at seeking to elucidate early hominid behavior (Behrensmeyer 1975; Binford 1981; Blumenschine 1987; Brain 1981). One of the primary concerns of this research has been to identify those agents (i.e., hominid or animal) responsible for animal bone accumulations. Moreover, taphonomy, in conjunction with experimental research, is often the main analytical tool used in reconstructing early hominid subsistence strategies. These are most celebrated in the debates that seek to identify our early hominid ancestors as scavengers or hunters (Blumenschine 1986; Blumenschine and Cavallo 1992; Brain 1981; Bunn 1981; Bunn and Kroll 1986; Lupo 1994; Potts 1984; Shipman 1986; Shipman and Rose 1983).

Faunal remains from complex societies are also biased, and to many extents in very different ways, from those of foraging or hunting societies. Different questions arise, and different taphonomic agents are at work, namely cultural ones. For the most part the faunal remains recovered from sites of complex societies are by-products of human activity. Primary contexts (e.g., occupation surfaces, burials, and caches) produce faunal material that is directly related to issues of subsistence, economy, and ideology. However, these contexts must also be subjected to taphonomic analysis in order to identify potential biases from pre- and/or post-depositional agents.

In the Near East faunal analysis has been aided by taphonomic inquiry (Zeder 1991:98–117). One of the central themes of Near Eastern archaeology, shared with Mesoamerican archaeology, is the emergence of complex society. Associated with questions of early complexity

in both areas are debates surrounding the rise of plant and animal domestication. Although both Mesoamerica and the ancient Near East saw the development of complex society closely aligned to the appearance of domesticated food resources, the primary difference between the two regions is the appearance of domesticated animals in the Near East and the lack of such domesticates in Mesoamerica. This is perhaps the main reason why faunal analysis has received so much more attention in the Old World than in Mesoamerica. In contrast, the only domesticates used by the ancient Maya were the dog and turkey. No beasts of burden existed.

Zooarchaeologists investigating complex societies are presented with a variety of questions regarding animal use. Apart from the dietary use of animals we must be concerned with questions of animal resource trade and exchange, the inclusion of animals in ritual deposits (e.g., burials, caches), political and ideological uses of animals, and differential access to animal resources (Crabtree 1990; Gumerman 1997).

Complex societies are hierarchical and stratified to varying extents. Social stratification is evident in differential access to resources, including, in some cases, animal products. In Classic Maya society the privilege that was afforded the elite (kings and royal families) brought with it differential access to animal proteins (Pendergast 1992; Pohl 1976, 1985b; White et al. 1993). By comparing midden deposits from elite vs. nonelite contexts we can investigate the nature and extent of this privilege.

Animals were also used in political negotiation and particularly in feasting events that sought to consolidate or create alliances (Pohl and Pohl 1994; Shaw 1991; Tozzer 1941). Animals also played an important role in ideology and, in particular, in Maya cosmology. The *Popol Vuh* (Tedlock 1996) has many references to animals in the context of Maya creation myths, and the depictions of animals in Maya

art also attest to their importance on a social and ideological level (Pohl 1990).

Differential access to meat, trade, and exchange of animal products and the importance of animals on both the political and ideological level are aspects of animal utilization that we can investigate. To work toward an understanding of the dynamic role of animals in Maya society, we must be confident that the samples we analyze are representative.

TRACING THE TAPHONOMIC HISTORY OF MAYA ARCHAEOFAUNAS

Bone recovered from Maya archaeofaunas has been subjected to various pre- and post-depositional processes. In this section I will briefly review some of the taphonomic agents at work in the Maya area, including cultural and natural agents. Neither works in isolation from the other. The degree to which each is responsible for bias present within a sample should be discernible by tracing the taphonomic history of an assemblage. Although I provide no specific examples herein, I aim to review these processes by presenting a hypothetical history of bone deposition from the moment an animal is procured to the time it is recovered by the archaeologist and presented for analysis.

Procurement

Animals were obtained by the Maya by hunting, trapping, fishing, and probably fortuitously in some instances (i.e., scavenging). Most of what we know about Maya procurement techniques comes to us from depictions of hunting scenes in Maya art and the codices (Pohl 1990:155–156). Techniques for obtaining carcasses included hunting with blowguns and spears, trapping with snares and nets, and fishing with nets (Pohl 1990:155). Dogs may have been used in the hunt as well. This is by no means an exhaustive list of hunting techniques, but an understanding of the range of techniques can inform our reconstructions of the ease of access of animals of different types and sizes. Both animal class and carcass size must

be considered in terms of differential taphonomic impact.

Carcass size can determine how much of an animal is to be transported from the kill site to the home site (Perkins and Daly 1968). Small animals are more likely to be brought back from the kill intact than are larger game. Larger game is likely to be processed to a greater or lesser extent based in part on its size (“schlepp effect”), although issues of utility and cultural preference will also determine what proportion of the animal is returned to the home for processing. The result of differential transport from a kill site to a home base has been discussed extensively in the European and North American literature (Coard and Dennell 1995; Grayson 1989; Lyman 1985a; Metcalfe and Barlow 1992), particularly with reference to ethnoarchaeological research (see Bartram 1993; Bunn 1993; Monahan 1998; O’Connell et al. 1990), and early hominid studies (Klein 1989; Turner 1989). It has not been effectively detailed, however, for the Mesoamerican situation.

More important perhaps than the differential return transport of carcasses is the differential destruction of the remains once they have been returned and discarded. The structural density of bone from small animals is generally less resistant to destructive forces than are those of larger game (see Lyman 1994b for a thorough discussion of bone histology and structural density). Not only can bone density bias preservation of small vs. large animals, but it can determine which bones of the body will survive (Turner-Walker 1995). For example, carpal and tarsal bones are much denser than ribs and are more likely to survive because taphonomic processes generally act slower on dense bones.

The use of dogs as hunting companions could also contribute to bone destruction and bias in the sample (Pohl 1976). Dogs may have been fed a portion of a carcass at the kill site, and this practice would affect patterning in return transport of body parts. Dog scavenging and feeding at the home site would also increase bone fragmentation and destruction in the very deposits where the remains are most

likely to be recovered (Kent 1981; Marean and Spencer 1991). Dogs are regularly fed from the offal remaining after butchering, and their scavenging through surface middens is a well-known activity in modern Maya households today and likely in the past as well.

Food Processing

The processing of animal carcasses introduces a variety of culturally related biases and taphonomic procedures including butchering and cooking techniques. Butchering involves the skinning of a carcass, disarticulation for the redistribution of meat, and the purposeful breakage of bone for marrow extraction. Butchering techniques can also affect bone distribution since only certain body portions may be kept for cooking and distribution, whereas others are discarded. The presence and location of cut marks typically record taphonomic signatures reflective of carcass skinning and disarticulation. A lack of cut marks can also inform us about disarticulation techniques. Fragmentation that results from marrow extraction can also be quantified through taphonomic analysis (Lupo 1994; Lyman 1987; Todd and Rapson 1988).

Heating the meat on bone by cooking can introduce a variety of taphonomic signatures, including discoloration (charring and calcination), shrinkage, cracking, and exfoliation (Buikstra and Swegle 1989). The extent of damage to bone is dependent on the structural density of the bone, the temperature to which it is subjected, and the length of time it is subjected to the heating process (Nicholson 1993; Olsen et al. 1984; Stiner et al. 1995; Taylor et al. 1995).

The burning patterns evident on archaeologically recovered bone can tell us something about the cooking practices of the Maya. Not only is the type of burning important, but so too is the distribution of burning on the bone. For example, is the whole bone heat altered, or have only portions of the bone been altered? Is there consistent patterning seen among heat-altered bone? These types of questions can also help us ascertain whether heat-altered bone is the product of cultural processes or natural

burning (Bennett 1999; Lyman 1994b; Nicholson 1995).

An important consideration is that once bone has been heated, and thereby chemically altered on a microscopic level, it is more prone to destruction from other taphonomic agents. Once thermally altered bone has been discarded as refuse, there is a greater likelihood that much of it will not survive and may be more prone to the effects of agents such as soil acidity, weathering, trampling, and leaching.

Bone was also used for expedient tools and for manufacturing formal tools and adornments. The reduction processes involved in the manufacturing of these items also affect bone survival and identifiability. The production of tools results in fragmentation. Generally bone tools appear to be made from dense elements, such as deer metapodials. In many cases both the final product and the accompanying bone debitage will survive because of the selection of dense bone. However, bone tools are often very difficult to identify to the particular skeletal element used and in many instances to the species used. This is particularly true with bone beads.

Identification of bone debitage requires a taphonomic study of fragmentation. Bone is more readily workable when it is fresh, and the processes of tool manufacturing on "green" bone lead to recognizable patterning in the resulting debitage (Emery 2001; Lyman 1994b; Todd and Rapson 1988). Taphonomy must be used to help distinguish fragmentation that results from human agents vs. natural agents (i.e., trampling).

Disposal

Disposal is perhaps the single most important cultural practice affecting bone survivorship. Once bone refuse is deposited, it is subjected to a variety of natural taphonomic agents, although the extent and type of agents depend on the location of deposition. For example, sealed deposits such as burials and caches provide bone with a certain amount of protection against natural elements. Sealed deposits can protect bone from destructive elements like water and

animal scavengers (e.g., rodent gnawing). Tree roots are notorious disturbers of Maya buildings, burials, and caches. If tree roots penetrate a sealed deposit, they can compromise the integrity of bone survivorship by exposing them to destructive natural agents such as rodents and other animals and water leaching. Unsealed deposits such as materials left on the surface and unprotected middens are more likely to be acted on by post-depositional processes.

Post-depositional Processes

Natural and cultural taphonomic agents act on bone following deposition, as do excavation techniques. Natural post-depositional agents that we should take account of are soils, water, sunlight, tree and plant roots, animal scavengers, and invertebrates such as termites (McBrearty 1990), ants (Gautier 1993), and earthworms (Armour-Chelu and Andrews 1994). Soil conditions can influence diagenesis rates (see below); water leaching and exposure to sunlight are both destructive agents and leave taphonomic signatures on bone; and the destructive influences of flora and fauna lead mainly to increased fragmentation of bone, although both can also displace bone materials.

Cultural agents that act on bone following discard or deposition primarily consist of redeposition events. Maya construction techniques necessitated large amounts of material to fill in construction cores. Midden material, including bone, was routinely cleared from within and around structures and reused as core inclusions. The disturbance of bone deposits therefore often involves taking bone from one type of environment and introducing it into a new one. It is quite probable that new taphonomic agents and processes will accompany the move from one environment to another. Arguably, the most destructive process in any redeposition event will be increased fragmentation of faunal material.

Perhaps as important, changes in the depositional environment can also remove taphonomic agents. For example, when bone is taken

from the context of a surface midden and used as fill in a construction core, a number of taphonomic agents are removed, including animal scavengers (particularly dogs) and various agents that lead to weathering of bone. These might include particular soil conditions associated with surface deposits (e.g., tree roots and leaf decay) and rain and sunlight.

Although redeposition of bone in construction cores can negate the effects of some taphonomic agents, new agents can be introduced. In addition to the increase in fragmentation caused by the physical removal of bone from one context to another, the nature of the core deposit can expose bone to specific destructive agents. These are highly dependent on the type of core deposits used in construction (see Loten and Pendergast 1984) but generally relate to soil types found within the core (e.g., alkaline vs. acidic).

Soil characteristics are perhaps the most important of the natural taphonomic agents. Soil acidity, alkalinity, and humidity all affect bone survival. Fungi and microorganisms within soils can lead to bone fragmentation and destruction. There is a consensus among archaeologists and zooarchaeologists alike that animal remains preserve poorly in the Maya environment. The tropical environment, and in particular soil conditions, is the catalyst cited most often for bone destruction in Maya sites. Destructive soil conditions include those with high acidity coupled with high humidity and rainfall amounts and the destructive nature of plant and tree roots.

To be sure, the tropical environment of the Maya area is harsh on organic materials, and the physical and chemical properties of tropical soils are generally detrimental to preservation, although some act positively on preservation. Acidic soils can initiate chemical weathering of skeletal tissue (Lyman 1994b:422). Weathering destabilizes the structural integrity of a skeletal element and leaves it vulnerable to further destruction as a result of other soil climate conditions. For example, exposure to water will

promote further disintegration through leaching. *Diagenesis* is a term often used to describe the disintegration or chemical alteration of bone or shell. Many definitions exist for diagenesis, but it is generally taken to mean the chemical and physical changes that occur in faunal remains following initial deposition (for various definitions, see Lyman 1994b:506).

Tropical soil climates (Mohr et al. 1972:3–80; Van Wambeke 1992:5–29) are extremely complex and dynamic. The development of tropical soil types depends on the relationships between temperature and moisture (Van Wambeke 1992:5–25). These relationships combine to produce a soil climate that in turn “influences soil formation, soil behavior, and plant growth” (Van Wambeke 1992:25–26).

We must be aware of the dynamics of tropical soils and understand that their development is influenced not only by natural processes but also by human interaction and impact on the environment (Graham 1989:139, 1998:119, 127–133; Graham and Pendergast 1992:102). Environmental diversity occurs not only regionally, within the Maya area, but in all likelihood it occurs through time as well. The Maya environment is not a static entity, and archaeologists and zooarchaeologists alike must be more cognizant of the dynamics of the interaction between the Maya and their environment.

Finally, the integrity of a faunal assemblage may also be compromised by archaeological excavation techniques. Excavation of Maya structures often involves the use of heavy equipment, such as large picks and shovels. The use of such tools can lead to the increased fragmentation of all artifact types. Breakage of bone as a result of archaeological techniques (including artifact processing and storage) is readily apparent in the form of the discoloration between the fresh break and the remaining bone specimen. Although it may be tempting to dismiss such material as bones exhibiting “trowel trauma,” it is important to take note of them and to quantify recent breakage for a few reasons. Recent breakage can mask fragmentation rates associated with cultural and/or natural taphonomic agents

acting on bone prior to excavation. To assess the integrity of an assemblage, fragmentation must be assessed in some way to distinguish and identify pre- and post-excavation breakage patterns. Breakage caused by archaeological activity may also have the potential of allowing us to examine the taphonomic history of a specific deposit before excavation. Bone that is structurally weakened by taphonomic agents should be more prone to breakage during excavation. It seems plausible that there might be some way to incorporate information attained from the quantification of recent breakage to help assess the taphonomic history of a given deposit.

DISCUSSION AND DIRECTIONS FOR FUTURE RESEARCH

I have listed and briefly described a select number of both natural and cultural agents that act on bone survivorship. None works in isolation, and each affects bone differently. For zooarchaeologists the importance lies in recognizing the effects of taphonomic agents on archaeofaunas. By recognizing taphonomic signatures we can begin to trace the taphonomic history of a given assemblage. Taphonomic agents can affect bone survivorship, the frequencies of various skeletal elements present in a sample, the completeness of a faunal assemblage (its representativeness or integrity), and the fragmentation of skeletal parts. In turn, all of these elements affect the identification of faunal remains. From the moment that an animal dies it is subjected to taphonomic processes. Human involvement in skeletal accumulation begins at the procurement stage and ends with disposal.

Although there is no doubt that tropical environments hamper the preservation of organic material, there is still a tendency among Maya zooarchaeologists to attribute poor preservation of bone solely to its exposure to humid tropical conditions. I have attempted in this chapter to address this “preservational bias” by examining a variety of potential destructive agents.

Perhaps of equal or greater importance than environmental conditions are the depositional history of bone deposits and/or the cultural factors at work in assemblage accumulation. The cultural agents I have reviewed exist in all societies, whether they are deemed complex or not. What differ are the types and numbers of cultural agents and the degree to which they affect survivorship of fauna in the archaeological record. Cultural agents shared among all human groups include procurement patterns, as well as distribution, processing, consumption, and discard practices. Not only do these practices play an important role in the taphonomic history of archaeofaunas, but they also reflect directly on site formation processes (Schiffer 1987).

Cultural factors are also at work on the post-depositional history of Maya archaeofaunas. Perhaps the single most important factor along these lines is the reuse of refuse material as fill to be included in construction cores. For the most part the Maya did not leave garbage lying around their sites. Building construction dictated a need not only for the basic construction materials (e.g., limestone, slate, and coral) but also for refuse, such as ceramic sherds, lithic debitage, and animal remains. Pendergast (1992, this volume) has shown that where large middens have been found, they tend to abut structures that have been abandoned.

The important point here is that the reuse of refuse material in cores leads to further fragmentation and destruction of bone. Perhaps as important, core materials are secondary contexts. Although it is tempting to draw conclusions regarding animal use through the examination of such material, there are definitely limits to what can be deduced. Finding a large quantity of faunal material from within the core of a given structure does not allow us to make any direct inferences regarding dietary preferences of the residents of that structure.

Where refuse was routinely gathered from various parts of a site for inclusion in a construction core, we can never know for certain if the materials found in the core of a given structure are associated with the inhabitants of that structure (see Pendergast this volume). We must be explicitly aware of the interpretive limitations of such materials.

Finally, we must recognize that the taphonomic history of any given assemblage is likely to be both complex and dynamic. This applies not only to faunal material but to other classes of artifacts as well. For us to be able to investigate bias within the archaeological record, we must apply more rigorous study to understanding those processes that act on archaeological deposits. This includes pre- and post-deposition agents of both formation processes and destructive processes.

To decipher taphonomic history we need to incorporate experimental research to a much greater extent. Such studies have provided positive research results in taphonomic inquiry in many regions, most notably in the study of early hominid evolution. The Maya environment is not static, and we should not assume that taphonomic processes, particularly those cited as products of environmental dynamics, have always been uniform on a spatial or temporal level. We must also be cognizant of the impact the Maya have had on their environment and how this might relate to taphonomy.

NOTES

1. This chapter follows definitions for zooarchaeological and taphonomic terminology provided in Lyman (1994b).

2. *Bone* is used here as a general term and includes teeth and antler, although it is recognized that each of these is distinct with reference to histology. Shell is not considered in this chapter, and I refer the reader to Claassen (1998) for a detailed discussion of invertebrate taphonomy.

Excavation and Recovery of a Funerary Offering of Marine Materials from Copán

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A unique assemblage of marine materials was featured among the offerings in a royal tomb excavated at the site of Copán, Honduras. Despite the highly fragmentary, degraded, and jumbled nature of the funerary deposit, its identification as such was possible because of the excavation strategy and post-excavation protocols utilized. Although the work in this case was carried out by archaeological conservators, this chapter emphasizes practical field techniques that can be used by nonconservators. Results of analysis of the marine material recovered by these techniques are reported.

Undisturbed archaeological contexts offer extraordinary opportunities for information retrieval. Elite burial places, for example, would be expected to contain the prepared remains of the deceased, regalia, furnishings, and offerings, as well as remnants of ritual activities that took place at the interment site. The potential for recovering the material evidence, however, is challenged by post-depositional processes that can remove nearly all traces of some materials, notably those of organic origin, and leave others in severely compromised states of preservation.

Such was the case in a royal tomb discovered in 1989 within Structure 10L-26 at the site of Copán, Honduras. The remains of the funerary installation consisted of a seemingly uninterpretable mess of fragments, among which were the degraded and disarticulated components of exotic marine materials, placed on the dais as an offering. The two assemblages that make up this offering might not have been recovered and identified had a sensitive excavation strategy and post-excavation protocols not been in place (see Emery, chapter 2 this volume). Although in this case the work was carried out by archaeological conservators, the

techniques described here should find practical application even when conservators are not available.

Results of analysis are also reported, highlighting the condition of the specimens as found and demonstrating the amount of information retrievable with careful field methods. These data should contribute toward an increased understanding of the symbolic connections that these exotic marine materials held for the Copán elite in life as well as in death.

ARCHAEOLOGICAL BACKGROUND

Recent archaeological research at the site of Copán, Honduras, has focused on the massive site core in order to test a series of hypotheses about the nature of Classic Maya dynastic history and ideology (Fash 1991; Sharer 1999). Tunnel-based excavations have allowed the remains of earlier architecture, sculpture, and ritual activity to be investigated with minimum impact on the final phase architecture. In the process four royal tombs within these monuments have been discovered to date by projects under the direction of William L. Fash (Harvard University) and Robert J. Sharer (University of

Pennsylvania). The complexity and fragility of the funerary deposits prompted each of the projects independently to seek conservation assistance from the Smithsonian Center for Materials Research and Education (formerly the Conservation Analytical Laboratory), beginning in 1990, soon after the discovery of the tomb within Copán Structure 10L-26.¹

This tomb was found during tunnel investigations of the massive structure whose final phase was adorned with the famed Hieroglyphic Stairway. Architectural, stratigraphic, ceramic, iconographic, and hieroglyphic lines of evidence support the conclusion that the tomb housed the remains of Ruler 12, who, according to the hieroglyphic texts, reigned from A.D. 628 until his death in A.D. 695 at approximately age 80.

The funerary chamber, the largest found to date in the ruins of Copán, consisted of a rectangular cyst measuring 7 m by 2 m by 1.5 m high, covered by 10 massive capstones (Figure 4.1). In the center of the chamber was a dais, on which the body was laid, made up of three large, finely hewn stone slabs set into the floor, 2.5 m in length and spanning the width of the cyst. Four niches were built into the walls of the chamber at the floor level, flanking the dais at its north and south ends. The chamber contained an impressive concentration of ceramic offerings, exceptional jade ornaments, and the remains of perishable furnishings, the likes of which had never been recorded at this site. Subsequent analysis showed that these furnishings included fully painted wooden pallets and woven matting. Additional ceramic offerings were placed outside of it at each of the cardinal directions, on top of 1 m of fill laid down over the capstones and at the crest of a surmounting corbeled vault (Fash et al. 1992).

CONDITION OF THE DAIS DEPOSIT

With the decay of its organic constituents the funerary installation on the dais had collapsed and fragmented, gradually settling into a deposit several centimeters thick over the entire surface. It consisted predominantly of very

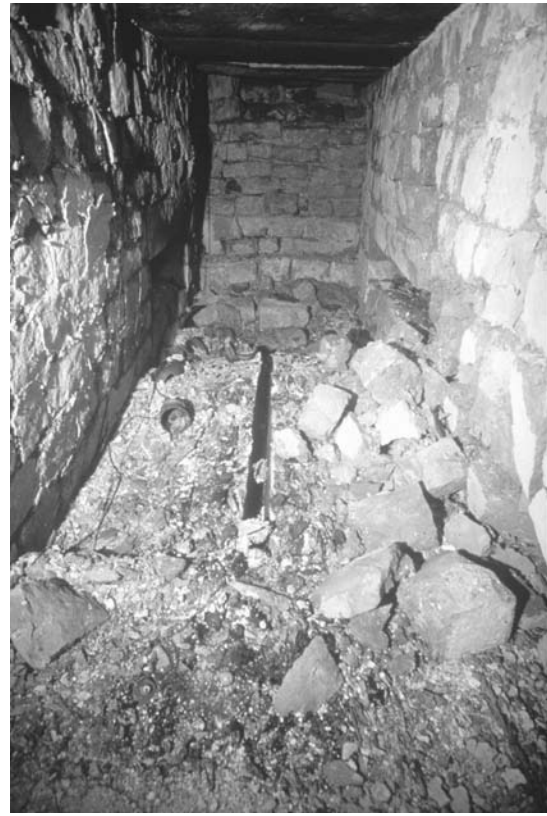


Figure 4.1. Copán Structure 10L-26 tomb chamber in 1989, looking south from the dais. Photograph by W. Fash.

small paint fragments, with various concentrations of particulates, including red cinnabar pigment, microscopic insect fecal matter (the result of complete digestion of organics), and mold distributed throughout. The human skeletal remains had degraded beyond recognition, the bones having been reduced to tiny pock-marked flakes. Earthquakes caused some wall collapse and further disturbance of the deposit, including toppling and minor dislocation of ceramics (many now broken), jade objects, and *Spondylus* shells.

The distribution of jade ear flares and pectoral components, and of blackish clay fragments that seem to have been a burial coating, confirmed the body's orientation with head to the north (Figure 4.2). However, little else about the original form of the installation could be detected from the jumbled appearance of the deposit.

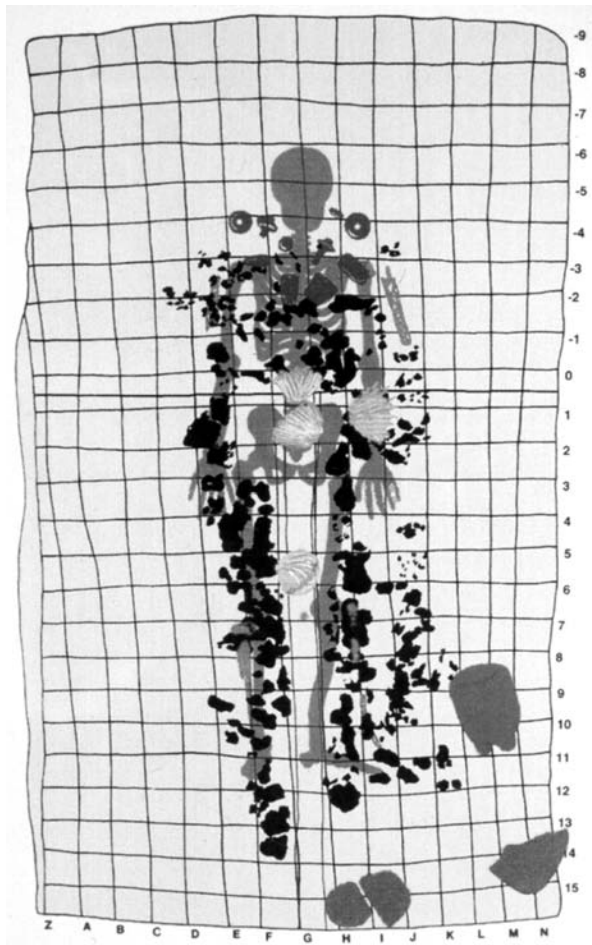


Figure 4.2. Plan map of dais grid, with selected offerings, for Structure 10L-26 tomb at Copán. Drawing by B. Fash.

RECOVERY TECHNIQUES

Excavation

Portions of the floors to the north and south of the dais were cleared by the archaeologists to install an elevated bench, allowing access to the fragile remains. Deposit characteristics (visible on the surface) were thoroughly documented, and then ceramic pieces, jades, and shells (i.e., anything that could be handled) were removed. The remaining materials to be documented, lifted, and analyzed by conservators consisted of small fragments with no recognizable form.² Fortunately, the horizontal spatial location of

fragments appeared not to have shifted significantly, but stratigraphic information was generally poorly preserved.

A grid of inert fine string (dental tape) was laid over the deposit at 10-cm intervals and linked to fixed points. The remains were systematically removed by grid square and, when possible, by general layer. Brushes or spatula tools were used to transfer fragments into shallow aluminum dishes, one for each sequential lift per grid square (Figure 4.3).

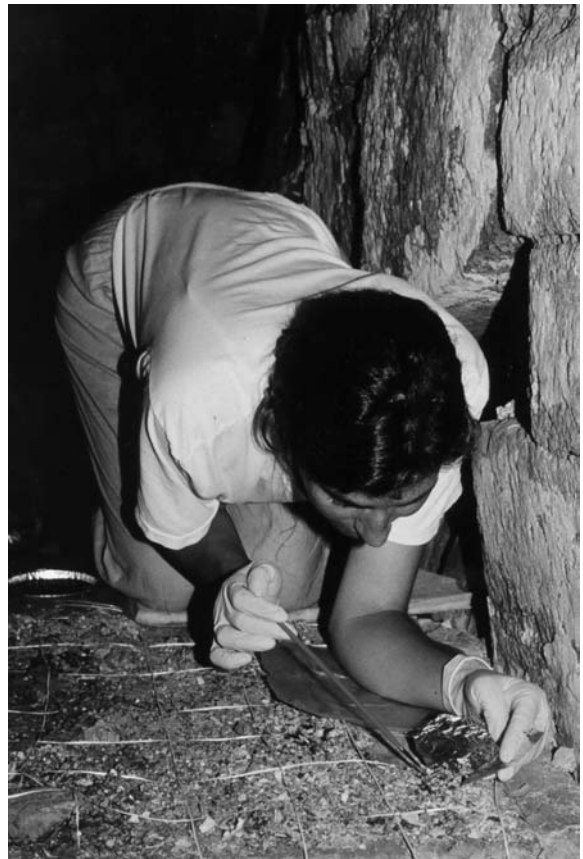


Figure 4.3. Removing deposit fragments from Structure 10L-26 tomb at Copán. Photograph by C. Magee.

Although consolidation is sometimes critical to the successful removal of fragile materials, this is generally reserved for situations where fragments maintain articulation that would be lost during lifting and difficult to reconstruct subsequently. In the tomb excavation, on rare occasion, select materials retained

sufficient alignment (such as paint flakes with decorative patterns) to warrant being lifted as more cohesive units; this was done using judicious application of consolidants and facing tissues. Mostly, however, the contents of each grid square were collected in a single operation as loose fragments, since no articulation was apparent (Figure 4.4). This collection method was advantageous because it meant that subsequent examination and analysis were not hindered by treatment materials.



Figure 4.4. Contents of dais grid square 1J, Structure 10L-26 tomb, Copán. Photograph by H. Beaubien.

Given the destructive nature of any lifting process, head-mounted magnification (an Optivisor™ head loupe) was particularly useful for monitoring the materials being lifted, and a head-mounted flashlight was often helpful as supplemental illumination. Some of the larger marine components were detected at this stage, but most were too small and intermixed to be obvious. With each lift general observations were recorded about subtle layering and associ-

ations with fragments in neighboring grid squares. For example, indications of layering were provided by paint flakes, according to the upward or downward orientation of the side with the paint (vs. stucco ground), by materials adhering to the clay fragments, and by materials resting directly on the stuccoed and painted stone dais.

Each of the dishes was then enclosed within a stable clear plastic bag and stored flat, in clear modular lidded containers organized by grid square. Cotton was specifically avoided: in a tropical environment it is an attractive nesting material for pests, attracts moisture, and can easily snag fragile fragments resting directly on it, causing further breakage. Containers whose form allowed lifted materials to be stored flat or stacked were preferred, and clear plastics were selected, so contents remained visible, promoting appropriately careful handling. Stability in a tropical environment was an important criterion in all instances.

Post-excavation Analysis

Once transported to the Centro Regional de Investigaciones Arqueológicas, the site's processing and storage facility, the contents of each dish were further examined and documented with the aid of a standard binocular microscope. Many of the components of what were later determined to be a variety of marine organisms were only detected at this stage. As each dish was reviewed, the various components were removed with plastic tweezers, microspatulas, or fine paintbrushes. Then they were sorted by specimen type, counted, and stored in separate sample containers or small self-closing bags (per grid square). From the total of 407 dais grid squares only 12 produced these components. The Instituto Hondureño de Antropología e Historia (IHAH) permitted the contents of one of them to be exported to the Smithsonian Center for Materials Research and Education (SCMRE) for further analysis (Figure 4.4), along with small samples of other deposit materials, including pigment powders, paint fragments, and the clay coating.

Reconstruction was carried out in only one case. Even though the sea urchin test fragments were readily identifiable as such, they were glued together in order to determine individual count and test size. A resin adhesive, Acryloid B-72™ (which is easily reversible in acetone), was used.³ The choice of adhesives, as well as diluted versions used as consolidants, is critical. Important qualities include the particular product's proven stability over time and its ability to be removed if necessary; its possible effect on subsequent analysis must also be considered carefully. Water-based "white glues" are not recommended in these situations because they become insoluble with time.

Preliminary identifications of all marine materials were carried out using textual references (including George and George 1979; and Sterrer 1986), analysis at SCMRE, and consulta-

tions with specialists and review of comparative collections at the Smithsonian Institution's National Museum of Natural History. What emerged as a particular challenge at this stage was that many of the small exotic species present in the offering are most familiar to scholars only in their fully articulated form. What survived archaeologically were typically very small, disarticulated and degraded calcareous forms that superficially resembled bits of stucco, broken branchlike pieces similar to rootlets, or needlelike siliceous forms that might be misinterpreted as acicular salt crystals or mold. In this case it was helpful to have access to modern specimens that could be taken apart to produce comparable components. For reference the inventory tables include general shape and size of many of the individual parts as found (see Tables 4.1 and 4.2).

Table 4.1. Western Cluster, Copán Structure 10L-26 Tomb

Taxonomic Category	Number of Specimens and Grid Square Source ^a	Approximate Size ^b	MNI
Spiny oyster Family Spondylidae	1 valve [1G] 1 valve [0G] 5 shell fragments [0G, 1F, 2G]	(not measured, 1989) (not measured, 1989) not measured	1
Stingray Family Dasyatidae	1 spine [1EF]* 1 spine [1F]*	L 53 mm L 32 mm	2 (spines only)
Fish, unidentified Chondrichthyes (cartilaginous) or Osteichthyes (bony)	68 plain "bead" vertebrae, possibly stingray tail [0F, 0G, 1F]*	Dm 1.5 mm, H 1 mm	1
Sea fan Family Gorgoniidae	Numerous branch fragments [0G, 1F, 2F]	L < 10 mm	1
Bivalve, unidentified Phylum Mollusca	1 tiny clam valve [1F]	L 2.5 mm x W 1.5 mm	1
Sea star (?) Subphylum Asterozoa, possibly Family Astropectinidea	Many assorted calcareous components [-1F, 0F, 0G, 1F], including: > 60 blocky shapes* 43 lobed shapes* 49 torqued rod shapes* 5 hooked shapes*	L/W 1.5–5 mm L < 2.5 mm L 6 mm x W 1.5 mm L 7 mm x W 5 mm	(1)

Continued on next page

Table 4.1. Western Cluster, Copán Structure 10L-26 Tomb (continued)

Taxonomic Category	Number of Specimens and Grid Square Source ^a	Approximate Size ^b	MNI
Red coral (?) Phylum Coelenterata	4 fragments [0F, 1F]*	L < 7.5 mm	(1)
Sponge (?)	2 fragments [1F]	L ~2 mm	(1)

Note: Dais grid squares: -1F, 0F, 0G, 1F, 1G, 2F, and 2G.

^bL = length; W = width; Dm = diameter.

^aItalics indicate high concentration; * if illustrated.

Table 4.2. Eastern Cluster, Copán Structure 10L-26 Tomb

Taxonomic Category	Number of Specimens and Grid Square Source ^a	Approximate Size ^b	MNI
Spiny oyster Family Spondylidae	1 valve [1I] 4 nacre fragments [0J, 1H]	(not measured, 1989) not measured	1
Sponge Phylum Porifera	clump of siliceous needlelike spicules [1I]*	L 1 mm, Dm < 50 µm	1
Sea urchin Family Echinometridae; <i>Echinometra lucunter</i>	1 test, reconstructed from many pieces [0J, 1J]* 8+ segments, masticatory apparatus [0J, 1J]* 12+ ribbed spines [0I, 0J, 1J]*	Dm 33 mm L 7 mm x W 3 mm L 5 mm, Dm < 1 mm	1
Brittle star Family Ophiocomidae	White calcareous components: ~450 smooth spines [0I, 0J, 1I, 1J]* ~170 arm crescents [0I, 0J, 1J]* ~100 arm "vertebrae" [0I, 0J, 1I, 1J]* Probably assorted components from the "unattributed" category below	 L 2–6 mm, Dm < 1 mm L 3 mm x W 2 mm L 3 mm x W 2.5 mm	1
Sea star Family Ophidiasteridae	20 yellow test fragments, paxillar area [1J] Probably assorted components from the "unattributed" category below	L 2 mm x W 1.5 mm	1
Sea fan Family Gorgoniidae	Numerous branch fragments [0I, 0J, 1H, 1I, 1J]*	L < 10 mm	1
Fish, unidentified Chondrichthyes (cartilaginous) or Osteichthyes (bony)	16 plain "bead" vertebrae, possibly stingray tail [0J, 1J] 3 flanged vertebrae [1J] 1 composite vertebra, possibly from a bony fish [1J]	Dm 1.5 mm, H 1 mm As above As above	3
Bivalve, unidentified Phylum Mollusca, probably Family Limidae	5 tiny clam valves [0J, 1J]	L 2.5 mm x W 1.5 mm	3

Continued on next page

Table 4.2. Eastern Cluster, Copán Structure 10L-26 Tomb (continued)

Taxonomic Category	Number of Specimens and Grid Square Source ^a	Approximate Size ^b	MNI
Gastropod, unidentified Phylum Mollusca	2 tiny shells [0J]	L < 2 mm	2
Pearls Phylum Mollusca, source undetermined	4 tiny pearls [1J]*	Dm 1–1.5 mm	4 (only pearls)
Unattributed, probable components of the brittle star and sea star, above [Subphylum Asterozoa]	Many assorted calcareous components, including: 63 platy triangular shapes [0J, 1J]* 54 platy round shapes [0J, 1J]* 6 platy T shapes [0I, 0J, 1J]* 11 “carcass” shapes [0I, 0J]* 6 L shapes [0J, 1J]*	L 3.5 mm x W 1.5 mm Dm 1.5 mm L 3.5 mm x W 2.5 mm L/W 5 mm L 4 mm x W 3 mm	

Note: Dais grid squares: 0I, 0J, 1H, 1I, and 1J.

^bL = length; W = width; Dm = diameter

^aItalics indicate high concentration; * if illustrated.

INVENTORY OF THE OFFERING CONTENTS

The marine materials were found in two concentrations, associated with red cinnabar pigment powder and underlying the abdominal region of the body on an east-west line. Both deposits' locations correspond with those of several *Spondylus* shells found on the dais, which probably served as containers for the delicate offerings until seismic activity overturned them.

Western Cluster

The western cluster, recovered from seven grid squares, contained the marine materials listed in Table 4.1; a representative selection is shown in Figure 4.5.

The offering consisted of two stingray spines, a fish (possibly a stingray tail), a small sea fan, a piece of red coral, probably a sea star, and several other very tiny marine organisms that may have been attached to other items in the offering. Found in this area and also likely contained in the same *Spondylus* was a concen-

tration of small chert fragments, possibly debitage. Two obsidian blades were found nearby, strengthening the association to bloodletting provided by the stingray spines.

Eastern Cluster

The eastern cluster, excavated from five grid squares, contained the marine materials listed in Table 4.2; a representative selection is shown in Figure 4.6.

The offering included a small sea urchin, a brittle star, a sea star (starfish), a small fan, a sponge, and a fish. The tiny shells and pearls were probably incidental adherents to other items.⁴ Numerous small green stone fragments, possibly debitage, were also found in this area and in one of the *Spondylus* valves thought originally to have held this offering.

SUMMARY

Given their fragmentary state and dispersion within the Copán Structure 10L-26 tomb's deposit, the exotic marine materials described



Figure 4.5. Selection from dais grid squares 0F and 1F, western cluster from Structure 10L-26 tomb, Copán: stingray spines; probable sea star components and fish vertebrae (in trays); red coral (lower right). Photograph by H. Beaubien.

here might not have been recovered without a framework of well-thought-out excavation protocols, microscopic scrutiny of all lifted materials, and selective technical analysis carried out by those involved in the excavation. Through careful processing disarticulated and degraded components were detected, the diversity of marine materials was recognized, and the care with which they were clustered and presented in *Spondylus* shells as funerary offerings could be appreciated.

In excavations such as this conservators are appropriate collaborators because of their knowledge of materials and of the process of degradation, their patience, their practical skills for lifting fragile remains, their discriminating use of appropriate adhesives and consolidants, their concern for proper housing and curation of the archaeological record, and their familiarity with analytical techniques for materials characterization. Unfortunately, conservators are not always present when excavation contexts warrant these skills, so it is particularly important that tech-

niques that can enhance information recovery be shared.

In this instance such techniques have contributed significantly to our understanding of elite Maya mortuary ritual (Fash et al. 2001). The selection of exotic marine species emphasizes the elite context and, in keeping with the pan-Mesoamerican conception of vertical levels of the world, introduces an elegant allusion to the watery realm. With further zooarchaeological analysis even more detailed interpretation may be possible, such as association of particular marine species and their origins, cosmologically, with placement relative to the human body or, sociopolitically, with specific ceremonial exchange networks.

Acknowledgments. The author wishes to acknowledge the enormous help provided by numerous specialists on the staff of the Smithsonian Institution's National Museum of Natural History in the identification of many of these materials. Particular thanks go to Cynthia

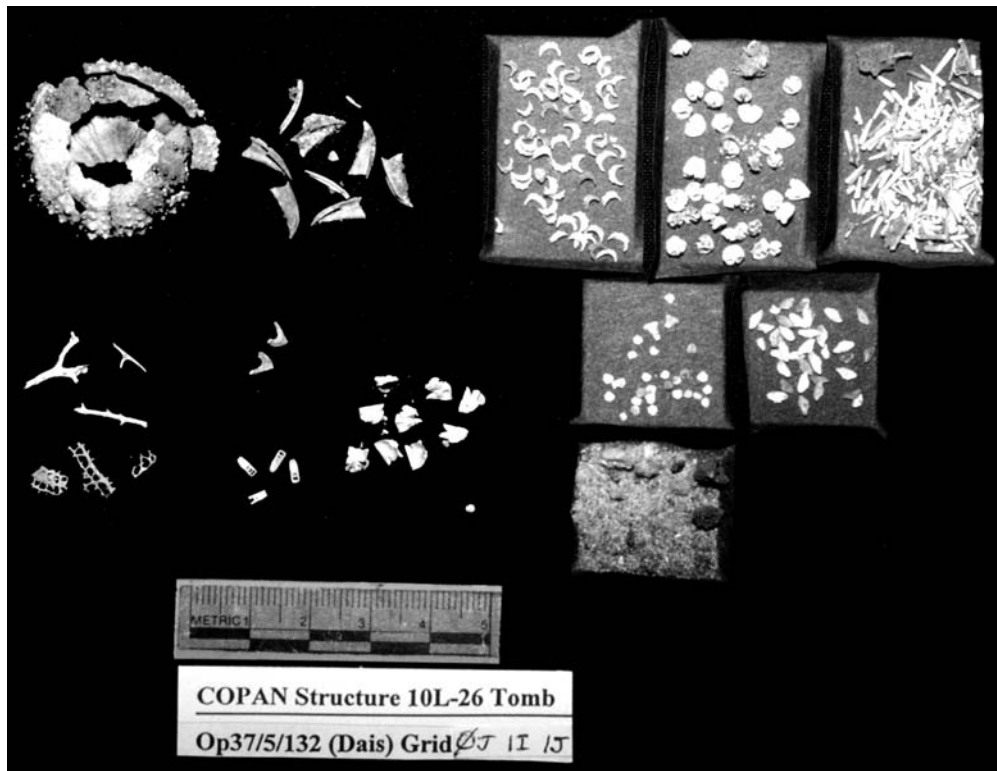


Figure 4.6. Selection from dais grid squares 0J, 1I, and 1J, eastern cluster from Structure 10L-26 tomb, Copán: sea urchin test and masticatory apparatus (upper left); brittle star components and sponge spicules (in trays); sea fan fragments and other unattributed marine components (lower left). Photograph by H. Beaubien.

Ahearn, Frederick Bayer, Klaus Ruetzler, Victor Springer, and Stanley Weitzman. Catherine Magee, former SCMRE postgraduate fellow, oversaw the final phase of dais excavation and contributed significantly to the analysis of deposit materials. My colleagues at SCMRE, notably Harry Alden, provided advice and technical expertise. None of this would have been possible without William L. Fash and Barbara W. Fash, Harvard University and Peabody Museum of Archaeology and Ethnology, whose work at Copán continues to inspire such collaborations.

NOTES

1. The investigations of Structure 10L-26 are part of a long-term program of conservation and investigation

that began in 1986 and continues to the present, under the auspices of the Instituto Hondureño de Antropología e Historia (IHAH), funded through the National Science Foundation, the National Endowment for the Humanities, the Wenner-Gren Foundation for Anthropological Research, the U.S. Agency for International Development, the IHAH, Northern Illinois University, and Harvard University. The investigations have been directed by William L. Fash of Harvard University. In 1998 a joint IHAH/Getty Conservation Institute project was initiated to address preservation of the Hieroglyphic Stairway, under the direction of Barbara W. Fash. Since 1990 conservation staff have been provided through the Smithsonian Center for Materials Research and Education (formerly Conservation Analytical Laboratory) and its archaeological conservation program, under the author's supervision, with additional funding from the Samuel H. Kress Foundation.

2. Conservation logbooks and conservation and technical analysis reports related to the dais excavations are on file at Copán and at SCMRE as follows.

Under CAL #5268/#5543 (Copán Archaeological Project): Beaubien 1989–1999, 1990; Griffin and Beaubien 1993; Magee and Beaubien 1996; Peschken 1997; Svoboda and Beaubien 1995; and Tsu and Beaubien 1997. Under CAL #5602 (Copán Structure 10L-26 tomb, special project): Magee 1997.

3. Acryloid B-72 is an acrylic copolymer manufactured by Rohm & Haas, available as resin beads and

dissolved in organic solvents, through conservation suppliers such as Conservator's Emporium in Reno, Nevada.

4. Eleven large pearls, approximately 1 cm in diameter, were recovered from the head region of the body and are thought to have been part of a headdress (Fash et al. 2001).



PART 2

Animal Remains and
Environmental Reconstructions

Ancient Maya Environment, Settlement, and Diet

Quantitative and GIS Spatial Analysis of Shell from Frenchman's Cay, Belize

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*Quantitative and spatial approaches to the study of marine and freshwater shells from midden and mound excavations at Frenchman's Cay, Belize, provide information on the use of shells for food, ornament, and construction. In addition identification of shell habitats provides clues to the changing local maritime landscape, which has been subject to sea-level rise. Transect excavations in household middens yielded 2,785 fragmentary and complete shells. They were sorted into 58 genera, with additional shells identified to the family level only. The shells were quantified by MNI in order to provide an indication of the relative importance of each species to the diet. Edible gastropods and bivalves document a subsistence regime focused on the shallow-water fighting conch (*Strombus pugilis*), queen conch (*S. gigas*), flat tree oyster (*Isognomum alatus*), and beaded chione (*Chione granulata*), among others, with freshwater "jute" (*Pachychilus* sp.) the only nonlocal shell. Comparison of different quantification methods indicates that counting shell fragments provides a poor measure of diet compared to the weight or MNI methods. Ubiquity provides a good measure of popularity and spatial variability. GIS was used to investigate local environmental changes in shell habitats resulting from sea-level rise. The shells were grouped by habitat and GIS used to spatially display shell habitats for each of the five excavation depths. Shells from coral foundations of buildings include environmental indicators of the shallow-water marine origin of the coral—perhaps harvested from storm beaches or quarried from the shallow sea around the island.*

Quantitative and spatial analyses of shells from excavations at Frenchman's Cay provide information on ancient Maya subsistence and environmental change at this coastal Maya community (Figure 5.1). Frenchman's Cay is on the outer range of some 200 islands located in a coastal bight known as the Port Honduras, along the southern coast of Belize. The Port Honduras is a complex estuarine-marine ecosystem. Several major rivers flow into the region and deposit silt and other detritus into the shallow coastal waters. The dry season–rainy season pattern of the Maya lowlands is

particularly dramatic in the region, with over 3,000 mm of rain concentrated between mid-June and January bringing fresh water into the Port Honduras. Because of its location on the outer range of the Port Honduras cays, Frenchman's Cay marks a transition between salty deep water on its windward side and the near shore estuarine waters on its leeward side. Consequently, the ancient Maya on the island had local access to seafood and other marine resources for subsistence and ritual needs from a variety of aquatic microenvironments.

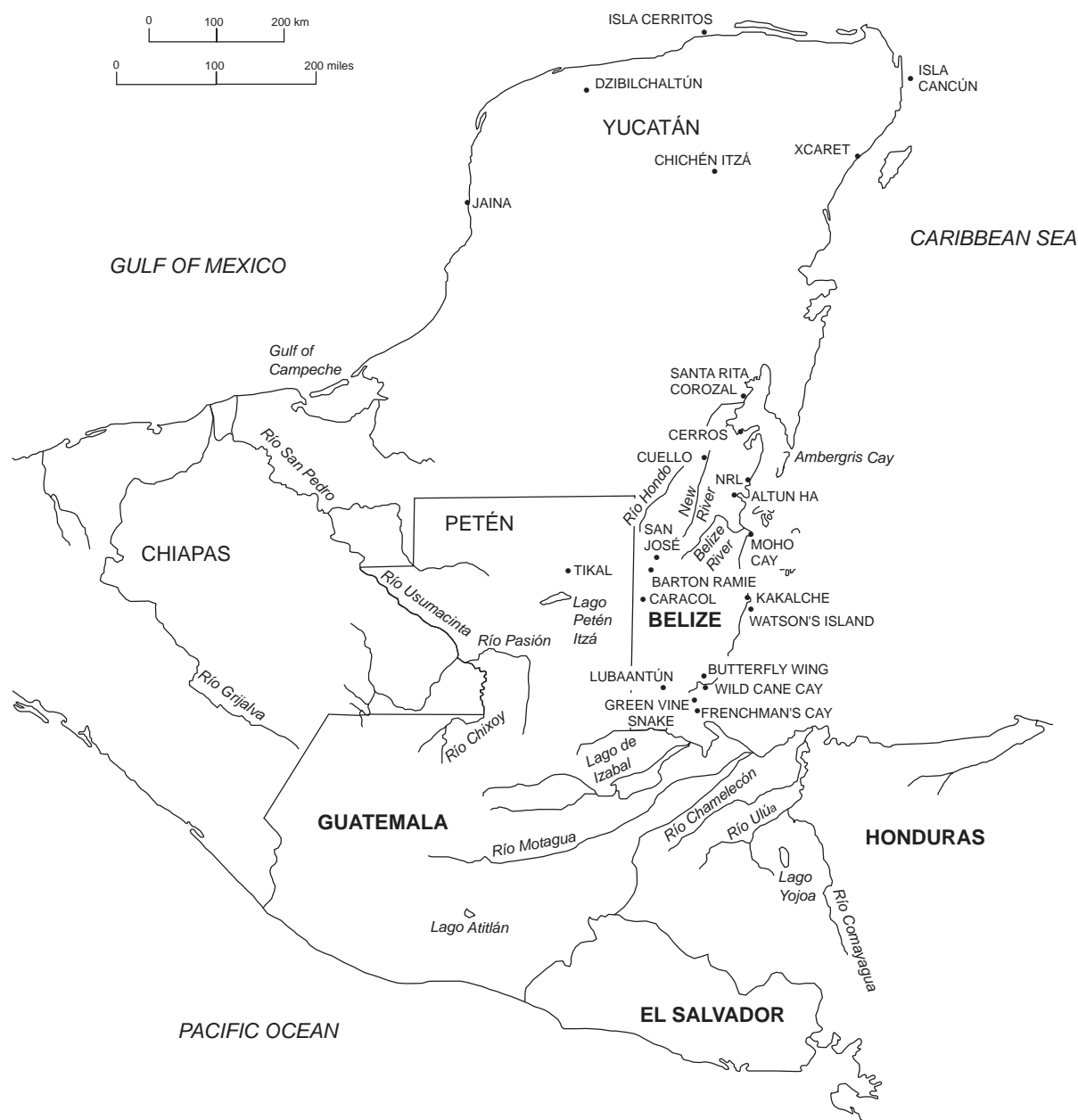


Figure 5.1. Map of the Maya area with Frenchman's Cay and other sites mentioned in the text.

The archaeological site on Frenchman's Cay is located in a small patch of coconut woodland at the southwestern end of the island (Figure 5.2). The coconut woodland includes coconut palms (*Cocos nucifera*), mango (*Mango rangifera*) and guava trees, grass, and other vegetation that require dry, nonsaline land for their roots.

The remaining 30 acres of the island consist of low-lying mangrove swamp. This area is dominated by mangals, a mangrove ecosystem consisting of red mangroves (*Rhizophora mangle*), black mangroves (*Avicennia germinans*), white mangroves (*Laguncularia racemosa*), and button-wood (*Conocarpus erectus*).

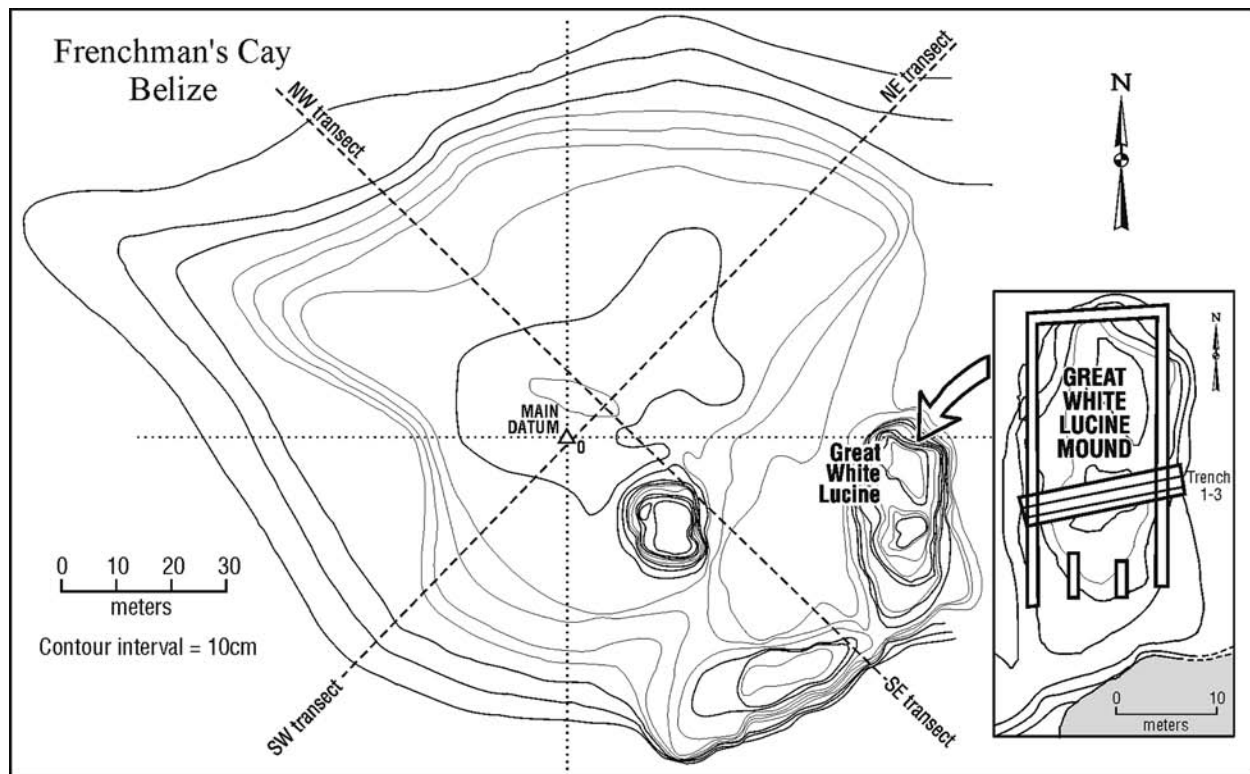


Figure 5.2. Map of the settlement area of Frenchman's Cay, showing the locations of transect excavations and Great White Lucine Trenches 1-3. Surveyed by H. McKillop and M. Braud, digitized by B. Duplantis, and enhanced by M. L. Eggart.

The ancient site has three mounds arranged around a plaza, including Great White Lucine on the east, Crown Conch on the south, and *Spondylus* on the west. Pottery sherds were evident on the ground surface over a much larger area, suggesting that the site was not localized to the area of the mounded remains. The presence of pottery sherds in the mangrove swamp to the north and east of Great White Lucine meant either that sherds had been distributed across the ground surface by hurricanes, that the ancient Maya had tossed or discarded refuse into a swamp, or that a once-dry area of Maya settlement had been inundated by a rise in sea level. Since other sites in the Port Honduras region had been submerged by sea-level rise (McKillop 1995b, 2002), this also was expected for Frenchman's Cay.

Excavations in 1994 and 1997 indicate that Frenchman's Cay is a Late Classic (A.D. 600–

900) to Early Postclassic (A.D. 900–1200) period village that participated in coastal Maya trade. Excavations along four transects in 1994 were carried out to identify the ancient boundaries of the site and to see if sea-level rise had impacted the archaeological settlement. The excavations were continued along each transect until no artifacts were recovered. Consequently, excavations extended beyond the island and into the sea along the northwest (NW), southwest (SW), and southeast (SE) transects and into the mangrove swamp along the northeast (NE) transect. Excavations in the three artificial coral mounds were carried out to investigate the coral construction, particularly to see if it resembled the architecture at nearby Wild Cane Cay (McKillop 2005). Since one of the mounds, Crown Conch, extended into the offshore area on the windward shore of the island, the mound excavations also were designed to investigate the

relationship between the construction of coral architecture and sea-level rise (Magnoni 1999; McKillop 1995a, 1997, 2005; Watson 1999). The spatial distribution and depth of Maya pottery sherds in the transect excavations were used to estimate the size of the ancient settlement and its relationship with the changing environment, specifically sea-level rise (McKillop et al. 2003).

Identification of the species and habitats of shells in the middens focused on spatial and temporal changes in food selection and, secondarily, on the information these changes might provide on sea-level rise. If sea level rose during the ancient occupation of Frenchman's Cay, then the changing species composition of shells in the transect excavations might reflect changes in the proximity of different habitats to the Maya community. If, however, sea level submerged the site after it was abandoned, changes in the species composition of shells would necessarily result from other causes, notably diet or other subsistence choices.

LANDSCAPE AND SEASCAPE OF FRENCHMAN'S CAY

Excavations indicated that the Maya site on Frenchman's Cay had been submerged about one meter since its prehistoric use. Inundation was evident both for the coral foundations shrouded by the mounds and for the middens discovered in the transect excavations. The lower stone foundation of Crown Conch was inundated to a depth of 80 cm (Magnoni 1999). Midden deposits below the earliest coral foundation of Great White Lucine were submerged to a comparable depth (McKillop 1997; McKillop et al. 2003).

Several habitats in the coastal waters around Frenchman's Cay would have been accessible to the ancient Maya, even if the modern proximity of these habitats was modified by sea-level rise. With sea level about one meter lower during the initial settlement of the cay in the Late Classic period, dry land would have extended into the shallow offshore areas on both the windward and leeward sides of the island. The Maya would have had direct access

to shallow waters with sand: mangrove habitats would have been located farther away at the other end of the island. Given this reconstructed seascape, fewer mangrove shells species would be expected in the lower levels of the shovel tests and in the coral rock foundation material associated with the Late Classic occupation. More mangrove shells would be expected near the ground surface of the island and the mounds, associated with the inundation of the island and the closer proximity of mangrove habitats to the site as time passed and sea level rose (see McKillop 1995b, 2002). Of course these hypotheses are based on an assumption that proximity to shell resources was an important factor in their selection.

PREVIOUS RESEARCH ON MARINE SHELLS IN THE MAYA LOWLANDS

Our research on the Frenchman's Cay shells follows in the tradition of investigating the ancient Maya use of shells for food, as material for artifacts (Meighan and Bennyhoff 1951; Richards and Boekelman 1937), and as trade goods (Andrews 1969); but we also follow a less common approach of using shell to investigate the ancient environment (see Covich 1983, 1990, for freshwater shells as environmental indicators at inland sites). We introduce the use of geographic information systems (GIS) in Maya shell studies to examine spatial and temporal variability.

The overview of Maya marine shells by E. Wyllys Andrews IV (1969) has become a standard reference for Maya archaeologists, as he presents data on the use and habitats of marine shells along the Yucatán and at lowland Maya sites. The dietary use of marine shells from species identification has been carried out at several coastal Maya sites (see Figure 5.1), including Isla Cancún (Andrews et al. 1974); Xcaret (Andrews and Andrews 1975); Isla Cerritos (Andrews et al. 1988); Santa Rita Corozal (Hamilton 1988); Cerros (Carr 1986a, 1986b); Moho Cay, near Belize City (McKillop 1984, 2004); Ek Luum and San Juan, on Ambergris Cay (Shaw 1995a); Northern River Lagoon, in northern Belize (Valdez and Mock 1991); Kakalche and Watson's Island, in

central Belize (Graham 1994:262); and Butterfly Wing, Wild Cane Cay, and Frenchman's Cay, in southern Belize (McKillop et al. 1997).

The preponderance of marine shells at off-shore island sites, such as Isla Cerritos, Cancún, Moho Cay, Ambergris Cay, Wild Cane Cay, and Frenchman's Cay indicates their dietary importance. From an ecological perspective, particularly using optimal foraging theory, several criteria might be paramount in resource selection (Jochim 1976). Distance evidently factors in resource selection, as marine resources were predominant. Access to a localized abundance of food resources prioritizes some shells and other foods above others. Such factors include size of the meat package, packing or solitary lifestyle, seasonality, nocturnal/diurnal availability, and usable by-products. At some mainland sites, such as Butterfly Wing, Kakalche, and Watson's Island, marine shells predominate; but this is not the case at other mainland sites, such as Santa Rita Corozal or Cerros, where locally available terrestrial or riverine shells were also present in the shell collections. Optimal foraging analysis was used in a previous study of animal remains from the island site of Moho Cay (McKillop 1984, 1985). In that study selection of resources was related to nearby animals with large meat packages (such as manatee), genera or species clustered or found in groups, or species that also had useful by-products, such as shell for carving.

Although the importance of marine shells, like other seafood, to the inland diet is controversial, the ritual use of marine shells is well documented. Evidence for the use of marine shells for food at inland sites derives from unworked shell in middens at inland sites (Andrews 1969), coastal preparation of other seafood for storage or export (Graham 1994; Valdez and Mock 1991), and ethnohistoric and ethnographic evidence (Andrews 1969; Lange 1971). Evidence for ritual use of marine shells includes the occurrence of worked and unworked shell in burials and caches (Andrews 1969; Feldman 1974a; McKillop 1980), the representation of marine shells in art (as musical horns and the death god emerging from a

shell), the use of a shell in mathematics (as with the number zero represented by a shell), and the use of other marine resources (McKillop 1996a). Marine shells are reported from many inland Maya sites. These include Tikal (Moholy-Nagy 1963, 1985), Chichén Itzá (Cobos 1989), Caracol (Cobos 1994), San José (Thompson 1939), Barton Ramie and the Belize Valley (Willey et al. 1965), Cuello (Covich 1983), Lubaantún (Hammond 1975:384–388), and Dzibilchaltún (Andrews 1969), among others (McKillop 1980). Marine shells at inland Maya sites located near the coast, such as Dzibilchaltún and Altun Ha, may have formed a significant part of the diet. By way of contrast, shells and other marine resources at sites farther inland were concentrated in elite and ceremonial contexts, suggesting restricted access to marine shells as an elite trade good, both for food and for ritual purposes (McKillop 1980, 1984, 1985, 1996a, 2002).

METHODOLOGY

Although the presence of marine shells at inland Maya sites documents important routes of trade and communication in antiquity, few studies of Maya shells have ventured beyond listing species or counting fragments by species. The abundance of marine shell at Frenchman's Cay from building platforms and floors and from transect excavations in midden deposits provided an opportunity to see what kinds of dietary and environmental information can be extracted from more extensive quantitative and spatial analyses of marine shell from a Maya community. We were particularly interested in spatial variability in dietary or environmental patterns, which can be detected by using GIS, which affords the opportunity to attach a large database of information to a map.

Previous reports of coastal Maya shells include a list of species and often some form of quantification, either by the MNI (minimum number of individuals) method (McKillop et al. 1997), the fragments or NISP (number of individual specimens present) method (Andrews 1969; Cobos 1994; Hamilton 1988; Shaw 1995a),

or by meat weight (McKillop 1984). Habitat information is generally provided to identify the procurement zones for shells and to identify trade routes. Ethnographic analogy is used to interpret which species are edible and how they were prepared (e.g., Andrews 1969; Hamilton 1988; Hammond 1975). Coastal production of shell artifacts is also discussed.

In contrast to some other areas of the ancient world, marine shells have not been the focus of much quantification. Therefore, we decided to investigate and compare several methods of quantification to show how the results varied, if at all, in order to build evidence for methods that might be appropriate for the environmental conditions, range of cultural contexts, and recovery techniques used at Maya sites. Although there is no standard for quantification of Maya shells, the fragments method (NISP) is commonly used, but as we suggest in this chapter, it provides questionable and highly variable results. Despite negative comments on the use of the weight method in vertebrate faunal analyses, this study shows that weighing marine shells by species in the Maya area is a good measure of relative meat weight and relative dietary importance of different species. By way of contrast, MNI (minimum number of individuals) is better for environmental than for dietary reconstruction, since the size of marine shells from Frenchman's Cay varies tremendously, from large conchs with big meat packages (such as *Strombus gigas*) to tiny bivalves with commensurately smaller meat packages. We found that use of MNI is not a good measure of the dietary contribution of the various marine shells at Frenchman's Cay. We suggest that a common method in botanical analysis, the ubiquity method, shows promise for studies of Maya fauna (see McKillop 1994, 1996b). In the ubiquity method the researcher counts the number of contexts or locations from which a species or genus is recovered. Ubiquity provides a good measure of popularity and spatial variability and also shows promise for comparing the use of ancient plant and animal remains in the diet.

Specific methods used to quantify the shells by genus in this study are as follows. The NISP, the number of individual specimens present, was simply the number of fragments of each genus or family. The MNI estimates were based on the identification of a feature present on each specimen, which meant that although a particular genus was marked "present" for purposes of ubiquity or had one or more fragments represented by the NISP method, if the specimen lacked the particular feature, it was counted as an MNI of zero. Weight was the total weight of the shells of each genus. Using habitats defined by Morris (1973), with additional information from Andrews (1969) and Vokes and Vokes (1983), each genus was assigned to a habitat.

The shells from the transect and mound excavations at Frenchman's Cay were quantified separately since they derive from different cultural settings. The transect excavations include shell used for food from household middens. In contrast, the mound excavations revealed the earthen floor and stone foundations of buildings. The shell from the household middens was in "primary" context, making it a good measure of the diet. By way of contrast, the shells from the mounds were in "secondary" context and included shell and other remains gathered from various locations for use as construction fill in the building foundations. Shells in the mound floors may reflect the material remnants of activities that took place in the buildings.

In estimating the ancient environment from shell remains, it was assumed that some shells were intentionally brought to the village for food, tools, ornamentation, or other uses. In contrast, other shells were inadvertently incorporated into the community, such as the shells brought with the coral rock for foundation materials. Shells may also have been mixed with sand or earth used as fill for the perishable pole-and-thatch house floors likely associated with the midden deposits found in the transect excavations. If the island had been higher and drier in ancient times, when the Late Classic Maya settled it, then there would have been more woodland plant species on the island and

fewer mangrove shell species in the adjacent coastal waters.

QUANTITATIVE ANALYSES OF SHELL FROM TRANSECT EXCAVATIONS

The analysis of shells from the Frenchman's Cay transects yielded 58 genera, with an additional four groups of shells identified to the

family level only (Table 5.1). They included 2,785 shells, weighing 13,528.46 g and consisting of 1,315 MNI. Most of the shells were identified to species as well, with a total of 98 species. The shells were quantified and rank ordered by several measures to estimate the relative contribution of the various shells to the ancient diet and environment.

Table 5.1. Summary Statistics for Shells from the Frenchman's Cay Transect Excavations

Habitat	Genus Name	Ubiquity	MNI	NISP	Weight (g)
Shallow water	<i>Acteonidae</i>	1	1	1	0.90
	<i>Batillaria</i>	19	79	79	10.20
	<i>Bulla</i>	10	11	14	14.10
	<i>Cerithium</i>	51	298	313	52.20
	<i>Americardia</i>	1	1	1	0.90
	<i>Chione</i>	49	90	114	114.30
	<i>Cittarium</i>	4	2	4	187.70
	<i>Codakia</i>	66	130	283	624.50
	<i>Columbella</i>	29	52	53	18.40
	<i>Conus</i>	3	3	4	21.00
	<i>Corbula</i>	2	3	3	0.03
	<i>Crassinella</i>	1	1	1	0.20
	<i>Anadara</i>	2	2	2	0.70
	<i>Fasciolaria</i>	6	4	7	20.10
	<i>Lucina</i>	37	65	133	177.60
	<i>Macoma</i>	1	1	1	8.40
	<i>Anodontia</i>	1	3	2	27.00
	<i>Melongena</i>	11	11	12	151.00
	<i>Mercenaria</i>	10	2	29	64.50
	<i>Murex</i>	7	4	8	69.80
	<i>Nassarius</i>	7	7	9	2.60
	<i>Natica</i>	3	4	4	1.10
	<i>Modulus</i>	27	39	45	23.30
	<i>Prunum</i>	13	21	21	4.20
	<i>Strombus</i>	70	75	179	8,663.10
	<i>Tellina</i>	5	5	6	4.40
	<i>Tivela</i>	5	7	7	9.80
	<i>Trochidae</i>	110	95	1,051	577.80
	<i>Xancus (Turbinella)</i>	1	1	1	380.90
	<i>Vasum</i>	13	11	14	876.90
Summary		565	1,028	2,401	12,107.63
Shallow, under rocks	<i>Astraea</i>	7	4	11	3.90
	<i>Nerita</i>	9	10	11	15.10

Continued on next page

Table 5.1. Summary Statistics for Shells from the Frenchman's Cay Transect Excavations (cont.)

Habitat	Genus Name	Ubiquity	MNI	NISP	Weight (g)
	<i>Arca</i>	16	18	20	48.00
	<i>Tegula</i>	6	6	9	7.50
	<i>Truncatella</i>	2	5	5	0.10
	<i>Arcopagia</i>	4	6	9	46.00
	<i>Arcopsis</i>	4	7	7	0.70
Summary		48	56	72	121.30
Intertidal	<i>Diodora</i>	9	14	14	6.70
	<i>Fissurella</i>	2	2	2	8.40
	<i>Hipponix</i>	2	2	2	0.40
	<i>Melampus</i>	5	5	5	1.50
	<i>Neritina</i>	13	18	21	5.10
	<i>Plicatula</i>	2	6	6	7.00
	<i>Polinices</i>	6	4	6	4.40
	<i>Thais</i>	1	3	3	3.30
	<i>Asaphis</i>	12	10	25	37.30
Summary		52	64	84	74.10
Mangrove roots	<i>Crassostrea</i>	17	27	40	142.80
	<i>Isognomon</i>	20	28	53	47.60
	<i>Littorina</i>	5	4	5	1.30
	<i>Ostrea</i>	1	2	2	3.40
Summary		43	61	100	195.10
Mangrove mudflats	<i>Cerithidea</i>	1	3	3	0.70
	<i>Hyalina</i>	2	2	2	0.30
Summary		3	5	5	1.00
Below tide to 6 m	<i>Barbatia</i>	7	5	7	4.40
	<i>Charonia</i>	2	3	3	734.30
	<i>Morum</i>	1	1	1	0.40
Summary		10	9	11	739.10
Moderately deep	<i>Chama</i>	25	44	47	59.70
	<i>Echinochama</i>	1	1	1	0.90
	<i>Parvilucina</i>	1	1	1	0.03
	<i>Pseudochama</i>	4	6	6	88.60
	<i>Arcinella</i>	1	12	12	4.80
Summary		32	64	67	154.03
Brackish	<i>Mytilopsis</i>	3	3	3	0.30
Fresh water	<i>Pachychilus</i>	22	25	42	135.90
Genera totals		659	1,212	1,719	12,945.16
Family totals		119	103	1,066	583.30
Grand total		778	1,315	2,785	13,528.46

Rank Order by Shell Weight

An important value of the weight method is that it does measure the relative shell size of the animal, which is often related to the size of the meat package inside. The large shells do have larger meat packages than the smaller genera. In the absence of data for meat yields per genus or species for biomass estimates (MNI x meat yield), weight of the shell provides an indirect measure of the meat.

Large gastropods are most common when shells are rank ordered by weight (Table 5.2). By weight, the large conch shells of the *Strombus* genus, including queen conch (*S. gigas*), fighting conch (*S. pugilis*), hawk wing (*S. raninus*), and ribbed conch (*S. costatus*), are dominant. Other weighty gastropods among the top 12 include the vase shell (*Vasum muricatum*), trumpet shell (*Charonia variegata*), lamp shell (*Xancus angulata*), magpie (*Cittarium pica*), and mud conch (*Melongena melongena*). Although solitary, these genera have large meat packages. A single one of these shells would have provided more

edible food than several smaller gastropods, such as the freshwater *Pachychilus*, ranked tenth by shell weight. In addition, three of the large shells have known useful by-products at other coastal sites: queen conch shells were made into scrapers at Moho Cay and elsewhere (McKillop 1984, 2004). Lamp shells were carved and used as trumpets at Wild Cane Cay (Dochstader 1964; McKillop 1987). Mud conch shells were carved into disks at Wild Cane Cay (McKillop 1987, 2005). Clear evidence of the dietary use of the queen conch is the circular hole in the spire made to detach the animal from the shell. *Pachychilus* sp. shells with the spires removed indicate clear evidence of human modification for food.

Several bivalves rank among the highest by weight because of their frequency, despite their smaller size compared with the large gastropods. These bivalves are *Codakia*, *Lucina*, *Crassostrea rhizophorae*, *Chione*, and *Pseudochama radians*. These gregarious bivalves may have been gathered in groups and boiled or steamed to open the shell and reveal the edible animal inside.

Table 5.2. Rank Ordering of Most Common Shells from the Transect Excavations at Frenchman's Cay by Different Quantification Methods

Weight (g)	MNI (Minimum Number of Individuals)	NISP (Number of Individual Specimens Present)	Ubiquity (Number of Recovery Locations)
<i>Strombus</i> sp. 8,663.1	<i>Cerithium</i> sp. 298	<i>Cerithium</i> sp. 313	<i>Strombus</i> sp. 70
<i>V. muricatum</i> 876.9	<i>Codakia</i> sp. 130	<i>Codakia</i> sp. 283	<i>Codakia</i> sp. 66
<i>C. variegata</i> 734.3	<i>Chione</i> sp. 90	<i>Strombus</i> sp. 179	<i>Cerithium</i> sp. 51
<i>Codakia</i> sp. 624.5	<i>B. minima</i> 79	<i>Lucina</i> sp. 133	<i>Chione</i> sp. 49
<i>Xancus angulata</i> 380.9	<i>Strombus</i> sp. 75	<i>Chione</i> sp. 114	<i>Lucina</i> sp. 37
<i>C. pica</i> 187.7	<i>Lucina</i> sp. 65	<i>B. minima</i> 79	<i>C. mercatoria</i> 29
<i>Lucina</i> sp. 177.6	<i>C. mercatoria</i> 52	<i>I. alatus</i> 53	<i>Modulus</i> sp. 27
<i>M. melongena</i> 151	<i>C. macerophylla</i> 44	<i>C. mercatoria</i> 53	<i>C. macerophylla</i> 25
<i>C. rhizophorae</i> 142.8	<i>Modulus</i> sp. 39	<i>C. macerophylla</i> 47	<i>Pachychilus</i> sp. 22
<i>Pachychilus</i> sp. 135.9	<i>I. alatus</i> 28	<i>Modulus</i> sp. 45	<i>I. alatus</i> 20
<i>Chione</i> sp. 114.3	<i>C. rhizophorae</i> 27	<i>C. rhizophorae</i> 40	<i>B. minima</i> 19
<i>P. radians</i> 88.6	<i>Neritina</i> sp. 18	<i>M. mercenaria</i> 29	<i>C. rhizophorae</i> 17

Note: Number following genus name indicates quantity.

They are commonly found at coastal Maya sites, where they are interpreted as food remains.

Rank ordering the Frenchman's Cay transect shells by weight places low ranking on some of the tiniest gastropods, notably *Cerithium*, *Batalia minima*, *Columbella mercatoria*, and *Modulus*, which may have figured more in our interpretations of the ancient environment than in the ancient Maya's quest for food. This measure also excludes *Isognomum alatus*, an important marker of the proximity to red mangroves—as they grow on mangrove roots—but also considered today to be a tasty oyster that likely also figured in the ancient food regime. *Isognomum* has a thin shell that easily fractures into small pieces, unlike the other sturdier mangrove oyster, *Crassostrea rhizophorae*, which is ranked ninth by weight in the Frenchman's Cay transect shells. In general, however, the weight method is a good reflection of the shell portion of the diet at Frenchman's Cay.

Rank Order by MNI

Rank ordering the shells by MNI includes five tiny yet gregarious gastropod genera among the top 12 genera or families (see Table 5.2). The prominence of a number of tiny gastropods by MNI underscores their value in the archaeologist's interpretation of the ancient landscape and seascape. Six species of tiny horn shells (*Cerithium* sp.) rank highest by MNI. Although these tiny shells may have had dietary value, they may not have been eaten but instead were brought to the households along with construction fill.

Other tiny yet gregarious genera also figure among the top 12 by MNI. They include the black horn shell (*Batillaria minima*), the mottled dove shell (*Columbella mercatoria*), two species of *Modulus* shells (*M. carchedonius* and *M. modulus*), and *Neritina*. The tiny shells are included among the most common shells in the Frenchman's Cay transect data by MNI, whereas by weight they are not. This reinforces the utility of weight as an indirect measure of dietary potential of the Frenchman's Cay shells.

Rank ordering by MNI includes several shells as highly ranked by weight as well. The bivalves *Codakia*, *Chione*, and *Lucine* are ranked

higher by MNI than they are by the weight method. However, the relative contribution of the large *Strombus* gastropods to the diet is diminished using the MNI method in comparison to the weight method. A small, edible bivalve, *Chama macerophylla*, is represented by MNI but is not among the most common by weight. Both *Isognomum alatus* and *Crassostrea mangle*, tasty shells from mangrove habitats, are included by MNI. For the Frenchman's Cay transect shell remains from household refuse, the weight method provides a useful measure for diet, whereas MNI provides important environmental clues.

Rank Order by Fragments (NISP)

In general, rank ordering the shells from the Frenchman's Cay transects by the fragments method tends to overrepresent some shells that are readily identifiable from small pieces, as well as a number of tiny gastropods, in comparison with the weight method. Rank ordering by fragments shows a similar high ranking of tiny gastropods as with the MNI method but more emphasis on some bivalves that tend to be identifiable from small pieces. As with the MNI rank ordering of shells, counting fragments ranks the tiny *Cerithium* sp. gastropods highest and includes three other tiny shells (*Batillaria minima*, *Columbella mercatoria*, and *Modulus*) in the top 12. Together, they are likely environmental indicators rather than dietary foundations of the ancient diet at Frenchman's Cay (see Table 5.2). The large *Strombus* shell is ranked higher than by MNI but not as high as with the weight method. No other gastropod was highly ranked by the fragments method. A serious problem with the fragments method is evident by the presence in the top 12 ranking of bivalves that easily fracture and are also quite identifiable from small fragments. This includes *Mercenaria mercenaria*, which is not in the top 12 ranking either by weight or MNI. Also included is *Isognomum alatus*, ranked in the top 12 by MNI but not by weight. However, for some bivalves the fragments method provides comparable rankings to MNI. *Codakia* was ranked second, as it was by MNI. Other bivalves also ranked highly

by MNI include *Lucina*, *Chione*, *Isognomum alatus*, *Chama macerophylla*, and *Crassostrea rhizophorae*. In sum, the fragments method over-emphasizes some bivalves, provides similar results for some bivalves and some gastropods, and deemphasizes large gastropods. Quantification of the shell by NISP is consequently less valuable than the weight method for dietary reconstruction at Frenchman's Cay.

Rank Order by Ubiquity

Rank ordering the shells by ubiquity demonstrates the extent to which different shell genera, species, or families are represented spatially across the community. Ubiquity shows the widespread use of *Strombus* sp. and *Pachychilus* sp. shells, in particular. *Strombus* shells are ranked lower by MNI and NISP. *Pachychilus* shells do not rank among the top 12 by either measure, so their relative importance at the site might be missed by those measures alone. The occurrence of *Pachychilus* sp. at any location, whether or not it is particularly abundant, indicates human presence, since the shell is not local. Use of the ubiquity measure shows the spatially widespread representation of the mangrove shells, *Isognomum alatus* and *Crassostrea rhizophorae*. The ubiquity measure reveals they were common at the site, although not highly represented in a particular location.

SUMMARY

Since all quantitative methods are estimations of the entire site's shell remains based on a sample, and acknowledging various anthropogenic and natural post-depositional site transformation processes, the use of a variety of quantitative methods provides useful insights into the ancient shells at Frenchman's Cay. Many of the same shells are represented among the top-12 lists, but their rank order varies. Others are selectively represented, variously including the dietary or environmental information that shells contain. For example, *Pachychilus* is not ranked in the top 12 by MNI or NISP. Three of the tiny gastropods, *Batillaria minima*, *Columbella mercatoria*, and *Modulus*, are not repre-

sented in the top 12 ranking by the weight method, and *Neritina* is represented in MNI only. This reflects their lack of importance in the diet. *Pseudochama radians* are represented in the top-12 ranking by the weight method only. Neither *Cerithium* nor *Isognomum alatus* is represented by the weight method. Of course, these shells would be included in any of the methods given a complete ranking, but the point is that only by varying the quantitative method do we see their high ranking.

HABITATS OF THE SHELLS FROM THE TRANSECT EXCAVATIONS

Except for two species of freshwater jute shells (*Pachychilus* sp.), the shell came from the sea, but was it obtained locally from the island's shore, from nearby shallow-water habitats, or from deeper water, implying the use of boats and/or diving? Given a sea level that was a meter lower during the ancient occupation of the community, were the habitats from which the marine shells derived accessible to the islanders? Habitat information for the transect excavation shell is quantified using MNI, NISP, ubiquity, and weight.

The shells from the Frenchman's Cay transect excavations derived from nine habitats (Figure 5.3; Table 5.1). When quantified by the number of genera in each habitat, shallow-water shells are most frequent (Figure 5.3a). The high frequency of shallow-water genera is underscored when genera assigned to particular shallow-water habitats are added. They include genera from under rocks in shallow water and genera below tide to 6 m depth. The Frenchman's Cay area is microtidal, with a tidal variation under 0.5 m (McKillop 2002). There are relatively few shell genera from moderately deep water or from mangrove habitats. The latter include mangrove roots, mangrove mudflats, and intertidal zones. Shells from freshwater and brackish water habitats are represented by one genus each. The presence of the freshwater shells, *Pachychilus* sp., indicates procurement at some distance from Frenchman's Cay, up one of the rivers on the adjacent mainland. The

occurrence of *Pachychilus* also documents human presence on the island, since it could not have been naturally incorporated into the site.

No shells from deepwater habitats were recovered, again underscoring the focus on nearshore, shallow-water shells.

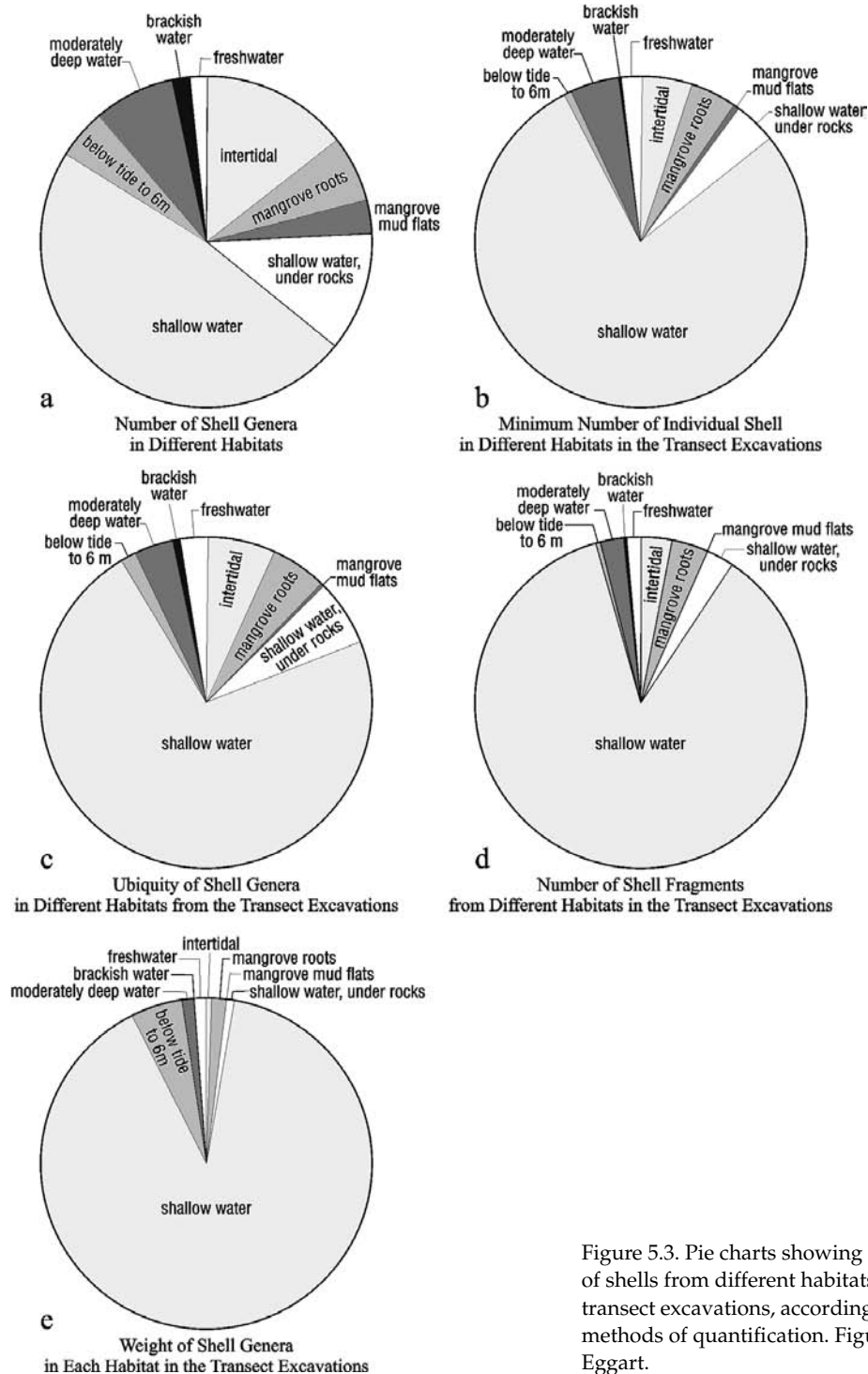


Figure 5.3. Pie charts showing frequencies of shells from different habitats from the transect excavations, according to different methods of quantification. Figure by M. L. Eggart.

The frequencies of shells by MNI and by ubiquity are quite similar (Figure 5.3b–c). Shallow-water shells are more frequent than they appear by simply counting the number of shell genera (Figure 5.3a). It follows that shells from other habitats are less common. The MNI shows that the brackish water genus *Mytilopsis* is rare in the Frenchman's Cay transect excavations. Both by MNI and ubiquity the freshwater *Pachychilus* is minor, although an important shell. Freshwater genera were recovered from 22 locations. Looking at the frequency of shell genera by the fragments method (Figure 5.3d) and the weight method (Figure 5.3e) further emphasizes the shallow-water habitats.

Habitat and Diet

Apart from the two species of *Pachychilus* sp., all shells were available nearby Frenchman's Cay. Virtually all species are edible, so all may have contributed to the ancient diet, as pointed out by other researchers (Andrews 1969). Weighty gastropods and bivalves were from shallow to moderately deepwater habitats. The great white lucine (*Codakia orbicularis*) and the smaller little white lucine (*Codakia orbiculata*) are from shallow water. The chiones (*C. cancellata*, *C. granulata*) are from shallow water. The Jamaican lucine (*L. pectinatus*) is from shallow water. The jewel box (*Chama macerophylla*) and left-handed jewel box (*Pseudochama radians*) are from moderately deep water, where they attach to rocks. The Caribbean oyster (*Crassostrea rhizophorae*) is easily gathered from mangrove roots, where it is plentiful. From this perspective the more solitary queen conch or mud conch (*Melongena* sp.), which provides large meat packages, competes with smaller, more gregarious shells, such as *Crassostrea rhizophorae* and *Isognomum alatus* on mangrove roots, or mudflat species, such as *Batillaria minima*, or intertidal species, such as the small but prolific *Melampus coffeus*. Together the various quantitative measures suggest a relative importance for these genera at Frenchman's Cay. Since most shells in the collection derived from shallow-water and other nearshore habitats, the subsis-

tence strategies of the Frenchman's Cay Maya can be interpreted as focused on the procurement of nearby marine shells. All marine genera were available in the nearby waters, unlike the situation at some other Maya sites, where some genera were procured from distant coasts (Andrews 1969; Cobos 1989).

Edible gastropods and bivalves found in the transect excavations document a subsistence regime focused on the shallow-water fighting conch (*Strombus pugilis*), queen conch (*S. gigas*), flat tree oyster (*Isognomum alatus*), and beaded chione (*Chione granulata*), among others. They are species that are either large meat packages, such as the queen conch, or gregarious medium-sized shells, such as the fighting conch or oysters. They are found in the nearby shallow marine waters, reinforcing a view of proximity as a major factor in the selection of food resources.

Shell Habitats by Depth in the Transect Excavations

The MNI was used as a quantitative measure to examine the habitats of shells by depth in the transect excavations to see if there were dietary or environmental changes from the ground surface to the base of the excavations. Depth was measured by 20-cm excavation levels to a maximum depth of 100 cm below ground surface. The data were grouped by habitat, showing the relative abundance of MNI from shells from each habitat according to the excavation level (Figure 5.4). Shallow-water genera predominate at all depths but are most frequent at the 60–80 cm depth and show an abrupt decrease at the 80–100 cm depth. Shells from moderately deep water are most common at the 80–100 cm depth and show a decline by level to the ground surface. Shells from the intertidal and mangrove root habitats increase in popularity from the ground surface to the 60–80 cm depth where they are most common, and then they abruptly decrease in the 80–100 cm levels. Shells from mudflats are poorly represented at all levels and absent from the 60–80 and 80–100 cm depths. The depth data for shells from mangrove habitats

support an interpretation of an earlier lower water table, with greater access to shallow water and moderately deepwater aquatic resources nearby. This interpretation is supported by the absence of shells from mangrove mudflats and the low frequency of shells from mangrove roots in the deepest (80–100 cm) level of the transect excavations. Additionally, there were higher frequencies of moderately deepwater shells at the 80–100 cm level, showing a more open water setting. As the sea level rose and mangroves encroached on the island, there was a shift to more emphasis on shells from shallow water and from mangrove habitats. The change began with the 60–80 cm level in the transect excavations. The possibility of spatial variability by depth will be explored in the next section using GIS.

In terms of dietary changes as revealed by the depth data in the transect excavations, the focus throughout was on shallow-water genera. Freshwater species (two species of *Pachychilus*) were present at all depths, being most common at the 20–40 and 60–80 cm depths and least common at the 80–100 cm depth. Minor changes include a slight diminution in the contribution of shells from moderately deep water from the deepest levels to the ground surface. Shells from the intertidal zone and from man-

grove roots diminish in importance from the 80-cm depth to the ground surface and were less frequent at the deepest level. At the time of initial settlement of the cay (80–100 cm depth) the Frenchman's Cay Maya ate fewer oysters (*Isognomum alatus* and *Crassostrea rhizophorae*) from mangrove habitats (mangrove roots and mangrove mudflats) and a few more clams from moderately deep water. Most of the shells were from shallow waters near the cay. Subsequently the contribution of shells from mangrove and shallow-water habitats increased, and moderately deepwater shells decreased (60–80 cm depth). They all decreased in frequency closer to the modern ground surface, with shallow-water shells remaining the most common food source at all levels.

SPATIAL ANALYSIS OF SHELL FROM TRANSECT EXCAVATIONS

Using GIS allows the spatial display of the quantitative data, adding this important dimension to the interpretation of the changing environment and diet. The spatial display includes 36 excavations along four transects, with five 20-cm levels. The geographic information system Intergraph MGE was used to display the quantitative data in a spatial format. Although we had used Excel and Visual dBase computer programs to quantify the shell data, neither of these databases is supported by MGE, so we imported our data into an Access database, which is supported by MGE. The Frenchman's Cay map had been digitized in Microstation, which is compatible with MGE. We attached the shell data to the digitized map by using the same coordinate fields (locations) in the shell and map databases. The query feature in one of the MGE components, Basic Nucleus, was used to display the occurrence of the shells at each location by habitat. We produced maps with dots showing the occurrence of shells. They included butchered shells, freshwater shells, shells from mangrove habitats, shells from shallow water, and shells from moderately deep water. For the GIS analysis we included shells from the shallow-water, under-

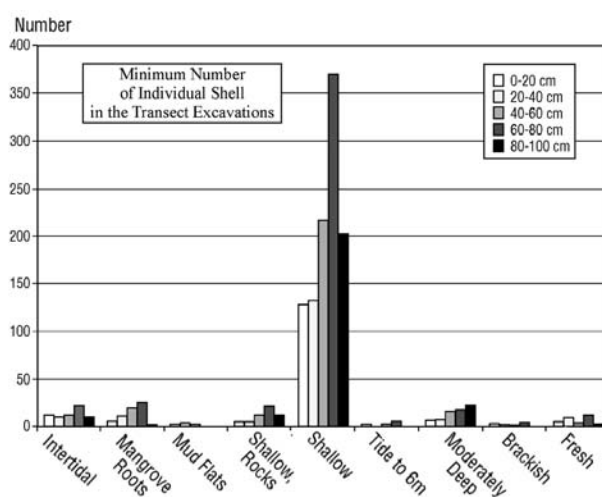


Figure 5.4. Minimum number of individuals (MNI) shells by depth in the Frenchman's Cay transect excavations. Figure by M. L. Eggart from GIS maps by H. McKillop and T. Winemiller.

rocks habitat in the shallow-water category. Additionally, we grouped mangrove mudflats, mangrove roots, and intertidal under the mangrove habitat. Maps were produced for each of the five 20-cm excavation levels. Spatial patterning indicates changes in diet and environment, as discussed below.

Freshwater and Butchered Shells

The distribution of freshwater “jute” (*Pachychilus polygonatus* and *P. pyramidalis*) and butchered shells (*Strombus gigas*) indicates the presence of ancient Maya from the deepest excavations to the ground surface on Frenchman’s Cay (Figures 5.5 and 5.6). Moreover, the presence of the jute shell indicates either direct procurement up nearby rivers or trade, since jute do not naturally occur locally. The distribution of freshwater and butchered shells beyond the area of the three mounds indicates ancient settlement was not restricted to the mound area. The distribution of these shells in the currently inundated area of the NE transect and into the sea along the NW transect indicates that there was a rise in actual or relative sea level that impacted the island. This is reinforced by the location of the water table at the ground surface along the NE transect and at the 20–30 cm depth along the other transects, with the fresh water and butchered shells indicating ancient human settlement below the current water table.

The absence of butchered and freshwater shells beyond 40 meters along the NE transect and beyond 10 meters along the SE transect in the plaza indicates the aerial limit to ancient settlement using shell remains. The lack of freshwater or butchered shells in the plaza, where activity was evidently focused because of the presence of the surrounding mounds, suggests a lack of food processing or shellfish discard in the plaza. The co-occurrence of other shell genera with the freshwater and butchered shells, which are clear indicators of the presence of the ancient Maya, may indicate some of these other shells were used.

Shells from Mangrove Habitats

Shells from mangrove habitats occur along all four transects, but their spatial distribution changes with depth from the ground surface (Figure 5.7). They are absent from the lowest level in the plaza (along the SE transect), underscoring the interpretation of dry land at the time of initial settlement and building construction. In contrast, shells from mangrove habitats are present in the plaza in the top level, which is currently inundated in the rainy season and often during the dry season as well. Shells from mangrove habitats are absent from the 0–20 cm levels along the NW transect, which is currently the driest part of the island. Shells from mangrove habitats are numerous along the NE transect at the 40–60 and 60–80 cm depths. Interestingly, freshwater and butchered shells are rare along the NE transect.

Shallow-Water and Moderately Deepwater Habitats

Shells from shallow-water habitats were found along all four transects and at all depths (Figure 5.8). However, they are absent in the plaza below the 40-cm depth. Shells from moderately deep water (Figure 5.9) are both less common, as indicated by the quantitative analysis, and more spatially restricted than the shallow-water shells. Shells from deep water are absent. Comparison between shallow-water and moderately deep-water shell distributions indicates a clear focus on the shallow-water habitats that surround the island.

DISCUSSION OF SPATIAL ANALYSIS OF TRANSECT SHELL

Spatial analysis of the transect shells by their habitats indicates there are differences in shell habitats, both horizontally and vertically, and that these patterns mirror sea-level rise. The rising sea level submerged the island community that was dry land surrounded by shallow water during initial settlement. Inundation of the site modified that idyllic coastal landscape, resulting

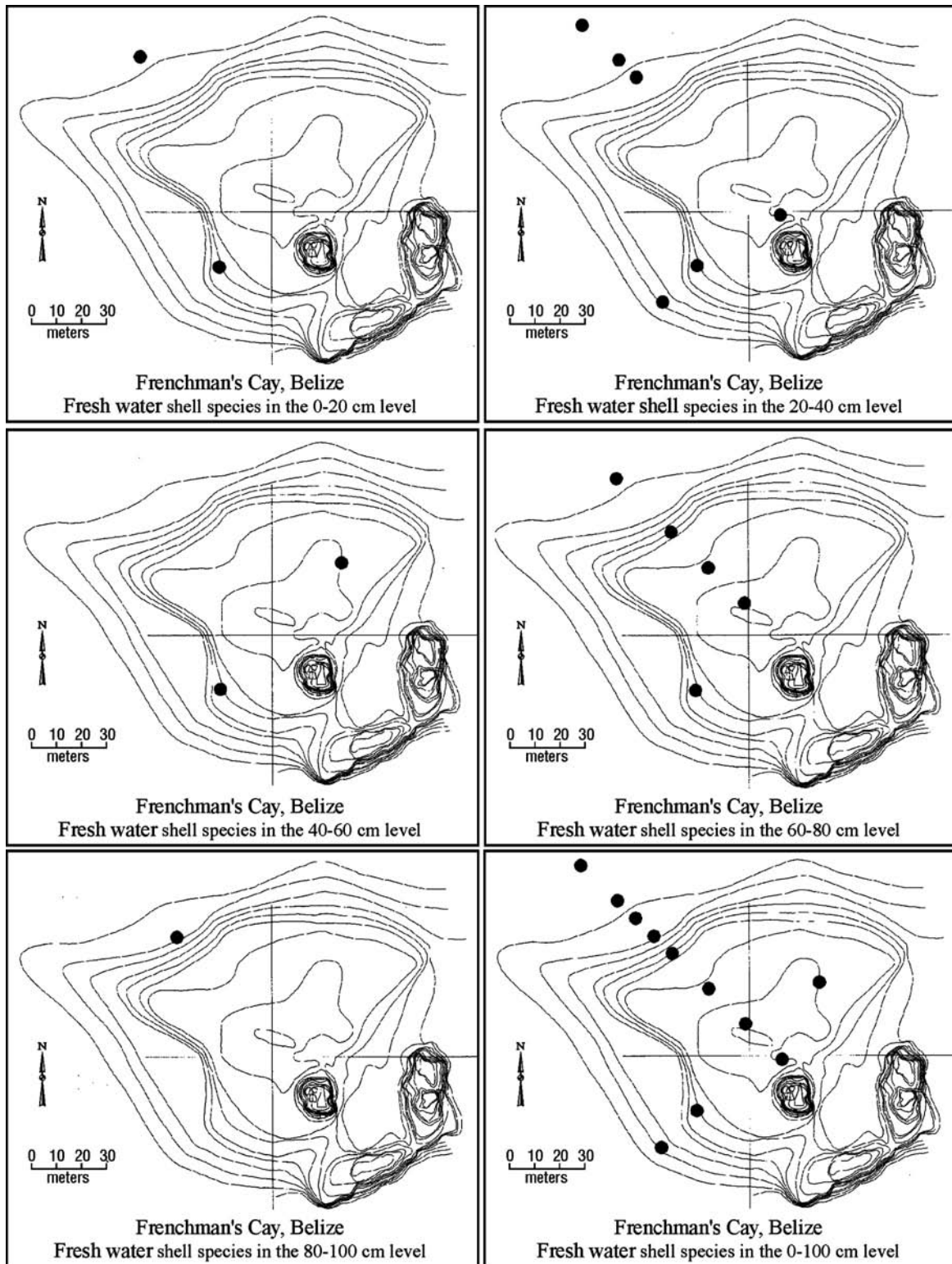


Figure 5.5. Spatial analysis of freshwater *Pachychilus* sp. shells in the transect excavations at Frenchman's Cay using the GIS Intergraph MGE. Figure by M. L. Eggart from GIS maps by H. McKillop and T. Winemiller.

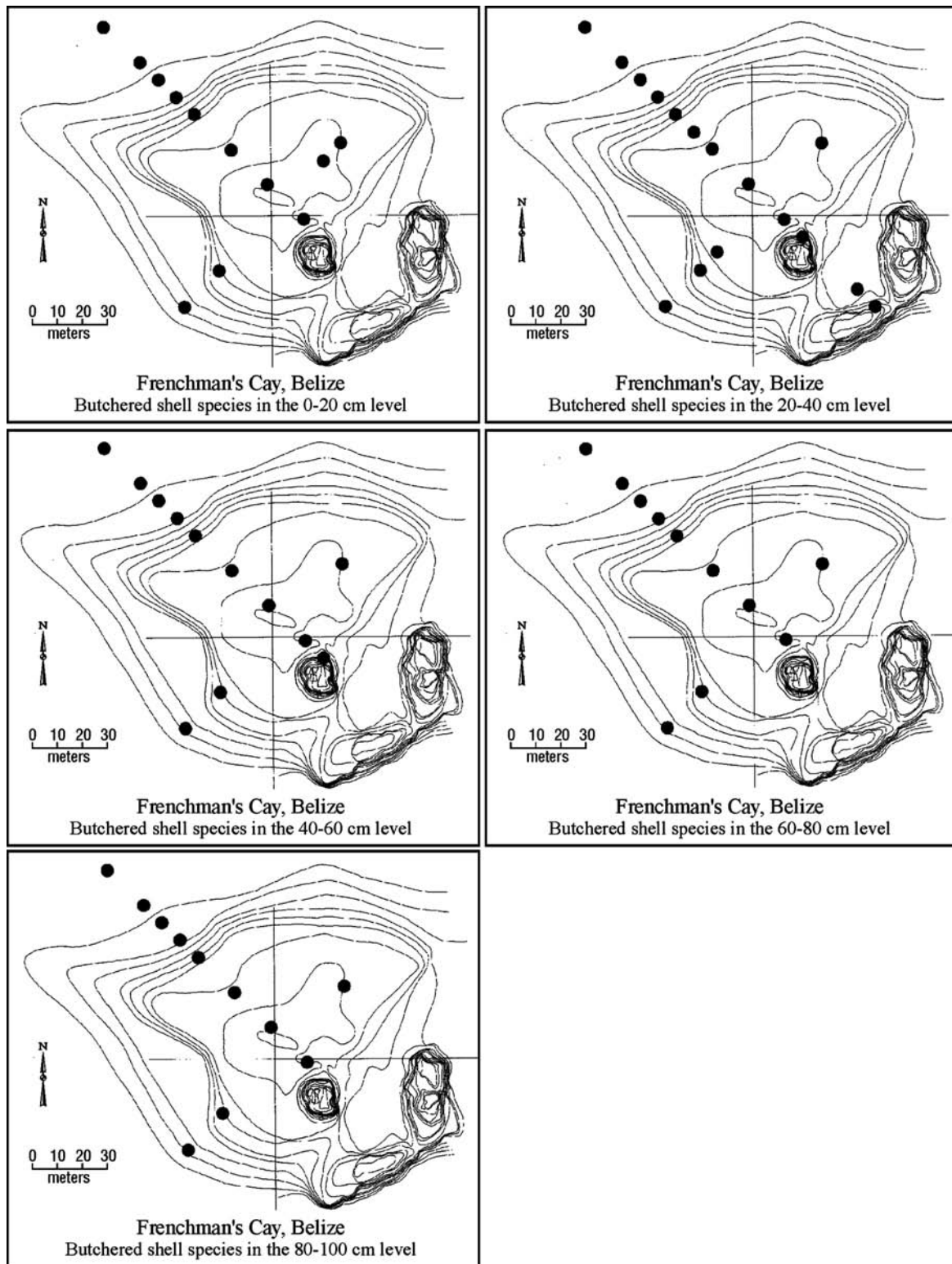


Figure 5.6. Spatial analysis of butchered *Strombus gigas* shells in the transect excavations at Frenchman's Cay using the GIS Intergraph MGE. Figure by M. L. Eggart from GIS maps by H. McKillop and T. Winemiller.

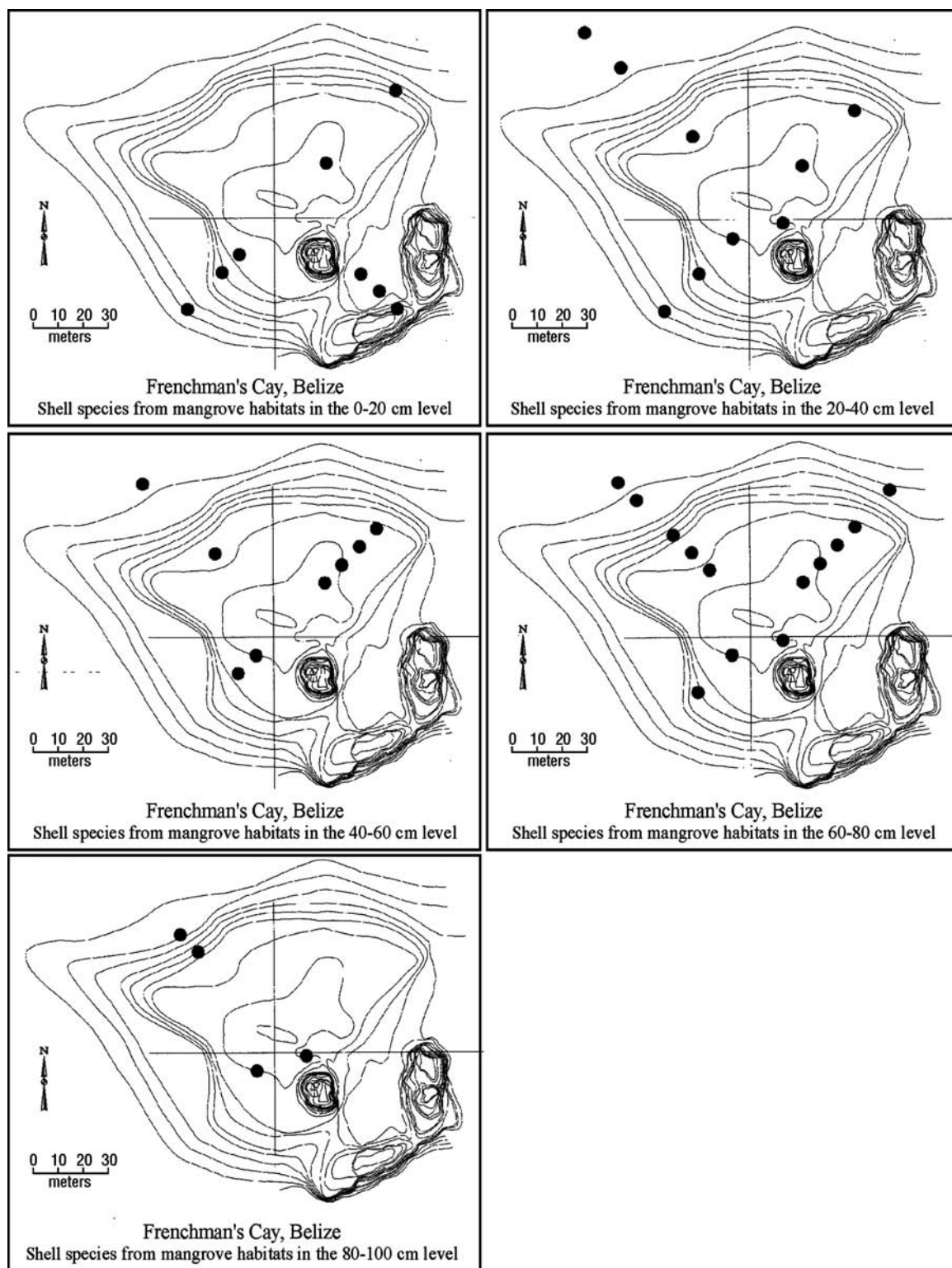


Figure 5.7. Spatial analysis of shells from mangrove habitats (intertidal, mangrove roots, and mangrove mudflats) in the transect excavations at Frenchman's Cay using the GIS Intergraph MGE. Figure by M. L. Eggart from GIS maps by H. McKillop and T. Winemiller.

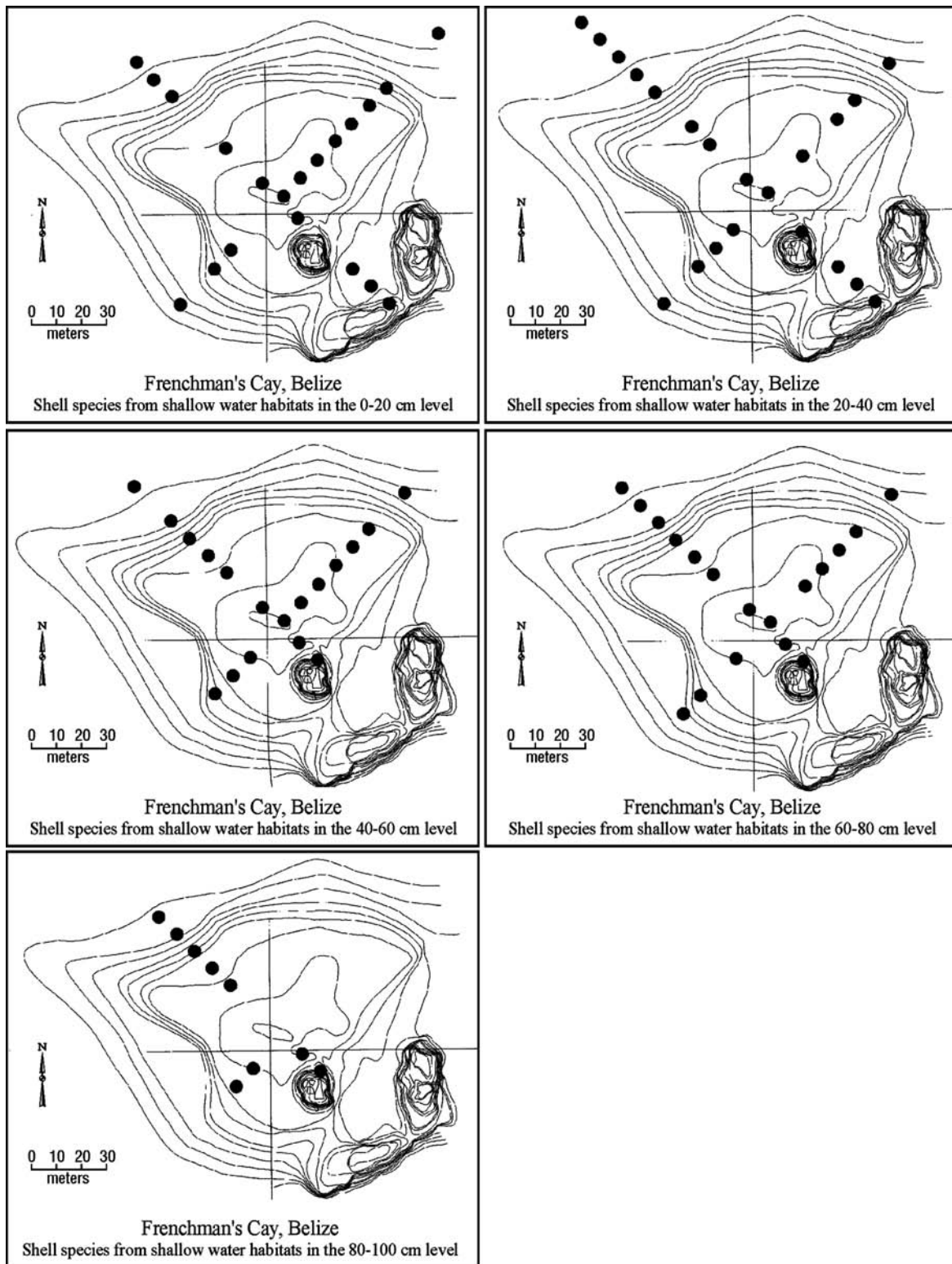


Figure 5.8. Spatial analysis of shells from shallow water (including shallow water, under rocks) in the transect excavations at Frenchman's Cay using the GIS Intergraph MGE. Figure by M. L. Eggart from GIS maps by H. McKillop and T. Winemiller.

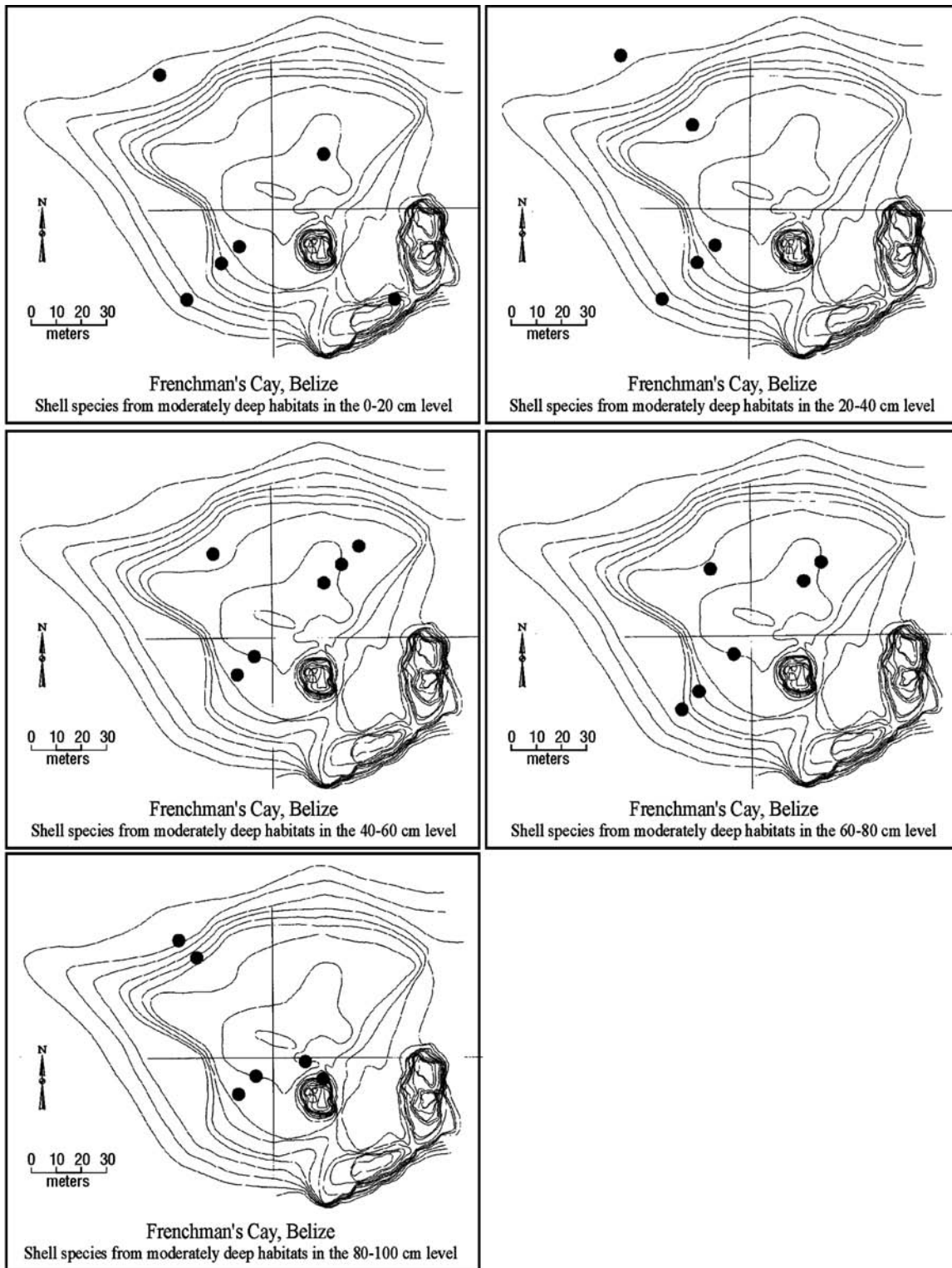


Figure 5.9. Spatial analysis of moderately deepwater shells in the transect excavations at Frenchman's Cay using the GIS Intergraph MGE. Figure by M. L. Eggart from GIS maps by H. McKillop and T. Winemiller.

in the current mangrove ecosystem, in which red mangroves mark the site periphery and also encroach on permanently inundated archaeological deposits. This interpretation of the changing landscape is based on optimal foraging theory in which resource selection, in this case marine shells, focused on the extraction of optimal food packages. Acknowledging that proximity is only one factor in such a model (along with species size, gregarious or solitary lifestyle, usable by-products, and nocturnal/seasonal availability), spatial analysis does reflect a change from shallow-water habitats to mangrove habitats, suggesting that proximity was an important factor in resource selection.

The distribution of freshwater species (*Pachychilus* sp.) and butchered shells in the 80–100 cm level along the transects documents the initial depth and area of human use of the island: the earliest settlement was concentrated away from the mounds in the area encompassed by the NW and SW transects. Associated shallow-water marine species at the 80–100 cm depth indicate dry land surrounded by shallow water, with limited access to mangroves and mudflats. The distribution of mangrove species along the NE transect at lower depths indicates a wetter environment in the past. The distribution of shells is also informative of the recent environment on the cay. The absence of mangrove genera near the ground surface along the NW transect reflects the recent dry environment, whereas their distribution along the other transects reflects the wetter modern landscape.

QUANTITATIVE AND SPATIAL ANALYSIS OF GREAT WHITE LUCINE SHELL

Identification of shells in the coral mounds on Frenchman's Cay was used to help identify the quarry location from which the Maya gathered large quantities of coral rock and finger coral for their building foundations. Great White Lucine is one of the three artificial coral mounds on the island that was excavated during the 1997 field season (McKillop 1995a, 1997,

2005; McKillop et al. 2003). The goals of the excavation were to investigate the coral construction by trenches and horizontal exposure to see if the Frenchman's Cay mounds were similar in age and construction to those at the nearby trading port of Wild Cane Cay (McKillop 2005). Excavations by cultural layers revealed three sequential building platforms faced with a limestone facade. The platforms were composed of a foundation of coral rock. A thin layer of finger coral was applied to the rough surface created by the pile of coral rock, with an earthen floor placed on the finger coral. The buildings were made of pole and thatch, which was not preserved but is suggested by the recovery of thatch-impressed clay from the excavations.

Three contiguous trenches, stretching 16 m across the mound, were excavated (see Figure 5.2). Each trench was 1 m wide and was divided into 16 excavation units, each measuring 1 x 1 m. Since we wanted to understand the construction of the buildings, we excavated in cultural layers. Beginning at the surface of the mound, we excavated the uppermost layer (Layer A), which was coral rock, and recorded shells and other artifacts in each unit (Tables 5.3 and 5.4). The uppermost coral rock layer was interpreted as the stone foundation for a floor that had been eroded. Below the coral rock layer we found an earthen floor (Layer B), supported by a finger coral subfloor (Layer C). Layer C rested on a thick coral rock foundation, Layer D. Below Layer D we found another earthen floor (Floor 2), which was supported by another coral rock foundation (Layer E). Mid-den deposits were encountered below the lowest coral rock foundation. The lower part of Great White Lucine is below the modern water table, including layers D and E.

The habitats of the coral do not provide specific information on where the coral was quarried or gathered. Therefore, we looked at the habitats of the shells that were brought in with the coral, including some shells that were attached to the rock, in order to provide a better understanding of the origin of the coral used

Table 5.3. Summary Statistics for Shells from Great White Lucine, Frenchman's Cay

Habitat	No. Genera	Ubiquity	MNI	NISP	Weight (g)
Intertidal	8	50	63	16	20.80
Mangrove roots	4	11	12	14	20.60
Shallow, under rocks	4	85	140	78	447.10
Shallow water	17	341	537	542	30,109.55
Below tide to 6 m	2	27	43	22	49.70
Moderately deep water	3	76	138	58	701.30
Fresh water	1	37	53	45	427.80

Note: No shells were recovered from brackish water or mangrove mudflats.

Table 5.4. Percentages of Shells from Each Habitat for Each Construction Level of Great White Lucine according to MNI

Level	Intertidal	Mangrove Roots	Shallow, Rocks	Shallow	Tide to 6 m	Moderately Deep	Fresh
A (foundation)	9.45	0.95	16.25	41.01	5.86	19.85	6.62
B (Floor 1)	8.22	2.74	12.33	61.64	4.11	8.22	2.74
C (subfloor)	3.77	7.55	18.87	56.61	5.66	3.77	3.77
D (foundation)			12.50	62.50	6.25	6.25	12.5
Floor 2				75.00		25.00	
E (foundation; above 120 cm)			2.94	88.24		2.94	5.88
E (120–185 cm)	5.00	1.67	25.00	40.00	3.33	16.67	8.33
E (185–205 cm)			10.20	61.23	2.04	20.41	6.12

for construction. The coral rock consisted principally of star corals and brain corals, but there was also some stag-horn coral and rose coral, indicating a general range from shallow to deep waters that characterize much of the region from the coast to the barrier reef, which is some 40 km offshore.

Quantitative analysis of the shells provided more specific information on the origin of the coral rock. Most of the shells derived from shallow-water habitats. The shells from each construction layer were grouped according to habitat and quantified by MNI (Tables 5.3 and 5.4; Figure 5.10). Shells from shallow water predominate overall and in each construction layer. None of the shells were from mangrove mudflats. Relatively few shells were from man-

grove roots, in contrast to the nonmound areas of the island. Shells from mangrove roots were present in the top (most recent) coral rock foundation (Layer A), the floor and subfloor of the previous building (Layers B and C), and in minor quantities in the lowest (first) foundation (Layer E, 120–185 cm depth). *Chama* and *Pseudochama* sp., which attach to living coral, were more common in the first and third foundation than in the second foundation. *Chama* and *Pseudochama* reflect the origin of the coral from moderately deep water. Freshwater jute were present in all layers in minor amounts as in the transect excavations and were incorporated into the construction fill as household food refuse gathered from other locations.

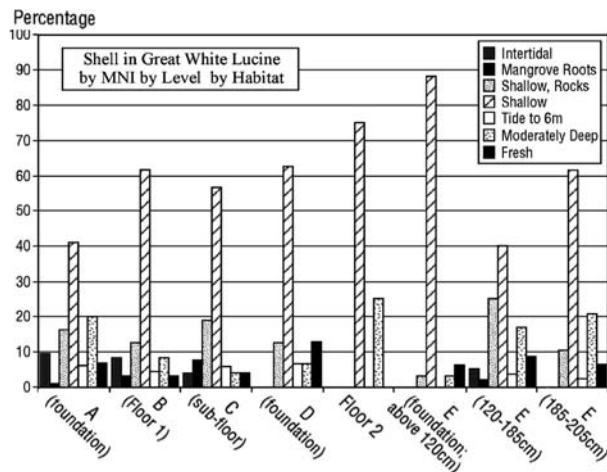


Figure 5.10. Minimum number of individuals (MNI) shells by depth and habitat in the Great White Lucine mound excavations.

There is little spatial variation in the distribution of shells from various habitats within the coral rock foundations of Great White Lucine, with one exception. Shells from shallow-water, moderately deep-water, and mangrove habitats occur in most units. However, shells from moderately deep water were only recovered from a single excavation unit in Layer D of the second rock foundation, whereas shallow-water genera are distributed more broadly through the layers (see Tables 5.3 and 5.4). No spatial patterning was examined for the lowest excavation levels of the lower coral rock foundation, since only one excavation unit was opened in the inundated setting.

Shells from the coral foundations include environmental indicators of the shallow to moderately deepwater origin of the coral building material. The variety of habitats for the shells may indicate the Maya gathered coral that had been driven onshore to form storm beaches. However, the dominance of shells from shallow water instead suggests harvesting of fresh coral or quarrying of dead coral from the sea around the island and occasionally farther away in moderately deep water. The absence of shells from mangrove mudflats reinforces the limited nearby extent of *Rhizophora mangle* during the settlement of the village, as also seen in the transect excavations. The occur-

rence of shells from mangrove roots in many of the units in the upper two building foundations reflects the modern inundated soil of the mangrove swamp, which has encroached on the mound.

CONCLUSIONS

Quantitative and spatial analyses of shells from excavations at Frenchman's Cay inform on Late Classic Maya economy and environment. The transect excavations in middens indicate dietary reliance on nearby marine resources with some use of riverine shell through trade or direct procurement. The spatial distribution of shell genera by habitat along the four transects provides a picture of a changing environment. The dry land needed for the initial settlement is indicated by shallow-water marine shells with a few from mangrove habitats. By way of contrast, shells from mangrove habitats were more common later, as indicated by their presence above an 80-cm depth and along the NE transect. Evidently mangroves began encroaching on the site margins.

The shells from the buildings in the mounded remains of Great White Lucine provide information on the ancient landscape, procurement areas for coral rock, and the organization of Maya labor. Shallow-water marine shells, along with some moderately deep-water shell (specifically two species that attach to coral), were common. Large quantities of coral rock and finger coral were either gathered from storm beaches or quarried from the sea in shallow to moderately deep water around the island. A work party may be identifiable from the restricted spatial distribution of moderately deepwater shells in one of the foundations. Shell data support the interpretation of a drier landscape during the construction of Great White Lucine and the modern encroachment of mangroves as a result of rising sea level. In summary, quantitative analyses, as well as spatial analyses, of shell from Frenchman's Cay using the GIS Intergraph MGE have allowed us to see the ancient Maya gathering coral from storm beaches and the shallow waters that would

have surrounded the island, as well as the more recent encroachment of mangroves that are slowly enveloping surface evidence of the ancient community.

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6

Environments of the Maya Collapse

A Zooarchaeological Perspective from the Petexbatún

Kitty F. Emery

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The “collapse” of Classic Maya social and political systems around A.D. 800 is a topic of enduring fascination for Maya archaeologists. Environmental change continues to be ascribed primacy in the search for causal agents in both this and other episodes of cultural disjunction. This research from the Petexbatún region of the Guatemalan Petén combines traditional and nontraditional zooarchaeological methods to investigate evidence for the dramatic environmental changes hypothetically associated with the period of regional abandonment in the Petexbatún. The results of ecosystem fidelity analysis of the Petexbatún faunal assemblage, as well as isotopic chemical studies of the remains of crop-feeding deer, indicate that in this area, at least, there is no evidence that an environmental failure was causative for political collapse.

ENVIRONMENTAL DEGRADATION: CAUSAL MECHANISM IN THE MAYA COLLAPSE

From the environmental determinism of culture history through the systems models of processual archaeology, the environment has often been cast in the role of causal mechanism in the origin, growth, and decline of civilizations. Despite a growing archaeological interest in social, economic, and political phenomena as motivators of culture change, prime importance is still frequently ascribed to environmental patterning. In Mesoamerican archaeology this enduring interest in environmental precursors is evident in the many current models of the growth and decline of Maya civilization that stress changing environmental conditions, particularly those that result from variability in land use and climate. The undercurrent of environmental causality is perhaps most apparent in the ongoing debate over the “collapse” of Maya society at the end of the ninth century A.D. (Cooke 1931; Culbert 1973, 1977, 1988; Gill 2000;

Hodell et al. 2000; Johnston et al. 2001; Santley et al. 1986). The Maya “collapse” marks the end of the Classic period and is characterized at many sites by a cessation in the construction of monumental architecture and in the erection of celebratory monuments and dedications that indicate at the least a dramatic change in the political sphere. The abandonment of many urban centers has been interpreted as evidence of large-scale population demise (e.g., Gill 2000; Sanders and Webster 1994) or (more likely) as a generalized pattern of out-migration and resettlement (e.g. Johnston et al. 2001).

Although the true nature of this societal discontinuity and the range of its impact over both space and time continue to be questioned, it is clear that the period between A.D. 750 and 900 was one of political turmoil, economic disruption, population movement, and often abandonment of political centers. No single or unicausal model will suffice to explain a societal change of this complexity and magnitude, but most recent theoretical reconstructions continue to stress an underlying environmental cause for the social and political upheaval.

The generalized model hypothesizes that increasing human population sizes, combined with growing demands for subsistence and status goods for a large elite class of nonproducers, resulted in the unsustainable use of natural resources. The requirement for more agricultural products led to both expansion of agricultural fields and intensification of agricultural production. Whereas some argue that these factors led inexorably to deforestation and the eventual loss of soil fertility (e.g., Abrams et al. 1996; Culbert 1988; Sanders and Webster 1994), others suggest that this pattern was exacerbated by a coincident and severe long-term drought (e.g., Curtis et al. 1998; Hodell et al. 2000).

Simultaneous with the pressure on both the flora and the soils of the rainforest, an increasing demand for dietary protein is hypothesized to have resulted in both generalized and selective overhunting of an already dispersed tropical fauna (Pohl 1990). Unsustainable hunting practices combined with severe habitat reduction through deforestation to cause a failure in animal population regeneration. In this model the final outcome of the unsustained use of the tropical flora and fauna was dietary insufficiency and the collapse of the complex Maya political and religious systems (Culbert 1988; Santley et al. 1986).

The model of environmental failure has been tested and retested over the past decades, but few archaeological materials are as effective as animal remains at broaching the complex issue of environmental change. The diverse techniques of zooarchaeology allow us to examine faunal remains as both artifact and ecofact—as a direct measure of use or as an indirect indication of wider ecological and social patterning. Zooarchaeology is by nature a conjunctive science, and its most robust research and concrete conclusions are achieved through the use of multiple perspectives and the creation of overlapping results. Its multidisciplinary methods and broad perspective make it effective in tackling sophisticated theoretical questions like those that surround the Maya collapse.

In this analysis I use the zooarchaeological remains recovered during the excavation of sites in the Petexbatún region of Guatemala to

test the model of environmental failure and its potential for causality in the specific case of the Petexbatún polity (Figure 6.1). The Petexbatún faunal remains can be used effectively to examine the evidence for dramatic changes in the tropical rainforest, either as a result of unsustainable deforestation and expansion of agricultural production or as a result of progressive desiccation during a long-term drought.¹

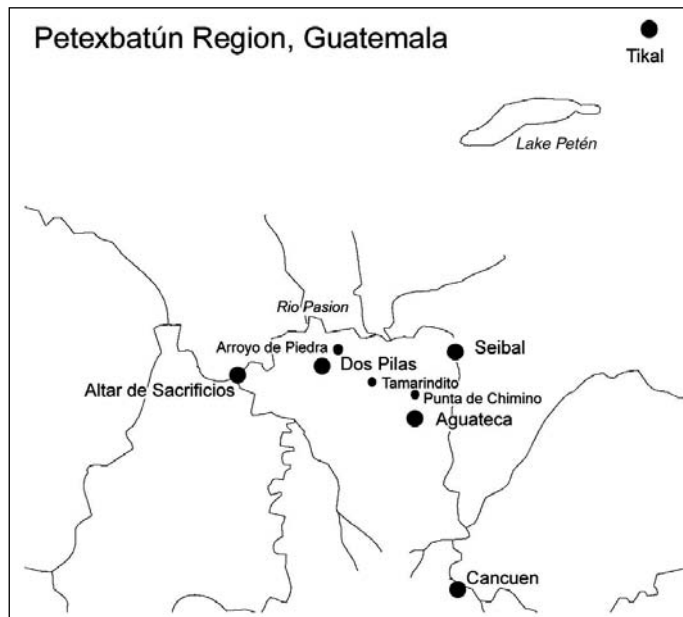
Both of these environmental failure scenarios are ecosystem models that can be tested using zooarchaeological remains as indicators of environmental patterning. The processes of environmental change, caused either by human activity or by climatic change, will have measurable effects on the animal populations used by the Maya. Both drought and agriculture/clearing will cause significant shifts in plant communities by removing canopy forest flora and increasing open spaces (either in the form of agricultural fields or pioneering flora such as savanna grasses that thrive in such gaps). Changes in the plant communities have indirect impacts on the rainforest animals, in some cases diminishing or increasing their available habitats, in other cases causing shifts in their dietary regimes that can be measured in their bony remains.

Traditional measures of ecosystem-allied species frequencies and population and community statistics are combined with isotopic bone chemistry to test for the ecological shifts that would signal environmental degradation on the scale suggested by models of environmental causality for the Maya collapse.

HISTORY OF THE PETEXBATÚN REGION

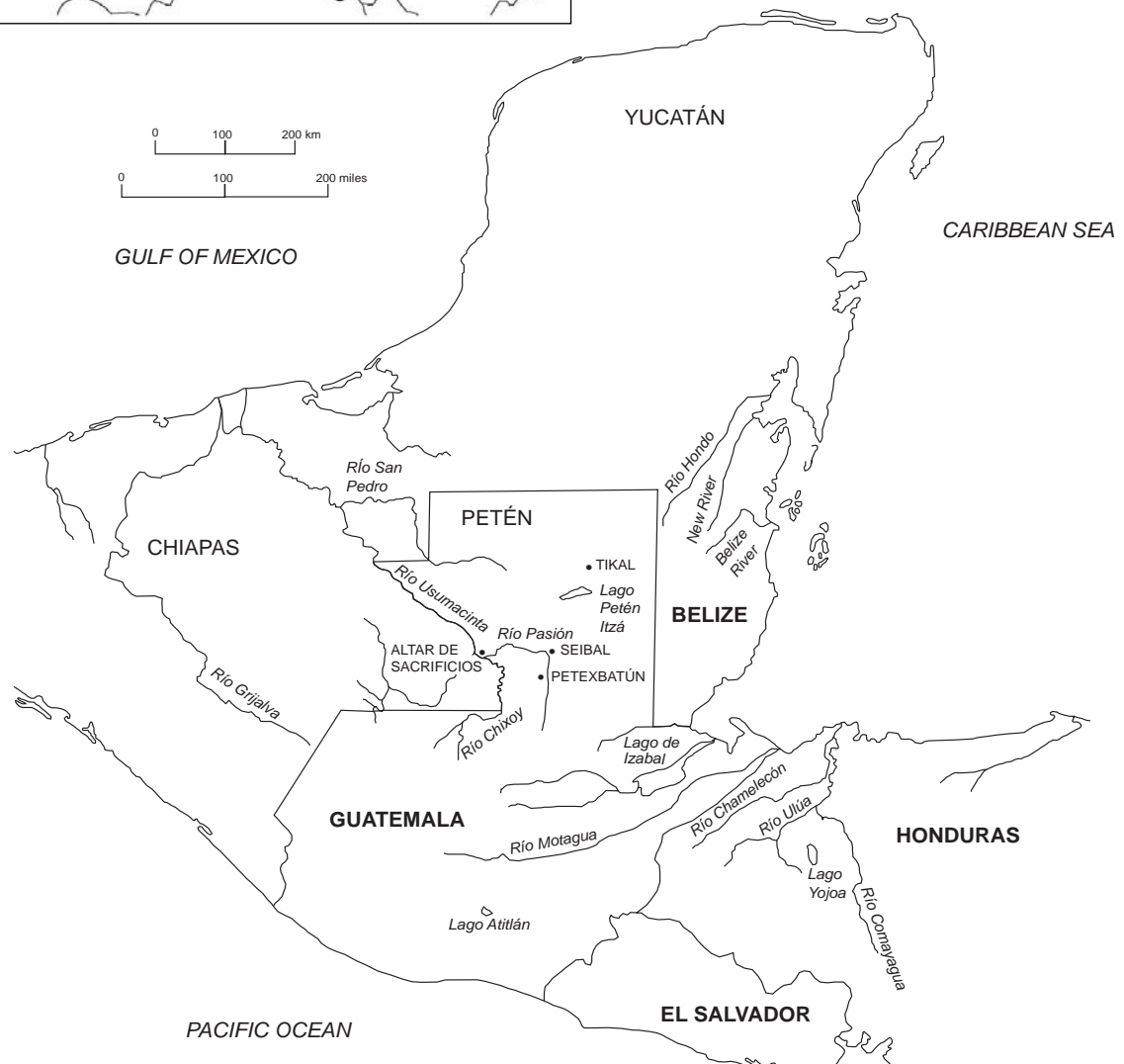
Between 1990 and 1997, as the zooarchaeologist for the Petexbatún Regional Archaeological Project, I analyzed a large collection of animal remains recovered from the various surface and cave sites of this region of the Petén of Guatemala (Emery 1997). The Petexbatún Regional Archaeological Project, codirected by Arthur Demarest of Vanderbilt University and Juan Antonio Valdes of the Universidad de San

6. ENVIRONMENTS OF THE MAYA COLLAPSE



BELOW: Figure 6.1. Map of the Maya area with sites mentioned in the chapter.

LEFT: Inset: Petexbatún region, Pasién drainage, Petén (modified from Mathews and Willey 1991).



Carlos, was a multidisciplinary effort focused on reconstructing the cultural and environmental patterns of the final days of the Petexbatún sites (Demarest 1996, 1997).

Archaeological and epigraphic research by the Petexbatún team provides a detailed history of occupation in this region (Demarest 1997; Foias and Bishop 1997; Houston 1993). The Petexbatún was first settled during the Preclassic period but was most densely populated during the Late Classic period, a time of intense political activity under the joint control of the ruling elite of the two largest sites, Dos Pilas and Aguateca. The core of the region includes five major sites (Dos Pilas, Arroyo de Piedra, Tamarindito, Punta de Chimino, and Aguateca), as well as a variety of smaller communities, but at its peak the polity may have extended south to the site of Cancuen, east to Seibal, and north to La Amelia (see Figure 6.1). At the Petexbatún sites the "collapse" event was abrupt and early. Construction of defensive walls, ditches, and other fortifications at most of the Petexbatún sites was followed immediately by the disappearance of the ruling elite and a widespread reduction in population (Demarest et al. 1997; Foias and Bishop 1997).

In this region the environmental collapse model has a more specific variant. The erection of defensive structures at all of the Petexbatún sites and the eventual destruction of at least one site (Aguateca) by burning (Inomata 1997) are clear evidence for political upheaval. Demarest (1990, 1997) has suggested that in this region the Late Classic Petexbatún policy of territorial acquisition and competition for limited resources caused undue pressure on the Petexbatún environments and resulted in their eventual overuse and destruction. According to this model warfare was both cause and symptom of the dramatic environmental degradation that eventually caused the abandonment of the Petexbatún region. However, other lines of inquiry (Dunning and Beach 1994; Dunning et al. 1997; Dunning et al. 1998; Wright 1997a, 1997b), including the zooarchaeological evidence presented here, suggest that despite the clearly dysfunctional nature of the political system in the region, there is no evi-

dence for environmental destruction as either cause or consequence.

THE PETEXBATÚN ASSEMBLAGE

The Petexbatún zooarchaeological assemblage consisted of more than 20,000 remains of both vertebrates and invertebrates. The remains were recovered from a wide variety of archaeological deposits, including elite and nonelite, occupation and nonoccupation, ritual and secular loci, spanning a period of almost a thousand years of occupation. The size and diversity of the Petexbatún faunal collection, in combination with the valuable archaeological and ecological data from the Petexbatún project, allowed me to use new methods to evaluate the various archaeological interpretations of the history of this period in the Petexbatún and elsewhere.

The faunal remains recovered by the Petexbatún project were generally trowel excavated except on occupation surfaces or in special deposits when the remains were recovered by screening (1/4"). Tests of relative recovery in screened and unscreened deposits indicate recovery was complete using trowel excavation. This suggests, as well, that soil conditions were too poor to permit the preservation of small or fragile remains. I analyzed remains using comparative material from the region, as well as collections housed at the Royal Ontario Museum in Canada, and relevant illustrated guides. MNI frequencies, presented here, were calculated using element side pairs matched by age and sex.

The results of basic analysis of species frequencies emphasize the importance of a few taxa in the Petexbatún assemblage. Molluscs are very common in the assemblages, both as dietary species and for use in artifact manufacture. Of the vertebrates, though, the dominant species were deer, turtles, dogs, agoutis, and peccaries. These basic counts are presented here as a total for all chronological periods (Table 6.1). Details of the zooarchaeological analysis are provided in other publications (Emery 1997), and this chapter will concentrate on secondary analyses of the base data.

Table 6.1. Petexbatún Animal Taxa Presented for the Entire Occupational Period

Taxonomy	% MNI	Common Name	Diversity Measures
<i>Philander opossum</i>	0.09	Gray 4-eyed opossum	Total MNI = 1,117
Sirenia/Perissodactyla	0.10	Manatee/tapir	# taxa (s) 45
<i>Procyon lotor</i>	0.13	Raccoon	Dominance 1.95
Brachyura	0.18	Crab	Richness (s-1/logN) 44.86
<i>Didelphis marsupialis</i>	0.18	Virginia opossum	Evenness (variance) 2,520.29
<i>Serpentes</i>	0.18	Snakes	Heterogeneity ($N*(N-1)/\sum n(n-1)$) 8.90
Sciuridae	0.20	Squirrels	
<i>Crax rubra</i>	0.21	Curassow	
<i>Tapirus bairdii</i>	0.21	Tapir	
<i>Sylvilagus</i> sp.	0.27	Rabbit	
<i>Lepisosteiformes</i>	0.32	Gar	
Dasyatidae/Myliobatidae	0.36	Rays	
Ranidae/Bufonidae	0.47		
Ranidae (0.34)		Frogs	
<i>Bufo marinus</i> (0.13)		Marine toad	
<i>Urcyon cineoargenteus</i>	0.48	Gray fox	
Crocodylidae	0.63	Crocodiles	
Intrusives	0.85		
<i>Homo sapiens sapiens</i> (0.31)			
<i>Neocyclotus dysoni</i> (0.09)			
<i>Helicina amoena</i> (0.45)			
cf. <i>Petenia splendida</i>	0.96	Blanco (cichlid fish)	
Ictaluridae/Pimelodidae	0.96	Catfish	
<i>Dasypus novemcinctus</i>	0.98	Armadillo	
<i>Meleagris ocellata</i>	1.23	Turkey	
Rodentia, small	1.48		
Muridae (1.09)		Rats and mice	
Geomyidae (0.39)		Pocket gophers	
<i>Dasyprocta punctata</i>	1.81	Agouti	
<i>Agouti paca</i>	2.34	Paca	
<i>Mazama americana</i>	3.17	Brocket deer	
Tayassuidae	3.55	Peccaries	
Felidae	5.26	Cats	
<i>Panthera onca</i> (2.72)		Jaguar	
Felidae, intermediate (0.90)		cf. Ocelot, jaguarundi	
Felidae, small (1.64)		cf. Margay	
<i>Canis familiaris</i>	5.46	Dog	

Continued on next page

Table 6.1. Petexbatún Animal Taxa Presented for the Entire Occupational Period (continued)

Taxonomy	% MNI	Common Name	Diversity Measures
Testudines	11.61	Turtles	
Testudines (1.52)			
<i>Kinosternon</i> sp. (1.55)		Mud/musk turtles	
<i>Dermatemys mawii</i> (3.95)		River turtle	
<i>Staurotypus triporcatus</i> (1.77)		Giant musk turtle	
<i>Trachemys scripta</i> (2.82)		Slider	
<i>Odocoileus virginianus</i>	13.82	White-tailed deer	
Freshwater Mollusca	42.51		
<i>Nephronais</i> sp. (1.07)			
<i>Pachychilus glaphyrus</i> (0.27)		Jute	
<i>Psoroniaias</i> sp. (6.45)		River clam	
<i>Pachychilus indiorum</i> (7.79)		Jute	
<i>Pomacea flagellata</i> (26.93)		Apple snail	
Total Petexbatún % MNI	100.00		

Note: Some taxonomic groups summed for calculation.

TESTING FOR ANTHROPOGENIC AND CLIMATIC ENVIRONMENTAL CHANGE

The first set of analyses presented here test the anthropogenic and climatic models that suggest the collapse of ancient Maya society resulted directly from an inability of the tropical rainforest to support the large resident human population. Both anthropogenic changes, resulting from unsustainable use of the rainforest ecosystem, and climatic changes, resulting from prolonged drought conditions, have been proposed either separately or in concert as underlying this aspect of the environmental change theory.

The anthropogenic environmental failure model depends heavily on the suggestion of agricultural expansion in response to increased demands for resources to feed a growing population. Deforestation is a necessary result of agricultural expansion. It is also more directly a result of increased population size as more land is required for settlement and more trees are cut for building supplies and other purposes. This deforestation and replacement of canopy with

agricultural plants can be tracked in the zooarchaeological record.

The impact of prolonged drought on the tropical ecosystem is much more complex because the combination of precipitation and watershed changes can dramatically alter entire landscapes. However, the final effect is, again, a change in plant communities from moist canopy rainforest to dry, open forest or, finally, open scrub or grasslands. Again these floral changes can be tracked in the zooarchaeological record.

I have used two different zooarchaeological methods to test for these effects of environmental change: an analysis of ecosystem-allied animal community patterning and an analysis of isotopic variability in deer bone recovered from archaeological deposits. These methods allow me to test two separate predictions that develop from the generalized model of environmental failure.

First, if increasing population pressure led to a shift from forest to field—a gradual expansion of agricultural fields and reduction of tropical forests—the coincident shift in the availability

and use of animal species attracted to agricultural lands as opposed to animals more commonly found within the canopy rainforest should be clearly visible in the archaeological record. Similarly, if conditions of dramatic climatic variability, such as drought, were the impetus for environmental degradation, the effects of these changes should also be reflected in changing species markers for ecosystems differentially affected by such conditions.

Second, as the floral community of the rainforest shifts from high canopy to savanna and agricultural species, this will affect the availability of food plants to the tropical fauna. The white-tailed deer, for example, is a range generalist with nonspecific food requirements. Its dietary patterns will vary with floral availability, and it will feed on plants associated with closed forest communities, as well as those in open areas. These plant communities can in some cases be distinguished by their different chemical characteristics, and these characteristics can be traced as isotopic signatures in zooarchaeological deer remains. This fact allows us to test for the predicted changes in chemical constituents associated with the dietary changes required by the environmental change model of the Maya collapse.

Ecosystem Resource Analysis

The model. Ecosystem analysis, the derivation of environmental descriptions from the relative frequency of retrieved archaeological animal remains, has a long history in the zooarchaeological sciences. Despite the bias imposed by human choice, use, and deposition of the animals culled from natural populations, no discussion of animal use can be effectively separated from the implications of resource availability as reflected in faunal assemblages. Interpreted appropriately, there is a direct and quantifiable link between the animal remains recovered in archaeological deposits, the ecosystems preferred and most frequently inhabited by these species, and the general environmental conditions implied by the presence of these habitats (although see Grayson 1984).

If environmental factors were causal to the collapse syndrome at the Petexbatún sites, we can predict extreme ecological changes consonant with environmental failure to be associated with the periods immediately before and during abandonment in the Petexbatún region. The "extreme" nature of the changes must be defined by evidence for statistically significant differences in use patterns. The types of environmental changes that would be predicted depend on the model proposed for the collapse in the area.

If the collapse was caused by a natural environmental change, such as drought, we would expect to see significant shifts in the availability of resources from naturally occurring environments (pristine canopy rainforest, rivers, lakes, seasonal and perennial swamps, and natural high bush or secondary forest), particularly in the seasonally or perennially inundated ecosystems, those most directly affected by drought conditions. Simultaneously we should see an increase in the frequency of species directly associated with savanna or other disturbed habitats as these became dominant ecosystems.

If, on the other hand, the environmental failure was caused by excessive land clearing as a result of settlement growth and extreme expansion of agricultural field use, we would expect to see a dramatic rise in the appearance of the remains of species with high affinity for agricultural fields and residential areas, coincident with a drop in the use of species from pristine, uncut forests.

The results. Using a large corpus of the available literature on the ecology of the Petexbatún and surrounding regions, in combination with my own observations over several years in the area, I created a hierarchy of microenvironmental zoning to form the basis for this investigation of variability through time. The Petexbatún region can be subdivided into the following ecological microenvironments: rivers, lakes, and their shorelines; perennial and seasonal swamps; and the canopy rainforest, *guamil* (high bush), *milpa* (agricultural land), and residential lands

that are found on all dry uplands and lowlands on and below the Petexbatún escarpment. Whereas all the Petexbatún sites should have had equal access to milpa, high bush, and residential zones, other zones vary slightly, depending on location. Riverine sites including Bayak, Punta de Chimino, and Aguateca had relatively greater access to resources from rivers and shorelines than did the sites of Tamarindito, Arroyo de Piedra, and Dos Pilas. Swamp resources were available to most of the sites but were only seasonally available at the inland sites of Arroyo de Piedra and Dos Pilas. These variations in natural availability were taken into account when resource use was interpreted for the region.

A glance at the species list for the Petexbatún shows that the fauna recovered represent most of the microenvironments surrounding the region. Simple presence/absence species measures are ineffective for environmental reconstructions, however, because of the combined biases of cultural selection, differential taphonomy, and habitat preferences of the animals themselves (Grayson 1984). But by calculating proportional fidelity measures for the different species (or degree of preference of a species for any given habitat), we can create a relative measure of ecosystem representation that provides a much more robust method for quantifying resource availability.

Relative fidelity can be calculated for each species as the proportion of time spent in each of the habitats preferred by the species based on detailed understanding of animal behavior. A species with exclusive fidelic preferences will spend 100 percent of its time in only one habitat. One with characteristic fidelic preferences may spend 25 percent of its time in canopy rainforest and 75 percent of its time in disturbed field edge, whereas a species with ubiquitous fidelity may spend equal proportions of its time in all available habitats (Smith 1974). So as an example, in the Petexbatún area, the large cats are exclusively fidelic to canopy rainforest. The collared peccary may prefer the canopy forest but be attracted as well to milpas and orchards when crops are mature. A detailed explanation

of the microzone fidelity measures for each species is available in Emery (1997).

Using this measure (based on minimum number of individuals [absolute MNI/assembly] x species relative fidelity for each microenvironment, expressed as relative frequency of species/microenvironment), I compared variability over both space (by site) and time (by period) (Table 6.2). I tested the derived measures for statistical significance using ANOVA tests.

My model of environmental collapse is based on agricultural mismanagement or climatic change or some combination of the two. First, to fulfill the requirements of the initial prediction of extreme expansion of agricultural lands during the period of highest occupancy and political activity at the Petexbatún sites, we would expect to see evidence for significant increases in the use of resources from agricultural ecosystems during the Late Classic period. Coincident with this shift we should see decreasing availability or use of animal species with high fidelity for pristine canopy forest ecosystems.

However, my analysis of chronological patterning in ecosystem resource use in the Petexbatún indicates a clear lack of any specific trajectory of either declining or rising use of any one ecosystem through time, and this observation is confirmed by a statistical consideration of these changes. Analyses of sample variance tests of sample means indicate that there is no significant variability in the use of species from pristine canopy rainforest during any of the time periods investigated (Figure 6.2 [F probability = 0.8139]). The statistical results also indicate that the same relative proportion of species with high fidelity for agricultural resources was used (and was therefore available) during all periods of occupation of the Petexbatún region. Despite a very slight rise in the mean use of resources from agricultural ecosystems in the Early Classic and late facet Late Classic periods in the Petexbatún (Figure 6.3), ANOVA tests show that these differences are not statistically significant (F probability = 0.4331).

Table 6.2. Chronological Distribution of Petexbatún Ecosystem Resource Use

	No. of Site Samples	Mean	Minimum	Maximum	Standard Deviation	ANOVA F Ratio	ANOVA F Probability
Disturbed environments						2.1759	0.1335
Preclassic	3	9.9333	2.30	23.75	11.9875		
Early Classic	2	38.4450	28.65	48.24	13.8522		
Early Late Classic	5	29.1780	13.30	41.36	11.9599		
Late Late Classic	4	38.0375	14.40	57.81	18.7591		
Terminal Classic	3	33.9133	23.27	41.28	9.4415		
Total	17	29.7924	2.30	57.81	15.6985		
Guamil						0.8927	0.4978
Preclassic		7.1900	1.57	17.50	8.9408		
Early Classic		20.3700	9.23	31.51	15.7543		
Early Late Classic		15.6940	3.85	28.64	10.1373		
Late Late Classic		15.0950	6.97	21.88	6.1371		
Terminal Classic		19.8167	11.23	25.09	7.5006		
Total		15.3300	1.57	31.51	9.2043		
Milpa						1.0258	0.4331
Preclassic		2.7400	0.72	6.25	3.0513		
Early Classic		11.5250	8.27	14.78	4.6033		
Early Late Classic		6.8780	1.92	15.41	5.8808		
Late Late Classic		10.5275	2.84	23.44	8.9346		
Terminal Classic		10.3600	5.52	14.06	4.3826		
Total		8.1676	0.72	23.44	6.1845		
Canopy						0.3871	0.8139
Preclassic		17.0200	0.43	44.38	23.8725		
Early Classic		17.8520	15.96	19.69	2.6375		
Early Late Classic		12.3940	8.08	16.23	4.0427		
Late Late Classic		12.5100	11.59	13.83	0.9483		
Terminal Classic		21.0667	12.37	34.89	12.1037		
Total		15.4071	0.43	44.38	10.3150		
Riverine/shoreline						0.7070	0.6024
Preclassic		64.3333	27.50	90.00	32.7121		
Early Classic		39.4100	26.51	52.31	18.2434		
Early Late Classic		51.8900	34.55	72.32	15.7900		
Late Late Classic		45.2100	27.50	69.20	18.1066		
Terminal Classic		39.5067	18.21	60.31	21.0543		
Total		48.8606	18.21	90.00	20.3085		
Exotics						0.7890	0.5542
Preclassic		3.0300	0.00	9.09	5.2481		
Early Classic		5.7650	0.00	11.53	8.1529		
Early Late Classic		14.9320	0.00	38.89	16.8015		
Late Late Classic		27.4500	8.75	65.67	25.8950		
Terminal Classic		17.3333	0.00	48.23	26.8236		
Total		15.1224	0.00	65.67	19.2644		

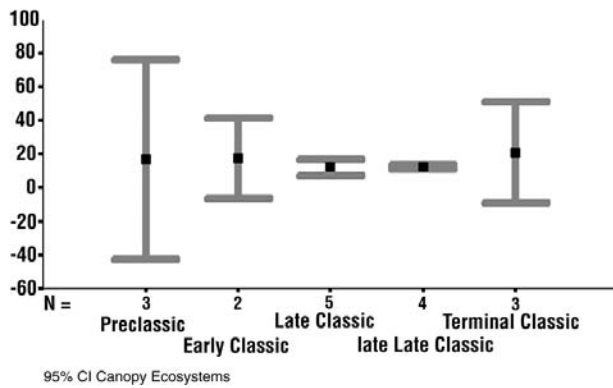


Figure 6.2. Simple error bar of the chronological distribution of canopy resource use at the Petexbatún sites.

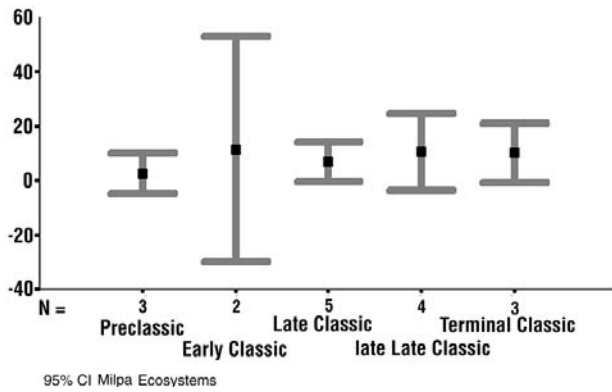


Figure 6.3. Simple error bar of the chronological distribution of milpa resource use at the Petexbatún sites.

Our second model of environmental failure—that caused by climatic factors—can also be tested by the analysis of mean and variance variability in ecosystem use over time in the Petexbatún region. The model of widespread, climate-induced environmental change predicts not only overall dramatic changes in natural ecosystem distributions but, specifically, a change in the relative availability of aquatic and semiaquatic species with high fidelity for riverine, lacustrine, shoreline, and swamp ecosystems. There is, however, no significant variability in the use or availability of animals from any of these habitats between any of the time periods examined (F probability = 0.6024). A combined analysis of these resources indicates that not only are no drastic changes apparent in the natural ecosystems represented by the assemblage as a whole, but that the specific prediction of variability in wet ecosystem resources also fails the statistical test (Figure 6.4).

Although this technique allows me to analyze broad environmental changes using a measure of ecosystem species fidelity, it is based on a complex series of assumptions, not least of which is the assumption of equivalence between resource availability and its use by human populations. Using this ecosystem measure, it is not possible to factor into this equation those dietary choices made with reference to issues other than resource availability, such as other economic, political, and ideological pres-

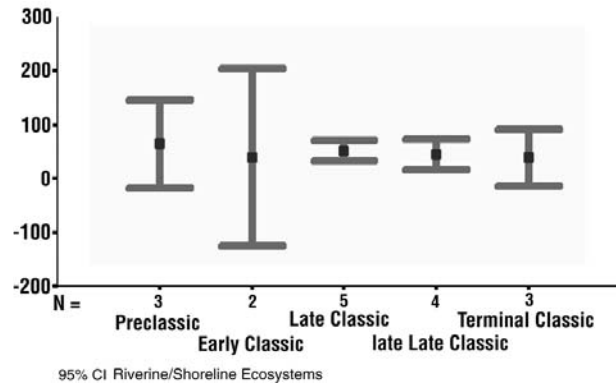


Figure 6.4. Simple error bar of the chronological distribution of riverine and shoreline resource use at the Petexbatún sites.

ures. To increase the predictive rigor of this analysis, therefore, I turned to a second and potentially less culturally biased measure.

Isotopic Bone Chemistry

The model. To further test the environmental model for collapse, I have used a second environmental measure to confirm the prediction of expansion of agricultural fields at the cost of canopy forest. Here I have turned to a technique more often used to describe ancient human diets—bone chemistry analysis. The differential incorporation of two isotopes of carbon (^{12}C and ^{13}C) into the tissues of different plant species (C_3 and C_4 plants) during photo-

synthesis provides a strong basis for distinguishing the incorporation of these plants in the diet of herbivorous animals. In the tropical rainforest the leafy green “browse” that is the common feed for white-tailed deer follows the C_3 photosynthetic pathway, incorporating less of the isotope ^{13}C , whereas maize and tropical grasses follow a C_4 pathway that can be chemically distinguished in their body tissues as a higher ratio of ^{13}C to ^{12}C . In the forested Petexbatún region corn is the only C_4 plant available in any quantity to browsing herbivores today. It is possible that under severe drought conditions that would encourage more open vegetation, savanna grasses could also have become part of the available dietary complement for the Petexbatún deer.

Deer around the world are known crop pests that are attracted to agricultural products and will feed in cornfields wherever they are available (Cormie and Schwarcz 1994). By quantifying carbon isotope signatures in samples of archaeological deer bone collagen from all of the major Petexbatún sites, I was able to test for the biotic patterning that would be caused by any expansion of agricultural fields or intensification in maize production during the Petexbatún occupational history.

This analysis of biotic patterns of change and stability is based on the quantifiable relationship between the relative availability of corn in agricultural fields to browsing herbivores (deer) and the registration of the consumption of corn (a C_4 plant) as opposed to the consumption of leafy browse (C_3 plants) in the form of a carbon isotope signature in the bone collagen of the deer. As a simplified equation, the greater the production of corn in areas

accessible to herbivorous edge browsers (field peripheries), the greater the inclusion of corn in their diet, and therefore the greater the proportion of corn registered in the archaeological deer bone. The gradual expansion and intensification of corn production in the Maya area is used, then, as a direct indicator of the overall ancient patterns of land use.

The results. To test the model of environmental failure using this technique, I subjected to isotopic analysis a representative collection of archaeological bone samples from six of the Petexbatún sites, from all five periods, and from the two broad environmental zones (inland and riverine). The results of the analysis clearly indicate that environmental stability was the rule before, during, and after the “collapse” period in the Petexbatún. The isotopic values for the archaeological deer bone range narrowly around -20.5 ppm, indicating a mixed diet of C_3 and C_4 plants, with a higher proportion of C_3 leafy browse (Table 6.3). This result suggests a relatively low level of corn production overall at the Petexbatún sites. The variability between both spatial and chronological sample groups examined is very low—also an indication of the lack of variability over time in both availability and inclusion of corn and other C_4 plants in the diets of the white-tailed deer of the Petexbatún sites (Figure 6.5). An ANOVA test confirms the impression of stability over time and indicates that there is no statistically significant difference among any of the periods examined (F probability = 0.9907) and therefore no evidence to support a contention of extreme expansion of agricultural fields over time in the Petexbatún.

Table 6.3. Descriptive Statistics for Petexbatún Deer Bone Collagen Carbon Ratios

	Count	Mean	Minimum	Maximum	Standard Deviation	ANOVA F Ratio	ANOVA F Probability
Environmental zones						0.0246	0.8760
Riverine	24	-20.5700	-22.09	-17.45	1.0938		
Inland	29	-20.5300	-21.92	-18.75	0.9329		
Total	53	-20.5500	-22.09	-17.45	0.9991		

Continued on next page

Table 6.3. Descriptive Statistics for Petexbatún Deer Bone Collagen Carbon Ratios (continued)

	Count	Mean	Minimum	Maximum	Standard Deviation	ANOVA F Ratio	ANOVA F Probability
Petexbatún sites						0.1399	0.9821
Dos Pilas	16	-20.4700	-21.92	-19.07	0.2645		
Aguateca	12	-20.4700	-21.91	-17.45	1.3971		
Arroyo de Piedra	10	-20.6500	-21.76	-18.75	0.8396		
Punta de Chimino	7	-20.8000	-22.09	-19.40	0.9193		
Tamarindito	3	-20.4700	-21.24	-19.84	0.7091		
Transect	5	-20.5000	-20.84	-19.96	0.3428		
Total	53	-20.5500	-22.09	-17.45	0.9991		
Chronological periods						0.0702	0.9907
Preclassic	5	-20.5000	-20.84	-19.96	0.3428		
Early Classic	10	-20.6500	-21.76	-18.75	0.8396		
Late Classic	7	-20.4500	-21.64	-19.28	1.0003		
Late Late Classic	12	-20.4700	-21.91	-17.45	1.3971		
Terminal Classic	19	-20.6000	-22.09	-19.07	0.9810		
Total	53	-20.5500	-22.09	-17.45	0.9991		

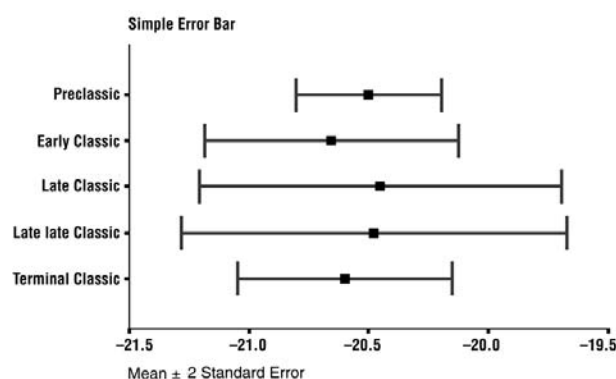


Figure 6.5. Simple error bar of the chronological distribution of carbon isotope ratios in the Petexbatún.

These results can also be considered in terms of the proposal of drought conditions and their impact on the Petexbatún environs. Current paleolimnological and oxygen isotope research has left no doubt that the climate of the Late Classic Maya world was significantly drier than it had been in previous centuries (Curtis et al. 1996; Curtis et al. 1998; Hodell et al. 1995). However, this isotopic analysis of deer bones from all periods of occupation of the Petex-

batún region indicates that these conditions did not impact the vegetation of the region enough to affect the dietary habits of the resident deer. If the vegetational changes caused by increased drought in the region were insufficient to cause a recognizable dietary change for the deer, it is unlikely that they were sufficient to cause or compound an environmental failure and coincident sociopolitical collapse.

DISCUSSION

The rainforest jungle has been characterized as a fragile ecosystem that cannot withstand the pressures of agricultural manipulation (e.g., Gallopín and Winograd 1995; Janzen 1983). Paleoenvironmental studies in several loci of the Maya world have demonstrated that ancient deforestation and soil erosion were contemporaneous with occupation in these areas and that they were most severe during the period of abandonment of these sites (Abrams et al. 1996; Binford et al. 1987; Brenner et al. 1990; Islebe et al. 1996; Rice et al. 1985; Rosenmeier et al. 2002). As well, climatological data suggest that this period is associated with drier

conditions worldwide than had been in effect for previous centuries (Curtis et al. 1996; Curtis et al. 1998; Hodell et al. 1995; Hodell et al. 2000).

Recent research suggests, however, that the process of environmental failure was a highly regionalized one, not homogeneous throughout the Maya area, and that it cannot be easily claimed as a causal agent in the collapse of Classic period Maya civilization. It appears clear that the Petexbatún region is one area where environmental failure did not occur and where the tropical ecosystem remained stable despite population growth and the rise and fall of a complex polity.

The combination of ecosystem fidelity analyses with isotopic evidence from archaeological deer bone argues for an overall stability in land use and natural environmental patterns in the Petexbatún area. Neither analysis supports a model of extensive anthropogenically induced environmental failure or extreme climatological change as causal mechanisms for the dissolution of Classic Maya society in this region. An analysis of ecosystem-allied animal community dynamics indicates that there was no change in the use of animals from different ecosystems and particularly no decrease in the use of animals from canopy rainforests, no increase in those from disturbed environments, and no change in those from wetlands. The isotopic analysis indicates a similar stability in the availability of corn or other C_4 plants to field-raiding herbivores through time, indicating no extreme expansion of agricultural fields or decrease in canopy rainforest.

These conclusions are amply supported by other research in the Petexbatún region and elsewhere. In these regions south of the Petén lakes, research by Nicholas Dunning, Timothy Beach, and David Rue has revealed relatively sparse evidence for environmental degradation, deforestation, or soil erosion (Beach 1998; Dunning et al. 1997; Dunning et al. 1998). To date, their research has shown heavy sedimentation, indicating high levels of environmental disruption in the form of agricultural activities in the area by at least 500 B.C. and possibly as early as 1000 B.C. (Dunning et al. 1997). This pattern rep-

licates the reported paleolimnological data from other sites in the Petén lakes region (Binford et al. 1987; Brenner et al. 1990; Rice et al. 1985). However, although the pattern of severe soil loss seems to continue in the Petén lakes until A.D. 1000, data from the smaller, self-contained Petexbatún lakes provide evidence for relatively minimal soil erosion on hillsides directly associated with the Petexbatún sites. This has been attributed to the ancient use of effective land management techniques in the area, examples of which have been revealed in the archaeological record around the Petexbatún sites (Beach 1998; Dunning and Beach 1994; Dunning et al. 1997) and include soil fertilizing, terracing, and the maintenance of hill-top forest reserves. Their ecological studies have also shown that despite the efficacy of these intensive agricultural techniques in the region, as indicated by the reduction in overall soil erosion from the Preclassic to the Late Classic, there remains some evidence of local erosional difficulties (Dunning and Beach 1994). These may be associated with the intensive exploitation of the resources located closest to residences and sites, particularly those protected by defensive works later in the occupation of the area (Demarest et al. 1997; Dunning and Beach 1994).

This paleoecological research has also provided little evidence in support of the climatic change model in the Petexbatún region (Dunning et al. 1997). Increased charcoal quantities and a shift in gastropod species are the only evidence for local drying, and both of these can be explained by other environmental or land-use factors. The climatic change model is well supported by research in other areas of Mesoamerica (Curtis et al. 1996; Hansen 1990; Hodell et al. 1995; Leyden et al. 1998; Metcalfe and Barlow 1992; Metcalfe et al. 1994; Rosenmeier et al. 2002) and regionally across the Americas (e.g., Horn and Sanford 1992). It is intriguing, however, that despite evidence for a climatic shift at the Pleistocene/Holocene boundary in the Petén lowlands (Curtis et al. 1998; Deevey et al. 1983; Leyden 1984, 1987), there is no clear evidence for dramatic or long-term drying in the Lago Petén

Itzá or Lago Tamarindito cores (Curtis et al. 1998; Dunning et al. 1997; Hodel et al. 2000). It is possible that paleolimnological methods are not yet well enough refined to distinguish these records (Curtis et al. 1998; Rosenmeier et al. 2002), but it is also possible that the effects of this drought were variable across the landscape (see also Leyden et al. 1998).

Finally, the model of environmental failure is directly associated with the suggestion that the terminus to the process of either anthropogenic or climatic environmental degradation is an insufficiency in dietary resources. As the environment degrades, it is less and less able to provide the required dietary resources for survival of the human population, with the result that health deteriorates and mortality rises. In the Petexbatún region there appears to be no evidence of this final and inevitable stage in environmentally based collapse. In other analyses of the zooarchaeological remains from the Petexbatún sites, I have documented stability in dietary animal resource use over time (Emery 1997). The diversity of species used did not change during the periods before and after the political collapse of the area. Species frequencies are not statistically different between periods, and there is no evidence for either the disappearance of favorite species or the inclusion of "famine" species. My evidence for dietary stability over time is supported by other research in the Petexbatún and the Pasi6n regions by Lori Wright, Petexbatún project osteologist (Wright 1997a, 1997b; Wright and White 1996). Her isotopic and morphological analyses of human health over the collapse period in the Petexbatún region, and at the sites of Seibal and Altar de Sacrificios, show that there is no evidence for a reduction in the inclusion of dietary protein over time at the sites of the Petexbatún or the surrounding Pasi6n region. Her analysis of morphological traits indicative of declining health in the form of increased anemia or childhood morbidity also revealed considerable stability over time and no evidence for either consistent ill health or declining health over the "collapse" period.

In summary, then, the model of environmental failure as causal to the collapse of the Maya civilization, and specifically the abandonment of the Petexbatún sites, is not supported by the zooarchaeological analyses carried out here. In the Petexbatún region there is no evidence for the deforestation and encroachment of agricultural lands that are posited by both climatic and anthropogenic models of unsustainable rainforest use. This is not to say, however, that these processes were not in action in other regions of the Maya world. Clearly agriculture in the tropical rainforests is associated with soil erosion in most cases. Equally clear is the evidence for changing climatic conditions worldwide during the period of Maya collapse. What this research emphasizes, though, is the local and heterogeneous nature of both the environmental and human responses to the effects of agricultural expansion, population growth, and climate change. Site-specific and local data are essential prerequisites to any conclusions regarding the nature or cause of the social, political, and economic changes seen at the end of the Classic period in Maya history.

CONCLUSIONS

Although the use of zooarchaeological remains for the elucidation of such patterns is not common in the archaeological literature, when multiple zooarchaeological analyses are combined with other archaeological and ecological research, the result is a series of overlapping perspectives that allow zooarchaeology to act as an effective methodological tool for the investigation of very complex theoretical issues.

In this analysis the combination of environmental measures provides evidence of stability in ecological conditions throughout the occupation of the Petexbatún region. Such evidence of stability refutes the environmental model of collapse in that region. I have set out to test the dominant hypotheses of several models and have described evidence used to support or discredit the predictions on which the models must be based. None of these is supported by

the zooarchaeological analyses. Thus the dominant hypotheses fail these tests.

Expansion of agricultural lands at the expense of canopy rainforest should be reflected in an increasing use of animal species with high fidelity for milpa and high-bush ecosystems (secondary growth) and a decrease in use of animal species with high fidelity for undisturbed pristine canopy rainforest ecosystems. As well, environmental failure as a result of a broad climatic change, such as drought, should result in both broad and dramatic changes in all ecosystem use across the Petexbatún region and specific changes in the use of a natural, unmodified ecosystem such as the riverine and shoreline zones. Ecosystem-allied community frequency analyses do not support either of these predictions.

An increase in the production of agricultural products and an intensification in the production of maize (hypothesized to have resulted in unsustainable maize monocropping) should be registered in the bony tissues of herbivorous crop raiders like the white-tailed deer. Isotopic analyses of $^{13}\text{C}/^{12}\text{C}$ ratios do not, however, indicate any significant increase in the incorporation of maize in the diet of the Petexbatún deer over the collapse period. Likewise, one of the predicted effects of drought conditions in a tropical rainforest is an increase in grasslands or savannas. Such a shift would also result in a change in deer diet as the deer included greater quantities of the grass in their diet. Again, this shift is not apparent in the chemical signatures of their bones.

The specter of dramatic environmental failure as a causal mechanism for societal disruption is one that has gained favor in the last few years, as scientists review both the effects of modern agricultural mismanagement and the evidence for future climatic change on the horizon. The Maya collapse, however, traditionally characterized by rapid depopulation and an abrupt failure of the social system, must be reevaluated in light of increasing evidence for the variability in both cause and effect surround-

ing this period of dramatic political, ideological, and economic change. In particular, we must reconsider the long-standing model of environmental failure as a causal mechanism for the Maya collapse as we increasingly recognize environmental heterogeneity and the complexity of both agricultural patterning and environmental responses to climatic change across the Maya lowlands.

Acknowledgments. This chapter is based on my doctoral dissertation, the completion of which would not have been possible without the generous assistance of many people in Guatemala and at various institutions in the United States and Canada. I would like to extend my gratitude to the members of the Consejo de Arqueología, and the directors of the Instituto de Antropología e Historia for providing both permits and kind assistance throughout my field and laboratory seasons with the Petexbatún Project. Chemical analyses were performed with much assistance from Lori Wright and Henry Schwarcz at McMaster University. None of the data would exist without the excavations carried out by the Vanderbilt University Petexbatún Regional Archaeology Project, directed by Arthur Demarest and Juan Antonio Valdes. And the dissertation would never have seen the light of day without the tireless enthusiasm of my doctoral committee and particularly John Henderson of Cornell University. The zooarchaeological research was supported by grants from the Social Sciences and Humanities Research Council of Canada, the Wenner-Gren Foundation for Anthropological Research, and Sigma Xi, as well as from the Cornell University Anthropology Department, Sage Graduate School, and Latin American Studies Program.

NOTE

1. These results are presented in greater detail in Emery (1997) and Emery et al. (2000). Coordinating analyses of dietary change and economic change in use of secondary animal products such as bone and shell are also presented in Emery (1997, 2001).

Fauna Exploitation from the Preclassic to the Postclassic Periods at Four Maya Settlements in Northern Belize

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This chapter outlines patterns of exploitation of animal resources by Maya settlements in Belize. Case studies from Preclassic settlements at Pulltrouser Swamp and Colha, a Terminal Classic settlement at Northern River Lagoon (NRL), and a Postclassic settlement at Laguna de On provide data on variation in the use of aquatic and terrestrial faunas over time and space. The size and frequency of various taxa in these samples reflect local adaptations to site environments and potential changes in human impacts on local animal communities or strategies for extraction of animal resources. The Preclassic and Postclassic patterns of exploitation are quite similar in the diversity of animals consumed, although the Postclassic sample includes species such as tapir and crocodile that did not form a part of earlier diets as represented by these samples. Small Classic period samples from Pulltrouser Swamp settlements provide a limited view of continued exploitation of terrestrial mammals and aquatic resources. For all sites except NRL, terrestrial mammals and turtles were the most abundant animals consumed. The Terminal Classic site of NRL provides data regarding specialized fish exploitation and processing, perhaps part of a marine resource industry at this site during an important period of social transformations in northern Belize.

This analysis of four faunal samples from northern Belize Maya sites quantifies patterns of aquatic and terrestrial resource utilization during the Preclassic (Pulltrouser, Colha), Terminal Classic (Northern River Lagoon), and Postclassic (Laguna de On) periods. The analysis of small samples from the Early and Late Classic periods (Pulltrouser) is also reviewed. These settlements vary in interesting ways according to their ecological settings and relative positions in the political and economic systems of northern and coastal Belize, reviewed below. Aquatic faunas, in particular, have been interpreted as secondary resources for pre-Columbian Maya agriculturalists (Lange 1971; White and Schwarcz 1989), as the conventional view of Maya diets emphasizes primarily corn, beans, and squash. This examination of four settlements indicates that the sig-

nificance of terrestrial game—including deer, tapir, agouti, paca, armadillo, canids, mustelids, peccary, and aquatic faunas (primarily fish and turtles but also crocodiles)—varies considerably over time in the northern Belize region. This variation may be attributed to changing local ecologies surrounding these ancient communities which affected the availability of particular species over time, as well as cultural factors. For all periods a wide range of local species were exploited, with large and small mammals and pond turtles representing the most abundant taxa recovered at all sites, except for the coastal fishing community of Northern River Lagoon (NRL).

Human population levels and the extent and type of agricultural cultivation at each site probably affected the quantities and types of

game available for exploitation, although directly measuring such impacts is difficult. Differences observed in faunal assemblages of this period compared to earlier and later occupations suggest that the maximum human impacts to local animal populations occurred during the Classic periods. Such changes varied at the local level, and a single regional pattern cannot be defined. More significant human impacts to game populations may have occurred at Laguna de On and Colha during the Late and Terminal Classic periods, where low numbers of animal remains have been found in household contexts during these periods compared to the Preclassic and Postclassic. Other sites, like those of Pulltrouser Swamp (K'axob, Tibaat, Pechtitón, and Los Cocos), have faunal samples that imply the availability of aquatic and terrestrial game in the vicinity throughout all periods. Northern River Lagoon represents one Terminal Classic community that expanded into a new coastal niche for the purpose of salt production and harvesting of marine animal resources (Mock 1994). Factors such as bone preservation and sampling design can also influence faunal recovery, and more work is needed in northern Belize before issues of human predatory impacts on local game populations can fully be assessed. The analysis below explores some trends from sites at which faunal recovery methods varied.

COLLECTION AND ANALYSIS METHODS

Samples from all four settlement zones represent bones collected from 1/4" screens used in excavation, where all deposits were screened. This screen size can be biased toward large fauna in some regions (Casteel 1972; Schaffer 1992; Wing and Brown 1979). At K'axob, one of the Pulltrouser Swamp communities analyzed here, this 1/4" fraction was supplemented by the analysis of fine-screen samples of bone collected from flotation, resulting in the improved recovery of microfaunas. The application of this technique at K'axob revealed the presence of small fish and rodents at the site that were not detected in larger screens.

All samples in this analysis were quantified by bone count (NISP). The Colha, Northern River Lagoon, and Laguna de On samples were additionally quantified by bone weight. Bone weight provides an important balance for bone count, especially for highly fragmented samples that can exaggerate quantification according to bone count (Casteel 1978). For example, if preservation conditions or human processing activities are likely to increase bone fragmentation, then bone counts can be inflated (Casteel 1978; Masson and Holderby 1994). Furthermore, some species (such as fish) have many more elements than others, and their relative representation may therefore be inflated by the use of bone count alone. Bone weight provides a more accurate assessment of the role of large taxa, which may be present in lower numbers in an assemblage but may represent far greater caloric contributions to the diet than many numbers of smaller taxa. Whereas bone count provides important data on dietary range, bone weight provides a more balanced perspective on the caloric significance of each taxon in the diet. A more sophisticated use of bone weight can be the calculation of biomass from bone weight using allometric formulae developed for particular species (Casteel 1978; Prange et al. 1979; Reitz and Cordier 1983; Reitz and Scarry 1985; Reitz and Wing 1999; Wing and Brown 1979). The calculation of biomass was not employed in this study because initial calculations of the percentage of biomass for some of the sites during analysis closely paralleled the percentages of bone weight, and these data did not significantly alter the patterns described below.

An additional method of faunal quantification that is not used in this study is that of MNI (minimum number of individuals). This technique involves tabulating the numbers of sided elements or unique elements in the body that represent the minimum number of animals of each species present in the archaeological sample. Although this method is commonly employed (see Stanchly this volume) and was calculated in the observations originally performed on the samples discussed here, it is not particularly helpful for analyzing these types of

samples. MNI works best for large samples of bone from a few locations, where tabulating the number of animals represented by elements recovered provides a realistic, conservative approximation of butchered and consumed remains used by the same group(s) of people over a short period (e.g., Masson and Holderby 1994). The data examined in this study represent small samples of bone from a wide range of test-pitting contexts across each settlement. As only a few pieces of bone were found from many different test units, MNI estimations for the sample as a whole are quite low based on element counts alone and do not reflect the likelihood that these elements were parts of many different individual animals consumed in a variety of spatially distinct contexts (Grayson 1984:29–31).

Detailed analysis of the relationship between MNI and NISP methods of zooarchaeological quantification by Grayson (1984:51–62) has also demonstrated that NISP generally reflects MNI in a linear or curvilinear relationship, and the nature of this relationship between the variables is affected by the manner in which analytical units are aggregated. The use of bone count may inflate the importance of particular small species or species whose remains were culturally or naturally fragmented (Grayson 1984:21). Used in conjunction with bone weight, however, the relative significance of each taxa to the diet is more easily assessed irrespective of fragmentation. The use of NISP and bone weight in the examination below is most appropriate for the dispersed contexts of the bone assemblages from these sites, given the limitations of MNI for this kind of sample. This decision follows Grayson (1984:92), who concludes “the number of identified specimens per taxon provides the best unit we have available for measuring the relative abundances of vertebrate taxa in archaeological and paleontological sites.”

The identification of faunal remains in these samples was facilitated by the use of comparative collections housed at the Vertebrate Paleon-

tology Lab and the Texas Archeological Research Lab of the University of Texas at Austin, with a supplemental trip to the collections of the Florida State Museum. Additional references consulted include osteology manuals published by Olsen (1973, 1982) and Gilbert (1993).

ECOLOGICAL SETTINGS OF COMMUNITIES EXAMINED

The environmental settings of the sites described below differ in important ways, reflecting the mosaic of local ecologies that characterizes northern Belize. This region is a flat coastal plain of relatively low elevation. Interspersed communities of well-drained, upland forest zones with rich clays are often located adjacent to zones of sandy pine flat seasonal wetlands, swamps, lagoons, creeks, and rivers. Annual rains cause water levels to rise, and salinity levels of the lagoons change throughout the year as groundwater mixes with saline penetration of the Caribbean Sea (Brenner, personal communication 1987). These factors create a complex ecological setting with a vast array of localized ecotones that provide rich environments for tropical aquatic life and terrestrial fauna. The sites examined here are located within 30 km of the Caribbean Sea (Figure 7.1) and all are adjacent to water systems that drain directly or indirectly into the sea. The Pulltrouser Swamp and Colha communities are located adjacent to inland swamp systems (Pulltrouser and Cobweb Swamps, respectively), with access to perennial freshwater drainages as well (the New River and Rancho Creek, respectively). Laguna de On is located on a freshwater lagoon that has fluctuating annual salinity but is potable year round. It is also located near a sandy pine wetland and the perennial water source of Freshwater Creek. Northern River Lagoon is located on a coastal mangrove estuary, in a primarily brackish setting. However, it is located at the mouth of the Northern River.

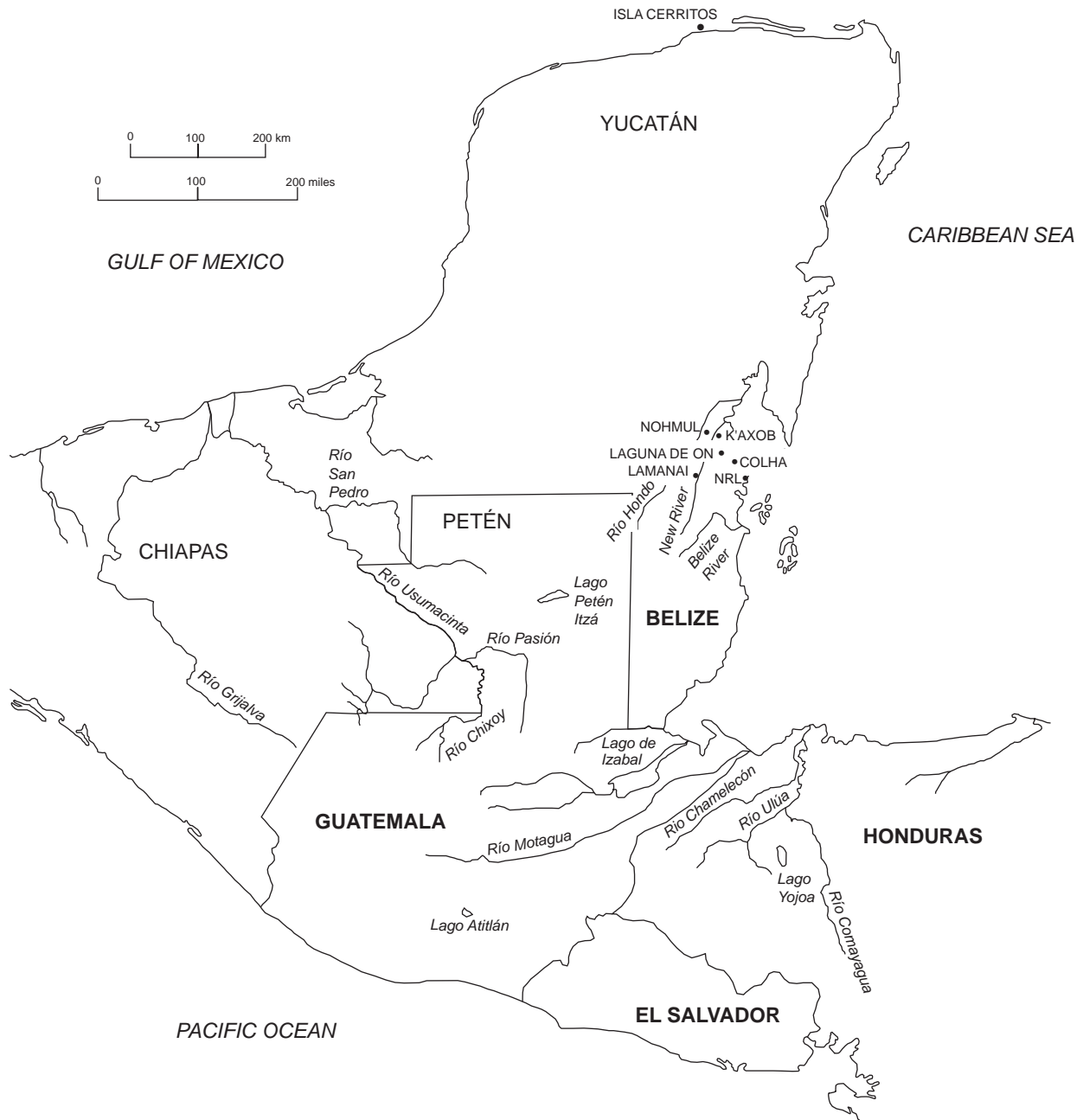


Figure 7.1. Location of northern Belize sites from which faunal bones were analyzed in this study. Map by K. F. Emery.

PERIODS REPRESENTED AT SITES EXAMINED

The four samples considered below provide a range of perspectives from inland and coastal

communities occupied during different periods which can be used to assess changing patterns of faunal use over time. The K'axob and Colha samples are primarily taken from Middle and Late Preclassic period domestic deposits

dating from 800 B.C. to A.D. 100 (McAnany 1995, 1998; Sullivan 1991). Small samples of later temporal components are also included from K'axob and nearby Pulltrouser Swamp settlements (including Tibaat, Pechtitón, and Los Cocos), but interpretive potential is hindered by the low quantity of bone in these samples. These samples date to the Protoclassic (A.D. 100–250), Early Classic (A.D. 250–600), Late Classic (A.D. 650–800), and Terminal Classic (A.D. 800–1000) periods. The Terminal Classic is also represented by the NRL sample, which provides a perspective from a coastal fishing and salt-producing settlement (Mock 1994; Valdez and Mock 1991). The Laguna de On sample is from the Postclassic period (A.D. 1050–1500), taken from domestic and ritual deposits on an island settlement at the lagoon's north end (Masson 1993a). The ecological setting of each of these sites is somewhat different, although all are located near natural aquatic features. The variation in local environments and cultural settings associated with each period is reflected in the faunal samples recovered from these locations, described below.

CULTURAL CONTEXTS OF SITES EXAMINED

The Pulltrouser Swamp communities represent a set of small settlements located in a zone of fertile agricultural clays around the inland, wetland margins of the swamp and near the New River (Fry 1990). One of these sites, K'axob, has been the focus of intensive investigation and reflects the development of an affluent agrarian economy throughout the Preclassic and Classic periods of Maya history (McAnany 1995). Although K'axob was never a prominent political center, house group excavations performed under the direction of Patricia McAnany (McAnany 1993, 1995) attest to the prosperity of lineage groups engaged in agricultural production over many centuries of this site's occupation. Domestic work groups at this site were tied directly into regional economies of northern Belize, although evidence suggests that de-

tails of agrarian production were locally determined and that such activities were not directly controlled by nearby political centers such as Nohmul. Regional centers and other sites in this area were probably consumers of surplus subsistence products grown at settlements specializing in agrarian production such as K'axob (McAnany 1986, 1993, 1995). The faunal assemblage analyzed here from K'axob represents the remains of animals consumed from hunting and fishing activities in the forests, fields, and wetlands surrounding the site.

The site of Colha is larger than K'axob, and a small monumental center was present at this site (Adams 1982; Shafer and Hester 1983). It is also situated at an inland location adjacent to a perennial flowing waterway (Rancho Creek) and wetland (Cobweb Swamp). Colha was home to numerous craft specialists who exploited fine quality local chert beds for the manufacture of surplus stone tool products. These were distributed throughout northern Belize and southern Quintana Roo and to other Maya communities located farther away during the Preclassic, Classic, and Postclassic periods (Gibson 1986; Hester and Shafer 1984, 1994; King and Potter 1994; Michaels 1987; Michaels and Shafer 1994; Roemer 1984). The monumental center and large residential groups at the site reflect the participation of upper-status members of this community in political and economic interaction in the northern Belize region during the Preclassic and Classic periods. Some elite groups may have also controlled agrarian resources at this site (King 1994). Faunal remains from the Preclassic period analyzed in this study may reflect local hunting, fishing, and turtling activities and perhaps the manipulation of yard animals such as dogs in feasting, as Shaw (1991) has suggested in her extensive study of animal use at this site.

The site of NRL is located on the coast of central Belize. This community was founded during the Late-to-Terminal Classic period (Mock 1994). This site is currently partially inundated, and it is located in a mangrove estuary of Northern River Lagoon. Mock (1994) suggests

that at the time it was occupied, sea levels were lower and the site was more suitable for habitation. Occupants of NRL specialized in salt production and fishing activities, and a wide variety of artifacts found at the site suggest residents also engaged in coastal trade (Masson and Mock 2004; Mock 1994). Northern River Lagoon was thus a coastal community that focused on specific economic activities, and it was not a political center at any point in its history. Faunal remains analyzed from NRL reflect a coastal subsistence focus and a probable industry in the surplus extraction of estuarine catfish that was salted for trade with inland communities (Mock 1994).

The site of Laguna de On was an island located on an inland lagoon (Honey Camp Lagoon, also known as Laguna de On) that was occupied during the Postclassic period. This island settlement was the nucleus of a community that also included occupations around the lagoon's shore (Masson 1993a, 2000). Laguna de On is a relatively small site, and it was not a political center during the Postclassic period. The production economy of Laguna de On was based on the extraction of chalcedony from nearby outcrops, expedient lithic tool manufacture, weaving, pottery making, and agrarian activities (Masson 2000). Hunting and fishing were also important activities at Laguna de On, and these probably provided supplementary dietary resources for local consumption. Data presented here suggest that forest and aquatic environments near the site were well stocked with a diverse range of species.

Of the four settlement zones compared in this chapter, Colha was the largest and most politically significant during its Preclassic and Classic occupations. Analysis of Maya faunal remains from much larger Classic period monumental centers in the Petén region of Guatemala indicates that certain game animals were manipulated by social elites (Pohl 1985b), and Shaw (1991) presents evidence for a similar pattern at Colha during the Preclassic period.

Colha's greater regional status is considered below in comparing its Preclassic assemblage to that of K'axob. The other settlements assessed here, including the Pulltrouser sites, NRL, and Laguna de On, represent communities that probably served supportive functions in regional political economies of various periods. It is likely that their surplus production economies were driven more by consumer demands and tribute payments than through direct, coercive control of production by nearby political centers. This model of relative production "autonomy" for small sites with regional Maya polities has been outlined in considerable detail in recent literature (King and Potter 1994; McNally 1993, 1995; Rice 1987).

RESULTS OF ANALYSIS BY SITE

K'axob/Pulltrouser Swamp

The faunal samples from K'axob and three other sites surrounding Pulltrouser Swamp in northern Belize were collected during two distinct seasons of investigation, the first in 1981 (at all sites) and the second in 1990 to 1993 (at K'axob only). Altogether, this sample totals 5,016 bone fragments. The 1981 season consisted of a testing program that sampled a broad range of contexts from settlements around Pulltrouser Swamp, including many architectural features (Fry 1990; Harrison 1990; Turner and Harrison 1983). This program resulted in the collection of small samples of faunal bone from four different periods at four different settlements. Most of the Protoclassic ($n = 280$), Early Classic ($n = 134$), Late Classic ($n = 22$), Terminal Classic ($n = 63$), and mixed context ($n = 148$) samples were recovered from this testing program. The small size of these samples limits interpretive possibilities (Tables 7.1, 7.2). The test-pitting samples are combined with the bone collected from subsequent seasons at K'axob in Table 7.1 to provide a more robust perspective on Pulltrouser Swamp faunal patterns.

Table 7.1. Pulltrouser Swamp Fauna NISP by Time Period, All Bone, All Samples (excluding fish, armadillo, and unidentified fragments)

Taxa	Middle Preclassic	Late Preclassic	Proto- classic	Early Classic	Late Classic	Terminal Classic	Mixed
	% of 345	% of 539	% of 144	% of 88	% of 20	% of 59	% of 69
<i>Odocoileus virginianus/Mazama americana</i> (White-tailed/brocket deer)	1.74	6.12	7.64	3.41	5.00	25.42	5.80
Peccary	—	0.56	—	—	—	—	1.45
Unidentified lg. mammal	5.51	3.15	4.17	7.95	10.00	35.59	10.14
Total large mammal	7.25	9.83	11.81	11.36	15.00	61.02	17.39
Canid	3.19	2.41	0.69	2.27	5.00	3.39	8.70
Carnivore	0.58	0.56	—	—	—	—	2.90
Agouti/paca (agouti/ <i>Dasyprocta</i> or gibbon)	—	—	0.69	1.14	—	3.39	—
<i>Dasyprocta</i> (gibbon)	1.45	—	—	10.23	—	—	2.90
Medium mammal	0.58	0.19	—	—	5.00	—	1.45
Small mammal	4.35	0.56	—	—	5.00	—	1.45
Mammal	27.54	53.43	15.28	22.73	25.00	3.39	13.04
Total small/medium mammal	37.68	57.14	16.67	36.36	40.00	10.17	30.43
Total rodent	15.94	8.53	20.83	5.68	0	3.39	4.35
Total bird	16.23	4.45	6.94	11.36	5.00	1.69	7.25
Turtle	16.81	12.43	38.89	31.82	20.00	20.34	18.84
Snake	1.16	0.93	0.69	1.14	—	1.69	4.35
Reptile	—	0.74	0.69	—	5.00	—	—
Crocodile	—	—	—	1.14	—	1.69	—
Lizard/fish	—	—	0.69	—	—	—	—
Lizard/iguana	0.29	0.74	—	1.14	—	—	1.45
Amphibian/lizard	0.58	1.11	—	—	—	—	14.49
Amphibian	0.29	—	—	—	—	—	—
Frog	—	1.67	2.08	—	—	—	—
Total reptile/amphibian	19.13	17.63	43.06	35.23	25.00	23.73	39.13
Crab	0.29	0.37	—	—	—	—	—
Marine shell	3.19	0.93	0.69	—	15.00	—	1.45
Shark/ray	0.29	1.11	—	—	—	—	—
Total crab/shell/shark/ray	3.77	2.41	0.69	0.00	15.00	0.00	1.45
Total counts of bone/shell	100 (345)	100 (539)	100 (144)	100 (88)	100 (20)	100 (59)	100 (69)

Table 7.2. Total Counts of Bone Fragments at Pulltrouser Swamp

	Middle Preclassic	Late Preclassic	Proto- classic	Early Classic	Late Classic	Terminal Classic	Mixed
Armadillo	300	11	—	6	—	—	1
Osteichthyes (misc. bony fish)	749	755	49	11	—	1	13
Siluriformes (catfish)	15	13	—	2	—	—	—
Unidentified bone	1,025	617	87	27	2	3	65
Bone/shell counts from Table 7.1	345	539	144	88	20	59	69
Grand total all bone	2,434	1,935	280	134	22	63	148

The 1990–1993 sample from the site of K'axob was primarily recovered from domestic groups of Preclassic age. The Preclassic deposits at K'axob are divided into the Middle Preclassic (Chaakk'ax Complex) and the Late Preclassic (K'atabche'k'ax Complex), according to Lopez (Lopez Varela 1996: Table 1). The sample sizes from these periods are more substantial, amounting to 2,434 and 1,935 bones, respectively. This bone includes samples collected from the 1981 season (from several Pulltrouser sites) and from 1990 to 1993 (from K'axob) 1/4"-screen general excavations as well as 1/16"-mesh flotation samples. Not all of this bone was identifiable to taxonomic class, as 1,025 pieces of the Middle Preclassic sample and 617 pieces of the Late Preclassic sample were unidentified (listed in Table 7.2).

The 1990–1993 investigations at the site encountered numerous burials placed in domestic areas designated for mortuary purposes (McAnany 1995). These seasons at K'axob focused on the excavation of many superimposed living surfaces and associated features at different residential localities across the site. Flotation samples of soil were processed from almost every feature, including middens, fire pits, floor surfaces, cache contents, and burial pits (Masson 2004). Large numbers of small fish and rodent bones were recovered in these samples that were not well represented in the 1/4" screen (see Tables 7.1, 7.2). Almost all fish bone listed in Table 7.2 was recovered from flotation. Interpretations of the uses of these small fish and their presence in K'axob features are explored below.

K'axob is located adjacent to Pulltrouser Swamp, the presumed source of the tiny fish (estimated live length of 4 to 5 cm) recovered at the site. The domestic zones tested by this project are located on elevated platforms surrounded by well-drained, fertile clays. The freshwater swamp itself is a rich biotic haven for a wide variety of plants, aquatic faunas, birds, and terrestrial game. These fish bones are very small, and it is unclear how they arrived into the archaeological contexts. It is unlikely that flooding or other natural means of soil deposition can account for the presence of the fish in K'axob features, because there is no evidence of natural soil deposits resulting from seasonal inundation of the constructed platforms. White plaster floors were periodically created to resurface living surfaces at this site, and fish bones are located within zones of occupational debris (McAnany 1995: Figure 3.12).

The presence of tiny fish in K'axob middens, fire pits, and burial fill suggests that they were brought to the site as part of the subsistence regime during the Preclassic period. The use of such small, low-yield aquatic resources can signal subsistence stress, as interpreted for North American Archaic sites where increased aquatic and plant food dependencies correlate with severe Holocene climatic episodes of warming and drying that may have diminished supplies of terrestrial game (Masson et al. 1995). The presence, however, of many other types of fauna and agricultural implements at this site suggests that the fish were not exploited as a famine food. It is possible that the fish were consumed, although perhaps they were inad-

vertent acquisitions in nets dragged through the swamp for higher-yield species such as turtles. The small size of these fish indicates that they could not have contributed a significant caloric intake to the diet. The excellent state of preservation of this extremely fragile bone suggests that the bones of these fish were not consumed and digested. It is possible that they were included in soups or stews, and bones could have been discarded after cooking.

Small fish in the K'axob sample were most commonly found in primary midden or burial deposits (Masson 2004). Burial fill deposits appear to be secondary midden or construction fill, probably deposits from midden or construction features that were removed for the initial excavation of burial pits that were replaced after the skeletons were laid to rest. Numbers of fish bone were so low in the Early Classic ($n = 13$) and the Terminal Classic ($n = 1$) that contextual comparisons are not merited. Other contexts of flotation samples, such as fill deposits, pits, fire features, and construction floors, yielded lower percentages of fish bone (Masson 2004). A higher incidence of fish bone in pits and fire features that were related to domestic food preparation might have implied the use of these small taxa as food—but this was not the case. Small fish continue to inhabit Pulltrouser Swamp today. Although these taxa from K'axob were probably not a significant food source, their recovery provides evidence that wetland conditions similar to those today existed in the past.

Table 7.1 summarizes the range of fauna exploited at K'axob and nearby Pulltrouser Swamp sites for six periods. As this sample was only quantified by bone count (not weight), numerous small fish bones are not included in the relative percentage calculations, as they would have substantially distorted the proportions of more significant taxon. For the Middle Preclassic, of 2,434 total bones, 764 were those of small fish. The Late Preclassic and Protoclassic also have large proportions of small fish bone (768 and 49 pieces, respectively). From the Middle Preclassic sample, a concentration of 300 armadillo bones is probably a recent intrusion. These bones are also removed from the

percentage calculations. The declining numbers of fish bones over time shown at the bottom of Table 7.2 may reflect the fact that fewer flotation samples were taken from later components, which were primarily investigated during the 1981 season.

Percentages discussed below for each period are those given in Table 7.1 (excluding fish, armadillo, and unidentified bone). Taxa present in the Middle Preclassic sample from Pulltrouser indicate a diverse strategy of small game exploitation. High-yield large-game resources (deer and peccary) are present in low percentages (7.2 percent). This observation is surprising because this period represents an early point in the establishment of agrarian, ceramic-making communities in this region, and population levels are inferred to have been lower than those of later periods (Fry 1990). The most significant taxa are small/medium mammals (37.6 percent), including dogs or foxes (Canidae, 3.1 percent), agouti (*Dasyprocta*, 1.4 percent), and many pieces of bone that were not identified to species. Rodents, birds, and turtles form significant proportions of the sample (between 15.9 and 16.8 percent). Next to small/medium mammals, turtles and birds represent the most frequent taxonomic categories, signifying the importance of wetland resources for Pulltrouser settlements at this time. Almost all turtles identified were aquatic species of the pond turtle (*Emydidae*) family. Low numbers of lizards, snakes, amphibians, and marine resources were also present.

The Late Preclassic sample indicates that earlier subsistence patterns continued at Pulltrouser Swamp during this period, with only slight differences. Large mammals (deer and peccary) make up 9.8 percent of the sample, a slight and insignificant increase from the Middle Preclassic period. Small/medium mammals are proportionately greater in the sample (57.1 percent), representing an increase of 20 percent over the earlier sample (Table 7.1; Figure 7.2). As much of this small/medium mammal category includes nonspecified "mammal bone" fragments that were not identifiable to species, it is difficult to determine which animals are represented in such large proportions. It is

likely that some of the small/medium mammal fragments represent dogs. Turtles (12.4 percent), small rodents (8.5 percent), and particularly birds (4.4 percent) are present in lower percentages than that observed for the Middle Preclassic. Snakes, rodents, lizards, amphibians, and marine resources are present in low numbers, comparable to the earlier sample (Table 7.1).

The use of aquatic fauna (frog and fish) in ritual caching is demonstrated in one Late Preclassic feature at K'axob (Masson 1993b, 2004; McAnany 1995:104, Figure 3.14). A quadripartite arrangement of four vessels containing these species may have been deposited in conjunction with rain ceremonies analogous to the modern Cha-Chac rituals of Yucatán (Masson 1993b, 2004). The association of this cache with possible rain rituals is based on the presence of near-term fetal or newborn deer teeth that were present along with frog and fish bone within the cache. The age of these deer teeth imply that the cache was deposited during late May or early June, coinciding perhaps with the onset of the annual rains (Masson 1993b, 2004).

The Protoclassic sample indicates an increased use of turtles (38.8 percent) and a

decrease in the significance of small/medium mammals at the Pulltrouser sites (Table 7.1). Small rodents are common in the sample (20.8 percent). Only one agouti/paca and one canid bone are represented in the small/medium mammal category. The frequencies of turtles are more than three times greater than those from the Late Preclassic sample. Birds form 6.9 percent, and lizards, snakes, and amphibians are present in low numbers. Unworked marine shell is practically absent in the sample.

The small Early Classic sample indicates that large-game proportions are relatively consistent with the earlier samples from the Late Preclassic and Protoclassic (11.3 percent; Table 7.1). Small/medium mammals, including canids and agouti, are more common (36.3 percent) than in the Protoclassic sample, and small rodents decline in frequency (5.6 percent). Turtles remain significant (31.8 percent; Table 7.1 and Figure 7.2). Birds are present (11.3 percent), and snake, crocodiles, and lizards were identified in low numbers.

The important taxa in the Late Classic sample include large game (15 percent), turtle (20 percent) and small/medium mammals (40 percent). No rodents were identified, and a few

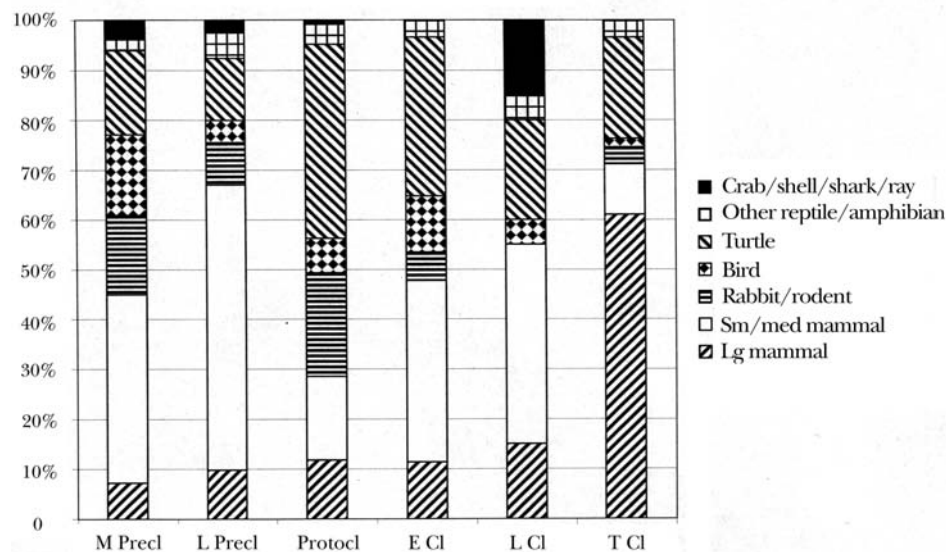


Figure 7.2. Relative percentages of selected fauna NISP at Pulltrouser Swamp sites for Preclassic through Terminal Classic periods (excluding fish).

bird bones (5 percent) and marine resources (15 percent) were present. Because this sample is small ($n = 22$), these percentages may not accurately reflect the Late Classic diet for Pulltrouser Swamp communities. The Terminal Classic sample, also small ($n = 63$), shows higher percentages of large mammals (61 percent), fewer small/medium mammals (10.1 percent), and significant proportions of turtle (20.3 percent). A single crocodile bone was also identified. These patterns suggest that turtle and large game represented the most significant taxa in the Pulltrouser diet during the Late and Terminal Classic periods. However, the size and contexts of these samples may not render them adequately representative. The presence of large mammal bone at Pulltrouser Swamp contexts at this time suggests that certain members of Terminal Classic communities at this location enjoyed access to large terrestrial game during this period, as has been observed for elite contexts in the Petén (Pohl 1985b).

The use of aquatic and terrestrial resources at K'axob thus appears to have varied over time (Figure 7.2). Except during the Protoclassic, from the Middle Preclassic through Late Classic times mammals were the most significant component of the diet. The majority of these mammals were not large-game species, and smaller mammals appear to have been far more prevalent. Large game is present in low proportions during all periods, except for the Terminal Classic, when the percentage of this category rises considerably. However, the Classic period samples are very small and may not be reliable. Turtles were continually exploited at this site and appear to have been proportionately more significant in the Protoclassic and Early Classic compared to periods before or after, if sample sizes are not misleading in this case.

Current models of the origins of Maya society in Belize (Lopez Varela 1996:316–336) suggest that migrations of villagers came into the area between 900 and 600 B.C. (or even earlier) and probably joined populations of preceramic horticulturalists who had been gardening the wetlands in this region since the middle of the

first millennium B.C. (Hester et al. 1996; Iceland 1997). The patterns described above suggest that the diets of occupants of K'axob and other communities around Pulltrouser Swamp were diverse. The frequency of large game is not notably higher during the Middle Preclassic compared to later periods. This pattern suggests that human predation after the Middle Preclassic did not adversely alter the availability of large game (or other taxa for that matter) with the development of state society in this region from the Late Preclassic forward. It is possible that game levels were already low from hunting practices of preceramic populations in northern Belize, or that neither these populations nor the Middle Preclassic Maya had a substantial impact on local game availability. Deer and peccary are notoriously versatile and are at home in horticultural or agricultural environments, as well as in natural forests. The constant presence of aquatic varieties of turtles and birds in samples of all periods suggests that the ecology of Pulltrouser Swamp remained relatively stable over the Preclassic and Classic periods and that the effects of human cultivation on turtling and fishing were reasonably balanced with regard to this productive wetland.

Colha

A small sample of Colha fauna from the 1989 excavation season was analyzed by the author (Masson 1989). This season focused on Preclassic domestic and ritual deposits (Sullivan 1991) under the auspices of the Colha Preclassic project directed by Fred Valdez Jr. Faunal analysis from previous seasons at this site has been published elsewhere, including samples dating to the Preclassic (Shaw 1991) and Postclassic (Masson 1999a; Scott 1982; Shaw and Mangan 1994). The 1989 season yielded a faunal sample of 517 bones. The bones were recovered from 1/4" screens, through which all soil was sieved. For this sample the quantification of faunal remains included bone weight and biomass in addition to bone count.

The site of Colha is the setting for two aquatic systems. Rancho Creek perennially drains

through the site, and the vast Cobweb swamp borders the site along its east-southeast margins. These freshwater features were home to a rich biotic assembly of aquatic and avian life, and the forests surrounding the site today have a wide variety of terrestrial game animals. Faunal bone from Colha was collected from floors, middens, fire features, and burial fill in Preclassic contexts (documented in Sullivan 1991) similar to those described above for K'axob. The comparison of

these two sites provides an interesting perspective on localized faunal exploitation during the Preclassic period. The faunal sample from the 1989 season at Colha can be divided into three temporal episodes (Tables 7.3, 7.4) based on ceramic analysis (Masson 1989: Table 1; Lauren Sullivan, personal communication 1989), including the Middle Preclassic ($n = 20$), the Middle/Late Preclassic transition ($n = 232$), and the Late Preclassic ($n = 265$).

Table 7.3. Faunal Bone by NISP and Weight in Middle Preclassic, Middle/Late Preclassic, and Late Preclassic Deposits at Colha, Operation 2031

	Middle Preclassic		Middle/Late Preclassic		Late Preclassic	
Taxa	% Count (of 16)	% Weight (of 22.3)	% Count (of 157)	% Weight (of 335.2)	% Count (of 150)	% Weight (of 369.8)
Unidentified mammal	18.8	10.8	43.9	23.3	13.3	10.1
Large mammal	6.3	17.0	5.1	6.7	2.7	5.7
<i>Odocoileus virginianus</i> or <i>Mazama americana</i> (white-tailed or brocket deer)	18.8	24.7	8.9	26.5	14.0	34.4
<i>Odocoileus virginianus</i> (white-tailed deer)	—	—	5.7	22.0	13.3	14.1
Subtotal large mammal	43.8	52.5	63.7	78.4	43.3	64.3
Medium mammal	—	—	5.1	5.5	10.0	9.1
Small mammal	6.3	12.6	—	—	0.7	0.9
Canid	12.5	5.4	8.9	5.4	4.7	4.4
Mustelid	—	—	1.3	1.8	0.7	0.9
Rodentia	—	—	—	—	2.0	0.5
<i>Sylvilagus</i> sp. (cottontail rabbit)	—	—	—	—	1.3	0.4
<i>Dasypus novemcinctus</i> (armadillo)	—	—	—	—	1.3	0.1
Subtotal small/medium mammal	18.8	17.9	15.3	12.7	20.7	16.3
Aves	6.3	1.3	—	—	—	—
Subtotal aves	6.3	1.3	—	—	—	—
Testudines (turtle)	18.8	10.8	10.2	3.0	26.7	9.5
<i>Staurotypus triporcatus</i> (turtle)	6.3	4.9	—	—	1.3	0.1
Emydidae (pond turtle)	6.3	12.6	3.8	2.3	1.3	4.8
<i>Pseudemys</i> (pond turtle)	—	—	2.5	1.8	4.7	4.5
Kinosternidae (mud turtle)	—	—	1.3	0.7	0.0	0.0
Subtotal turtle	31.3	28.3	17.8	7.8	34.0	18.9

Continued on next page

Table 7.3. Faunal Bone by NISP and Weight in Middle Preclassic, Middle/Late Preclassic, and Late Preclassic Deposits at Colha, Operation 2031 (continued)

	Middle Preclassic		Middle/Late Preclassic		Late Preclassic	
Taxa	% Count (of 16)	% Weight (of 22.3)	% Count (of 157)	% Weight (of 335.2)	% Count (of 150)	% Weight (of 369.8)
Osteichthyes (bony fish)	—	—	2.5	1.0	1.3	0.4
Siluriformes (catfish)	—	—	0.6	0.1	0.0	0.0
Scaridae (parrotfishes)	—	—	—	—	0.7	0.1
Subtotal fish	—	—	3.2	1.1	2.0	0.6
Total identified bones	100 (16)	100 (22.3)	100 (157)	100 (335.2)	100 (150)	100 (369.8)

Table 7.4. Identified and Unidentified Vertebrate Bones from Colha, Operation 2031

Vertebrate bones	Middle Preclassic		Middle/Late Preclassic		Late Preclassic	
	Count	Weight	Count	Weight	Count	Weight
Identified from Table 7.3	16	22.3	157	335.2	150	369.8
Unidentified	4	0.8	75	21.4	115	29.4
Total bones	20	23.1	232	356.6	265	399.2

The first of these subsets is too small ($n = 20$) to merit extensive interpretations. Of the 16 identifiable bones, large (43.8 percent) and small/medium (18.8 percent) mammals were most common, and identified species in these categories include deer and dog. Bones of turtle (31.3 percent) and bird (6.3 percent) were also present (Table 7.3) (Masson 1989: Table 1). No fish were present in the sample. Little more can be said of this limited view of Middle Preclassic Colha subsistence.

The sample of 232 bones from the Middle/Late Preclassic at Colha provides a better subsistence profile (see Table 7.3). Percentages discussed below are those of counts of identified fragments ($n = 157$). Large (63.7 percent) and small/medium (15.3 percent) mammals were also common in this sample, including the identified species of deer, dog, and a mustelid (Table 7.3). Turtles form the only other major category of identified taxa (17.8 percent), and these include primarily aquatic species such as pond turtles (*Emydidae*, *Pseudemys*) and mud

turtles (*Kinosternidae*). A few fish bones are present (including one catfish), and snake, amphibians, and birds are absent. White-tailed or brocket deer were thus the most abundant taxon, followed by turtles and canids.

During the Late Preclassic, large mammals (43.3 percent by count), small/medium-sized mammals (20.7 percent by count), and turtles (34 percent by count) are the dominant taxa in the sample (Table 7.3). A more diverse range of mammals is present, compared to the Middle/Late Preclassic sample. The Late Preclassic sample includes rodents, rabbit, and armadillo, in addition to the mustelid, canid, and deer found in the Middle/Late Preclassic. The most common mammals are deer (27.3 percent) and canid (4.7 percent), although numerous medium mammal long-bone fragments may also represent canids. This pattern is very similar to that of the Middle/Late Preclassic sample. Turtles are present in increased quantities compared to the Middle/Late Preclassic sample.

As observed in the Middle/Late Preclassic sample, fish are found in low numbers, and snakes, frogs, and birds are absent in the Late Preclassic sample from Colha (Table 7.3). The assemblages from the Middle/Late and Late Preclassic samples are similar in their relatively specialized focus on two primary categories of terrestrial mammals and turtle. Large fish (those detectable in 1/4" screens) do not appear to form a significant portion of the diet in either component. It is also notable that crocodiles are not present in either sample. Crocodiles were consumed in later periods at northern Belize sites (discussed below) but appear to have been ignored as a food source during the Preclassic, according to both the Pulltrouser and Colha samples. Only two crocodile bones were identified at Pulltrouser, one each in the Early Classic and Terminal Classic samples. It is not known why this species was not exploited in earlier periods. The presence of fish and pond turtle in the samples suggests that environments hospitable to crocodiles were located near the sites, and there is every reason to believe that crocodiles were available. Faunal samples from the Florida Everglades indicate a similar pattern in that alligators represented a logical food choice enjoyed by historical indigenous populations but appear to have been largely overlooked in prehistory (Masson and Hale 1989).

Turtles increase relative to mammals over time during the Preclassic in this specific context (Op 2031) at Colha, although both remain of prime importance (Figure 7.3). Small mammal proportions shrink relative to turtle, whereas large mammal levels increase slightly (Figure 7.3). The chart shows the relative proportions of these taxa to each other, not to the entire sample of bone. Shaw (1991) has demonstrated that canids, specifically the domesticated dog, were a significant animal used for ritual feasting during the Preclassic at Colha. Shaw demonstrates that the focus on canid consumption closely correlates with emerging complexity and community feasting hosted by Preclassic elites at this site. As a domesticated species, dogs represent a more easily controlled protein resource (Shaw 1991). Large quantities

of white-tailed or brocket deer in these samples suggest that hunting was also an important component of the Colha subsistence strategy. Deer may alternatively have been raised in domestic areas along with dogs.

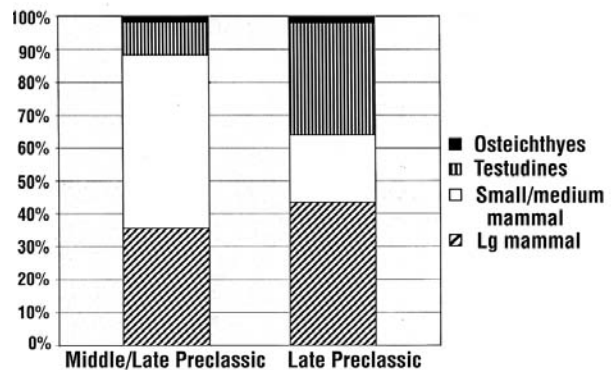


Figure 7.3. Relative percentages of selected fauna NISP by class from Colha (Middle/Late Preclassic and Late Preclassic periods).

In comparing Colha patterns of animal resource exploitation in the Preclassic to those of the Pulltrouser settlements, interesting variation is observed (Figures 7.2 and 7.3). Turtles and large game are more significant during the Late Preclassic at Colha. Unlike Colha, small/medium mammal proportions are not reduced in the Late Preclassic at Pulltrouser. Instead, they increase (Figures 7.2 and 7.3). The Pulltrouser diet appears more diverse through the inclusion of birds and more rabbits or rodents in the Preclassic samples. Large fish or marine products are rare at both sites. These patterns may reflect differences in availability of local fauna at each community. Alternatively, Colha residents had greater access to large game such as deer through control of hunting or distribution of valued animal products. This latter interpretation complements Shaw's (1991) argument for the manipulation of dogs in feasting by Preclassic elites at Colha.

Northern River Lagoon (NRL)

This sample of 4,498 bones from NRL was collected during the 1987 investigations of this site

by Thomas Kelly under the auspices of the Colha Project (Kelly 1988). This sample was taken from 19 excavation levels (each 20 cm deep) from five test pits (each 1 x 1 m in dimension), designated NRL 11SW, 11SE, 12NW, 12NE, and 13SE. These bones were collected from the test pits with the use of a 1/4" screen and were quantified by bone count and bone weight (Table 7.5). The results presented here,

initially realized in the author's original unpublished 1989 analysis, have been confirmed through ongoing studies of additional samples of bone from the site collected in 1993 which were analyzed under the author's supervision in a seminar in zooarchaeology taught at the University of Texas at San Antonio in 1993 (Delgado and Scaese 1993; Mock 1994).

Table 7.5. Faunal Bone NISP and Weight Recovered at Northern River Lagoon

Taxa	NISP	% NISP (of 4,409)	Wt. (g)	% Wt. (of 4,496.8)
<i>Trichechus manatus</i> (manatee)	20	0.45	41.1	0.91
Subtotal marine mammal	20	0.45	41.1	0.91
Large mammal	2	0.05	3.7	0.08
Mammal (cf. <i>Odocoileus</i> /deer)	6	0.14	11.1	0.25
<i>Odocoileus virginianus</i> (white-tailed deer)	9	0.20	64.1	1.43
<i>Tapirus bairdi</i> (tapir)	1	0.02	6.3	0.14
<i>Tayassu</i> sp. (peccary)	2	0.05	26.3	0.58
Subtotal large terrestrial mammal	20	0.45	111.5	2.48
Misc. terrestrial mammal	28	0.64	51.1	1.14
Sm. rodent	7	0.16	1.3	0.03
<i>Dasyprocta</i> (agouti)	1	0.02	2.6	0.06
Small mammal	1	0.02	1.4	0.03
Subtotal small mammal	9	0.20	5.3	0.12
Aves	9	0.20	2.2	0.05
Reptile	1	0.02	0.1	0.00
Crocodile	3	0.07	10.8	0.24
Iguana	1	0.02	0.1	0.00
Poisonous snake	1	0.02	1.1	0.02
Turtle	4	0.09	11.6	0.26
Sea turtle	5	0.11	17.3	0.38
Subtotal reptile	15	0.34	41	0.91
Frog/toad	1	0.02	0.7	0.02
Perciformes (noncatfish)	1,954	44.32	2,621.6	58.30
Siluriformes (catfish)	1,199	27.19	968	21.53
Osteichthyes (bony fish)	1,072	24.31	593.3	13.19

Continued on next page

Table 7.5. Faunal Bone NISP and Weight Recovered at Northern River Lagoon (continued)

Taxa	NISP	% NISP (of 4,409)	Wt. (g)	% Wt. (of 4,496.8)
Shark/ ray	83	1.88	61.7	1.37
Subtotal fish	4,308	97.71	4,244.6	94.39
Total identified bone	4,409		4,496.8	
Total vertebrata (unidentified)	89		68.5	
Grand total bone	4,498	100.01	4,565.3	100.02

The NRL site is located in a mangrove swamp at the edge of a coastal estuary of the same name. Marine resources have previously been observed to represent viable alternatives for Maya subsistence (Lange 1971), and coastal settlements exploited these during the Preclassic (Cliff 1982), Classic, and Postclassic periods (Guderjan and Garber 1995; McKillop 1984). The site was investigated in several seasons of the Colha Project (Hester 1979; Kelly 1980, 1982; Kelly and Valdez 1979; Mock 1994; Valdez and Mock 1991). Although much of the site is currently semi-inundated, water levels were probably lower in the Terminal Classic, and the site would have been situated on higher, more habitable ground in the past (Mock 1994). The site of NRL was not settled until the Late and Terminal Classic periods, and this site was probably established as a specialized resource extraction locality to buttress economic shortages and shifts associated with the collapse of Classic period political centers in the southern lowlands (Mock 1994; Valdez 1989; Valdez and Mock 1991:524). The colonization of NRL may alternatively reflect the expansion and exploration of new ecological niches for habitation and exploitation during a transitional period in Maya history (Masson and Mock 2004). Terminal Classic ceramic production patterns have been described as regionalized and highly variable (Rice 1987), and the NRL community may have been engaged in entrepreneurial activities to meet new needs generated from this cultural milieu (Masson and Mock 2004). The exploitation of marine faunas was conducted in conjunction with intensive salt production at this site (Mock 1994; Valdez and Mock 1991). Because the site represents a single temporal component, the assemblage is analyzed here as one composite sample.

Most taxonomic categories at NRL, including marine mammals, terrestrial mammals, rodents, birds, turtles (including sea turtles), and reptiles, do not individually form more than 0.6 percent of the sample by bone count; fish were the primary dietary resource (Table 7.5; Figures 7.4 and 7.5). Few differences are observed in the representation of these taxa by weight (Table 7.5). It is notable that so few sea turtle, manatee, and crocodile were present at the site, given the high yield potential of these larger game animals. Only nine pieces of turtle bone were identified at the site from the 1987 sample, and five of these pieces were identified as sea turtle. Three pieces of crocodile bone were found. Iguana, snake, and frog were also present in scarce quantities.

Shellfish and crustaceans were also recovered at NRL. Crabs were far more numerous than conch or whelk, forming 84.7 percent of the sample of shellfish and crustaceans. Considering the abundance of shellfish around the Belizean reef, and the value of this raw material for ornament manufacture at inland sites, it seems odd that there are not greater numbers of marine shells at NRL. Perhaps this disparity reflects a pattern of exchanging whole marine shells with inland sites and not retaining them or working them at the site, rendering them invisible archaeologically. Information on the frequency of conch and other shellfish at contemporary inland Terminal Classic sites might provide supporting evidence to suggest that coastal sites were involved in procuring this resource for inland exchange.

Fish represent 97.7 percent of the sample of identified bone (Table 7.5; Figure 7.4). Fish identified at this site include catfish, tarpon, barra-

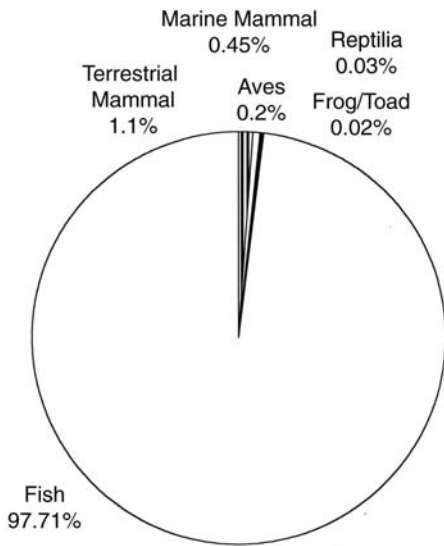


Figure 7.4. Percentage of fauna NISP for all bone at Northern River Lagoon (Terminal Classic).

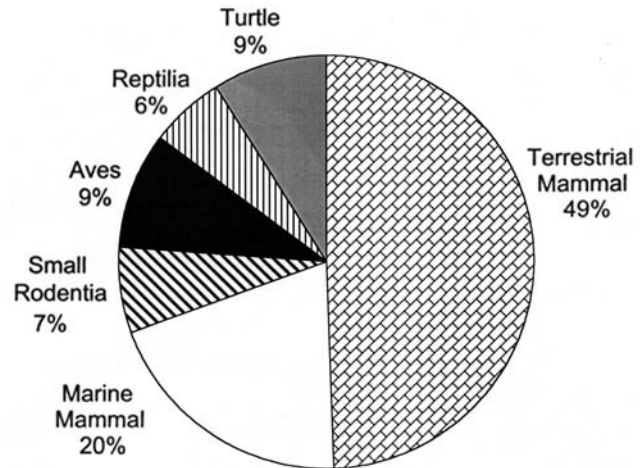


Figure 7.5. Percentage of fauna NISP from Northern River Lagoon Terminal Classic period deposits (excluding fish).

cuda, drums, jacks, snapper, ladyfish, reef wrasses, needlefish, sharks, rays, and numerous other reef species and noncatfish bony fishes (Perciformes) that were not identified to species (Table 7.6). Most of these species can be found along the Belizean reef but also venture into the coastal estuaries such as NRL. Fishing activities conducted from this site were probably fairly localized and may have extended as far as the reef (about 20 km to the east).

Figure 7.5 charts the proportions of all faunal categories except for fish so that the significance of these less abundant animals can be assessed relative to each other. This chart indicates that after fish, terrestrial mammals were most significant. These mammals include primarily deer but also peccary, tapir, and agouti. Manatee, a marine mammal, is also present. Deer elements identified in the sample include cranial fragments, teeth, a scapula, a vertebra, and long-bone fragments. Peccary and tapir foot elements were identified, and a single agouti tooth was present. Manatee elements include a humerus, cranial fragments, pelvic fragments, a phalange, ribs, vertebrae, long-bone fragments, and teeth. Deer and manatee were thus proba-

bly butchered and consumed locally, as many portions of the carcass are present. Little can be said of the other mammals based on these limited data.

Among the identified bones from NRL (Table 7.5), 44.3 percent (by count) are Perciform fish, 27.1 percent are Siluriform fish (order that includes all catfish), and 24.3 percent of the sample comprises other bony fishes (Osteichthyes). Cartilaginous fish (sharks and rays) form only 1.8 percent of the sample. Percentages of fish are presented in Table 7.6. Among the fish, *Galichthyes felis* (estuarine catfish) is the single most numerous species (27.67 percent of all fish by count), followed by the inclusive categories of Perciformes and Osteichthyes (26.76 percent and 24.88 percent, respectively). Other numerous species include barracuda (*Sphyrna barracuda*, 5.08 percent) and jacks (Carangidae, 7.2 percent).

The analysis of fish elements suggests a focus on surplus processing of estuarine/marine catfish at this site. Elements identified for catfish are listed in Table 7.7. An MNI of 103 individual catfish was determined from the number of right cleithrum present in the sample. Elemental

Table 7.6. Fish from the Northern River Lagoon Site

	No. of Fish	% of Total
<i>Aetobates</i> sp.	4	0.09
<i>Albula vulpes</i>	6	0.14
<i>Archosargus probatocephalus</i>	1	0.02
Batfish	4	0.09
Carangidae	310	7.20
<i>Centropomus</i> sp.	6	0.14
Charcharhinidae	23	0.53
Diodontidae	5	0.12
Elopidae	43	1.00
<i>Epinephelus</i> sp.	6	0.14
<i>Galichthys felis</i> (catfish)	1,192	27.67
Gerridae	6	0.14
Ictaluridae (catfish)	7	0.16
Labridae	1	0.02
<i>Lagodon</i> sp.	1	0.02
Lutjanidae	10	0.23
<i>Megalops</i> sp.	18	0.42
<i>Micropterus</i> sp.	7	0.16
Misc. fish frags.	83	1.93
<i>Mugil</i> sp.	2	0.05
<i>Opsanus</i> sp.	2	0.05
Osteichthyes	1,072	24.88
Perciformes	1,153	26.76
Rajiformes	60	1.39
Reef wrasse	7	0.16
Sciaenidae	22	0.51
Sciaenidae/Scombridae	1	0.02
<i>Sphyræna barracuda</i>	219	5.08
<i>Strongylura</i> sp.	37	0.86
Total fish	4,308	99.98

Table 7.7. *Galichthys felis* (Marine/Estuarine Catfish) Elements Recovered at Northern River Lagoon

Element	No. of Elements	% of Total
Articular	8	0.67
Basicrania	7	0.58
Basioccipital	68	5.67
Branchiostegals	62	5.17
Ceratohyal	30	2.50
Cleithrum	284	23.69
Coracoid	64	5.34
Crania	170	14.18
Dentary	2	0.17
Epihyal	1	0.08
Dorsal spine	106	8.84
Hyomandibular	7	0.58
Lacrima	1	0.08
Operculum	1	0.08
Otoliths	2	0.17
Parasphenoid	8	0.67
Pectoral spine	132	11.01
Penultimate	5	0.42
Posttemporal	26	2.17
Prefrontal	1	0.08
Pterygiophore	3	0.25
Preoperculum	1	0.08
Pterotic	3	0.25
Quadrate	1	0.08
Supracleithrum	14	1.17
Vomer	1	0.08
Other crania	71	5.92
Vertebrae	120	10.01
Total	1,199	100.0

analysis of fish bones reveals a disparity of element representation for this species but not for other types of fish (Table 7.8; Figure 7.6). Specifically, catfish cranial elements were apparently removed on-site (as they are abundant), and vertebrae are present in extremely low relative pro-

portions, suggesting they were exchanged inland with the meaty portion of the fish. Table 7.8 shows that catfish vertebrae form only 10 percent of the catfish bones identified, whereas for other fish (noncatfish) vertebrae form 47.6 percent of the bone sample. This discrepancy is

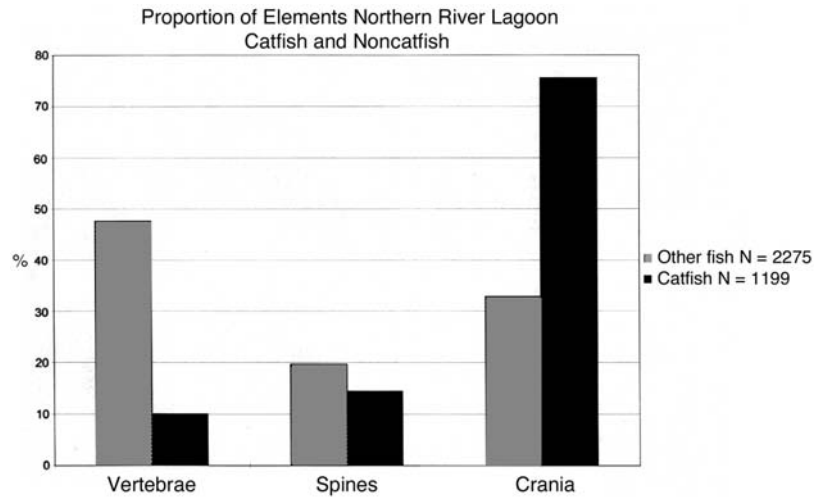


Figure 7.6. Proportion of elements of Northern River Lagoon catfish and noncatfish.

not explained by noncatfish having more vertebrae than catfish, nor are catfish vertebrae any less durable or prone to differential preservation than other types of fish vertebrae. Spines, which appear to have been removed from catfish at NRL, are present in greater proportions for catfish than observed for noncatfish (25 percent and 19.6 percent, respectively; Table 7.8). Cranial elements appear overrepresented for catfish (64.9 percent) compared to other fish (32.8 percent). Catfish do not have more cranial bones than other fish, so this pattern is not naturally explained. These data suggest that catfish crania and spines were being removed on-site, and vertebrae were being transported to different locations, perhaps inland sites. Vertebrae may have been transported out of the site with salted and dried edible portions of the carcass.

Given the evidence for salt production at this site (Mock 1994; Valdez and Mock 1991), it

appears that drying and salting catfish was also part of the site's economy. Although many other fish were harvested from the lagoon and the adjacent Caribbean Sea, they appear to have been wholly consumed on-site, as greater proportions of vertebrae relative to cranial elements are present in the sample. Fish processing has been observed at another coastal Maya site in northern Yucatán, Isla Cerritos (Carr 1989). At this site Carr (1989:8) similarly suggests that differential proportions of cranial to postcranial fish remains imply that fish were being processed as a surplus product for inland exchange and that this industry was closely linked to salt production.

Three patterns of animal resource use at NRL emerge from this analysis. First, the exploitation of catfish for possible salt fish production is implied by disproportionate patterns of element representation that suggest that this fish was specially processed. Second, fish were singularly the most important dietary resource at this site. Third, a diverse but limited exploitation of marine and terrestrial resources supplemented the diet of this site's occupants. Manatee and sea turtle were available locally, but other terrestrial mammals such as deer, pecary, and tapir may have been obtained from inland locations through exchange or hunting

Table 7.8. Comparison of Element Representation of Catfish vs. Other Fish from Northern River Lagoon

	Vertebrae	Spines	Crania	Total
Catfish	10.01%	25.02%	64.97%	100%
Other fish	47.60%	19.60%	32.80%	100%

forays. A diverse list of marine and estuarine fish, turtle, crocodile, manatee, and terrestrial mammals suggests that protein resources were abundant for inhabitants of NRL. Not only does this community appear to have thrived by subsisting on coastal resources, but it also may have specialized in extracting them for local exchange.

There is currently no complementary evidence from inland Terminal Classic sites in northern Belize that indicates a preponderance of catfish vertebrae and lack of cranial remains, as would be expected for consumers of an NRL salt fish product. It is also possible that catfish vertebrae may have been ingested with the salted meat to which they were attached, rendering them invisible archaeologically. If this were the case, then these species could just as likely have been consumed at NRL as exchanged to other sites.

Other depositional issues make it difficult to track subsistence patterns at inland Terminal Classic sites. Domestic deposits of this age are located in the surface deposits of the jungle floor. They are commonly intermingled with those of earlier periods, on which they rest, and they are often disturbed by vegetation. These attributes can make Terminal Classic components difficult to isolate for analysis (Graham 1985; Masson 1995b; Pendergast et al. 1993).

Faunal samples are thus rare from Late and Terminal Classic inland sites in northern Belize such as Colha and Laguna de On, and more work needs to be done to determine whether this pattern reflects shortages in game, problems in preservation or depositional context, or a combination of these variables. The possibility that some sites experienced genuine resource shortages should not be ruled out, given that pollen records indicate that the Late-to-Terminal Classic was a time of maximum deforestation and high population levels (Chase 1990: Table 10.1; Fry 1990: Tables 14.3 and 14.4; Turner 1990: Figure 15.1), and these factors may have affected the availability of game around some communities in northern Belize. However, the sample described previously from Pulltrouser

suggests that some settlements did enjoy access to faunal resources during this period, so this problem, if it existed, could have been a localized phenomenon. The lack of fauna at some Late or Terminal Classic sites is unlikely to be explained by lack of bone preservation from this period. From highly similar depositional contexts, bone of earlier Preclassic age is well preserved (at the sites of Pulltrouser and Colha), and later Postclassic fauna (at Laguna de On and Colha) that also lies near the surface has survived in an excellent state of preservation despite exposure to erosive elements.

Whether or not inland game shortages were in effect at some communities, catfish processing at NRL may have been producing salted fish as a commodity for exchange with consumers at inland sites in northern Belize or other locations through coastal trading networks that were expanding at this time (Masson and Mock 2004; Mock 1994). Along the Belize coast other communities that focused on trade and salt production were established around the same time as NRL (Guderjan and Garber 1995; McKillop 1984). It is interesting to consider the reasons why catfish appears to have been differentially processed or consumed in a manner that removes greater quantities of this fish's vertebrae from the site compared to other species of fish. The frequencies of fish recovered at the site indicate that catfish were not overwhelmingly more abundant than other types of fish in the NRL sample (see Table 7.6), yet they were processed differently. This species could be caught via shallow diving in the lagoon, dragging nets across the lagoon's sandy bottom, using traps, or by line fishing, as could most other types of fish identified.

Laguna de On

A sample of 786 pieces of faunal bone was collected from the 1991 season at the site of Laguna de On (Table 7.9) (Masson 1993a: Table 21) from 1/4" screens used during excavations. Analysis is currently in progress of larger faunal samples collected from the 1996 season (Wharton and Stanchly 1998), which have thus far confirmed

the interpretations and patterns indicated by the 1991 sample described below. An abundance of faunal populations around the Postclassic communities of Colha and Laguna de On is reflected in dense midden deposits at these sites from which large quantities of animal bone have been recovered (Masson 1993a; Scott 1982; Scott 1980; Shaw and Mangan 1994; Wharton and Stanchly 1998). The presence of high forest ecological communities in this vicinity is indicated by the abundance of tapir, a species that requires a large range of mature forest (Masson 1993a). Reasons for this ecological abundance may be related to decreased pressures on the environment resulting from lower human population levels. Pollen and geomorphological analyses from Cobweb Swamp (at Colha, 10 km southeast of Laguna de On) indicate the return of high forest to northern Belize during the Postclassic period after extreme deforestation during the Late and Terminal Classic periods (Jacobs 1991; John Jones, personal communication 1993). Although local forests appear to have rejuvenated, milpa farming activities continued through the Postclassic period (John Jones, personal communication 1993).

Currently, archaeological survey of Postclassic settlement is inadequate to address the issue of population levels in northern Belize, as many village components of this date are located in off-mound or subsurface deposits that make settlement more difficult to detect in heavily forested areas (Chase 1990; Masson 1999b). A decline in the cash-cropping activities (for cacao and cotton production) that funded the earlier monument building and warfare exploits of Classic period rulers may account in part for the return of large tracts of jungle forest after the A.D. 900 political collapse of the southern lowlands (Masson 1999b). Although declining populations probably also lessened human impacts on forest environments, more settlement survey is needed before this hypothesis can be accurately assessed (Masson 2000). It is clear that Postclassic populations had access to abundant quantities of terrestrial and aquatic game. The effects of an accessible supply of ani-

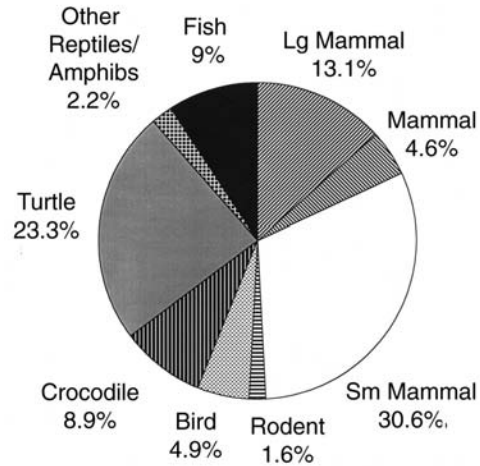


Figure 7.7. Percentage of fauna NISP at Laguna de On (Postclassic).

mal proteins are reflected in the relatively robust, healthy, and long-lived human population at Laguna de On (Masson 1993a; Rosenzweig 1998).

Large and small terrestrial mammals, turtles, and crocodiles are the most abundant taxonomic categories at Laguna de On (Table 7.9; Figure 7.7). Large mammals (13.1 percent by count) include white-tailed deer, brocket deer, peccary, and tapir. Small/medium mammals (30.6 percent) include canids, raccoon, opossum, armadillo, and mustelids. Turtles (23.3 percent) and crocodiles (8.6 percent) were present in quantities comparable to the mammals. Most of the identified turtles are aquatic pond turtles of the Emydidae family. In subsequent analyses of fauna from this site, Wharton and Stanchly observe that turtles are often the most frequent fauna in domestic contexts at Laguna de On (Wharton and Stanchly 1998: Figures 2–5), and turtles represent one of the key staple foods of other Postclassic settlements as well (Masson 1999a). Bird bones (including turkey) were present in the sample in low numbers, as were rodents, snakes, and frogs.

Fish are numerous but do not contribute as much to the sample by weight (Table 7.9).

Table 7.9. Faunal Bone by NISP and Weight Recovered from Laguna de On (1991 season)

	NISP	% Count (of 541)	Weight	% Weight (of 674)
<i>Odocoileus virginianus</i> (white-tailed deer)	18	3.33	56.5	8.38
<i>Mazama americana</i> (brocket deer)	23	4.25	28.2	4.18
<i>Tayassu pecari</i> (peccary)	21	3.88	23.3	3.46
<i>Tapirus bairdi</i> (tapir)	9	1.66	29.2	4.33
Subtotal large mammals	71	13.12	137.2	20.36
Canidae	5	0.92	5.8	0.86
<i>Procyon lotor</i> (raccoon)	4	0.74	2.4	0.36
<i>Didelphus marsupialis</i> (opossum)	3	0.55	0.7	0.10
<i>Dasypus novemcinctus</i> (armadillo)	94	17.38	67.6	10.03
Mustelidae	10	1.85	4.8	0.71
Medium/small mammal	50	9.24	34.1	5.06
Subtotal medium/small mammal	166	30.68	115.4	17.12
<i>Dasyprocta</i> (agouti)	2	0.37	0.5	0.07
Rodentia	7	1.29	2.5	0.37
Subtotal rodent	9	1.66	3	0.45
Mammal (miscellaneous)	25	4.62	22.7	3.37
Crocodylidae	47	8.69	144.6	21.45
Iguanidae	1	0.18	0.1	0.01
<i>Pseudemys</i> (pond turtle)	10	1.85	35.1	5.21
Testudines (turtle)	92	17.01	140.6	20.86
Emydidae (pond turtle)	24	4.44	35.8	5.31
Snake	9	1.66	2.5	0.37
Subtotal reptile	183	33.83	358.7	53.22
Frog/toad	11	2.03	3.8	0.56
<i>Meleagris</i> (turkey)	3	0.55	7.5	1.11
Aves	23	4.25	13.2	1.96
Phasianidae	1	0.18	0.2	0.03
Subtotal bird	27	4.99	20.9	3.10
Siluriformes (catfish)	17	3.14	4.1	0.61
<i>Galichthys felis</i> (catfish)	16	2.96	4.7	0.70
Perciformes (noncatfish)	8	1.48	1.3	0.19
Osteichthyes (bony fish)	8	1.48	2.2	0.33
Subtotal fish	49	9.06	12.3	1.82
Total identified bone	541		674.00	
Total unidentified bone	245		92.3	
Grand total all bone	786	99.99	766.3	100

Among the fish catfish are the most important species, particularly *Galichthys felis*, the same taxon that was harvested at NRL. In this case catfish are represented by cranial head plates and vertebrae (Masson 1993a: Table 21), suggesting that this species was captured and consumed by occupants of Laguna de On. There is no evidence that this site received only postcranial remains through exchange with coastal settlements, as is hypothesized for Terminal Classic consumers of NRL fish. The sample size of catfish ($n = 33$) at Laguna was very small compared to NRL.

Figure 7.7 illustrates the broad, diverse base of the animal diet at Laguna de On, in which many different species contributed significant proportions. Small to medium-sized mammals, particularly armadillo, and turtles were the most important. Crocodiles, fish, and large mammals each contributed 8.6 percent or more to the diet, and reptiles, birds, and rodents were also present. Aquatic resources (turtles, crocodiles, and fish) formed 41 percent of the animal diet at Laguna de On. These data suggest that the ecological setting of this Postclassic community consisted of game-rich forests and well-stocked aquatic features.

CHANGING PATTERNS OF ANIMAL RESOURCE EXPLOITATION OVER TIME

Considered collectively, faunal samples from the four settlements examined here represent a more robust view of the use of aquatic resources in northern Belize over time than any one site could have provided individually. Pulltrouser Swamp and Colha illustrate patterns in the Preclassic, and the Pulltrouser data hint at trends in the Protoclassic, Early, Late, and Terminal Classic periods. Northern River Lagoon represents one specialized coastal perspective on a Terminal Classic fishing community, and Laguna de On provides a view from the Postclassic period. Figures 7.8–7.11 graph the relative frequencies of mammals and turtles at all of these sites to facilitate comparisons.

The Preclassic assemblages indicate that the Pulltrouser Swamp (K'axob, in particular) and

Colha communities regularly exploited turtle as an important dietary resource (Figure 7.11), but turtles occupied a secondary position compared to terrestrial mammals at these sites (Figure 7.8). Small mammals are more important at Pulltrouser, and large mammals are more important at Colha (Figures 7.9 and 7.10). Turtles became even more important in the Protoclassic and Early Classic periods at Pulltrouser, when the relative significance of small/medium mammal bone decreased from the Preclassic levels (Figures 7.8 and 7.11). It is possible that the increased use of turtles represents a switch toward resources of secondary preference at this site following a decline in availability of mammals, or perhaps turtles were raised as a food source in the swamp. The samples are small for the Classic period, so these patterns must be viewed as preliminary to a more substantial investigation. Large-game levels remained relatively constant at low percentages for most periods at K'axob, until the Terminal Classic, when they increased sharply (Figure 7.9). However, as the sample size for the Terminal Classic is small, this pattern also must be regarded with caution.

Terminal Classic faunal exploitation strategies of a specialized nature are reflected at NRL, where patterns suggest that fish provided the primary animal resource at this site. The low percentages of mammals and turtles (see Figures 7.8–7.11) for this site reflect the fact that 97.7 percent of the identified bone in this sample consisted of fish bones. A broad range of other marine resources and a few terrestrial resources were also consumed at this site, although not in great quantities.

Postclassic patterns of fauna use at Laguna de On Island suggest that forest resources were abundantly available during this time. Compared to the other sites in Figures 7.8 through 7.11, Laguna de On does not differ markedly in the percentages of certain categories of mammals or turtles. The diversity of the Laguna de On sample, not reflected in these graphs, does distinguish this site from earlier ones examined in this study. The exploitation of crocodiles also appears to have been commonplace during the Postclassic, despite the sparing use of this

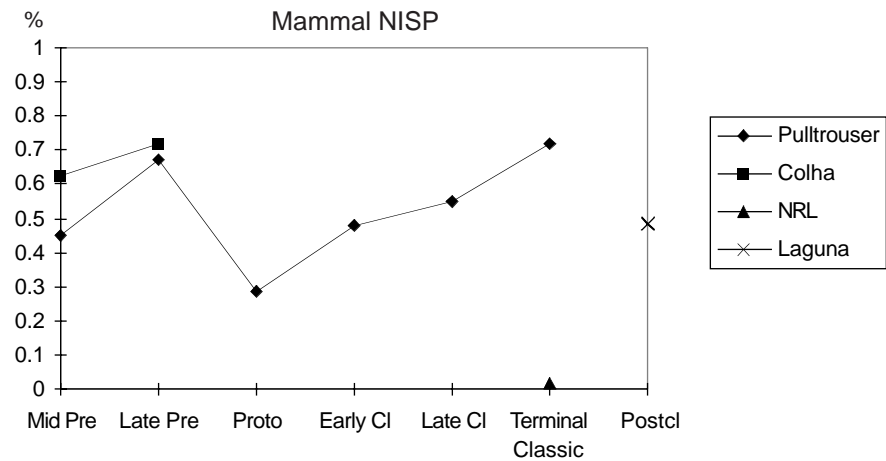


Figure 7.8. Percentage of mammal NISP by site/period for all sites.

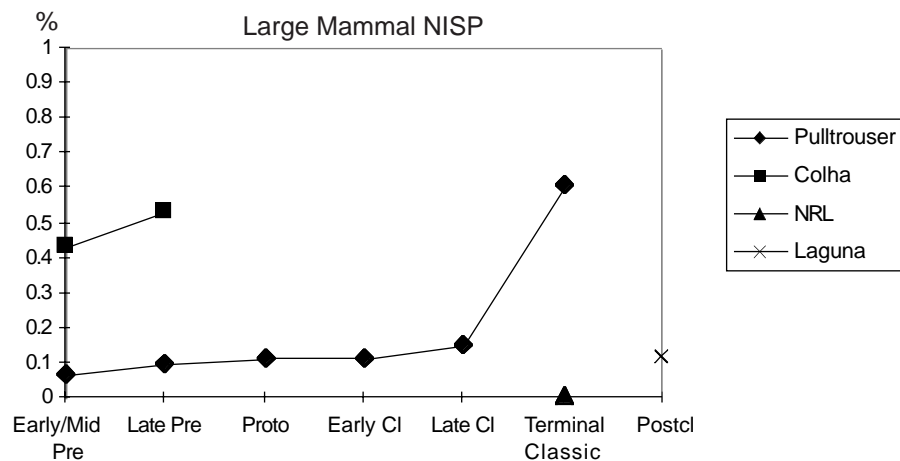


Figure 7.9. Percentage of large mammal NISP by site/period for all sites examined.

resource reflected in the earlier samples. Tapir is also very rare in earlier periods (only one bone was found at NRL), but elements of this species are found at Laguna de On. Subsequent analyses of Laguna de On fauna (Wharton and Stanchly 1998) indicate that tapir is commonly recovered at this site. Patterns of broad spectrum exploitation of abundant faunas are also observed for Postclassic Colha (Scott 1982; Scott 1980; Shaw and Mangan 1994).

SUMMARY

It is clear from the examination of these data that primary resources for northern Belize communities fluctuated considerably over time. Different degrees of terrestrial and aquatic resource exploitation detected in these samples indicate dynamic relationships between human and animal communities. Variables that affected these

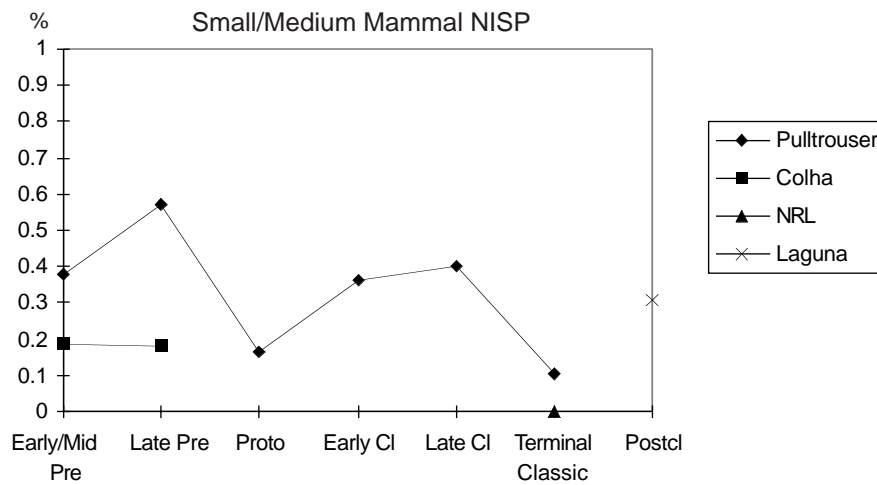


Figure 7.10. Percentage of small/medium mammal NISP by site/period for all sites examined.

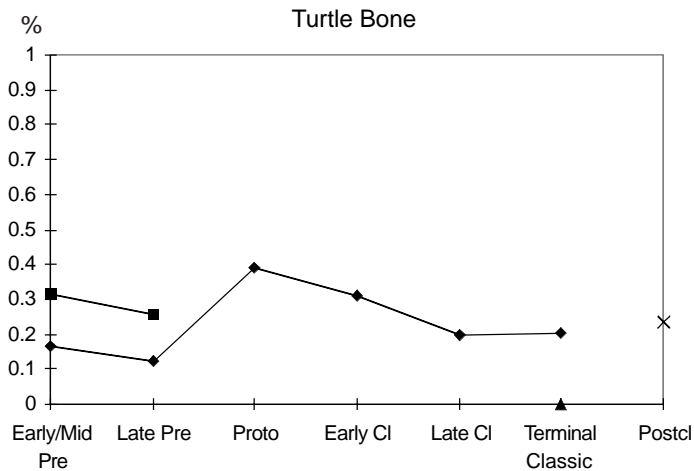


Figure 7.11. Percentage of turtle bone by period for all sites examined.

local ecologies were probably both cultural and natural. The size of the communities, cultural attitudes that determined preferred and exploitable resources, and regional and community-based social or political rank represent cultural variables that could have affected dietary choices at these sites. Differences between K'axob and Colha suggest the latter site may have had greater access to large game during

the Preclassic period, perhaps because of its higher political standing in the regional hierarchy. Another major difference is that the consumption of crocodiles in northern Belize was largely avoided prior to the Postclassic period, and the absence of tapir remains before the Terminal Classic may signal a lack of high forest environments. The presence of tapir in the Postclassic may suggest a return of high forest

niches to northern Belize. Common terrestrial game at all the sites examined here, including deer, peccary, and various small mammals, are equally at home in pristine forests, secondary growth, or agricultural landscapes; and they remained locally available through time. Plentiful quantities of turtles at these sites suggest that this resource was an important dietary component. Despite changing proportions over time, the exploitation of turtles was continual, along with terrestrial mammals, at least for the early and late perspectives on Maya history provided by this study.

These data supplement models of Maya subsistence that emphasize agricultural products by documenting a range of hunting, turtling, and fishing activities. Northern River Lagoon is the only site studied here that focused on faunal resource extraction as a surplus industry, perhaps geared toward exchange with other sites. The investigators of this site suggest this industry may have developed in response to dietary stress experienced by inland communities or perhaps in response to new opportunities for exchange during a time of societal transition (Valdez and Mock 1991). More data are needed to fill the gap of knowledge concerning Classic period animal exploitation and game availability at this time in northern Belize. The assemblages described above suggest the Preclassic, coastal Terminal Classic, and Postclassic community adaptations in northern Belize exploited an abundant array of resources from forests, fields, lakes, rivers, lagoons, swamps, and the sea.

Acknowledgments. I am grateful to Thomas R. Hester and Thomas C. Kelly for providing me with the opportunity to examine NRL faunal samples from the 1987 season. The faunal identifications were augmented by the opportunity

to compare them to the zooarchaeological collections of the Vertebrate Paleontology Lab (University of Texas at Austin) and the Florida State Museum. Thomas Hester assisted me in obtaining a travel grant to the Florida State Museum through the University Research Institute of the University of Texas. I also thank Fred Valdez for giving me the opportunity to analyze the 1989 Colha materials and Lauren Sullivan for providing chronological information on that sample. I would like to thank Skipper Scott, Ernest Lundelius, and Rick Toomey for their assistance with identifications. A number of students in zooarchaeology seminars conducted at the University of Texas at San Antonio and Pacific Lutheran University contributed many hours to sorting these and other faunal samples, and I wish to thank them. Former University of Texas students Naomi Cleghorn and Erin Barrett provided tremendous assistance in a year-long zooarchaeological apprenticeship. Florencio Delgado, Andrew Scease, and Shirley Mock have also provided valuable input in their continued analysis of 1993 NRL materials. I am grateful to Patricia McAnany for allowing me to analyze the Pulltrouser Swamp materials and for much assistance on temporal and contextual information. The Pulltrouser Swamp and K'axob projects were supported by grants from the National Science Foundation. The Colha Project has also been supported by the National Endowment for the Humanities, the National Geographic Society, the Center for Field Research: Earthwatch, and the Centro Studi e Ricerche Ligabue. The NRL project has been supported by NSF, and research at Laguna de On was provided by the Center for Field Research: Earthwatch, the Foundation for the Advancement of Mesoamerican Studies, and the Wenner-Gren Foundation.



PART 3

New Interpretations of Ancient Species Significance

Ancient Lowland Maya Utilization of Freshwater Pearly Mussels (*Nephronaias* spp.)

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*The ancient Maya exploited a wide variety of animal resources, including local freshwater shellfish. Although a number of faunal investigations have focused on such freshwater snails as *Pomacea flagellata* (apple snail) and *Pachychilus* sp. (jute), relatively little is known about the freshwater mussel known as *Nephronaias* spp. This chapter examines the archaeological use and distribution of these molluscan species in ancient Maya society both as a food source and as a ritual item. Ecological information on the habitat of *Nephronaias* spp. as well as the methods of procurement used to harvest them from their riverine environment are also provided. These data, combined with nutritional yields, allow for an evaluation of the dietary role that this freshwater mussel played in lowland Maya subsistence practices.*

The lowland Maya utilized a wide variety of animal resources as food and ritual items, including mammals, fishes, birds, reptiles, crabs, and several molluscan species of both freshwater and marine origin. Evidence for the exploitation of such a wide range of aquatic and terrestrial species is fairly common in Maya faunal assemblages (Emery, chapter 1 this volume) and has allowed researchers to reconstruct patterns of procurement, consumption, trade, and social and ritual use of animals.

Over the past few decades, emphasis has been placed on the study of marine resources and the role they played in ancient Maya society (Ball and Eaton 1972; Carr 1985; Cobos 1989; Feldman 1974a; Freidel 1978; Hamblin 1984, 1985; Lange 1971; McKillop 1984, 1985; Moholy-Nagy 1978, 1985; Pohl 1985a; Powis et al. 1999; Stanchly 1995; Wing and Scudder 1991). Although significant data have been collected on the dietary and social use of marine resources, particularly shellfish (e.g., *Spondylus* and *Strom-*

bus), relatively little is known about the exploitation by the Maya of freshwater molluscs.

Traditionally, archaeological reports have recorded the presence or abundance of freshwater shellfish remains, but archaeologists generally have paid little attention to these often ubiquitous invertebrate remains (Coe 1959:55–60; Ricketson and Ricketson 1937:199; Thompson 1939:180–182; Willey 1972:220–228, 1978:162–167). Research by Moholy-Nagy (1978) on *Pomacea flagellata* (apple snail) and by Healy et al. (1990) on *Pachychilus* spp. (common name “jute”) has indicated that freshwater invertebrate remains were not only used for dietary purposes but were also included in ceremonial and ritual deposits (see also Stanchly and Iannone 1997). Despite the intensive studies conducted on these two species of snails, another commonly found freshwater mollusc, identified as *Nephronaias*, has been largely neglected by Maya zooarchaeologists and archaeologists. This study provides the first substantive data on

the archaeological use and distribution of this mussel or clam by the Maya from the beginning of permanent settlements around 900 B.C. until the Spanish Conquest in the mid-1500s (Figure 8.1). By way of introduction to this study I will

describe some aspects on the taxonomy, ecology, nutritional yields, and modern usage of *Nepheronia*s in order to suggest why the Maya exploited this clam for more than 2,500 years.

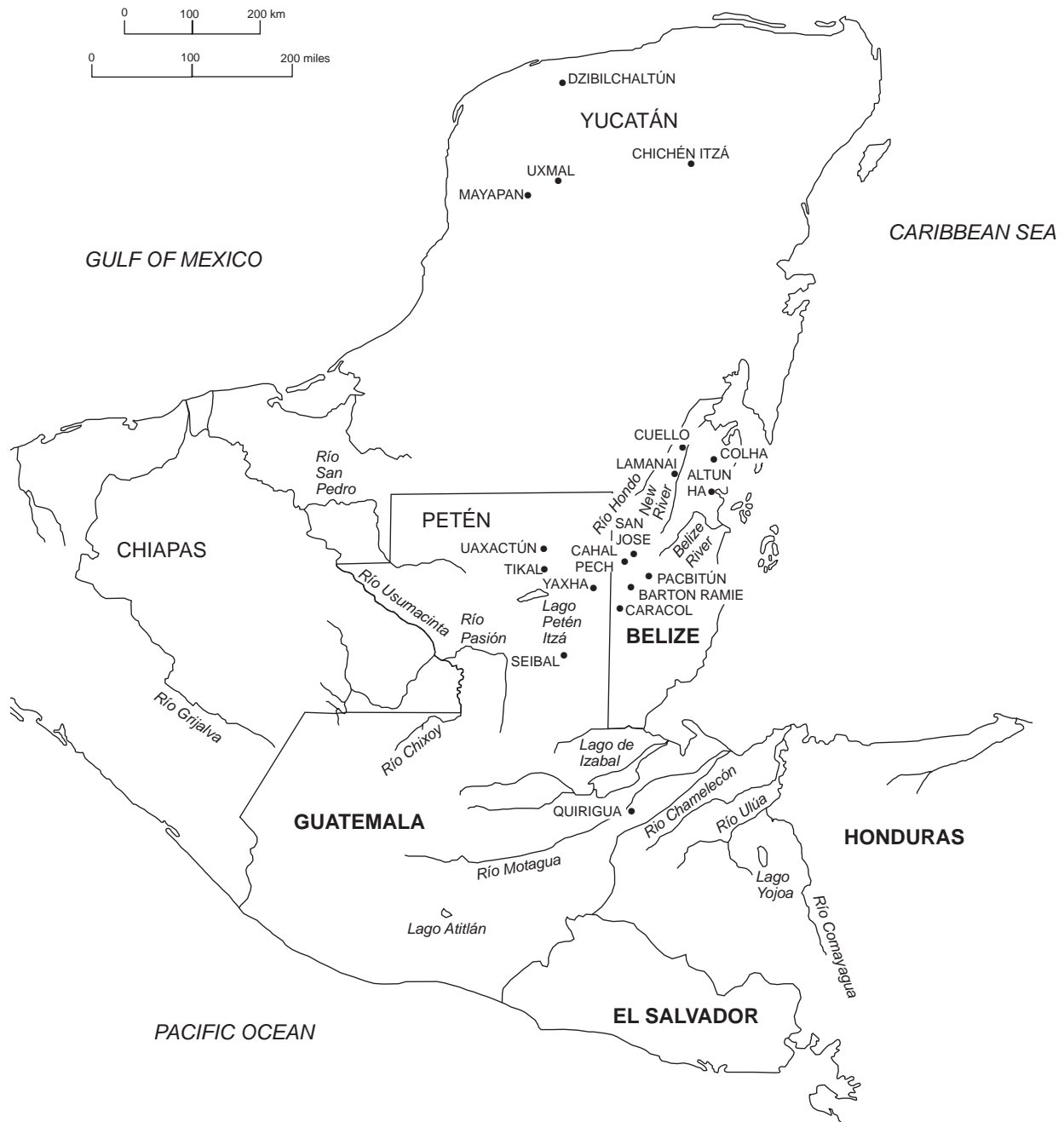


Figure 8.1. Map of sites mentioned in the chapter.

METHODOLOGY

The *Nephronaias* remains presented in this study are derived from both archaeological and modern samples. The archaeological material is mainly based on published data from selected lowland Maya sites with *Nephronaias* spp. Only those reports that had specifically identified *Nephronaias* remains were included in this study. Modern *Nephronaias* shells were collected in order to conduct comparative studies (habitat analysis, collection speed analysis, ethnographic analysis) with the archaeological material. All of the mussel remains mentioned throughout the text are quantified by the number of identified specimens (NISP).

SPECIES IDENTIFICATION AND DESCRIPTION

Nephronaias is a bivalve and a member of the family Unionidae, the largest of the four groups of clams that occupy freshwaters around the world. The shells of these mussels are elongated or oval and, when the animal is alive, covered by a brownish colored protective periostracum (Burch 1973:5). The internal surface is thickly coated with nacre or mother-of-pearl that ranges from silvery white through pink to dark purple. Modern adult unionids, including *Nephronaias*, generally range in size from 2.5 to 25.5 cm. Archaeological specimens of *Nephronaias* from the Maya sites examined in Table 8.1 fall within a smaller size range, measuring from about 2.5 to 8 cm (Figure 8.2).

Table 8.1. Selected Sites of the Maya Lowlands with *Nephronaias* spp. Remains

Site	Comments	Total	References
Altar de Sacrificios	79 unmodified pieces; 1 bead from a Late Classic burial	80	Smith 1972; Willey 1972
Altun Ha	9 modified and 6 unmodified specimens in Early and Late Classic burials and caches	15	Pendergast 1982, 1990
Barton Ramie	765 unmodified specimens mostly from Preclassic deposits; 8 perforated bivalves (pendants) found in Late Classic burials	773	Willey et al. 1965
Blackman Eddy	More than 12,500 unmodified specimens from early Middle Preclassic ritual deposits; numerous uncut remains in Middle Preclassic caches	12,500 +	Garber et al. 1998
Cahal Pech	More than 5,200 unmodified specimens in Preclassic middens, plazas, and fill (including 125 from early Middle Preclassic fill in Plaza B); 5 pendants in Late Classic burials	5,205 +	Cheetham 1998; Iannone 1994; Powis 1996; Stanchly 1992, 1995
Caracol	44 unmodified and 13 modified bivalves from various Classic period contexts	57	Cobos 1994
Chichén Itzá	54 unmodified fragments from Terminal Classic and Early Post-classic contexts	54	Cobos 1989
Colha	285 specimens from middens, plazas, and fill mostly from Middle Preclassic; 12 perforated valves and beads in Middle Preclassic burials; 1 ring in Late Classic burial	298	Dreiss 1994; Feldman 1994
Cuello	2 perforated valves in Late Preclassic burials; 7 rings from Middle Preclassic and Late Classic burials; several unmodified specimens in various deposits	9 +	Hammond 1991
Dzibilchaltún	4 perforated valves in Late Preclassic burials; 3 unmodified Late Preclassic fragments	7	Andrews 1969; Taschek 1994

Continued on next page

Table 8.1. Selected Sites of the Maya Lowlands with *Nephronaias* spp. Remains (continued)

Site	Comments	Total	References
Mayapan	1 Late Postclassic (Decadent) perforated valve	1	Andrews 1969
Pacbitún	More than 1,500 uncut specimens in Middle Preclassic middens; 43 Middle Preclassic beads	1,543 +	Healy 1990; Hohmann and Powis 1996, 1999
Quiroz Cave	47 Late Classic cut specimens (35 circlets, 7 irregulars, 5 pendants) in Chamber 6 cache	47	Pendergast 1971
San José	5 perforated valves in Preclassic burials and 6 in Classic burials; others in various contexts	11	Thompson 1939
Seibal	30 unmodified specimens, mostly from Preclassic deposits	30	Feldman 1978; Willey 1972
Tikal	228 unmodified bivalves of a related species of which 70 are modified	228	Moholy-Nagy 1978, 1994
Uaxactún	Possible <i>Nephronaias</i> remains in Preclassic contexts in Plaza E	N/A	Ricketson and Ricketson 1937
Uxmal	7 unmodified and 4 cut pieces, including 1 inlay from Late Classic contexts	11	Cobos 1998

There are 22 species of *Nephronaias* found in southern Mexico and northern Central America (Haas 1969). Within the Maya area only five species of *Nephronaias* have been documented in the archaeological literature based on shell morphology and modern geographic distributions.



Figure 8.2. Photograph of one of the five species of *Nephronaias* identified archaeologically in the Maya area. This representative specimen of the genus is named *E. sphenorhynchus* or *N. sphenorhynchus* (formerly *N. ortmanni*). It shows a perforation at the hinge of each valve. This artifact was recovered from Late Classic burial 2 at the Tolok Group, Cahal Pech, Belize. Photograph by Terry G. Powis.

Andrews (1969:32–33) recorded three species of *Nephronaias* (*N. ortmanni* [Frierson], *N. goascoransensis* [Lea], and *N. yzabalensis* [Crosse and Fischer]) at the Belizean sites of Barton Ramie and San José. Dreiss (1982:220) reported a fourth species (*N. calamitarium* [Morelet]) at Colha, in northern Belize, and Feldman (1972:123) noted a fifth species (*N. sphenorhynchus* [Crosse and Fischer]) in the Usumacinta region of the Petén, Guatemala. Of the five identifiable *Nephronaias* species, *N. ortmanni* occurs with the highest frequency in sites dating to the Preclassic (900 B.C.–A.D. 250) and Classic (A.D. 250–900) periods. Other related species in the family Unionidae (*Psoroniaias percompressus* [Crosse and Fischer], *P. quadratus* [Bush], and *P. semigranosus* [Simpson]) have also been found in the Maya lowlands, but they occur in relatively fewer numbers and contexts (Andrews 1969).

The identification of *Nephronaias* to the species level is complex because of the similarity between various members of the genus. As a result taxonomic classifications within the genus change frequently. For example, *N. ortmanni* is now considered a junior synonym of *Elliptio sphenorhynchus* in some malacological literature [Crosse and Fischer 1893] (Frierson 1913:14–15,

1917:47–49; Ortmann 1921:25–26). In other analyses *E. sphenorhynchus* may also supersede *Nephronaias sphenorhynchus* (see Feldman 1978:167; Frierson 1913:14–15, 1917:47–49; Haas 1969; Ortmann 1921:25–26; Seed 1983:43–47; Solem 1974:123; Vokes 1980:74, 76). Given the taxonomic difficulty and complex synonymy, archaeologists and zooarchaeologists are encouraged not to rely on existing archaeological literature or outdated malacological classifications as a basis for their identifications of these or any other taxonomically complex molluscan groups (see Powis 1997 for a discussion on the history of the taxonomic classification of *Nephronaias* spp.).

HABITAT

The modern habitat and range of *Nephronaias* spp. cover the entire Maya area. Like the freshwater snails *Pomacea* and *Pachychilus*, modern specimens of *Nephronaias* have been reported throughout southern Mexico, the Yucatán Peninsula, Guatemala, and Belize (Healy et al. 1990:173; Moholy-Nagy 1978:66). This fully aquatic species is limited to a habitat of fresh and brackish water and is most commonly found in less stagnant waters of lakes, rivers, and streams. The high turbidity of fast-moving water systems is completely suitable for the clams because the water is well aerated and carries an abundance of microscopic food particles, including zooplankton, phytoplankton, and organic detritus (Matteson 1955:127).

In order to more fully understand the habitat preferences of these poorly known freshwater mussels, an ecological study was conducted in June and July of 1997 in a number of streams and rivers in proximity to the Maya sites of Cahal Pech and Pacbitún, both located in the Belize Valley. Preliminary observations from Barton Creek, located 5 km east of Pacbitún, have revealed that *Nephronaias* inhabit similar environments as *Pachychilus*, preferring swift waters moving at speeds from 20 to 30 m per minute. The mussels are generally found in water less than a meter deep and also seem to prefer sandy bottoms in the middle of the river.

They can be located in depths of 45 cm or more in the shifting sands of the riverbed. In our survey they were found to be solitary and small (1 to 3 cm) and, during the summer months, difficult to collect in large numbers. At Barton Creek, for example, it took a crew of eight people nearly two hours to collect 10 specimens (see Procurement Methods section below).

NUTRITIONAL ANALYSIS

The recovery of large quantities of discarded *Nephronaias* valves in midden contexts at a number of Preclassic sites, especially those located in the Belize Valley, suggest that they were collected from nearby rivers and brought back to these sites for consumption purposes (Table 8.1). The recovery of freshwater *Pomacea* remains at Tikal led Moholy-Nagy (1978:70) to state that “[t]he large numbers of shells recovered, their often clustered occurrence, unmodified condition, and the circumstances that their distribution shows a chronological rather than spatial pattern, all indicate a primary utilization as food.”

Similarly, Healy et al. (1990:180) have suggested that other freshwater snails, namely *Pachychilus*, “most likely were used as a protein supplement in their subsistence system.” Like *Pomacea* and *Pachychilus*, *Nephronaias* may also have provided an additional source of nutrition for the ancient Maya. The nutritional composition of modern *Pomacea* and *Pachychilus* snails has already been determined (Emery 1986:81–82; Healy et al. 1990:177–178; Moholy-Nagy 1978:70–71), but, to date, no compositional analyses have been conducted on the 22 species of *Nephronaias*.

Despite the complete lack of available data on the nutritional aspects of *Nephronaias*, or any other related freshwater mussel from the lowlands, an attempt is made to assess its potential as a food source for the Maya. To do this, some generally accepted interpretations of nutritional values for three North American mussels (*Proptera alata*, *Actinonaias carinata*, and *Unio biviae*) are used (Erlandson 1988; Parmalee and

Klippel 1974; Sidwell 1981). The comparative data from these freshwater mussels (all belonging to the family Unionidae, like *Nephronaias* spp.), coupled with the existing nutritional information from analyzed specimens of *Pomacea* and *Pachychilus*, provide some preliminary observations regarding the role *Nephronaias* might have played in the total diet of the Pre-classic Maya. The data are speculative, and it is acknowledged that there are problems with comparing relative food values of different freshwater mussels from North and Central America even though they are all related phylogenetically (see Claassen 1991:271–275). Some contributing factors include intra- and inter-species variation, proportion of edible flesh to gross weight, differing growth rates, sex, availability of food resources, responses to aestivation, water temperature, currents, flooding, and modification of the environment by human activities (e.g., pollution, cultivation of land, dams) (Matteson 1955).

A comparison of the composition of three freshwater Unionid mussels from the Mississippi River drainage with several other invertebrates (freshwater, marine, and land species) and vertebrates (terrestrial and aquatic) that were available to the Maya are provided in Table 8.2. Based on 100-gram portions, the values shown for the mussels are most comparable with the freshwater snails. The mussels have higher levels of protein than *Pachychilus* but less than *Pomacea*. One of the freshwater mussels, *Unio biviae*, contains the highest amount of fat relative to the other molluscs but is average in its caloric, protein, and carbohydrate yields. The freshwater mussels contain considerably higher values of carbohydrates than the turtle, rabbit, deer, and catfish but are very low in caloric yield and protein compared to these vertebrates and freshwater fish. Of the foods selected, the values for freshwater molluscan species are most comparable to the raw oyster (*Ostrea lurida*).

Table 8.2. Nutritional Composition of Selected Foods per 100-Gram Portions

Taxa/common name	Kilo-calories	Protein (g)	Fat (g)	Carbohydrates (g)
Molluscs				
<i>Pachychilus indiorum</i> (freshwater snail, raw)	84	6.3	1.2	12.0
<i>Helix pomacea</i> (land snail, raw)	75	15.0	0.8	2.0
<i>Ostrea lurida</i> (oyster, raw)	82	9.6	2.5	5.4
<i>Proptera alata</i> (freshwater mussel, raw)	77	9.5	0.8	7.8
<i>Actinonaias carinata</i> (freshwater mussel, raw)	58	7.8	0.7	4.5
<i>Unio biviae</i> (freshwater mussel, raw)	75	7.8	1.6	7.3
Reptiles				
Testudines (species name not available) (turtle, roasted)	89	19.8	0.5	0
Fishes				
<i>Ictalurus</i> sp. (freshwater catfish, raw)	103	17.6	3.1	0
Mammals				
<i>Odocoileus</i> sp. (deer, raw)	126	21.0	4.0	0
<i>Sylvilagus</i> sp. (rabbit, raw)	73	21.0	5.0	0

Note: Data compiled from Claassen (1991: Table 10.1); Erlandson (1988: Table 1); Healy et al. (1990: Table 2); Moholy-Nagy (1978: Table 4); and Sidwell (1981: Table 3).

Another limitation to this kind of comparative study is that most of the analyzed invertebrate specimens listed in Table 8.2 were collected in unspecified seasons (Cheryl Claassen, personal communication 1997). It is important to know what environmental and cultural factors were involved in shellfish gathering at different times of the year. For example, molluscan physiology may have been an important environmental factor to the Maya because most shellfish species have higher meat weight-to-shell weight ratios just prior to and following spawning (Waselkov 1987:110). An increase in meat weight at different times of the year may also mean higher levels of fat, which could have been an important consideration to the Maya. Therefore, a comparison of relative food values of different subsistence resources should include an emphasis on shellfish seasonality.

The nutritional yield of freshwater mussels has led to a number of different interpretations as to whether prehistoric populations could have subsisted entirely on their meat (Claassen 1986:33–34, 1991:269–275, 1998:183–195; Erlandson 1988; Healy et al. 1990:177–178; Meighan 1969; Moholy-Nagy 1978:70–71; Parmalee and Klippel 1974; Waselkov 1987:119–123; Wing and Brown 1979:139–142). Parmalee and Klippel (1974) and Erlandson (1988) have debated the number of *Proptera alata* needed to fulfill the protein requirements of a 25-member group. Assuming a minimum daily requirement of 30 to 40 grams of protein, based on the World Health Organization's recommended daily allowance, only 7.5 specimens would be necessary to satisfy the daily protein needs of one person (see Scrimshaw and Young 1976:60). It is possible, then, that the Preclassic Maya living in proximity to rivers, streams, and creeks may have been able to harvest enough freshwater shellfish, if desired, during certain critical times of the year to fulfill their daily dietary needs (Emery 1989; Healy et al. 1990:174). However, more research is needed about the harvest rate of *Nephronaias* across the lowlands to know whether their population was stressed in prehistoric times.

The faunal evidence from a number of Belize Valley sites supports the notion of continuous exploitation of freshwater shellfish throughout the Preclassic period (Powis et al. 1999; Stanchly 1995:141; White et al. 1996). How much freshwater shellfish, then, was actually being consumed by these inhabitants, compared to other food resources? It is important to know which available resources were selected for consumption by the Belize Valley Maya and which were consumed consistently enough, and in quantities large enough, to have been nutritionally significant (Powis et al. 1999:371). Isotopic analysis of human bone provides a direct means of bridging the distance from menu to meal. At the site of Cahal Pech an examination of the isotopic data indicates that meat consumption was a mixture of terrestrial herbivores, reef fish, and possibly some freshwater fish (Powis et al. 1999; White et al. 1996). A combination of the botanical, faunal, and isotopic data from this site seems to support a model of a broad-based subsistence pattern in which maize, terrestrial herbivores, and reef fish were important to their diet but that freshwater shellfish, including *Nephronaias*, were not consistently consumed in quantities large enough to register an isotopic distinction in human bone (Healy 1998:8; Powis et al. 1999:374; Stanchly 1995; White et al. 1996). This supports the notion that *Nephronaias* remains, although found in large quantities at the site, were never utilized beyond supplementing the Maya main diet of agricultural foodstuffs and terrestrial and marine species. However, it should be pointed out that the skeletal sample is small ($n = 3$) and that it may not be indicative of the Preclassic population at Cahal Pech or of the Belize Valley in general. Furthermore, shellfish consumption is difficult to identify specifically because of the overlap in isotopic values between freshwater fish and shellfish and between marine shellfish and freshwater shellfish (Powis et al. 1999:374). It is suggested that freshwater shellfish, including *Nephronaias*, may have been regarded as a famine food instead of as a dietary staple. Periodic use of shellfish when other proteins could not be readily obtained could explain their

absence as isotopic signatures. Furthermore, given the difficulties in collecting modern *Nephronaias* shells from Barton Creek, the ancient Maya may also have had similar problems in collecting large quantities for consumption at different times of the year. And 7.5 mussels per person per day for any family and/or community might well have strained any mussel population.

PROCUREMENT METHODS AND MODERN USAGE

If the mussels were a part of the ancient Maya menu, especially throughout the Preclassic period, then what can be said about the methods of collecting, processing, and consuming them? Five local informants, all adult males aged 18 to 60, from the modern Maya village of San Antonio, Cayo District, Belize, were asked to provide insights into contemporary methods of procuring these freshwater mussels. Specifically, the ethnographic study concentrated on gathering *Nephronaias* from Barton Creek, located 5 km east of the site of Pacbitún. Based on the experience of these men, *Nephronaias* are only found in this one creek, although there are numerous local waterways in the vicinity of the site. It is possible that Barton Creek was also the only locale for exploitation of the mussel by the Preclassic Maya of Pacbitún. Since this is the only species of mussel found in the area, the men simply referred to it as a "clam" in English. Our informants also did not have a specific name for it in Yucatec Maya.

The San Antonio men said that although the mussels were available year round, seasonal emphasis in exploitation occurred during the months of April to September. The men stated that it was easier to collect the mussels at this time. They said this is when the water is at its lowest level and clearest for optimal viewing. *Pachychilus* are also found in this creek, but they are far more plentiful than the mussels during summer months. The *Pachychilus* seemed to cluster together on the rock bottom, whereas the mussels are generally found individually buried

deep in the sand. This makes it more time-consuming to collect large numbers of mussels by shifting through the sand by hand, compared to the easier harvesting of *Pachychilus*. Only 10 *Nephronaias* specimens were collected in 90 minutes by eight individuals, including the five Maya informants. We were able to gather 20 times as many *Pachychilus* in that same time period. We returned every day for a week and collected mussels from different areas of this river. Each time the results were the same. The *Nephronaias* shells that were collected were very small, consistently averaging about 1 to 3 cm in length and 0.8 grams in weight, compared to the much larger archaeological specimens. The differences in size between modern and archaeological remains may have to do with such factors as collection strategies (dry vs. wet season gathering), differences in growth cycles, availability of nutrients in the water, turbidity, water temperature, and low water levels.

Our sample of 10 small mussels from Barton Creek during the summer months of 1997 indicates that the collection of *Nephronaias* at other times of the year would likely have permitted the recovery of larger animals. For example, the 10 modern specimens recovered in 1997 ranged from 1 to 3 cm in length. At Pacbitún the Preclassic specimens recorded were generally between 5 and 7 cm in length. Similarly, the *Nephronaias* sample recovered from Plaza B, particularly Substructure B-4, in the site core of Cahal Pech also measured on average 5 cm. Archaeological remains ($n = 12,500$) of *Nephronaias* recovered from a basin-shaped deposit below Structure B1 at Blackman Eddy, Belize, were also typically larger, ranging in size from 6 to 8 cm (Garber et al. 1998:9).

Testing the theory that archaeological and modern specimens differ in size will necessitate additional scientific study and experimental collection during the dry and rainy seasons. The abundance of *Nephronaias* shells from several sites demonstrates that the Preclassic Maya were exploiting a variety of mussel sizes, including large ones up to 8 cm and more in size. They may have been procuring them either

on a seasonal basis or all year round, depending on scheduling decisions. The Preclassic Maya may have harvested small mussels during the dry season and large mussels in the rainy season or, perhaps, collected both during the rainy season, when they might have both been more plentiful. It may be that these early inhabitants were following a pattern of opportunistic collection of mussels.

According to the local informants of San Antonio village, nobody today admits to collecting, preparing, or consuming *Nephronaias*. Instead, they occasionally prefer to eat *Pachychilus* snails boiled in soup (see Healy et al. 1990:178–180). Some of the older men admitted to tasting the mussel when they were younger but claim that the snails taste better in soups than the mussels. They further state that they purposefully pass over them in the creeks when collecting *Pachychilus*. Given the experience of these collectors and the knowledge they possess about the different kinds of shellfish inhabiting the streams and rivers, it is clear they prefer to harvest *Pachychilus* rather than mussels, which occupy the same local waterways.

It should be noted that the men taking part in this preliminary study of modern Maya usage of *Nephronaias* represent only a small portion (5 out of more than 700) of the total number of residents living in San Antonio. It must also be taken into account that women, children, and the elderly were not surveyed to see whether they collected the mussels. For *Pachychilus* consumption Healy et al. (1990:178–180) found that only the elderly in San Antonio village would admit to eating this snail soup. This suggests that more accurate data are needed from a wider segment of San Antonio village, including both sexes and different age groups, on harvesting freshwater shellfish. Such a survey might offer other insights into procurement methods as well as contemporary Maya food preparations.

The inhabitants of the village of Indian Church, located adjacent to the archaeological reserve of Lamanai, in northern Belize, consume freshwater clams on an irregular basis. The *Nephronaias* mussels are gathered by both

Maya and mestizo families from the New River Lagoon and are boiled into soups on special occasions (Carlos Godoy, personal communication 1999). The residents of Indian Church eat both mussels and *Pachychilus* for the same kinds of familial and communal purposes. Both sexes from all age groups partake in the consumption of clam soup.

Despite the modern preference for one freshwater mollusc over another, *Nephronaias* was clearly exploited by the ancient Maya. In addition to their dietary and decorative uses *Nephronaias* shells could have been ground up and used as temper in pottery, as the present-day Kekchi Maya of southern Belize do (Healy et al. 1990:171; Hughes Hallett 1972). *Nephronaias* shells may also have been ground up and slaked to form powdered lime to serve as an alkali for maize preparation as *Pachychilus* shells are used today among the Lacandón Maya of eastern Chiapas, Mexico (Nations 1979). Thompson (1970:112) reported that the Jicaque of Honduras used freshwater snails as a source of lime to chew with tobacco during the eighteenth century. Perhaps *Nephronaias* shells were similarly used in tobacco chewing during prehistoric times.

ARCHAEOLOGICAL USE AND DISTRIBUTION

Nephronaias remains have a broad spatial and temporal patterning in the Maya lowlands. They are recovered from all major periods of occupation, including the Preclassic, Classic, and Postclassic periods. Several sites have produced evidence of the use of *Nephronaias* spp. and are listed in Table 8.1. The selected sites document a continuous exploitation of freshwater mussels across the Maya area from the early Middle Preclassic (900–600 B.C.) through the Late Postclassic (A.D. 1200–1550) period. The majority of excavated *Nephronaias* shells are derived from elite and nonelite domestic contexts and are often associated with residential household middens, but this material is also frequently found in mixed construction core as well.

In these latter contexts the discarded valves are generally found broken and fragmented with only a portion of the hinge remaining intact. The determination of function for these fragmented remains is obscured by a number of factors. The fragmentation may have been caused by the ancient Maya breaking the shell for the extraction of the meat prior to discard. The valve bodies may have broken into various sizes on impact when they were tossed into the middens. Post-depositional processes such as high acid levels in the soil and rodent burrowing may have caused disintegration and poor preservation of the shells (Stanchly this volume), especially if juvenile ones were discarded. It is also possible that only a specific portion of the valve was required for artifact manufacture and that the hinge alone was useless and discarded.

The recovery of large quantities of intact or unmodified valves in primary household midden contexts indicates that they were prepared and used as a food source (see Andrews 1969:59; Healy et al. 1990:175). Many of the midden deposits that contain *Nephronaias* remains have been dated to the Middle Preclassic (900–400 B.C.) and Late Preclassic (400 B.C.–A.D. 250) periods at the sites of Barton Ramie, Cahal Pech, Colha, and Pacbitún. These freshwater bivalves are often recovered in association with both *Pomacea* and *Pachychilus* snails, all three of which were collected from the same rivers and streams. For example, a late Middle Preclassic midden deposit excavated in the Tolok Group at Cahal Pech contained 2,143 *Nephronaias* remains along with 605 *Pachychilus* and 159 *Pomacea* snails (Powis and Hohmann 1995:48–62; Powis et al. 1999:369). The mussels were found stacked on top of each other and tossed beside the broken remains of the freshwater snails. Both the *Pomacea* and *Pachychilus* showed evidence that they were intentionally cracked open for meat removal. The shells of *Pachychilus* consistently exhibited a broken apex and/or punctured spire that would have severed the attachment of the snail to its shell for removal (Healy et al. 1990:175; Stanchly 1995:131). These broken or punctured spires indicate prepara-

tion of the snails by the Maya for cooking purposes. Recent excavations in Plaza B at Pacbitún have revealed approximately 1,500 *Nephronaias* valves in association with more than 230,000 *Pachychilus* snails from several Middle Preclassic midden deposits (Hohmann and Powis 1996:121; Powis et al. 1999:369; Stanchly et al. 2004:9). Forty-three *Nephronaias* beads of various forms have also been recovered from midden contexts at Pacbitún. They were associated with more than 3,100 shell beads, chert micro-drills, and shell detritus, suggesting the presence of shell ornament production during the Middle Preclassic period at the site (Hohmann and Powis 1999:11).

In addition to the recovery of *Nephronaias* shells from Preclassic household midden deposits, specimens have been found in ceremonial/ritual contexts. For example, at the site of Blackman Eddy, a Middle Preclassic ritual deposit containing approximately 12,500 *Nephronaias* valves was found at bedrock below Structure B1. The discarded valves were found intact and layered inside a basin-shaped depression along with hundreds of *Pomacea* and *Pachychilus* snails (Garber et al. 1998:9). Another example includes a perforated *Nephronaias* valve dating to the early Late Preclassic (400–200 B.C.) period, which was found in Burial 34 at Cuella (Hammond 1991:186) (Figure 8.3). This pendant was located over the pelvis of an adult male and may have served as a pubic shield (Robin 1989:224–225). At Colha six Middle Preclassic (900–300 B.C.) burials from Operation 2012 contained a total of 12 *Nephronaias* beads of various forms (Dreiss 1994:178–180). Four perforated specimens belonging to *Psoroniaias semigranosus*, which are related to *Nephronaias*, were recorded from a Late Preclassic tomb at Dzibilchaltún (Andrews 1969:3). To date, these modified specimens from Dzibilchaltún represent the only Preclassic examples of the species *Psoroniaias* identified in the lowlands.

There appears to be a temporal trend or shift in the use of the mussels for social rather than dietary purposes sometime in the Late Preclassic/Early Classic transition (ca. A.D. 200–400) (Andrews 1969:59; Pohl 1985a:109). At Bar-

ton Ramie, Willey et al. (1965:527) observed that "[i]n somewhat curious contradistinction to their Preclassic occurrence in refuse debris, the *Nephronaias* shells were fashioned into artifacts only in the Classic period." Numerous examples have been recorded for the social use of *Nephronaias* shells in Classic period Maya society (see Table 8.1). Perforated valves with holes drilled near the hinges for suspension and used as pendants persist into the Early and Late Clas-

sic period. In fact, there is an increase in the number of these modified shells recovered from burials at this time, including eight at Barton Ramie (Willey et al. 1965:504, 507, 526–527), five at Cahal Pech (Aimers 1992:7; Iannone 1994:57; Powis 1996:B-2; Stanchly 1994:117) (Figure 8.4a), one at Dzibilchaltún (Taschek 1994:35), and 10 at San José (Thompson 1939:180).

There is also an increase in the number of shells exhibiting exterior surface grinding or smoothing. They are cut into various types of artifacts, such as beads, pendants, rings, mosaics, and inlays. The nacreous artifacts, particularly inlays and rings, are most widely distributed in the Late Classic (A.D. 250–900) period. Examples include two thin, quadrangular-shaped inlays found in a Late Classic burial (Burial 2 in the peripheral Tolok Group) at Cahal Pech (Powis 1996:46) (Figure 8.4b); four rings and a pendant from Classic period Burial 130 at Cuello (Hammond 1991:186; Robin 1989:387–388) (Figure 8.5); and a beautifully decorated *Nephronaias* shell pendant found in a Late Classic elite burial (Tomb E-1/1) at Altun Ha (Figure 8.6). This last specimen was carved in a cruciform shape with a ball at the base of the cross, and the upper portion was carved with a death's head (?) jaw (Pendergast 1990a:34).

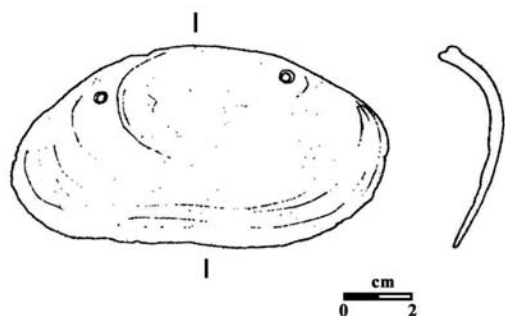


Figure 8.3. *Nephronaias* valve perforated for use as a pendant (SF# 1427) from Late Preclassic Burial 34 at Cuello, Belize. Drawings by Sheena Howarth, courtesy of Norman Hammond. Reprinted with the permission of Cambridge University Press.

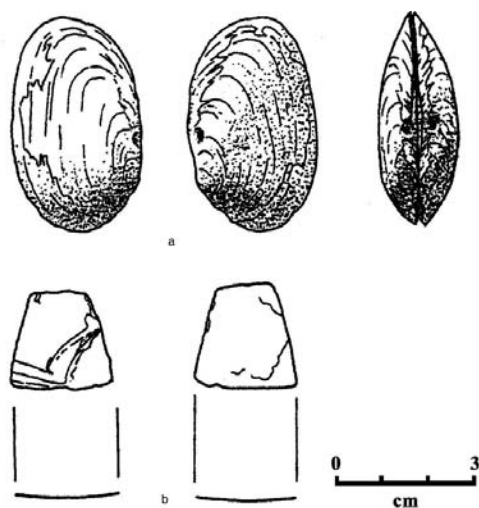


Figure 8.4. Three artifacts recovered from Late Classic Burial 2 at the Tolok Group, Cahal Pech, Belize: (a) *Nephronaias* valves with perforations for use as a pendant; (b) two quadrangular-shaped shell inlays. Drawings by Ruth Dickau. Reprinted courtesy of Paul F. Healy.

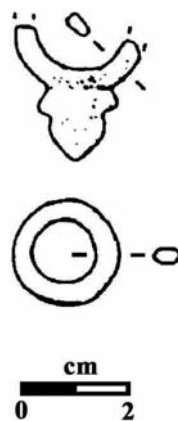


Figure 8.5. *Nephronaias* nacre artifacts: (a) pendant (SF# 1295) and (b) ring (SF# 1294) from Classic period Burial 130 at Cuello, Belize. Drawing by Sheena Howarth, courtesy of Norman Hammond. Reprinted with permission of Cambridge University Press.

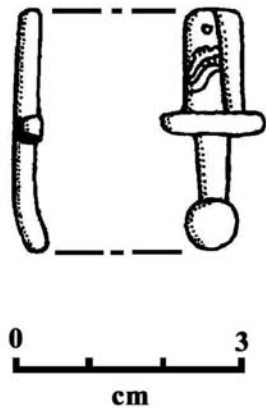


Figure 8.6. *Nephronaias* shell pendant carved in shape of a cruciform from Late Classic Tomb E-1/1 at Altun Ha, Belize. Drawing by David Findlay. Reprinted courtesy of David M. Pendergast.

The data presented above strongly suggest that the highest frequency of *Nephronaias* utilization by the Maya was during the Preclassic period. Although their popularity as a food source appears to have declined steadily into the Classic period, *Nephronaias* shells were still collected during this later period, albeit on a much smaller scale for mostly nondietary purposes. What we may be seeing, then, is a change in ideology in the ways in which *Nephronaias* was regarded, with Preclassic dietary use being gradually replaced by Classic period ritual use. The lower numbers used in Classic times may also reflect post-depositional processes, research strategies, sampling strategies, quantification issues, and harvest pressure of mussel populations. As an example of how the numbers have shifted, Table 8.3 provides a list of sites with *Nephronaias* remains dating to the Preclassic, Classic, and Postclassic periods. As Table 8.3 shows, a total of 20,395 specimens were found in Preclassic domestic midden contexts, whereas only 175 specimens were recovered from Classic period domestic contexts. Although the sample size from Blackman Eddy ($n = 12,500$) is disproportionately large compared to the other sites combined ($n = 7,895$), the consumption of *Nephronaias* by the Maya is still significantly higher in the Preclassic than in the Classic period. Further-

more, within the Preclassic sample 99.7 percent of the total mussel remains listed (20,395 out of 20,463) were unmodified and used for consumption purposes. Comparatively, only 64 percent of the entire Classic period sample (175 out of 274) was unmodified and used as food sources. Clearly, there is a marked decline across time in the overall use of the mussel as a food item. At the same time, there is a slight increase in the number of modified *Nephronaias* produced from the Preclassic ($n = 68$) to the Classic ($n = 99$) but a subsequent decline again during the Postclassic period.

The quantitative comparison presented above is preliminary in nature, as *Nephronaias* shells are not represented as either percentages of total shell in the archaeological assemblages or as a proportion of the total faunal assemblage from the sites listed in Table 8.3. This is because very few archaeological reports over the past 50 years have documented such information in detail to quantify modified and unmodified clam shells in various contexts through time. If it were possible to have these percentages of *Nephronaias* from Preclassic to Postclassic times for each of the sites listed in Table 8.3, then we would be able to obtain a more precise indication of how important this clam was to the ancient Maya. Therefore, it is important to understand that the quantification issue is a difficult one, especially for comparing shell assemblages and contexts at the intra- and intersite levels, but that does not negate the importance of such a perspective in a preliminary review such as this one.

DISCUSSION AND CONCLUSIONS

Traditionally, Maya zooarchaeological studies of molluscs have tended to focus on the exploitation of marine shellfish, with only occasional reference to the importance of freshwater shellfish in the archaeological record. Within the past two decades the recovery of large quantities of these freshwater invertebrates in a variety of primary contexts, both domestic and nondomestic, has led a few researchers to examine more closely the nature and extent of their exploitation as both food and ritual items by the ancient Maya.

Table 8.3. Frequencies of Unmodified and Modified *Nephronaias* spp. Remains from Selected Maya Sites Mentioned in Text

Site	Preclassic		Classic		Postclassic		Totals
	Unmodified	Modified	Unmodified	Modified	Unmodified	Modified	
Altar de Sacrificios	0	0	5	1	0	0	6
Altun Ha	0	0	6	9	0	0	15
Barton Ramie	765	0	0	8	0	0	773
Blackman Eddy	12,500	0	0	0	0	0	12,500
Cahal Pech	5,205	0	0	5	0	0	5,205
Caracol	0	0	44	13	0	0	57
Chichén Itzá	0	0	0	0	54	0	54
Colha	285	12	0	1	0	0	298
Cuello	0	4	0	5	0	0	9
Dzibilchaltún	3	4	0	0	0	0	7
Mayapan	0	0	0	0	0	1	1
Pacbitún	1,500	43	0	0	0	0	1,543
Quiroz Cave	0	0	0	47	0	0	47
San José	0	5	0	6	0	0	11
Seibal	30	0	0	0	0	0	30
Tikal	112	0	113	0	3	0	228
Uaxactún	0	0	0	0	0	0	N/A
Uxmal	0	0	7	4	0	0	11
Totals	20,395	68	175	99	57	1	20,795

Up to the present, studies have concentrated primarily on the Classic period use of freshwater snails (Healy et al. 1990; Moholy-Nagy 1978; Stanchly and Iannone 1997).

This preliminary study indicates that the ancient Maya also exploited freshwater mussels. There is evidence to suggest the continuous exploitation of this pelecypod fauna for more than 25 centuries, spanning the early Middle Preclassic through the Late Postclassic. The presence of intact valves in a number of Preclassic household middens strongly indicates that *Nephronaias* shells were specifically collected for gastronomic purposes at that time.

Based on the archaeological evidence, *Nephronaias* was most heavily exploited during the Middle and Late Preclassic periods for dietary purposes. Judging from isotopic data, however,

freshwater shellfish played a minor role in the Preclassic Maya subsistence regime overall. Given the large numbers needed to fulfill the daily protein requirements for a family or a community, *Nephronaias* was most likely used to supplement the Maya diet. Furthermore, given the difficulties of subsisting solely on molluscs, it seems more likely that *Nephronaias* served as a dietary supplement or famine food (Healy et al. 1990:178; Meighan 1969:420; Moholy-Nagy 1978:71; Parmalee and Klippel 1974:432). This viewpoint is echoed by Moholy-Nagy (1978:71), who has stated that "even the few grams of protein provided by *Pomacea* snails could have been an important supplement to people living on a marginal diet."

In times of environmental crisis *Nephronaias*, along with *Pachychilus* and *Pomacea*, may have

served a more important dietary role than in years when food was abundant. The additional protein derived from the freshwater mussels could have been particularly important, given the increasing reliance over time on plant foods by the Preclassic Maya (White et al. 1996). It has also been noted that such supplementary food resources may have been especially significant at times when the meat of other animals was not obtainable, such as following unsuccessful hunting expeditions (Healy et al. 1990:178). Therefore, it is suggested that this mussel, although important, was supplemental in nature and was not a staple food source during either the Preclassic, Classic, or Postclassic period. The isotopic data from Cahal Pech reinforce this conclusion, but additional studies are needed from other early Maya sites with *Nephronaias* remains to show whether freshwater shellfish (including *Pachychilus* and *Pomacea*) contributed more significantly to the Preclassic Maya diet.

Throughout the Preclassic period there was a decline in the number of *Nephronaias* being used as a food resource. Their reduced numbers across the lowlands may signal a shift away from mussels being consumed for dietary purposes. This change, whether deliberate or not, occurred sometime during the Late Preclassic/Early Classic transition. Pohl (1985a:109) has suggested that the change from dietary to social use for several of the freshwater mollusc species, including *Nephronaias*, may have been related to changes in food processing, refuse disposal, and/or a deliberate decision made by the Classic period Maya elite. Although the suggestions by Pohl (1985a:109) are thought-provoking, there is no clear understanding as to why there was a shift in the use of *Nephronaias* from food items to ritual and ornamental items. The mussels were consistently eaten for centuries, so they must have been palatable to the ancient Maya. Why, then, were the mussels increasingly less relied on during the Classic period for food when human population pressures were rising and potential aquatic and terrestrial resources were on the decline?

The shift to social use for *Nephronaias* in the Classic period may have had more to do with

their relationship with Maya ideas of cosmology. In Classic times the shell was often associated with death and the underworld, as well as with water and the moon goddess Ixchel (Andrews 1969:48). Depictions of shells, especially marine, in hieroglyphic writing (used as the basic glyph for zero), mural paintings, codex representations, polychrome vessels (painted underworld scenes), and cave paintings suggest that they were highly valued and imbued with ritual significance by Classic period elites (Coe 1978; Miller 1986; Spinden 1957; Stuart 1981). According to Andrews (1969:48) the Maya “seem to have endowed the marine mollusc with magic or symbolic properties which led to a number of ritual usages.”

Although many researchers have observed the importance of marine shells in Maya religious beliefs and customs, it should be stressed that freshwater shells have similarly been depicted in pieces of Maya artwork. Indeed, Emery (1986:80) has noted that many renditions of shells in Classic Maya artwork illustrate the association between gods and certain shells without any particular identifying features. This information indicates that shells represented a revered item regardless of their aquatic origin. Many examples of the uses of freshwater shells in ritual contexts have already been presented in this chapter, and they, like marine shells, are strongly tied to water symbolism in Maya cosmology. A good example of freshwater shells reflecting the idea of water symbolism comes from a ritual deposit containing thousands of freshwater mussels and snails found at the base of Structure B1 at Blackman Eddy. The basin-shaped deposit contained alternating layers of freshwater shells with small *Pachychilus* placed predominantly at the base, clam shells placed in the next layer, and large *Pachychilus* and *Pomacea* snails layered on top (Garber et al. 1998:9). Freidel et al. (1993:234) have said that the Maya “deposited precious caches that remade the Primordial Sea under the floors of their buildings,” and such deposits, like the one located beneath Structure B1 at Blackman Eddy, signify, according to Garber et al. (1998:10), creation myth reenactments.

By the Classic period there was a clear emphasis on the use of *Nephronaias* shells for both ritual and ornamental purposes. They remained as subsistence items but only marginally compared to earlier times. These shell artifacts, cut into various forms, such as beads, pendants, inlays, and rings, were now being deposited primarily in burials and dedicatory caches. In Postclassic times mussel shells continued to be used in ritual offerings, but they were also occasionally found in midden contexts at Lamanai, for example (Norbert Stanchly, personal communication 1999).

FUTURE RESEARCH

Four avenues of future research involve a more detailed examination of both the archaeological and modern uses of *Nephronaias* spp. First, given the taxonomic difficulty involving the various *Nephronaias* species, further research by, and discussions with, malacologists on modern specimens should be performed to clarify their identification to the species level (see Emery, chapter 2, this volume). Until the taxonomy is clear, archaeologists should identify these remains only to the genus level. Second, more data need to be gathered on different segments of modern Maya populations, especially the elderly, who have shown with the *Pachychilus* study that they still eat freshwater shellfish. This line of inquiry might allow both zooarchaeologists and archaeologists to develop a better understanding of the role this freshwater mussel once played in ancient Maya society. Third, additional data should also be collected on the local ecology of *Nephronaias* in different regions of the lowlands to determine specific habitat preferences and population densities. Last, more research is needed on the Postclassic use of *Nephronaias*. Clearly, the Maya utilized them throughout the Postclassic period, but with such little published information on their distribution and use during this time few observations can be made. It is hoped that with an emphasis placed on the collection of *Nephronaias* remains from Postclassic contexts researchers will be better able to identify general patterns of use, both as food and ritual items.

Another direction, not fully addressed in this chapter, is how ancient Maya communities would have prepared the mussels for consumption. Were mussels boiled in soups like *Pachychilus*, or were they prepared differently by being roasted, baked, steamed, or cracked open by using a shucking tool? What kind of damage would have been caused by these different opening methods? There are many ways to prepare freshwater shellfish, so it is important to establish some of the cooking techniques that may have been employed in ancient times by examining how Maya households perform such culinary acts today. It would be of interest to know the age and sex of those persons who procured, prepared, and consumed the mussels, whether on a seasonal or year-round basis. Furthermore, were the mussels eaten fresh, or were they dried and stored for later consumption in times of crisis? Were freshwater mussels exploited for familial purposes only, or were they also traded locally within the community or, perhaps, regionally? If the latter, what was the method of preparation and presentation (for example, salt drying or smoking), and how were they transported? Were the meat and the shell traded together or separately?

These kinds of questions need to be more fully addressed so that we can gather better information on the nature and extent of the exploitation of freshwater mussels by the ancient Maya. In this way archaeologists can gain additional insights into the development of certain trends, such as the temporal shift from the use of mussels as food in the Preclassic to their use as ritual and ornamental items in the Classic and Postclassic periods.

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Feast, Field, and Forest

Deer and Dog Diets at Lagartero, Tikal, and Copán

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The issue of animal domestication among the Maya has traditionally been approached using evidence from ethnohistory, artistic representation, and a wide variety of zooarchaeological analytical techniques. These lines of evidence have led to the belief that dogs were domesticated and to the speculation that deer husbandry may have been practiced. Both genera are frequently found in archaeological contexts and are also prominent in symbol and ritual. This chapter introduces another form of data to augment and refine current interpretations of human-animal relationships among the Maya. Stable carbon and nitrogen isotopes from bone collagen are used to determine the diets of these animals. Because maize is the known agricultural staple of the Maya, and most wild plants have a different isotopic signature from maize, we assume that animals that consumed the greatest quantities of maize will also be those most purposefully fed.

This study focuses on Late Classic data ($n_{\text{deer}} = 8$, $n_{\text{dogs}} = 6$) from a Lagartero midden that appears to represent a single feasting event and on data from a variety of contexts at Copán ($n_{\text{deer}} = 20$, $n_{\text{dogs}} = 2$) and Tikal ($n_{\text{deer}} = 5$, $n_{\text{dogs}} = 1$). With the exception of one feral animal, dogs from all sites are consuming significant quantities of maize. Most deer appear to have been wild. However, some deer at Lagartero had almost pure maize diets, suggestive of purposeful feeding, and some at Copán had a dietary maize component that would be consistent with occasional crop grazing. In order to contextualize these data both regionally and temporally, they are compared with data from other Maya sites, including Cuello, Colha, Lamanai, and Pacbitún (Figure 9.1).

The Maya are distinctive among ancient Mesoamerican cultures in the degree to which they incorporated animals into their art, archi-

tecture, and, one might assume, their world-view and daily life as well. Some paintings seem to represent mythological themes, such as a corpus of pots including the Late Classic vase from Actún Polbilche cave (Figure 9.2) showing the deer hunter and ballgame god (Hellmuth 1986) ambushing a stag ridden by a woman and showing a dwarf who is holding a spindle and unspun cotton. Others, such as figurines depicting women holding dogs (Figure 9.3), appear more true to life, given the early ethnohistoric accounts of women raising dogs, dancing with them at festivals, or sacrificing them in cacao orchard ceremonies (see Pohl and Feldman 1982; Tozzer 1941). Defining the precise nature of Maya relationships with animals has been difficult, however. Their only acknowledged domesticates are the dog (see, e.g., Shaw 1991, 1995b; Wing and Scudder 1991) and the turkey (Hamblin 1984; Kerr 2001).

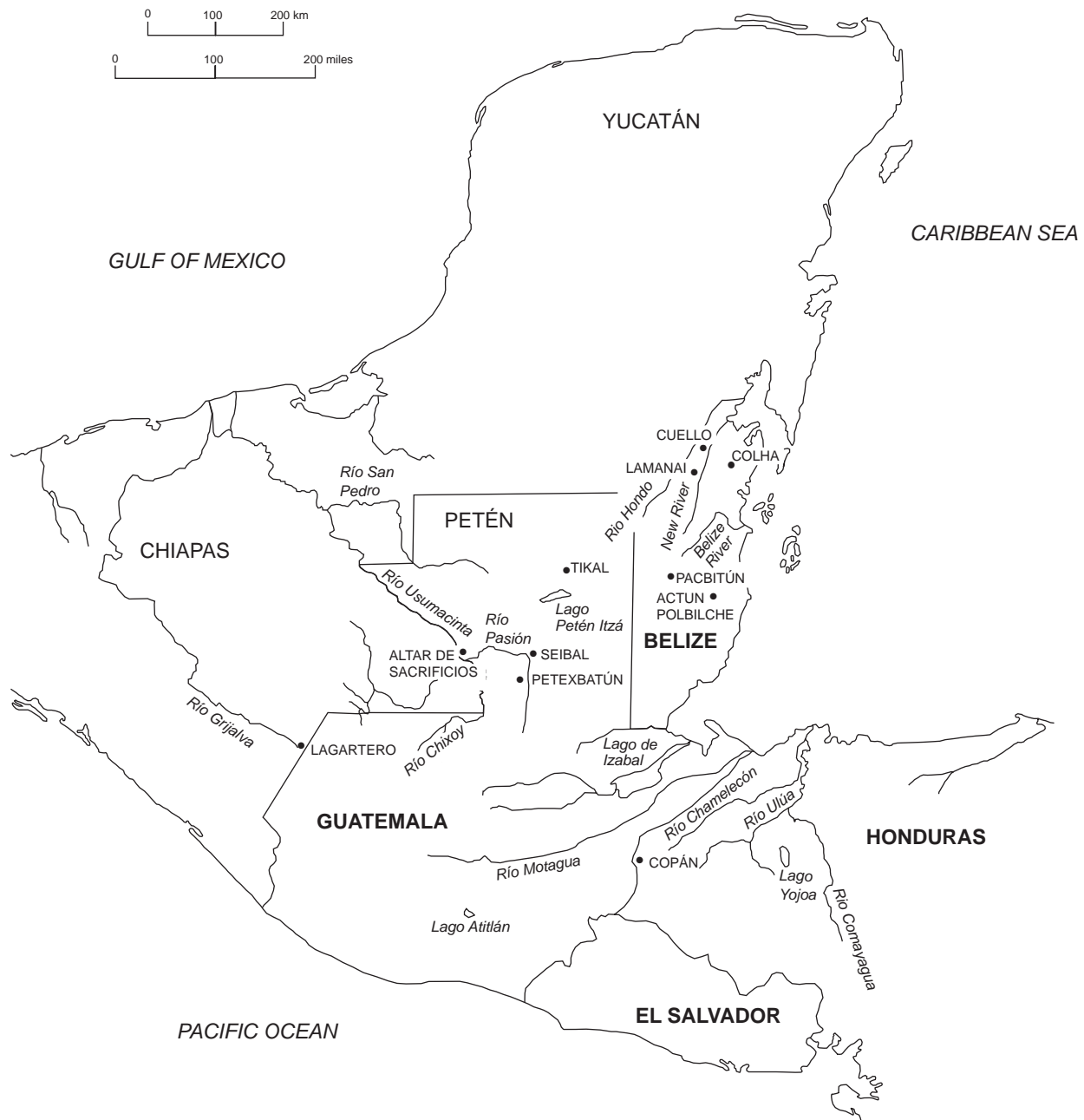


Figure 9.1. Map showing sites mentioned in chapter text.

Stable isotope analysis has the potential to provide a new dimension to the investigation of Maya relationships with animals through an examination of diet. Analysis of bone collagen from animals such as deer and dogs will allow us to determine the diets of these animals

because the food of domesticates vs. wild animals likely had substantially different stable isotopic compositions, which would be recorded in the carbon and nitrogen of the collagen. Although dependency on humans for survival is a primary condition for domestication, dietary

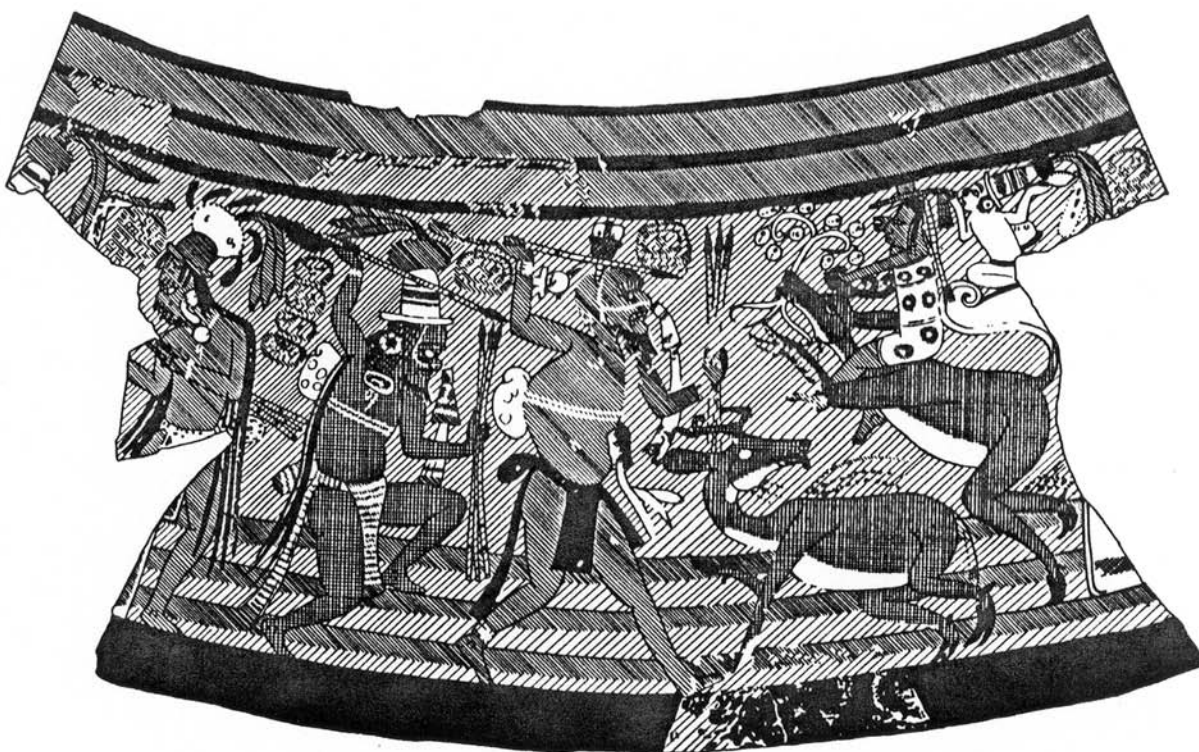


Figure 9.2. Late Classic polychrome vase from the cave of Actún Polbilche, Belize, showing a mythological deer hunt that may have been an ancient water rite. Cotton held by the dwarf may signify rain clouds and fertility. Possible squashes tied to the backs of the hunters may refer to the fact that squash expands rapidly after a rain. Illustration courtesy of David Pendergast.



Figure 9.3. Late Classic figurine from Altar de Sacrificios shows a woman dressed in ceremonial robes holding a dog and a drinking cup (Willey 1972: Figure 34f). Copyright 1972 by the President and Fellows of Harvard College.

dependency alone may not be a necessary and sufficient condition. For example, dependent scavengers such as commensal animals could not be considered domesticated and may not be easily distinguished from animals that are purposefully fed. Similarly, animals that are purposefully fed may or may not have the same diets as humans, depending on whether or not they are being fed "human" food. Regardless, we assume that there is a continuum of human control over animal feeding that relates to domestication. Because maize was the agricultural staple of the Maya, it was probably fed to animals that they were tending intensively. Our rationale is that relatively high maize consumption and low dietary variability should indicate a close relationship between animals and humans and perhaps imply purposeful feeding. We assume that purposeful feeding for ideological reasons represents the most controlled form of animal feeding and should result in the most restricted diets. At the other end of the spectrum relatively low maize consumption should indicate a wild state. Diets intermediate to those of wild animals and humans should indicate a looser bond (e.g., a type of semidomestication, or occasional scavenging from garbage or maize fields bordering naturally wild areas). The use of stable isotope analysis thus may allow us to evaluate variables such as animals' dependency on humans for food in assessing human-animal relationships. This approach would be particularly useful in the New World, where many animals may not have undergone skeletal changes as a result of their association with humans, as was more the norm in the Old World. Our experiment with stable isotope analysis is an example of the potential that analysis of animal bone holds. We present evidence here that some deer and dogs were fed special maize diets in preparation for use of the animals in ritual contexts.

Another innovative application of the stable isotopic technique to Mesoamerican zooarchaeology is the study of deer bones from the period of the Maya "collapse" in the Petexbatún region of Petén, Guatemala, which demonstrated that agricultural degradation was not a cause of the

disappearance of the political elite (Emery 1997, chapter 6 this volume; Emery et al. 2000). Maize production, as indicated by consumption of maize by deer browsing in fields, remained stable through the period when elite culture disappeared. The continued presence of small-scale agricultural producers is demonstrated by such behavior. Our data also have the potential to provide insight into agricultural practices and human impact on the environment: the data on wild deer from Classic Maya contexts suggest that population densities and farming impacts might not have been as high as Mayanists have assumed in recent times.

SAMPLE DESCRIPTION

We chose to focus our study on deer and dog bones. Dogs were definitely domesticated, and the Maya used them for guarding their homes, for hunting, and for food, according to prehistoric art, ethnohistoric reports, and cut marks on the bones indicating butchering (Pohl 1990; Pohl and Feldman 1982). The question of deer domestication has generated considerable debate. Early ethnohistoric data suggest that deer were tamed and kept in household compounds or, if not actually fully domesticated, trained (at least on occasion) to gather in specific locations beyond the settlements (Pohl and Feldman 1982). Although possible animal pens have been discovered in archaeological excavations (e.g., Hamblin 1984; Pohl 1990; Rice 1993), no zooarchaeological evidence for domestication has been uncovered. Moreover, previous stable carbon isotopic analyses of Preclassic period deer bones at Cuello (van der Merwe et al. 2000) and Classic period deer bones from Petexbatún (Emery 1997; Emery et al. 2000) did not reveal any evidence for domestication.

Deer and dog bones from the site of Lagartero (Ekholm 1979) present an unusual opportunity to revisit the question of Maya relationships with deer and dogs (Figure 9.4). This site had an unusual refuse pit at the south base of a long pyramidal building platform (Mound 7a) on the south side of the northwest plaza. The pit appeared to represent the ceremonial dumping of

artifacts and animal remains over a fairly limited period in Late Classic times, possibly in connection with some kind of end-of-cycle ceremony such as a calendrical or political event. Excavators uncovered half a million potsherds, about ten thousand of which were special polychrome serving pieces, in a 24 x 10-m zone of concentrated refuse up to 2.6 m deep. The most outstanding artifacts were the figurines, which included more than one hundred representations of dogs and an unusually high percentage of women wearing elaborately decorated clothing and making hand gestures. Ekholm (1979) notes that the Lagartero area is in a significant cotton-growing and textile-production zone, the fame of which can be documented back to the Colonial period. She suggests that fabric production may have been the basis of wealth at Lagartero in prehistoric times, since the figurines emphasize the beauty of the costumes, and

many of the figurines bear traces of textiles imprinted on them.

The animal bones, many of which were burned along with the earth below them, were largely deer and dog, but a variety of species was represented including reptiles (such as turtles and lizards), birds and amphibians, as well as mammals. This species breadth is related to the Maya worldview encompassing what Hopkins (1980) has deduced are the four classes of creatures recognized by the Maya: walkers, fliers, crawlers, and swimmers. These four animal categories are specified in offerings in the Dresden Codex, a Postclassic period sacred, painted-bark book that was most likely based on similar documents from the Classic period (see Reifler-Bricker 1990). These categories appear to survive today in, for example, the Chuj (Hopkins 1980) and possibly the Tzeltal Maya groups (Hunn 1977) of Highland Guatemala and Mexico.

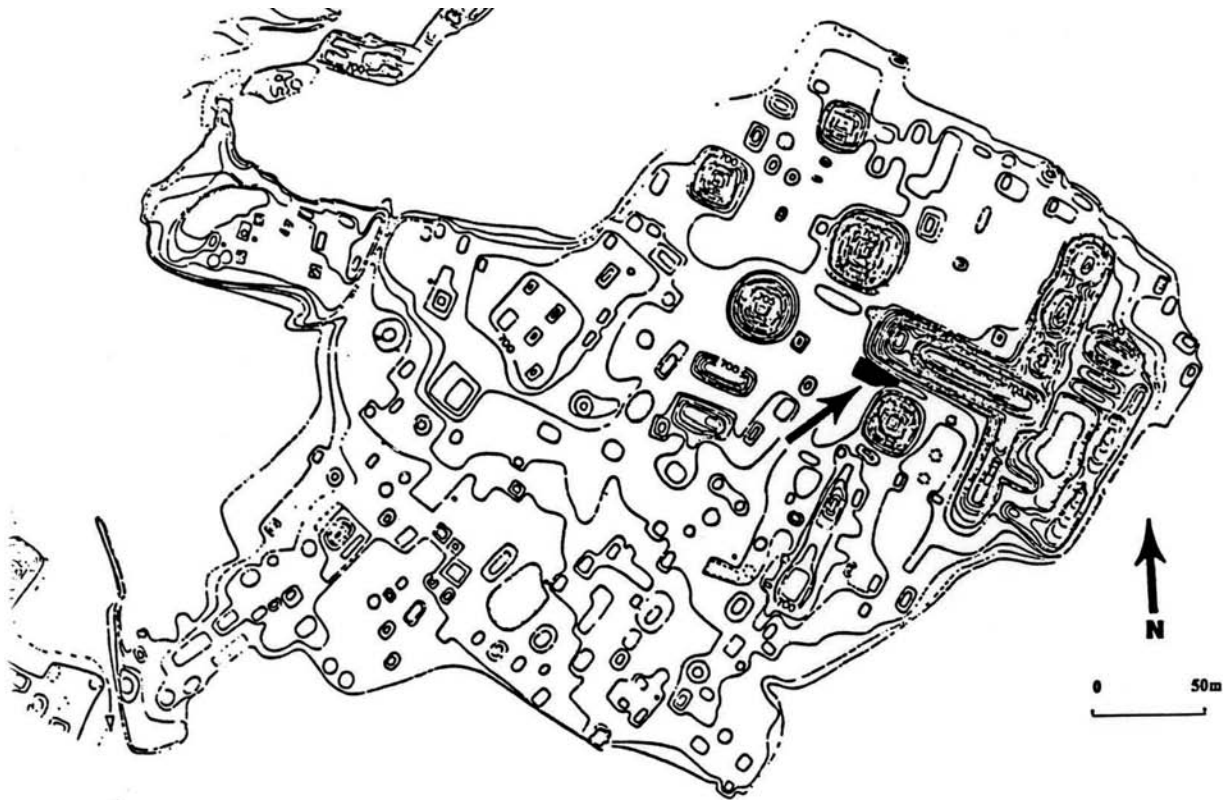


Figure 9.4. Map of the ceremonial center (Limal Group) at Lagartero. Location of the midden described in this chapter is marked with an arrow. Adapted from map provided by S. Ekholm.

Whatever the ceremony or ceremonies represented at Lagartero, it is clear that the refuse dump was the end result of a tremendous amount of planning and logistical finesse and was, we thought, most likely to have evidence of special treatment of animals. Accordingly, we analyzed eight samples of deer and six samples of dog from the Lagartero dump. Unfortunately, we do not have material from other refuse areas in Lagartero to use for comparison.

We have compared the Lagartero data to animal bones from Tikal and Copán. The Tikal bones consisted of one Preclassic (Tzec-Chuen) dog bone (specimen 12P 474/163) from a chultun or natural limestone pit (Chultun 5D6) deep in the excavations of the North Acropolis. The deer bones spanned a range of dates. The one brocket deer (*Mazama*) bone (Specimen 41 A-20/23) was associated with Late Preclassic (mostly Chuen) fill sealed under an early floor in the West Plaza. The other deer were all white-tailed (*Odocoileus*). Specimen 3C-16/7 came from an Early Classic (Manik, Late Facet) context in a chultun. Specimen 29C-2/3 came from a chultun with Ik-Imix associations, and Specimen 68I-47/28 also dated to the Late Classic (Imix) period, when the site of Tikal was at the peak of its power. Finally, five specimens (97D-54/12, 98F-6a-8/6, 98K-31, 98K-10/4, and 99A-18/4) came from the Terminal Late Classic Eznab midden, which was deposited by late peoples reoccupying the former royal residential area (Group 5D-11) after the abandonment of the Tikal site center. These Tikal bones, especially the chultun materials, appear to represent household trash.

The Copán materials included 20 white-tailed deer bones and 2 dog bones from structures in the pocket outside the Copán site center. All of the occupation dated to the Terminal Late Classic Coner phase. The area CV 43 was a fairly large plaza group interpreted as an extended family compound with servants' quarters that included CV 45. The area CV 20 was a medium-sized plaza group with a religious and administrative building. The bones from these Copán pocket excavations were also probably general midden refuse.

We can compare the data from Lagartero, Tikal, and Copán with literature from other sites and periods, that is, Preclassic Colha (White et al. 2001), Preclassic Cuello (van der Merwe et al. 2000), Classic Pacbitún (White et al. 1993), and Postclassic/Historic Lamanai (White and Schwarcz 1989).

THEORETICAL BACKGROUND

Stable isotope analysis for diet reconstruction is based on variation in carbon- and nitrogen-isotope ratios at the bottom of the food chain and the systematic "fractionation" of those ratios upward in the food chain. Plants create the most basic level of isotopic variation by selectively incorporating or excluding atmospheric ^{13}C during photosynthesis. Plants that discriminate the most against ^{13}C during photosynthesis are called C_3 plants and have an average $\delta^{13}\text{C}$ value of -26.5‰ (O'Leary 1988; Smith and Epstein 1971). Wild plants, trees, nuts, fruits, and vegetables in the Maya area would fall into this category. Plants that incorporate more ^{13}C during photosynthesis are called C_4 plants and have an average value of -12.5‰ (O'Leary 1988). Most C_4 plants are tropical grasses, the most important of which was maize in the Maya area. The plant $\delta^{13}\text{C}$ values listed above were obtained from modern specimens. The $\delta^{13}\text{C}$ values of ancient Maya plants should have been more positive, given the subsequent $\sim 1.5\text{‰}$ decrease in the $\delta^{13}\text{C}$ value of atmospheric CO_2 that has occurred because of fossil fuel burning during the industrial era (Friedli et al. 1986; Marino and McElroy 1991).

The distribution of ranges in $\delta^{13}\text{C}$ values of C_3 vs. C_4 plants is bimodal (Lerman and Troughton 1975), so the relative dependency on one or the other plant type is evident in the tissues of their consumers. There is only one other category of plants (CAM or Crassulacean acid metabolism). These plants have more flexible photosynthetic processes, resulting in a range of $\delta^{13}\text{C}$ values that is inclusive of C_3 and C_4 plants (-17 to -12‰). Some CAM plants could have been consumed by the Maya (e.g., nopal cactus and piñuela), but they are not thought to

have been a major food source for humans, deer, and dogs.

Figure 9.5 illustrates the range of isotopic values for the food sources available to the Maya. Maize (a C_4 plant) has been established as the staple crop of the Maya through stable isotope analysis of human skeletal material (Gerry and Krueger 1997; Reed 1994; Tykot et al. 1996; White 1997; White et al. 1993; White and Schwarcz 1989; Wright 1994, 1997a), as well as through ethnohistorical accounts (Landa 1566, in Hellmuth 1977; Marcus 1982; Tozzer 1941) and paleobotany (Crane 1986; Lentz 1991; Miksicek et al. 1981; Pohl et al. 1996; Rue 1987).

Domesticated animals (e.g., dogs and turkeys) would have a significant C_4 component to their diets. Notably, as omnivores dogs may have consumed the meat (or feces) of other animals. Consequently, their $\delta^{13}C$ values will reflect those of the consumed animals and their products. Dogs probably also consumed human food, which could have included not only terrestrial animals but also freshwater fish and snails (which are C_3 -like) and marine-reef resources (most of which are C_4 -like).

Wild terrestrial animals exploited by the Maya should, however, have been C_3 -feeding herbivores. Exceptions would be animals such

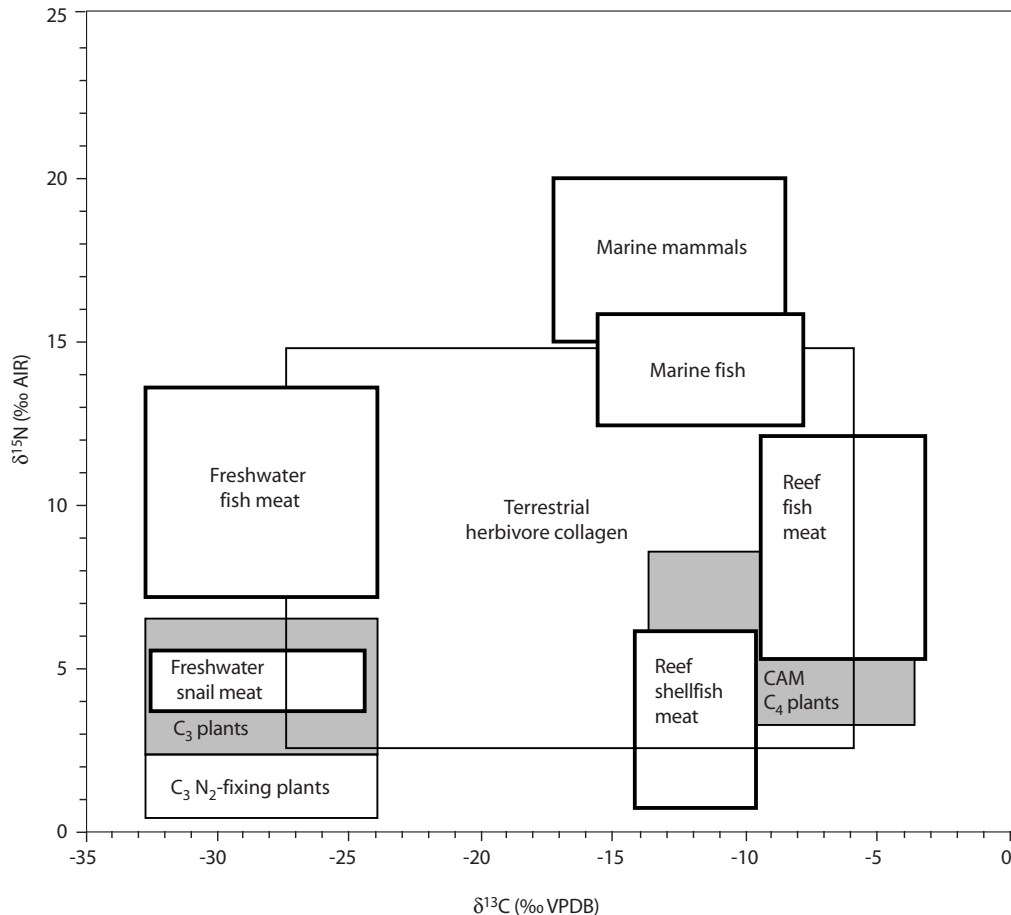


Figure 9.5. Theoretical model of major Maya food sources (after White et al. 2001). (Food values from Tykot, van der Merwe, and Hammond 1996; White and Schwarcz 1989; Wright 1994). Note that the $\delta^{13}C$ values are not adjusted for a diet-collagen offset ($\sim 5\text{‰}$) and the $\delta^{15}N$ values are not adjusted for trophic level ($\sim 3\text{‰}$).

as some deer and peccary that graze on maize fields bordering wild areas.

The component of bone analyzed here is collagen, which under most conditions dominantly represents the protein component of the diet (Ambrose and Norr 1993; Krueger and Sullivan 1984; Lee-Thorp et al. 1989; Tieszen and Fagre 1993). Both plant and animal protein contributed to the $\delta^{13}\text{C}$ values obtained in this research. Although under normal conditions dietary protein is routed to collagen during its synthesis, $\delta^{13}\text{C}$ values can only indicate whether the protein is from C_3 or C_4 sources. In theory nitrogen isotope ratios can be used to complement carbon isotope ratios. They provide more accurate estimates of the type of dietary protein (e.g., terrestrial vs. aquatic animals, legumes vs. other plants) and its level in the food chain. Nitrogen isotope ratios do not vary among plants, with the exception of legumes (e.g., beans, which likely were a part of Maya diets) and blue-green algae (which are abundant in the Caribbean Barrier Reef). These organisms have $\delta^{15}\text{N}$ values close to 0‰ because they fix nitrogen differently from other plants, which have $\delta^{15}\text{N}$ values ranging from 2‰ to 6‰. An enrichment of 3‰ to 4‰ in ^{15}N occurs in consumers as nitrogen passes from one level in the food chain to the next (DeNiro and Epstein 1981; Schoeninger 1985). Plants at the base of the marine food chain have $\delta^{15}\text{N}$ values about 4‰ higher than plants in terrestrial food webs (Wada et al. 1975), except for reef and mangrove ecosystems (like those that are abundant off the coast of Belize). The abundance of N-fixing blue-green algae in these systems produces $\delta^{15}\text{N}$ values that are like those of terrestrial systems (Capone and Carpenter 1982). For Maya ecologies freshwater fish tend to have higher $\delta^{15}\text{N}$ values than terrestrial animals or reef fish (Keegan 1992; Keegan and DeNiro 1988; Minagawa and Wada 1984; Wright 1994). The $\delta^{15}\text{N}$ values of terrestrial herbivores overlap with those of reef fish and shellfish, but they lie between those of freshwater fish and legumes (Wright and White 1996).

In contrast to the isotopically homogeneous reservoir of atmospheric CO_2 from which the $\delta^{13}\text{C}$ value of most food is derived, variations in the $\delta^{15}\text{N}$ values of food sources can be created

by variability in the ^{15}N content of the growth medium (Granhall 1981; Heaton 1987; Keegan and DeNiro 1988; Virginia and Delwiche 1982). For example, the use of fertilizer can affect $\delta^{15}\text{N}$ values (Peterson and Fry 1987; Tiessen et al. 1984; Turner et al. 1983). The Maya used a number of agricultural techniques, some of which would not have produced a fertilizer effect (e.g., the swidden system, which required constant movement from one area to another) and some of which could have (e.g., wetland fields, which were self-fertilizing, and terraces, which were intentionally fertilized using vegetative and human wastes) (Flannery 1982). Therefore, $\delta^{15}\text{N}$ values should be interpreted with caution.

METHOD

Collagen was extracted from bone using an adaptation of the procedure described by Longin (1971). Because bone collagen from lowland Maya sites is not generally well preserved (Tykot et al. 1996; White et al. 1993; White et al. 1996; White and Schwarcz 1989; Wright 1994), loss of collagen resulting from preparation methods was minimized by using a dilute solution of HCl (0.25N; see Chisholm et al. 1983) and by refluxing the collagen-based "gelatin" derived from that product at a relatively low temperature (58°C) (see Brown et al. 1988). Samples of gelatin were combusted with CuO at 555°C, and the resulting N_2 and CO_2 gases were analyzed for $^{13}\text{C}/^{12}\text{C}$ and $^{15}\text{N}/^{14}\text{N}$ ratios on the SIRA mass spectrometer at McMaster University. The stable isotope ratios of carbon and nitrogen are expressed in per mil (‰) as δ values:

$$\delta = [(R_{\text{sample}}/R_{\text{sample}})-1] \times 1,000$$

where $R = ^{13}\text{C}/^{12}\text{C}$ or $^{15}\text{N}/^{14}\text{N}$. The carbon isotope results are presented relative to Vienna PeeDee belemnite (VPDB). The nitrogen isotope results are presented relative to atmospheric nitrogen. This calibration was achieved using an interlaboratory glycine standard. Precision for $\delta^{13}\text{C}$ values was $\pm 0.1\text{‰}$; $\delta^{15}\text{N}$ values were reproducible to $\pm 0.2\text{‰}$.

To help detect the presence of postmortem alteration (e.g., DeNiro 1985), C/N ratios of collagen were also analyzed using a Carlo-Erba Analyser at the University of Western Ontario. Reproducibility for both carbon and nitrogen averaged $\pm 2\%$.

RESULTS

Diagenesis

Prior to interpreting the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values in terms of the dietary variation, it is necessary to evaluate whether primary stable isotopic com-

positions have been preserved in the bone collagen. According to the criteria of DeNiro et al. (1985), C/N ratios outside the range 2.9 to 3.7 can indicate diagenetic alteration of collagen. All of the C/N ratios in the samples from each of the three sites analyzed here are within the range of "normal" collagen (Tables 9.1 and 9.2). Furthermore, there is no statistically significant correlation between either $\delta^{13}\text{C}$ values or $\delta^{15}\text{N}$ values and C/N ratios. We therefore assume that the original stable isotope compositions of the collagen have been preserved.

Table 9.1. Stable Isotopic Values and C/N Ratios for Deer by Site

Site/sample no.	Deer		
	$\delta^{13}\text{C}\text{‰}$	$\delta^{15}\text{N}\text{‰}$	C/N
<i>Lagartero</i> (Late Classic)			
B352 19Z 100-120	-21.5	5.2	3.2
B137 16A 100-120 OD	-7.3	5.0	3.3
B217 16V 160-180	-21.7	4.7	3.3
B137 16A 100-120	-19.3	6.6	3.3
B360 19AA 80-100	-12.7	6.7	3.3
B263 19G 20-40	-22.8	4.2	3.2
B352 19Z 100-120	-20.6	5.4	3.3
B176 16K 160-180	-19.4	5.7	3.2
Mean	-18.2	5.4	3.3
SD	5.4	0.9	0.1
<i>Copán</i> (Late Classic)			
CV 45 1-1023	-17.9	4.1	3.5
CV 45 1023	-18.7	4.9	—
CV 45 1023	-20.6	4.1	3.5
CV 43 1-1027	-18.9	7.2	3.1
CV 43 1-918	-20.0	7.5	3.3
CV 43 1-571	-19.5	7.6	3.2
CV 43 1-615	-19.7	4.7	3.4
CV 43 902	-20.1	5.9	3.2
CV 43 1-524	-20.3	2.7	3.2
CV 43 1-1057	-21.9	3.9	3.3
CV 43 1-903	-20.0	3.4	3.1
CV 20 1-202	-20.6	3.7	3.3
CV 20 1-270	-21.7	4.2	3.2
CV 20 1-202	-21.0	6.3	3.3
CV 20 1-239	-16.4	4.0	—
CV 20 1-239	-22.0	4.0	3.4
Site/sample no.	Deer		
	$\delta^{13}\text{C}\text{‰}$	$\delta^{15}\text{N}\text{‰}$	C/N
CV 20 1-239			
CV 20 1-238	-22.4	6.1	3.2
CV 20 1-220	-21.3	4.2	3.2
1-843	-16.8	5.2	3.3
Mean	-20.0	4.9	3.3
SD	1.6	1.4	0.1
<i>Tikal</i> (Late Preclassic)			
41A-20/23 (under floor) ^a	-22.0	4.7	3.2
<i>Tikal</i> (Early Classic)			
3C-16/7 (chultun)	-20.6	5.6	3.2
<i>Tikal</i> (Late Classic)			
98K-10/4	-21.4	3.3	3.3
681-47/28	-20.0	6.6	3.3
29C-2/3 (chultun)	-21.3	5.0	3.5
Mean	-20.9	5.0	3.4
SD	0.8	1.7	0.1
<i>Tikal</i> (Terminal Classic) (all from midden)			
98F-66A-f/6	-20.3	5.9	3.2
97D-54/12	-19.3	6.1	3.2
99A-18/4	-20.6	5.0	3.4
98K-31	-21.8	6.0	3.2
Mean	-20.5	5.8	3.3
SD	1.0	0.5	0.1
Mean for all samples	-19.7	5.0	3.3
SD for all samples	2.8	1.2	0.1

^a*Mazama americana*.

Table 9.2. Stable Isotopic Values and C/N Ratios for Dogs by Site

Site/sample no.	Dogs		
	$\delta^{13}\text{C}\text{‰}$	$\delta^{15}\text{N}\text{‰}$	C/N
<i>Lagartero</i> (Late Classic)			
B339 19Y 80-100 TR99	-21.9	4.3	3.3
B137 16A 100-200 DO	-13.8	8.9	3.3
B137 16A 100-120	-15.4	5.8	3.3
B282 19J 40-60	-10.3	7.4	3.2
B169 16K 20-40	-8.7	8.2	3.2
B338 19Y 80-100	-7.6	8.5	3.2
Mean	-13.0	7.2	3.3
SD	5.3	1.8	0.1
<i>Copán</i> (Late Classic)			
CV 43 1-573	-9.4	10.6	3.3
CV 68 1-876	-10.0	7.5	3.2
Mean	-9.7	9.1	3.3
<i>Tikal</i> (Late Preclassic)			
12P-474/163	-14.5	12.0	3.2
Mean for all samples	-12.4	8.2	3.2
SD for all samples	4.7	2.5	0.1

Deer

The most striking aspect of the stable isotope data is the contrast between the general uniformity of deer diets and the extreme variability of dog diets (Tables 9.1 and 9.2). The $\delta^{15}\text{N}$ values for deer in the Lagartero, Copán, and Tikal samples reflect the herbivorous nature of deer (mean for all samples = $5.1 \pm 1.2\text{‰}$). These deer are also mainly C_3 plant-consumers (mean $\delta^{13}\text{C}$ for all samples in this study = -19.7 ± 2.9). The *Mazama americana* found at Tikal has a lower $\delta^{13}\text{C}$ value (-22.0‰) than the *Odocoileus virginianus*, a difference that is also found at other sites (Cuello, Lamanai, and Pacbitún; Table 9.3), and probably reflects plant choices particular to this species. *Mazama* is a high forest species, whereas *Odocoileus* is an edge browser that would gravitate to areas that have been cleared

for maize fields. In general, however, archaeological deer from Lagartero, Copán, and Tikal are characterized by isotopic uniformity between sites (mean $\delta^{13}\text{C}$ values by site range from -20.9‰ to -18.2‰ , and mean $\delta^{15}\text{N}$ values by site range from 4.9‰ to 5.8‰) (Figure 9.6a, b). The carbon isotopic values are close to those obtained for deer bones from Preclassic through Terminal Classic times at sites in the Petexbatún region of southern Petén, Guatemala (Emery 1997; Emery et al. 2000). The $\delta^{13}\text{C}$ values of Petexbatún deer bones clustered around -20‰ . Modern deer in the Maya lowlands have lower average $\delta^{13}\text{C}$ collagen values (-24‰ to -23‰ , [van der Merwe et al. 2000; this study, Table 9.4]). Modern wild plants from the Maya area that are commonly consumed by deer (Table 9.4) have an average $\delta^{13}\text{C}$ value of -29.1‰ . Given that the difference between bone collagen and diet is generally 5‰ (van der Merwe 1978; see also Ambrose 1993 for circumstances under which this relationship can be altered), the $\delta^{13}\text{C}$ values of modern deer are consistent with those of their food. The $\delta^{13}\text{C}$ values of the archaeological deer are approximately 2‰ less negative than those of the modern deer. Most of this change can be accounted for by the 1.5‰ difference between the $\delta^{13}\text{C}$ values of preindustrial and postindustrial atmospheric CO_2 (Marino and McElroy 1991).

There are, however, several samples of deer that have anomalous $\delta^{13}\text{C}$ values. Wild deer do feed on maize according to carbon isotope studies of modern North American deer bones (Cormie and Schwarcz 1994). Farmers in northern Belize reported to Pohl that the deer feed on maize stalks, especially the young plants, in contrast to peccaries, which eat the maize cobs. At Lagartero there are two deer that must have consumed significant amounts of maize (Table 9.1; Figure 9.7a). One (B137 16A 100-120 OD) must have been exclusively fed maize from its infancy because its $\delta^{13}\text{C}$ signature is extremely positive (-7.3‰) and because bone collagen records food consumption over approximately a 25-year period (Tieszen et al. 1983), which is notably longer than the lifespan of deer. The $\delta^{13}\text{C}$ value of this deer strongly suggests that it

Table 9.3. Comparison of $\delta^{13}\text{C}$ Values for Maya Deer and Dog between Sites

Site	Period	Deer			Dogs		
		N	$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)	N	$\delta^{13}\text{C}$ (permil)	$\delta^{15}\text{N}$ (‰)
Lagartero SD	Late Classic	8	-18.2	5.4	6	-13.0	7.2
			5.4	0.9		5.3	1.8
Copán SD	Late Classic	20	-20	4.9	2	-9.7	9.1
			1.6	1.4		—	—
Tikal SD SD	Late Preclassic	1	-22.0 ^a	4.7	1	-14.5	12.0
	Early Classic	1	-20.6	5.6	0	—	—
	Late Classic?	3	-20.9	5.0	0	—	—
			0.8	1.7		—	—
	Terminal Classic	4	-20.5	5.8	0	—	—
			1.0	0.5		—	—
Colha ^b SD	Preclassic	16	-21.1	5.0	23	-13.1	8.7
			0.8	1.5		4.3	1.1
Cuello ^{c,d} SD SD	Preclassic	6	-20.3	—	12	-15.6	7.5
			0.8	—		3.9	2.0
		5	-21.9 ^a	—	0	—	—
			0.7	—		—	—
Lamanai ^e	Postclass/Hist	2	-21.8 ^a	4.5	1	-10.7	8.9
Pacbitún ^f SD	Classic	5	-19.2	8.7	1	-8.2	7.3
			3.9	4.3		—	—
		1	-20.4 ^a	4.1	0	—	—

^a*Mazama americana*.^bWhite et al. 2001.^cvan der Merwe et al. 2000.^dTykot et al. 1996. (N.B. Data for Cuello from van der Merwe et al. and Tykot et al. do not include $\delta^{15}\text{N}$ values for deer.)^eWhite and Schwarcz 1989.^fWhite et al., 1993.

had a C_4 -restricted diet or was purposefully fed for ritual consumption. The other C_4 -consuming deer at Lagartero (B360 19AA 80-100) has a $\delta^{13}\text{C}$ value similar to that expected for dogs scavenging on human food, including both meat and plant refuse. This deer may have had very regular access to a maize field or have been purposefully fed for a shorter period.

It is possible that these two deer at Lagartero were tamed for the reenactment of ceremonies with mythological themes that are frequently depicted on Classic period pots. An example might be the scene of a woman riding a deer accompanied by a dwarf holding cotton (Figure 9.2) since women and cotton are themes common to both the Lagartero dump site and the

Table 9.4. $\delta^{13}\text{C}$ Values for Modern Plants and Animals in the Maya Area (after White et al. 2001)

Food source	$\delta^{13}\text{C}$
Maize	-11.2
Wild and domesticated C_3 foods	
Ramon	-29.2
Camote-cacas	-29.4
Camote	-27.2
Palm	-24.7
Cassava	-27.0
Taciste	-28.4
Macal	-26.8
Salsa (beb)	-28.2
Oregano	-28.8
Trumpet wood	-27.2
Mangle	-29.3
Golondrina	-28.7
Jicaco	-27.3
Mean	-27.9
SD	1.3
C_3 plants consumed by deer	
Habin	-28.6
Papaya	-29.3
Xkintal	-29.8
Chichibe	-30.6
Pixoy	-27.0
Jobo	-29.3
Mean	-29.1
SD	1.4
Fauna	
Deer (<i>Odocoileus virginianus</i>)	-24.3
Armadillo	-27.2
Peccary ^a	-23.3
Tapir ^a	-24.2
Kinkajou ^a	-22.4
Gibnut ^a	-22.0
Armadillo	-22.0
Ants	-19.8
Termites	-26.9

Note: Samples collected in Belize by Mary Pohl.

^aThese data from van der Merwe et al. 2000.

deer-riding scene. Female figurines wearing the "witches' " hat seen on the woman in this scene were actually found in the Lagartero dump (Ekholm, personal communication 1998). Another possibility might be the deer sacrifice (represented, for example, on the Calcehtok vessel; Pohl 1981) marking period endings such as the New Year, a ceremony that survives to the present day as the bullfight, with the European domestic animal substituting for the native deer (Pohl 1981). Large numbers of pots have individual scenes from both of these ceremonies, demonstrating that they were of particular importance in ancient Maya ritual.

At Copán there are five deer that have $\delta^{13}\text{C}$ values more positive than -19‰ , which suggests some inclusion of C_4 foods in their diets (Table 9.1; Figure 9.7b). Compared to the C_4 consumers at Lagartero, however, the lower $\delta^{13}\text{C}$ values of these specimens (-18‰ to -16.4‰) are more consistent with occasional grazing from maize fields, which is a common behavior for deer (Pohl 1977; Reina 1967). In contrast to the ritual feasting context for the deer at Lagartero, the occurrence of deer with mixed C_3/C_4 diets is probably not an uncommon phenomenon at other Maya sites. In an earlier isotopic analysis of fauna, two of six deer from Pacbitún also had $\delta^{13}\text{C}$ similar to those at Copán (White et al. 1993).

Deer from Tikal exhibit very uniform $\delta^{13}\text{C}$ values that do not indicate any significant consumption of maize and that are consistent with values expected from ancient wild deer (Table 9.1; Figure 9.7c). In this way the Tikal data are essentially the same as those from Cuello (van der Merwe et al. 2000), Lamanai (White and Schwarcz 1989), and the entire Preclassic sequence at Colha (White et al. 2001).

It is probably safe to assume that most deer consumed by the Maya were hunted, because most of the deer analyzed at Lagartero, Copán, and Tikal, as well as at sites previously analyzed by other researchers, have unambiguous C_3 signatures. This observation is consistent with findings for the Petexbatún region of southern Petén, Guatemala (Emery 1997; Emery et al.

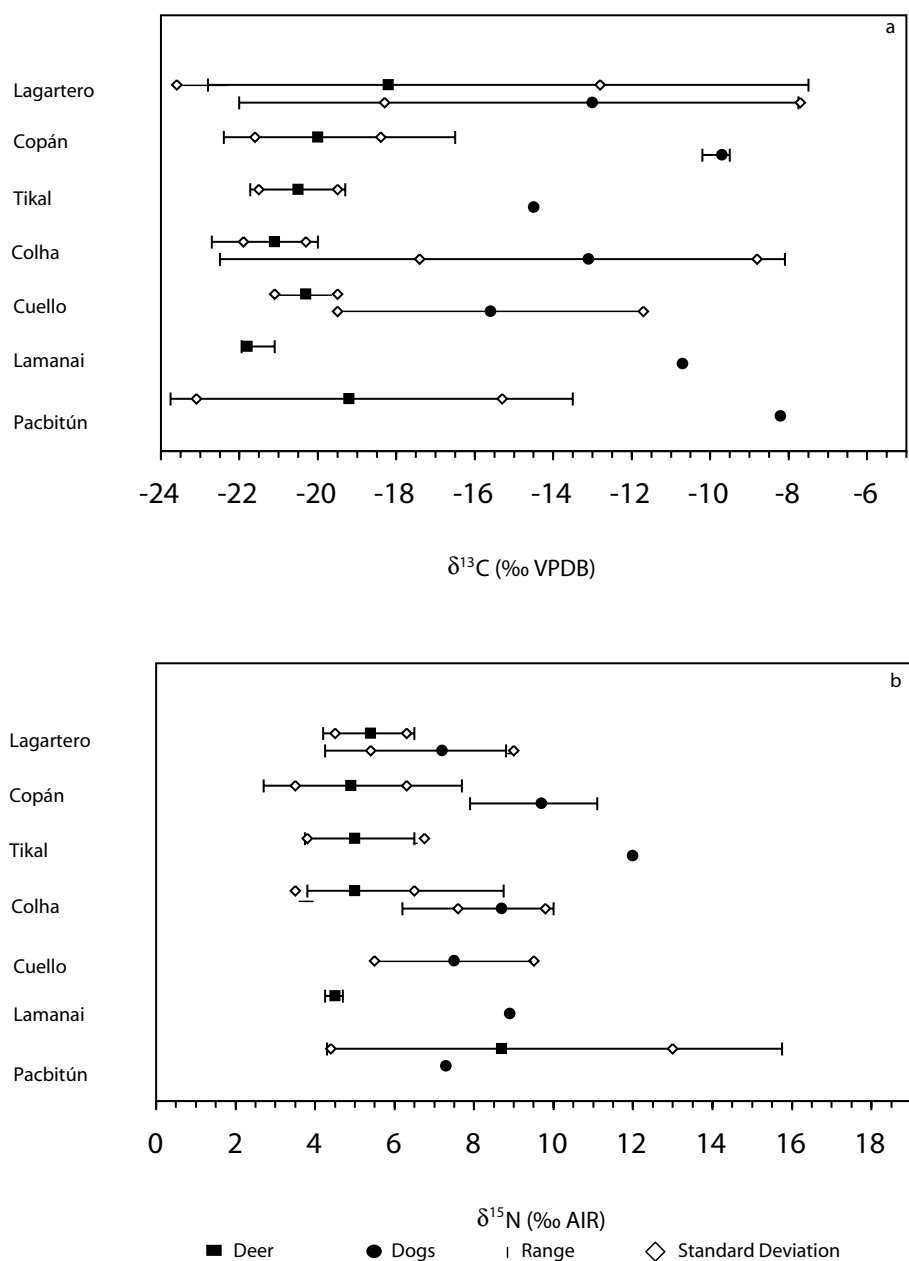


Figure 9.6. Comparison of carbon and nitrogen isotopic data by site for deer and dogs: (a) $\delta^{13}\text{C}$; (b) $\delta^{15}\text{N}$.

2000). The data raise the question of how dense Maya human populations were and how much habitat destruction they had caused. Deer can be hunted out locally quite easily, in part because

they do not disperse as quickly as they reproduce. Although the presence of deer as an indicator of low population density could be an artifact created by the importation of venison,

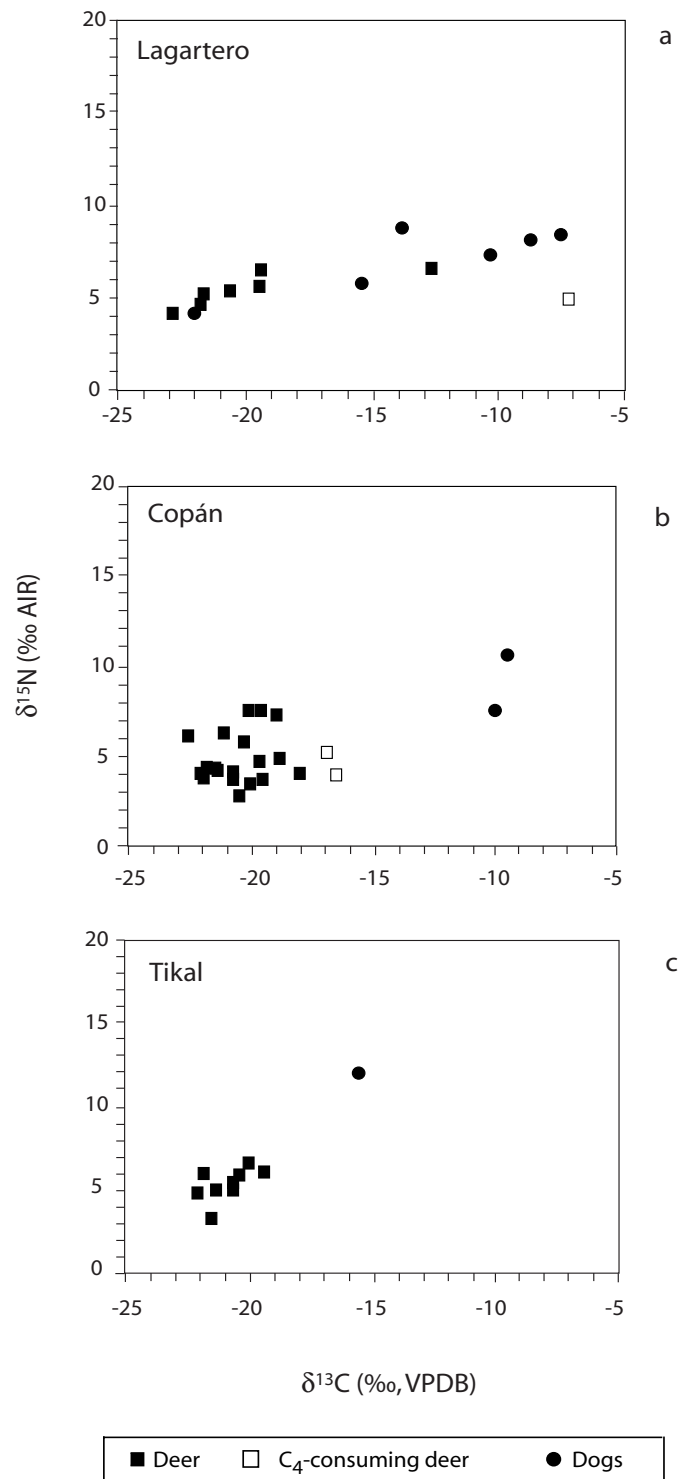


Figure 9.7. Carbon and nitrogen isotopic data for deer and dogs from (a) Lagartero, (b) Copán, (c) Tikal.

there appears to have been adequate habitat for deer in the Maya area during the Classic period, which challenges the extremely high population estimates for central Tikal (i.e., 60,000 or more) during the same period (Culbert et al. 1990). These data bring into question the evidence for extreme habitat destruction that has been suggested on the basis of paleolimnological and soil erosion studies from the central Petén (Deevey et al. 1979; Leyden et al. 1994). This environmental evidence has also been correlated with extremely high population estimates for central Tikal. Lower estimates, such as those first given by Haviland (1969, 1972) and more recently by Ford (1990), may, in fact, be more realistic. Part of the problem in reconciling these very different estimates of population has been the uncertainty in radiocarbon dates from lake sediment pollen cores (e.g., Deevey et al. 1979). Nevertheless, if the original dates of increasing sedimentation are to be taken as valid, the majority of deforestation would have occurred in the Preclassic period, after which the environment may have stabilized, perhaps with the aid of Maya conservation techniques or change in climate, at least until the very end of Classic times. This scenario would agree with what we know of Belize (Pohl et al. 1996) and Honduras (Rue 1987).

Dogs

Interpreting the meaning of the stable isotopic data for dogs in relation to both animal and cultural behavior can be complex because dogs are omnivores, and it is assumed they lived in closer proximity to humans than did deer. Dogs are both opportunistic scavengers and dependent feeders. If the food they are either scavenging or being fed is simply left over from the meals of humans, they will mirror the dietary regime of the humans with whom they are associated (Burleigh and Brothwell 1978; Cannon et al. 1999; Clutton-Brock and Noe-Nygaard 1990; Day 1996).

The $\delta^{13}\text{C}$ values obtained for dogs are much more variable than those of deer. The dog samples from all three sites have $\delta^{13}\text{C}$ values that reflect a complete range from pure C_3 to pure C_4 consumers (Table 9.2; Figures 9.7 and 9.8). In

contrast to the deer, however, all but one of the dogs consumed significant quantities of C_4 foods. The $\delta^{15}\text{N}$ values for dogs are not only higher than those for deer, but they also exhibit greater variability (mean for all dog samples in this study = $8.2 \pm 2.5\text{‰}$, compared to mean for all deer samples = $5.1 \pm 1.2\text{‰}$; Table 9.2; Figure 9.6a, b). The higher values indicate greater carnivory, and the variability indicates a broader range of feeding patterns.

Both $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of collagen can be used to determine the source of dietary protein. Most of the $\delta^{15}\text{N}$ values indicate consumption of terrestrial animals, but dogs that are more enriched in ^{13}C also tend to be more enriched in ^{15}N . If high $\delta^{15}\text{N}$ is indicative of carnivory, then the enriched $\delta^{13}\text{C}$ values suggest that the meat they ate was ^{13}C rich (Schwarcz 1994). If these dogs were scavenging human food, it must have included either meat from animals who were consuming significant quantities of C_4 foods (e.g., dogs, deer, turkeys) or marine resources. In this sample there are two dogs with substantially higher $\delta^{15}\text{N}$ values (CV 43 1-573, from Late Classic Copán, and the Late Preclassic dog from Tikal; Table 9.2; Figure 9.7c) that show an enrichment of ^{15}N indicative of a marine diet. Consumption of marine foods is not uncommon among the ancient Maya (Coyston 1995; White and Schwarcz 1989; White et al. 1996; Williams 2000) and may be associated with high status (White and Schwarcz 1989). The result for the Preclassic Tikal dog reported here is of particular interest because it indicates a marine-based diet. The chultun in which it was found was dug in bedrock at the bottom of the North Acropolis, and the domestic refuse inside was well preserved because it was sealed by construction fill. The dog bone was associated with abundant marine shell material (*Strombus*), which the Maya obtained to craft high status ornaments, as well as four fish vertebrae, which were not identified. Marine parrotfish (*Sparisoma viride*) bone from sealed construction fill also on the North Acropolis (12P-163), and of the same age (late Middle Preclassic to early Late Preclassic period), provides further evidence for the presence of long-distance trade in marine materials

probably from the Caribbean coast. The marine diet of this Preclassic Tikal dog could indicate the high socioeconomic status of its owners.

Some of the Lagartero dogs must have been fed a high C_4 diet and hence been physically restrained in the process, given the omnivorous feeding habits of dogs. Figurines such as the contemporaneous Late Classic artifact from Altar de Sacrificios (Figure 9.3), showing a woman dressed in ceremonial costume and holding a drinking cup and a dog, point to a special ritual role for some dogs. The Lagartero ceremonial dump yielded dog figurines in addition to those of women with ritual association (Ekholm, personal communication 1997). Bishop Landa (Tozzer 1941) describes a Yucatecan rite in which old women danced with dogs. These dogs had spotted markings on their backs resembling the cacao or chocolate bean, which refers to the most sought-after festival drink, usually made by mixing cacao paste with ground corn and water. Paintings reveal that the Maya had spotted dogs in the Classic period, and they may have participated in such a rite. It is also of interest that the only dog that consumed no maize (B339 19Y 80-100 TR99) (Table 9.2) also came from Lagartero. It too does not appear to have been extremely carnivorous. This could have been a wild dog, or it could have been restrained and deliberately fed a nonmaize diet, perhaps of squash or manioc. Squash and manioc were early domesticates in the Maya lowlands (Pohl et al. 1996), and even today Yucatec Maya offer a gruel of ground squash seeds along with corn in ceremonies to the rain god Chac (cf. *National Geographic* 1998:61). Phytolith or starch grain analysis of residues on animal teeth might shed further light on what a dog such as this was eating.

With the possible exception of the "wild" Lagartero dog, all of the dogs with $\delta^{13}C$ values less positive than -10‰ were probably scavenging or being fed leftovers. Both dogs and deer with $\delta^{13}C$ values more positive than -10‰ probably were purposefully fed from an early age and may have been penned or contained in some way to prevent natural scavenging of C_3

foods. It is not surprising that among the remains of the ritual feasting at Lagartero there are animals with $\delta^{13}C$ values more positive than at the other sites examined here, suggesting the purposeful feeding of dogs for ritual ceremony. This practice is also evident at Colha, where the dogs found in locations that have a ritual meaning (e.g., caches) had $\delta^{13}C$ values indicating pure maize diets, compared to those that were found in locations that denote nonritual use (e.g., middens) (White et al. 2001).

Compared to deer, dogs exhibit greater variability in stable isotope composition both within and between sites analyzed in this study and sites previously studied (Figure 9.6a, b). The variability in $\delta^{13}C$ values of dogs is not unlike that found for humans within and between sites (Wright and White 1996). The contribution of time-period differences to the variations in the $\delta^{13}C$ and $\delta^{15}N$ values of the dogs is also difficult to assess (Figure 9.8a, b) because the sample sizes are small and geographic area is not controlled. The sites compared here represent a diversity of environmental regions within the Maya lowlands, and the diet of humans is known to vary by region (Gerry and Krueger 1997; Wright and White 1996). At Colha, where there is a well-controlled temporal sequence for the Preclassic period, the $\delta^{13}C$ values of dogs found in middens become increasingly positive over time. This trend may indicate either greater consumption of C_4 foods by humans over time or greater control over dog diets. Analysis of a temporally analogous sample of humans is needed to determine how closely dog $\delta^{13}C$ values track those of humans.

CONCLUSION

Carbon and nitrogen isotopic analysis has most commonly been done using human skeletal material with a focus on what food consumption can tell us about Maya culture, social structure, ideology, political economy, and trade (Reed 1994; White 1999a; White and Schwarcz 1989; White et al. 1993; Wright 1994). Nevertheless,

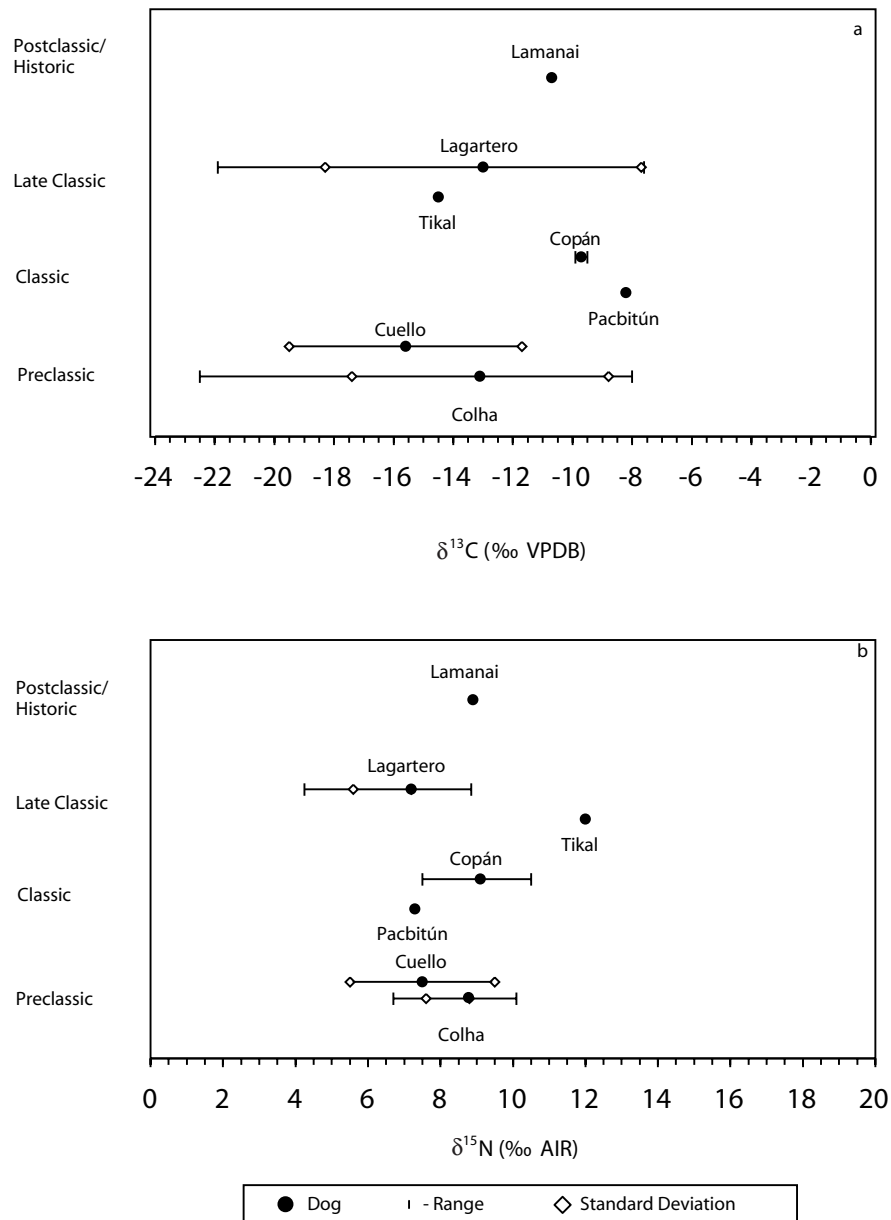


Figure 9.8. Comparison of carbon and nitrogen isotopic data by period for dogs: (a) $\delta^{13}\text{C}$; (b) $\delta^{15}\text{N}$.

animals such as deer and dogs, with which the Maya were closely associated, were also imbued with symbolic religious meaning, representing the interface between culture and nature. The diets of these animals can be used to characterize the complex nature of the interaction between the Maya and their animals. This chap-

ter illustrates the potential for using animal bones to understand more about both Maya behavior and animal behavior. In both deer and dog samples there is a wide range of dietary regimes represented, from pure C_3 to pure C_4 diets. The diets of the deer indicate at least three different human-animal relationships. The

majority of deer had herbivorous $\delta^{15}\text{N}$ values and $\delta^{13}\text{C}$ values characteristic of pure C_3 plant consumption. We can surmise that these deer had fed on C_3 plants for their lifetime and became part of the archaeological record from being hunted in their natural, wild environment. There were also a few deer that had consumed some C_4 plants (maize). Most likely, these were deer that came regularly to graze on maize, especially young plants sprouting in milpa fields. There may have been "semidomesticated" deer that were husbanded in a large area that bordered on milpa fields as well. It is also possible that these deer were purposefully fed but not for all of their lives. Perhaps the most significant finding in terms of cultural behavior is the presence of deer at Lagartero that must have had a restricted C_4 diet from a very young age. This kind of purposeful feeding must have required physical restraint or confinement.

In summary, Maya deer were raised for the feast, or took advantage of the field, but were native to the forest. Whether the practice of fattening for ritual or feasting was widespread remains to be seen. The use of stable isotopic data to determine the human impact on the environment also needs further consideration. Our data on Maya deer suggest that there was suitable habitat for wild or semidomesticated animals even in the Classic period and that the modification of the environment by human populations was not as extreme as previously thought.

The relationship among dogs, humans, and their environments is more complex than that for deer because dogs and humans are both omnivorous. Although the $\delta^{15}\text{N}$ values of dogs indicate consumption of a variety of protein sources (e.g., terrestrial vs. marine animals),

some dogs, notably at Lagartero, were also given a restricted C_4 diet and must have been physically restrained as well. It is not known yet if this practice was widespread, but there is good evidence for it now, not only at Lagartero but also from Colha. The carbon and nitrogen isotopic variability in dogs between these sites, which represent different environments and time periods, is similar in degree to that of humans. Nevertheless, whether dogs are a valid proxy for human diets in the Maya area requires further investigation. The efficacy of this approach really depends on how the dogs were fed. Did they behave as true scavengers or as dependent feeders on scraps from human meals, or did humans take more conscious control over the diets of dogs in the process of breeding and raising them for food?

Acknowledgments. We thank Chris Jones, University of Pennsylvania, for the Tikal bones and Susanna Ekholm of Na Balam, San Cristóbal de las Casas, and the Instituto Nacional de Antropología y Historia, Mexico, who loaned the Lagartero bones for study. The Copán bones were provided by Gordon R. Willey, Harvard University, and Richard Leventhal, University of California, Los Angeles. We also thank Martin Knyf, McMaster University, and Kim Law and Paul Middlestead, University of Western Ontario, for technical support and sample processing. This research was supported by the Social Science and Humanities Research Council of Canada (SSHRC) grants to Henry Schwarcz and Christine White and to Christine White and Fred Longstaffe and a National Science and Engineering Research Council of Canada (NSERC) grant to Henry Schwarcz.

Empirical Data for Archaeological Fish Weight Analyses

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*In this chapter the percent usable meat is ascertained separately for 14 marine fish families or genera based on a sample of purchased fresh fish. This percentage varies, depending on the group, from 67.5 percent to 81.3 percent, well below the 90 percent figure used in the literature. For five of these genera (groupers *Epinephelus*, barracudas *Sphyraena*, snappers *Lutjanus*, and parrotfishes *Sparisoma* and *Scarus*), regressions of a bone measurement against body weight were calculated, and this regression was then used to predict the body weight of each bone from an archaeological fish-bone sample from one structure at the Marco Gonzalez site, Belize. The average predicted live weight was multiplied by the MNI from the archaeological sample and then multiplied by the percent usable to derive a predicted actual meat weight from the archaeological sample. Of the 17 fish families or genera represented in the Marco Gonzalez site, four groups—groupers (*Epinephelus* and *Mycteroperca*), crevalle jacks (*Caranx hippos*), snappers (*Lutjanus*), and barracudas (*Sphyraena*)—make up more than 83 percent of the calculated usable meat. For this site the proportion of the total calculated usable meat does not change substantially for any of the 17 groups, whether the new usable percentages or the 90 percent figure is used. This need not necessarily be so for other archaeological fish-bone samples; consequently, more accurate usable percentages and live weights should be sought for all meat weight predictions.*

Archaeologists often estimate the percent usable meat from an archaeological sample (e.g., Wing 1980) in order to assess the relative importance of various taxa for human subsistence. Various procedures have been developed to estimate the portion of an animal that is usable (e.g., Smith 1975; Stewart and Stahl 1977; White 1953; Wing and Brown 1979). For fish, similar methods have also been developed (e.g., Casteel, 1974, 1976). Meat weight estimation can be done by using bone weights, minimum number of individuals (MNI), or regressions on bone size (Grayson 1984:172–174). Grayson (1984) showed that the bone weight method was invalid and that the MNI method produces order of magnitude level of information only. He showed that using regressions on bone size can be a very accurate

method, but it has the disadvantage of being applicable to individuals only.

This chapter will calculate preliminary percent usable meat for 11 Caribbean fish families based on specimens purchased in a fish market. Regressions on bone measurements to body weight are then used to estimate a predicted whole fish weight for a sample of archaeological fish bones. The percent usable is then used to calculate the amount of usable meat actually available from each fish family for an archaeological sample.

The sample used is from only one level of one structure (Structure 27, level 21) of the Marco Gonzalez site, Belize, which dates to about A.D. 1000 to 1200, or Early Postclassic (Graham and Pendergast 1989; Pendergast

1990b; Pendergast and Graham 1987, 1990). This site is located on Ambergris Cay (an off-shore island) and consists of at least 49 raised structures built on platforms of quarried reef stone, huge amounts of shells, and middens (Graham and Pendergast 1989). Although the pottery and other artifacts from this site have been studied in order to date the site and to provide information on trade patterns (Graham and Pendergast 1989), this is the first report on the faunal material, other than an unpublished report (Seymour 1991). Given the number of structures at this site, and the fact that structures are often built on top of middens, this site could produce a huge amount of faunal material if fully excavated. In addition, preliminary analyses indicate that there is very little terrestrial input to the middens. The evaluation of available protein from this midden material is important for a number of reasons: to evaluate the number of people who might have lived there, to evaluate the possible seasonality of habitation, to evaluate possible nutritional deficiencies, or to evaluate the site as a possible trading location. These broader conclusions will not be attempted here, however, because of the limited sample utilized. They can be answered only after a large amount of midden material (and other archaeological samples, such as pottery) has been analyzed. It is hoped that the data assembled here will be of use to others wishing to attempt this kind of analysis in the future.

METHODS

Percent Usable Meat for Recent Fish

A total of 46 fresh fish, representing 12 families and 14 genera, were purchased from Kensington market in Toronto. This market supplies fresh fish and other products to the sizable Toronto Caribbean community. The species obtained were those that were found in the Marco Gonzalez site or at least Caribbean species in a genus represented in the Marco Gonzalez material. All identifications were by the author and were made in the lab of the Department of Palaeobiology, Royal Ontario Museum (ROM). All fish

were purchased fresh and processed the same day, without being frozen.

The following procedure was used to calculate the percent usable meat. Each fish was weighed while still fresh (weight 1); then each was filleted and the fillet was weighed (weight 2). A percent fillet calculation was performed as follows:

$$(\text{weight 2} / \text{weight 1}) \times 100 = \\ \% \text{ fillet weight}$$

A fillet is obtained by first removing the skin and then extracting the majority of the meat from the side of the fish. The fillet thus consists of the meat without the head, tail, fins, bones, or skin and does include loose pieces of meat. The fillet weight in and of itself is not of great interest here, since this weight will vary according to the skill of the person doing the job. However, it will be used in the calculations as noted below and may be considered a minimum usable fraction. The guts were then removed and weighed (weight 3); guts were taken to be the intestinal mass only or that part of the internal organs that could be removed relatively easily. The remaining fish carcass, with both edible and inedible portions remaining attached to it, was weighed (weight 4). The carcass was then placed in the dermestid beetle colony at the ROM. Once all edible portions were consumed by the dermestids, the carcass was removed from the colony, sealed in a plastic bag, and placed in a freezer for several weeks. This served to kill any remaining dermestids, including their larvae and eggs, so that infestation of the collections would not occur. Once removed from the freezer, the carcass was weighed again (weight 5). The difference between weight 4 and weight 5 was assumed to be the amount of edible meat that remained on the fish carcass after filleting and that was consumed by the beetles. When added to the initial fillet weight, therefore, a total usable meat weight was derived. The following formula expresses this relationship:

$$(\text{weight 4} - \text{weight 5}) + \text{weight 2} = \\ \text{weight 6 (total usable)}$$

This amount was expressed as a percentage of the original whole fish weight by calculating:

$$(\text{weight 6} / \text{weight 1}) \times 100 = \% \text{ usable}$$

This may be considered a maximum usable fraction of each fish and does not account for cultural variability in meat choice, discussed later. Note that weight 1 (fresh weight) is not equal to weight 2 (fillet weight) + weight 3 (guts) + weight 4 (carcass weight before bug-room treatment) because the skin was not weighed.

Regressions for Body Weight

To estimate the body weight of individual fish represented by archaeological bones, several regressions were performed using the method described in Casteel (1974). Convenient and reproducible measurements were taken on reference skeletons with known body weight. The first measurement, dorsal-ventral depth of dentary at symphysis (Figure 10.1, measurement X), was used for the grouper genus *Epinephelus*, barracuda genus *Sphyræna*, and snapper genus *Lutjanus*; the second measurement, maximum width of the tooth-bearing posterior portion of the ventral pharyngeal arch (Figure 10.2, measurement Y), was used for the parrotfish genera *Sparisoma* and *Scarus*. These measures were chosen because they could be taken on elements frequently occurring in the archaeological sample, and they have easily recognizable measurement landmarks. These measures were then regressed against body weight using the Multiple Regression module of the StatSoft statistics package Statistica, version 5.0 (StatSoft 1995). It calculates the correlation coefficient (r), which gives a measure of the fit of the line, which can vary between zero and one. This regression was then used to predict the body weight of fish whose bones were preserved at the Marco Gonzalez site. StatSoft also provides a t -test statistic, which indicates the probability that the slope of the line is significantly different from zero.

Regressions were performed at the genus level because of the lack of comparative material for some species. Fish species in the same genus often are differentiated only by color

markings, fin spine counts, and other minor characteristics and are very similar in overall body form. Consequently, as long as there were no obvious morphological differences between species for the particular skeletal measurements used, this method was deemed reasonably accurate.

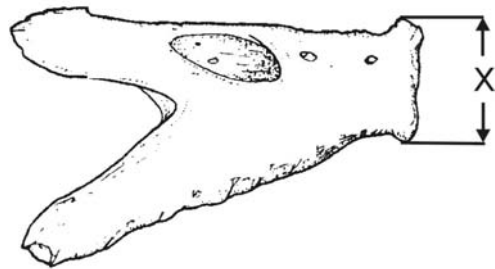


Figure 10.1. Lateral view of the right dentary of the flounder, *Hippoglossus stenolepis*, with measurement X indicated, used in Regressions 1–3. Illustration adapted from Canon (1987:105).

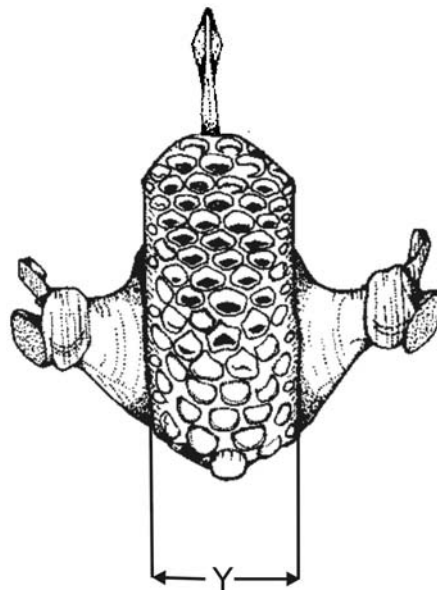


Figure 10.2. Dorsal view of the ventral pharyngeal arch of the parrotfish, *Scarus* sp., with measurement Y indicated, used in Regressions 4 and 5. Illustration adapted from Wheeler and Jones (1989:97).

Amount of Usable Meat Represented by Archaeological Fish-Bone Samples

Fish were arranged in convenient groups: a group might be a species (e.g., crevalle jack, *Caranx hippos*), or more than one species in the same genus (e.g., *Lutjanus* snappers), or more than one genus in a family (e.g., groupers of the genera *Epinephelus* and *Mycteroperca*). The MNIs for each group from the Marco Gonzalez site were multiplied by the average predicted live weight calculated on the Marco Gonzalez site bones. This number gave the total meat weight for the group as represented by the bones in the Marco Gonzalez site. The total meat weight was then multiplied by the percent usable calculated on the fish market specimens, to give an actual estimate of the amount of usable meat represented by the Marco Gonzalez archaeological fish-bone sample. Since Tables 10.1 through 10.6 give average live weights for only 5 of 17 categories of archaeological fish bone present at the Marco Gonzalez site, live weights on file at the ROM were used for the fish families for which regressions were not performed. For the three fish groups for which a percent usable value was not calculated, the percent usable of another group of somewhat similar body form was substituted: for the hogfish *Lachnolaimus* I used Sparidae (porgies), for the cobia *Rachycentron* I used Sphyracnidae (barracudas), and for the catfish *Arius* I used Centropomidae (snooks).

For comparison these same calculations are performed with the 90 percent usable figure for all fish, as employed by Wing (1980).

RESULTS

Percent Usable Meat for Recent Fish

The results of the percent usable calculations on the fish market specimens are presented in Table 10.1. Two phenomena are immediately apparent. First, the percent fillet figures are all very low, usually about half the percent usable figures or less. Second, the percent usable figures are all less than 90 percent, and only one group average (*Caranx hippos*, crevalle jack) is greater than 80 percent. The largest fish (two *Epinephelus* groupers and one *Sphyracna* barracuda) have the largest percent usable figures (between 84.0 percent and 86.5 percent), which are closest to the 90 percent figure used by Wing (1980). Finally, the percent guts was generally low, although this percentage could not be calculated on the largest fish.

Regressions for Body Weight Represented by Archaeological Fish-Bone Samples

Both the recent bone data from which the regression equations were calculated and the body weight represented by the archaeological fish-bone samples are reported by genus: *Epinephelus* groupers in Table 10.2 and Figure 10.3, *Sphyracna* barracudas in Table 10.3 and Figure 10.4, *Lutjanus* snappers in Table 10.4 and Figure 10.5, *Sparisoma* parrotfish in Table 10.5 and Figure 10.6, and *Scarus* parrotfish in Table 10.6 and Figure 10.7. All regressions calculated have very high correlation coefficients except for that calculated for *Sparisoma*, although this *r* is still reasonably high. All regression lines are significantly different from zero except the *Sparisoma* regression.

Table 10.1 Percent Usable Meat

Family/CN ^a	Genus and Species	Initial wt (g) (wt 1)	% Fillet (wt 2)	% Guts (wt 3)	% Usable (wt 6)
Serranidae					
R2675	<i>Epinephelus niveatus</i>	1,205	39.4	—	86.5
R2631	<i>Epinephelus itajara</i>	598	31.2	8.9	71.7
R2616	<i>Epinephelus guttatus</i>	310	30.0	6.8	73.2
R6262	<i>Epinephelus drummondhayi</i>	928	36.3	—	83.1
R6282	<i>Epinephelus flavolimbatus</i>	1,708	43.3	—	84.0
Average Serranidae					79.7

Continued on next page

Table 10.1 Percent Usable Meat (continued)

Family/CN ^a	Genus and Species	Initial wt (g) (wt 1)	% Fillet (wt 2)	% Guts (wt 3)	% Usable (wt 6)
Carangidae (crevalle jack only)					
R6263	<i>Caranx hippos</i>	1,618	35.0	6.9	81.8
R6264	<i>Caranx hippos</i>	1,040	34.1	5.3	80.8
Average crevalle jack					81.3
Lutjanidae					
R2691	<i>Lutjanus buccanella</i>	550	38.2	—	78.6
R6284	<i>Lutjanus jocu</i>	355	36.0	5.1	75.5
R6285	<i>Lutjanus griseus</i>	338	36.1	5.0	76.0
Average Lutjanidae					76.7
Sphyraenidae					
R2707	<i>Sphyraena guachancho</i>	879	49.5	5.5	82.8
R2706	<i>Sphyraena guachancho</i>	711	50.8	6.9	82.1
R2683	<i>Sphyraena guachancho</i>	340	44.4	8.5	68.8
R6281	<i>Sphyraena barracuda</i>	3,357	54.3	—	84.5
Average Sphyraenidae					80.0
Balistidae					
R6268	<i>Balistes vetula</i>	733	19.4	18.0	62.6
R6269	<i>Balistes caprisus</i>	1,021	29.8	17.6	70.1
R6270	<i>Balistes caprisus</i>	1,103	27.8	8.4	76.0
Average Balistidae					69.6
Scaridae (<i>Scarus</i> only)					
R2708	<i>Scarus vetula</i>	340	30.6	7.9	75.3
Carangidae (other <i>Caranx</i>)					
R2629	<i>Caranx bartholomaei</i>	435	41.6	7.8	82.1
R2630	<i>Caranx crysos</i>	363	43.5	5.0	78.0
R6265	<i>Caranx latus</i>	548	39.1	6.9	79.9
R6266	<i>Caranx latus</i>	442	35.1	7.7	77.8
R6267	<i>Caranx latus</i>	171	37.4	8.2	80.7
Average Carangidae					79.7
Sparidae					
R2682	<i>Calamus arctifrons</i>	110	34.6	8.2	78.2
R6274	<i>Calamus penna</i>	1,171	25.6	—	79.8
R6286	<i>Calamus pennatula</i>	241	34.4	3.7	78.0
Average Sparidae					78.7

Continued on next page

Table 10.1. Percent Usable Meat (continued)

Family/CN ^a	Genus and Species	Initial wt (g) (wt 1)	% Fillet (wt 2)	% Guts (wt 3)	% Usable (wt 6)
Haemulidae					
R2680	<i>Haemulon parrai</i>	408	22.1	4.9	71.6
R2681	<i>Haemulon parrai</i>	280	16.1	3.9	70.7
R2615	<i>Haemulon sciurus</i>	265	29.1	7.6	75.5
R6287	<i>Haemulon plumieri</i>	466	22.8	3.6 +	75.5
R6288	<i>Haemulon plumieri</i>	173	28.3	5.2	73.4
Average Haemulidae					73.3
Scaridae (<i>Sparisoma</i> only)					
R2677	<i>Sparisoma chrysotermum</i>	445	27.6	10.1	68.7
R2678	<i>Sparisoma chrysotermum</i>	345	29.3	5.5	67.8
R2679	<i>Sparisoma viride</i>	340	23.5	13.5	64.7
R2613	<i>Sparisoma viride</i>	300	24.7	19.7	65.3
R2709	<i>Sparisoma aurofrenatum</i>	230	23.9	7.4	72.2
Average <i>Sparisoma</i>					67.7
Centropomidae					
R2628	<i>Centropomus ensiferus</i>	448	40.8	4.5	79.7
Acanthuridae					
R2614	<i>Acanthurus chirurgus</i>	205	36.6	14.6	69.8
R6289	<i>Acanthurus coeruleus</i>	173	26.0	13.9	63.0
R6290	<i>Acanthurus coeruleus</i>	207	30.9	14.5	68.1
R6291	<i>Acanthurus chirurgus</i>	228	33.8	10.5	71.0
R6292	<i>Acanthurus chirurgus</i>	183	29.5	9.8	65.6
Average Acanthuridae					67.5
Gerreidae					
R6271	<i>Eugerres plumieri</i>	487	23.6	9.2	69.2
R6272	<i>Diapterus auratus</i>	175	36.0	5.7	76.0
R6273	<i>Diapterus auratus</i>	147	31.3	6.8	70.8
Average Gerreidae					72.0
Other Labridae					
R6283	<i>Halichoeres radiatus</i>	318	44.7	4.4 +	74.2

^aCN = Catalog number of the dry skeleton in the Department of Palaeobiology, Royal Ontario Museum.

Table 10.2. Regression 1

Raw data on recent fish for regression of body weight vs. dorsal-ventral depth of dentary at symphysis (= measure) for *Epinephelus* sp. groupers

CN ^a	Species	Body Weight (kg)	Measure (mm)
R2165	<i>E. itajara</i>	196.8	53.6
R2137	<i>E. nigritus</i>	102.0	41.3
R6282	<i>E. flavolimbatus</i>	1.708	11.7
R6262	<i>E. drummondhayi</i>	0.928	8.6
R2246	<i>E. itajara</i>	0.707	6.6
R5213	<i>E. adscensionis</i>	0.654	6.5
R2631	<i>E. itajara</i>	0.598	6.5
R3257	<i>E. itajara</i>	0.566	7.0
R2432	<i>E. guttatus</i>	0.441	6.4
R2232	<i>E. striatus</i>	0.346	5.4
R2616	<i>E. guttatus</i>	0.310	5.6

^aCatalog number in the Department of Palaeobiology, Royal Ontario Museum.

Regression Equation 1:

$\log y = 2.795 (\log x) - 5.895$ (where x = measure and y = body weight), $r = 0.9955$, $t = -27.66$, 9 *df*; therefore $p < 0.000$, significant

Using this regression, the predicted weight for Marco Gonzalez bones of *Epinephelus* sp. groupers is as follows:

CN	Measure (mm)	Predicted Weight (kg)
MG21-F132	28.3	31.4
MG21-F131	23.3	18.2
MG21-F134	18.3	9.3
MG21-F121	15.1	5.4
MG21-F128	14.2	4.6
MG21-F133	14.2	4.6
MG21-F127	13.9	4.3
MG21-F123	13.6	4.1
MG21-F124	13.3	3.8
MG21-F122	13.1	3.7
MG21-F129	11.7	2.7
MG21-F125	9.0	1.3
MG21-F126	5.7	0.4
Average	—	7.22

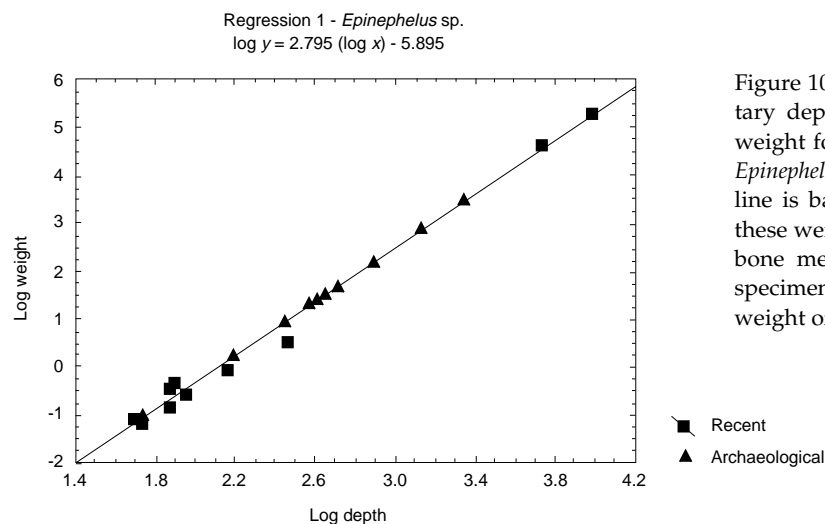


Figure 10.3. Regression 1, log of the anterior dentary depth plotted against the log of the body weight for a sample of recent and archaeological *Epinephelus* sp. grouper specimens. The regression line is based solely on the recent specimens, as these were of known body weight. Since only the bone measure is known for the archaeological specimens, this plot was used to predict the body weight of each archaeological specimen.

Table 10.3. Regression 2

Raw data on recent fish for regression of body weight vs. dorsal-ventral depth of dentary at symphysis (= measure) for *Sphyraena* sp. barracudas.

CN ^a	Species	Body Weight (g)	Measure (mm)
R5422	<i>S. barracuda</i>	4,017	17.0
R2721	<i>S. barracuda</i>	3,700	12.7
R6281	<i>S. barracuda</i>	3,357	12.6
R2618	<i>S. barracuda</i>	2,345	11.3
R2707	<i>S. guachancho</i>	879	8.2
R2706	<i>S. guachancho</i>	711	7.0
R1837	<i>S. guachancho</i>	368	5.6
R2683	<i>S. guachancho</i>	340	5.4

^aCatalog number in the Department of Palaeobiology, Royal Ontario Museum

Regression Equation 2:

$\log y = 2.419 (\log x) + 1.804$ (where x = measure and y = body weight), $r = 0.9822$, $t = 4.236$, 6 *df*; therefore $p < 0.0055$, significant

Using this regression, the predicted weight for Marco Gonzalez bones of *Sphyraena* sp. barracudas is as follows:

CN	Measure (mm)	Predicted Weight (g)
MG21-F584	19.0	7,525
MG21-F585	15.6	4,675
MG21-F586	15.3	4,465
MG21-F587	14.2	3,722
MG21-F588	12.6	2,791
MG21-F589	12.5	2,738
MG21-F590	8.8	1,172
MG21-F591	7.3	745
MG21-F592	7.2	721
MG21-F593	5.2	328
Average	—	2,888

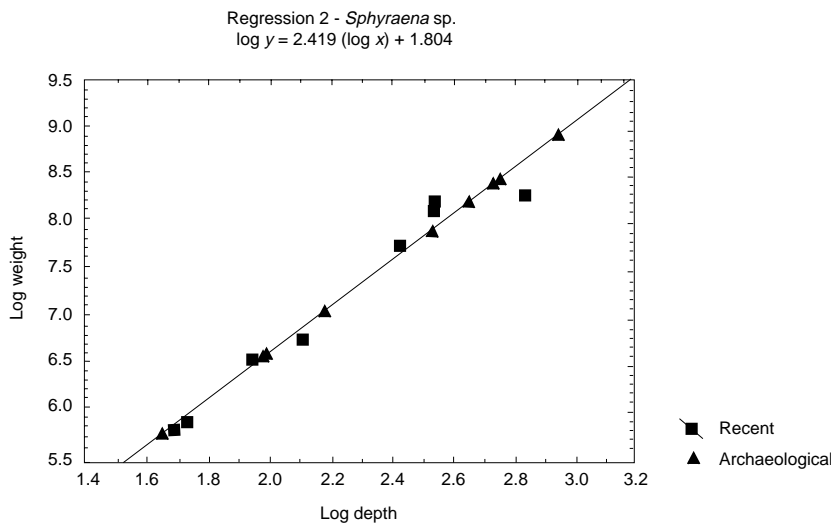


Figure 10.4. Regression 2, log of the anterior dentary depth plotted against the log of the body weight for a sample of recent and archaeological *Sphyraena* sp. barracuda specimens. The regression line is based solely on the recent specimens, as these were of known body weight. Since only the bone measure is known for the archaeological specimens, this plot was used to predict the body weight of each archaeological specimen.

Table 10.4. Regression 3

Raw data on recent fish for regression of body weight vs. dorsal-ventral depth of dentary at symphysis (= measure) for *Lutjanus* sp. snappers.

CN ^a	Species	Body Weight (g)	Measure (mm)
R2206	<i>L. vivanus</i>	1,030	7.4
R5336	<i>L. griseus</i>	931	7.9
R5335	<i>L. griseus</i>	837	8.0
R5333	<i>L. campechanus</i>	820	7.4
R3259	<i>L. vivanus</i>	652	5.6
R5334	<i>L. campechanus</i>	651	7.0
R2183	<i>L. campechanus</i>	610	6.3
R1554	<i>L. griseus</i>	513	6.6
R5332	<i>L. jocu</i>	491	6.1
R2431	<i>L. cyanopterus</i>	472	6.3
R4946	<i>L. vivanus</i>	433	6.2
R6284	<i>L. jocu</i>	355	5.5
R6285	<i>L. griseus</i>	338	5.0
R4933	<i>L. analis</i>	255	4.1
R2435	<i>L. griseus</i>	232	4.8
R1862	<i>L. synagris</i>	186	4.0
R4913	<i>L. synagris</i>	146	3.9
R2245	<i>L. synagris</i>	138	4.0
R4888	<i>L. analis</i>	125	3.2

^aCatalog number in the Department of Palaeobiology, Royal Ontario Museum

Regression Equation 3:

$\log y = 2.366 (\log x) + 1.984$ (where x = measure and y = body weight), $r = 0.9581$, $t = 6.497$, 17 *df*; therefore $p < 0.0000$, significant

Using this regression, the predicted weight for Marco Gonzalez bones of *Lutjanus* sp. snappers is as follows:

CN	Measure (mm)	Predicted Weight (g)
MG21-F396	13.8	3,443
MG21-F397	10.5	1,801
MG21-F398	9.9	1,570
MG21-F399	8.2	1,004
MG21-F400	7.8	893
MG21-F401	7.1	714
MG21-F402	6.2	519
MG21-F403	5.9	461
MG21-F404	5.9	461
MG21-F405	5.4	374
MG21-F406	5.2	342
MG21-F407	4.6	256
MG21-F408	4.5	243
Average	—	929

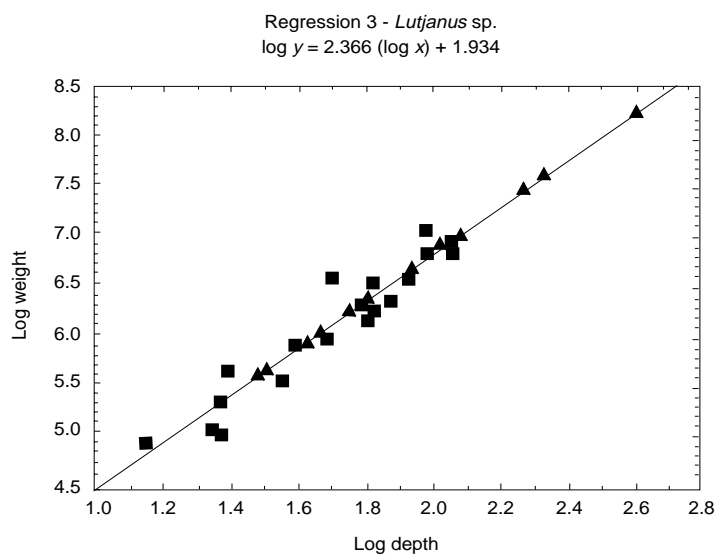


Figure 10.5. Regression 3, log of the anterior dentary depth plotted against the log of the body weight for a sample of recent and archaeological *Lutjanus* sp. snapper specimens. The regression line is based solely on the recent specimens, as these were of known body weight. Since only the bone measure is known for the archaeological specimens, this plot was used to predict the body weight of each archaeological specimen.

Table 10.5. Regression 4

Raw data on recent fish for regression of maximum width of posterior part of ventral pharyngeal arch (= measure) for *Sparisoma* sp. parrotfish.

CN ^a	Species	Body Weight (g)	Measure (mm)
R2248	<i>S. rubripinne</i>	511	18.6
R2677	<i>S. chrysopteron</i>	445	15.4
R2227	<i>S. aurofrenatum</i>	423	13.0
R2153	<i>S. chrysopteron</i>	399	15.0
R2678	<i>S. chrysopteron</i>	345	14.9
R5928	<i>S. rubripinne</i>	322	12.7
R2709	<i>S. aurofrenatum</i>	230	11.8
R4889	<i>S. chrysopteron</i>	213	11.5

^aCatalog number in the Department of Palaeobiology, Royal Ontario Museum.

Regression Equation 4:

$\log y = 1.665 (\log x) + 1.460$ (where x = measure and y = body weight), $r = 0.8577$, $t = 1.3566$, 6 df ; therefore $p < 0.2237$, not significant

Using this regression, the predicted weight for Marco Gonzalez bones of *Sparisoma* sp. parrotfish is as follows:

CN	Measure (mm)	Predicted Weight (g)
MG21-F531	20.1	637
MG21-F526	14.2	357
MG21-F528	10.8	227
MG21-F527	8.9	164
Average	—	346

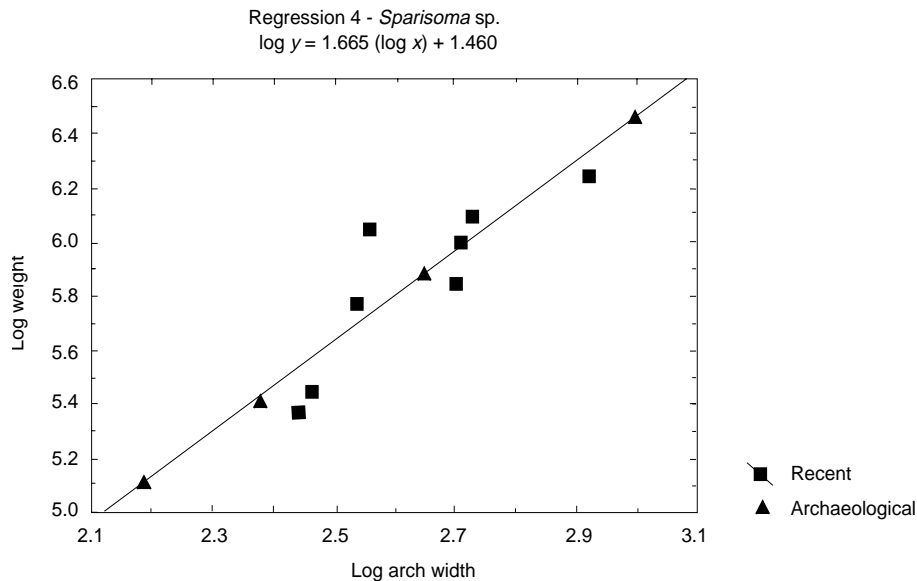


Figure 10.6. Regression 4, log of the ventral pharyngeal arch width plotted against the log of the body weight for a sample of recent and archaeological *Sparisoma* sp. parrotfish specimens. The regression line is based solely on the recent specimens, as these were of known body weight. Since only the bone measure is known for the archaeological specimens, this plot was used to predict the body weight of each archaeological specimen.

Table 10.6 Regression 5

Raw data on recent fish for regression of maximum width of posterior part of ventral pharyngeal arch (= measure) for *Scarus* sp. parrotfish.

CN ^a	Species	Body Weight (g)	Measure (mm)
R2142	<i>S. guacamaia</i>	2,516	20.7
R2157	<i>S. coelestinus</i>	1,918	16.8
R2235	<i>S. coelurus</i>	1,451	17.1
R1771	<i>S. vetula</i>	465	8.5
R2754	<i>S. coelestinus</i>	432	9.0
R2708	<i>S. vetula</i>	340	9.1
R5021	<i>S. taeniopterus</i>	270	7.6
R2200	<i>S. taeniopterus</i>	236	7.2
R5022	<i>S. taeniopterus</i>	180	7.1

^a Catalog number in the Department of Palaeobiology, Royal Ontario Museum

Regression Equation 5:

$\log y = 2.286 (\log x) + 0.944$ (where x = measure and y = body weight), $r = 0.9843$, $t = 2.548$, 7 df ; therefore $p < 0.0382$, significant

Using this regression, the predicted weight for Marco Gonzalez bones of *Scarus* sp. parrotfish is as follows:

CN	Measure (mm)	Predicted Weight (g)
MG21-F506	21.0	2,714
MG21-F503	16.1	1,477
MG21-F507	15.9	1,434
MG21-F504	9.4	432
Average	—	1,514

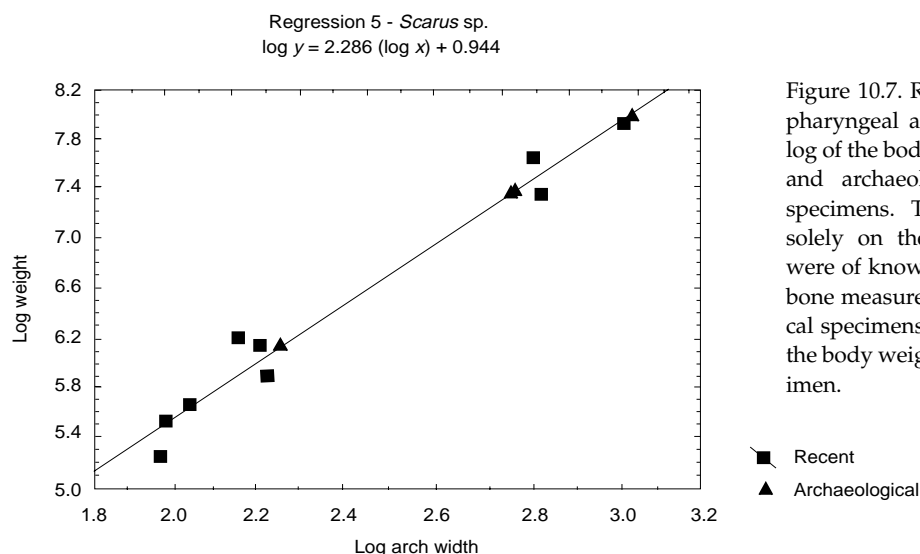


Figure 10.7. Regression 5, log of the ventral pharyngeal arch width plotted against the log of the body weight for a sample of recent and archaeological *Scarus* sp. parrotfish specimens. The regression line is based solely on the recent specimens, as these were of known body weight. Since only the bone measure is known for the archaeological specimens, this plot was used to predict the body weight of each archaeological specimen.

Amount of Usable Meat Represented by Archaeological Fish-Bone Samples

The MNIs for the Marco Gonzalez site are in Table 10.7, and the amount of usable meat (calculated two ways) represented by archaeological fish-bone samples is in Table 10.8. The results show that four major fish groups dominate the

sample (groupers, crevalle jacks, snappers, and barracuda), making up more than 83 percent of the usable meat. This proportion and the relative proportion of the 17 individual groups barely change if the 90 percent usable figure is used, although the total meat weight obviously increases with the 90 percent usable figure.

Table 10.7. MNIs for Structure 27, Level 21, of the Marco Gonzalez Nonvertebral Fish Bone Sample

CN	Family (common name)	Genus and Species	Element	MNI
F38	Ariidae (sea catfishes)	<i>Arius</i> sp.	Supraoccipital	1
F41-42	Centropomidae (snooks)	<i>Centropomus</i> sp.	L. dentary	2
F64-75	Serranidae (groupers)	<i>Epinephelus</i> sp.	L. premaxilla	12
F145-147	"	<i>Mycteroperca</i> sp.	R. maxilla	3
F153	Rachycentridae (cobias)	<i>Rachycentron canadus</i>	L. quadrate	1
F203-223	Carangidae (jacks)	<i>Caranx hippos</i>	R. cleithrum	21
F161-165	"	<i>Caranx crysos</i>	Vomer	5
F190-191	"	<i>Caranx bartholomaei</i>	L. premaxilla	2
F311	"	<i>Trachinotus</i> sp.	Vomer	1
F333-351	Lutjanidae (snappers)	<i>Lutjanus</i> sp.	R. maxilla	19
F411-412	Gerreidae (mojaras)	<i>Gerres cinereus</i>	R. premaxilla	2
F420-425	Haemulidae (grunts)	<i>Haemulon</i> sp.	R. maxilla	6
F448-459	Sparidae (porgies)	<i>Calamus</i> sp.	L. premaxilla	12
F479-484	Labridae (wrasses)	<i>Lachnolaimus maximus</i>	Pharyngeal arch	6
F485	"	<i>Halichoeres radiatus</i>	Pharyngeal arch	1
F487	"	Other Labridae	L. premaxilla	1
F503-505	Scaridae (parrotfishes)	<i>Scarus</i> sp.	Ventral pharyngeal arch	3
F506-508	"	<i>Scarus coelestinus</i>	Ventral pharyngeal arch	3
F526-528	"	<i>Sparisoma</i> sp.	Ventral pharyngeal arch	3
F529-530	"	<i>Sparisoma viride</i>	Ventral pharyngeal arch	2
F531	"	<i>Sparisoma rubripinne</i>	Ventral pharyngeal arch	1
F584-594	Sphyraenidae (barracudas)	<i>Sphyraena</i> sp.	L. dentary	11
F606-614	Acanthuridae (surgeonfishes)	<i>Acanthurus</i> sp.	Pterygiophore, dorsal I	9
F627-633	Balistidae (triggerfishes)	<i>Balistes</i> sp.	Fin spine, dorsal I	7

Note: CN = catalog number; MNI = minimum number of individuals; L = left, R = right.

Table 10.8. Calculation of Meat Weight for Each Fish Type at the Marco Gonzalez Site

Fish Type	MNI	Live Wt.	MNI x Live Wt.	% Usable (1)	Meat Wt. (1)	% of Total (1)	% Usable (2)	Meat Wt. (2)	% of Total (2)
Serranidae	15	7.22	108.3	79.7	86.3	40.6	90.0	97.5	40.4
<i>Caranx hippos</i>	21	3.0	63.0	81.3	51.2	24.1	90.0	56.7	23.5
<i>Sphyraena</i>	11	2.888	31.8	80.0	25.4	12.0	90.0	28.6	11.8
<i>Lutjanus</i>	19	0.929	17.7	76.7	13.6	6.4	90.0	15.9	6.6
<i>Scarus</i>	6	1.514	9.1	75.3	6.9	3.3	90.0	8.2	3.4
Other Carangidae	7	1.0	7.0	79.7	5.6	2.6	90.0	6.3	2.6
<i>Balistes</i>	7	1.0	7.0	69.6	4.9	2.3	90.0	6.3	2.6

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Table 10.8. Calculation of Meat Weight for Each Fish Type at the Marco Gonzalez Site (continued)

Fish Type	MNI	Live Wt.	MNI x Live Wt.	% Usable (1)	Meat Wt. (1)	% of Total (1)	% Usable (2)	Meat Wt. (2)	% of Total (2)
<i>Lachnolaimus</i>	6	1.0	6.0	78.7	4.7	2.2	90.0	5.4	2.2
<i>Calamus</i>	12	0.5	6.0	78.7	4.7	2.2	90.0	5.4	2.2
<i>Rachycentron</i>	1	3.0	3.0	80.0	2.4	1.1	90.0	2.7	1.1
<i>Haemulon</i>	6	0.5	3.0	73.3	2.2	1.0	90.0	2.7	1.1
<i>Sparisoma</i>	6	0.346	2.1	67.7	1.4	0.7	90.0	1.9	0.8
<i>Acanthurus</i>	9	0.2	1.8	67.5	1.2	0.6	90.0	1.6	0.7
<i>Centropomus</i>	2	0.5	1.0	79.7	0.8	0.4	90.0	0.9	0.4
Other Labridae	2	0.3	0.6	74.2	0.5	0.2	90.0	0.5	0.2
<i>Gerres</i>	2	0.3	0.6	72.0	0.4	0.2	90.0	0.5	0.2
<i>Arius</i>	1	0.5	0.5	79.7	0.4	0.2	90.0	0.5	0.2

Note: MNI = minimum number of individuals; Live Wt. = average live whole fish weight as calculated in Tables 10.2 through 10.6 or as estimated from the files of the Royal Ontario Museum; MNI x Live Wt. = minimum number of individuals multiplied by the live weight; % Usable (1) = percent of the fish that is usable or potentially usable, as calculated in Table 10.1; % Usable (2) = 90%, as used by Wing (1980); Meat Wt. (1) or (2) = meat weight calculated by multiplying percent usable by (MNI x Live Wt.); % of Total (1) or (2) = percent of the total meat weight represented by each species.

DISCUSSION

Percent Usable Meat for Recent Fish

Even from this limited sample it is clear that different fish families have a different percent usable meat, as here defined. They range from 67.5 percent for Acanthuridae to 81.3 percent for *Caranx hippos*. This phenomenon is important to acknowledge and to take into account when performing percent usable calculations.

There are a number of sources of error in the percent usable calculation. In particular, the largest fish used here were gutted before purchase so that the percent usable calculations are inflated by 5 percent or more (depending on the species). Fresh, nongutted fish are therefore more desirable for future calculations. Also, as mentioned, regressions for some of the fish groups were not calculated because of a lack of data, so an average live weight had to be estimated. To improve accuracy in the future, this should be avoided, and all calculations should be based on average weights calculated from regressions.

It is assumed here that past peoples did not eat the skin (primarily scales), guts, and bones; these may not be valid assumptions, especially if fish were thrown whole into a pot to cook. At least we know in this case they did not eat some of the bones, as these were preserved in the midden at the Marco Gonzalez site. However, the assumption that people did not eat the guts may not be valid. If the gut weight were to be included with the percent usable, many numbers would rise close to 90 percent (Table 10.1), the percent used by Wing (1980). More information about a particular culture's food preparation methods is required before any of these assumptions can be validated.

Logarithms

Classically, the natural logarithm of the data, rather than the raw data itself, is used in these kinds of studies (e.g., Casteel 1974; Reitz et al. 1987). This is a type of data transformation that is commonly used in order to study the slope of the regression line through a series of data points (e.g., Gould 1966; Schmidt-Nielsen 1977).

Even if the slope of the line is not of particular interest, and even if a good amount of clustered data is present, the data are usually logged anyway in order to take into account the allometric effects of scaling (Prange et al. 1979; Reitz et al. 1987). For fish there has been some discussion suggesting that the overall scaling of skeletal mass to body mass is isometric rather than allometric (Berrios-Lopez et al. 1996), although some ontogenetic variation has been noted. In studies such as the present one, where a known series of points is used to predict an unknown, it is probably better to calculate the logarithms of the data in order to try to remove any possible scaling effects, even if the scaling is close to isometric.

Regressions for Body Weight Represented by Archaeological Fish-Bone Samples

An evaluation of each of the five regressions follows.

Regression 1 (*Epinephelus* groupers; Table 10.2 and Figure 10.3). This regression is not particularly satisfying for several reasons. First, the slope of the line is highly dependent on the two largest fish. Additional data on large specimens are required in order to gain confidence in this particular regression. Second, all but the smallest of the Marco Gonzalez bones measured fall into the gap between the large (> 100 kg) and small (< 1 kg) recent comparative data. Since there are no recent comparative data within this range, all predictions require a rather large interpolation.

Regression 2 (*Sphyraena* barracudas; Table 10.3 and Figure 10.4). An increase in the sample size, particularly of nongutted large individuals, is required. Nevertheless, this regression has a high correlation coefficient.

Regression 3 (*Lutjanus* snappers; Table 10.4 and Figure 10.5). Several of the Marco Gonzalez bones are larger than any of the recent bones, requiring an extrapolation. Without large recent skeletons for inclusion into the data set, these predictions may be subject to a degree of error.

Regression 4 (*Sparisoma* parrotfish; Table 10.5 and Figure 10.6). There appears to be a slightly different proportion in this element between the species used and *S. viride*, so data

on *S. viride* are not included in this regression. This regression equation has the lowest *r* value and *t* value of all the regressions calculated, suggesting that the relationship between these two variables is not as clear-cut as it was for the other regressions, probably because of the small sample used.

Regression 5 (*Scarus* parrotfish; Table 10.6 and Figure 10.7). The *t* and *r* values are high; an increased sample size would be all that would be required to make this a very good regression.

Amount of Usable Meat Represented by Archaeological Fish-Bone Samples

Wing (1980) estimated a single average live weight for each species and multiplied this by the MNI. Subsequently, this number was multiplied by the estimate of percent usable meat, which was taken as 90 percent for all fish except Ariidae, for which she used 77 percent, without indication as to how either figure was derived. This gave a final figure for the net amount of usable meat for each species. This same method is utilized here, except that the average live weight is actually based on a regression that is based on the archaeological bones, and the newly calculated percent usable figures for each family were substituted for the 90 percent figure that Wing (1980) used.

For the Marco Gonzalez site the proportion of fish groups in the sample barely changes whether the 90 percent usable or the newly calculated percent usable figure is used (Table 10.8). Archaeological inferences for this site therefore do not differ if these newly calculated percent usable figures are used, but this need not be the case for every site. For a site with a large number of fish bones, these more accurate percentage usable figures may make a difference to the overall meat weight proportions. An increased accuracy in calculations and estimates should be desirable, in any case.

Archaeological Inferences

Even with the realization that much in Table 10.8 is an estimate only, the fishery at Marco Gonzalez might be thought of as a fishery for the larger carnivorous fish, with all the others

playing a lesser role. Two reasons suggest caution in accepting this statement: there was a bias against the collection of smaller bones at this site because fine-mesh screens were not used for collection, and the approximately sixteen hundred vertebrae collected were not identified here; only the skull elements were used.

Since the bulk of the meat protein was derived from the larger carnivorous fish, hooks were probably the main fish procurement tool, although nets or fish pots were probably necessary in order to obtain some of the other fish species found at this site. Unfortunately, no archaeological remains of fishing equipment have been found at this site.

Several carnivorous fish species occurring in this site are commonly caught by hook, including the catfish (*Arius* sp.), jacks (*Caranx* sp.), groupers (*Epinephelus* sp. and *Mycteroperca* sp.), snappers (*Lutjanus* sp.) (Wing and Reitz 1982), and, presumably, the barracudas (*Sphyræna* sp.). The occurrence of a large jewfish (*Epinephelus itajara*) is of particular note in this respect. The largest bones (not dentaries) indicate a fish weighing about 135 kg (an estimate only), as they are intermediate in size between the two largest ROM skeletons, which represent fish of weights 196.8 and 102 kg. In order to capture a fish of this size, special equipment or at least a sizable boat would be required!

CONCLUSIONS

Different fish families have a different percent usable meat, as here defined. They range from 67.5 percent for surgeonfishes (Acanthuridae) to 81.3 percent for crevalle jack (*Caranx hippos*), with most families between 70 percent and 80

percent. If enough recent comparative data are available, regressions are useful to predict the approximate weight of a fish represented by an archaeological bone. For Marco Gonzalez Structure 27, level 21 material, the overall proportion of meat represented by the different fish types does not change if accurate usable meat figures are used or the same percentage for all fish types is used. This may well not be the case for other sites, particularly those with a large sample.

Acknowledgments. Thanks are extended to the Canadian Employment and Immigration Centre for the approval of grant 7898HK8, under the Section 38 program. This grant allowed me to purchase fish specimens from the Kensington Market in Toronto in 1989 and to hire Rae Sudsbury, Richard May, Lawrence Taylor, and Ron Sander to prepare fish skeletons. These skeletons were indispensable for the identifications made in this study; they are housed in the Department of Palaeobiology, ROM. Thanks are also extended to the Ontario Government's S.E.E.D., Challenge, and Futures Programs, which allowed me to hire the following people to prepare fish skeletons: in 1984, Cathy Yasui, Chris Neill, and Tiina Kurvits; in 1985, Heather Dewar; in 1987, Angela Gibson; and in 1988, Thomas Carr; and to the Toronto High Schools COOP program, which enabled Ethan Friendly to prepare even more fish skeletons in 1990. Since 1990, additional fish skeletons were prepared by Anne Davis, Diane Dawson, Mindy Myers, Michael Richardson, Ozzie Teichner, and the author. Elizabeth Graham kindly provided the archaeological fish bones for analysis from the Marco Gonzalez site.



PART 4

Maya Animals in Ritual, Politics, and Economics

Animal Utilization in a Growing City

Vertebrate Exploitation at Caracol, Belize

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The lowland Maya site of Caracol, Belize, has been excavated extensively during the last two decades. A substantial amount of vertebrate faunal remains has been recovered from both ceremonial and domestic contexts. Preliminary analysis provides insight into the exploitation of habitats and trading practices from the Late Preclassic/Early Classic transition (ca. 200 B.C.–A.D. 200) to the Terminal Classic (A.D. 800–1000). Changes in resource procurement and animal management practices show how growing complex societies adapted to increasing population and environmental stresses.

This chapter will reveal effects of population growth on the land, subsistence practices, and ceremonial behavior at the Maya site of Caracol, Belize. Located in the western foothills of the Maya Mountains, Caracol is approximately 500 m above sea level. The nearest permanent body of water is the Macal River, 15 km away. The environment today is moist subtropical forest within the Petén Biotic Province and has changed little since the Late Pleistocene (Miller and Miller 1994:18).

Caracol presents a good opportunity for study for many reasons, including the site's continuous occupation from the Preclassic (ca. 600 B.C.) through the Terminal Classic (ca. A.D. 1000). This lengthy history allows us to examine long-term patterns of changing faunal use. Eighteen years of intensive archaeological excavation at this site under the direction of Arlen and Diane Chase (Chase and Chase 1987; D. Z. Chase and A. F. Chase 1994) of the University of Central Florida have produced a diverse and large faunal assemblage from all parts of the site. As of 1998 the Caracol Archaeological Project had excavated approximately 84,763 pieces (or 12,500.99 g) of faunal remains col-

lected from a variety of contexts, including structural fill, living surfaces, burials, and caches throughout Caracol. The recovered bone provides a means to explore patterns of use among Caracol's socioeconomically diverse population.

The size and complexity of this site allows us to ask questions about the relationship between its populace and the surrounding environment. Caracol developed from a small village in the eighth century B.C. to a large Classic Maya city that by A.D. 650 covered approximately 177 km² and had a population of more than 115,000 people (A. F. Chase and D. Z. Chase 1994:5) (Figure 11.1). A city of such size would have required a complex infrastructure to meet the subsistence needs of its residents. To meet the food requirements at Caracol, early construction engineers interlaced agricultural terraces in all parts of the city, even within its center (Chase and Chase 1996). Reservoirs were built to provide water for Caracol's populace, typically four to five within 1 km². What remains unanswered, however, is how meat was supplied to an expanding population that encroached on the surrounding forest. Several

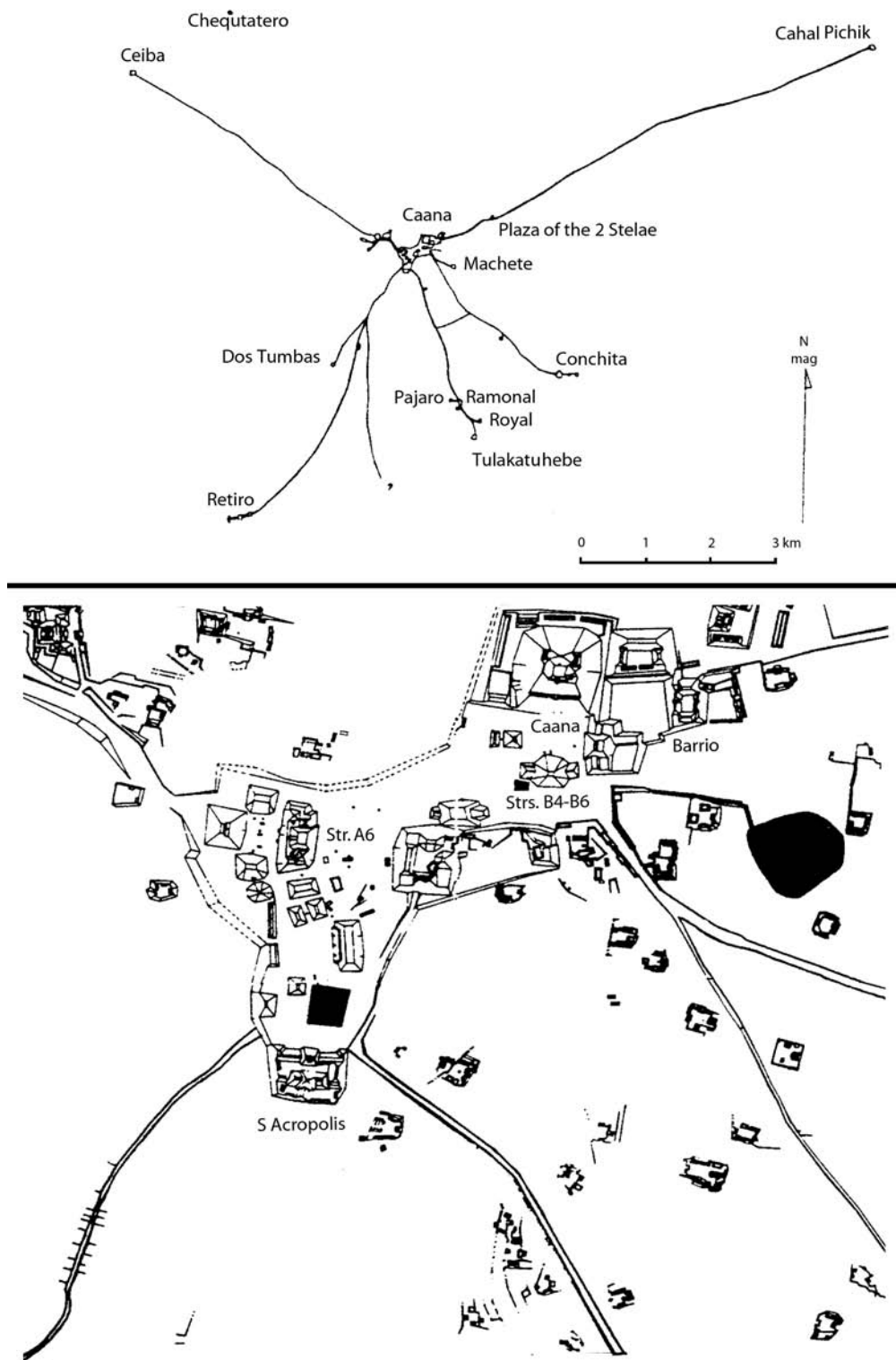


Figure 11.1. Map of Caracol, Belize, showing central square kilometer as mapped through the 1992 field season (from D. Z. Chase and A. F. Chase 1994:3).

technological responses have been offered based on Ford's (1986) postulates for subsistence strategies as they might apply to animal utilization. With changes in environmental resources the Caracol Maya could have (1) increased hunting distances into unused areas; (2) developed methods of animal domestication and/or taming, as well as targeted and managed hunting; or (3) used other previously underutilized fauna. The faunal remains from Caracol will help us to understand how Caracoleños adapted to population pressure and societal complexity using technological responses.

Greater societal complexity within a city can be recognized through adaptive mechanisms of social organization such as the emergence of specialization, increased socioeconomic differentiation, and increased reliance on trade imports. The greater the population, the greater the organizational needs for management and integration of all people (e.g., Carniero 1970; Ford 1986:11; Zeder 1991). From this, powerful centralized leadership emerges to effectively manage the specialization and exchange within the economy (Brumfiel and Earle 1987:2; Polanyi 1944). Specialization is a common solution when natural resources are unevenly distributed or when the production process involves some gradually acquired skills or significant economies of scale (Brumfiel and Earle 1987:5; Zeder 1991). Specialization with regard to animal resources can take many forms, from meat distribution to animal management to the production of finished bone products. The distribution of meat is believed to have become increasingly segregated from animal management and thus itself to become a specialized activity (Zeder 1991:250).

The main goal of my research is to investigate the relationships between sociopolitical status, subsistence, and animal use, and how they were affected by increasing social complexity in Maya society at Caracol. This chapter will focus on the variability in animal use between outlying residential groups and the elite groups within the urban epicenter.

SUBSISTENCE CHANGES

It has only been since the 1980s that zooarchaeology has played a prominent role in Maya studies. During this time researchers such as Elizabeth Wing (1980), Mary Pohl (1981, 1983, 1990), Nancy Hamblin (1984), Helen Sorayya Carr (1985), June Morton (1987), and Leslie Shaw (1991; Shaw and Gibson 1986) demonstrated that faunal analysis can do more than just reconstruct paleoenvironments and provide a list of possible menu items from the past. Faunal analysis can reveal complex trade networks, times of population stress, different groups of people within a city, the roles of different socioeconomic groups, and ceremonial practices, all of which this current research continues to address.

Arlen and Diane Chase (A. F. Chase and D. Z. Chase 1994:6) believe that major changes in the environment accompanied the growth of Classic Maya populations, necessitating shifts in subsistence strategies. One such change included the depletion of primary forest growth and the increase in fields and brushy areas (A. F. Chase and D. Z. Chase 1994:6; Lee 1996:413; Miller and Miller 1994:12). These habitat changes would have been more inviting to animals such as opossum, deer, and rabbit, whereas other wild game, such as the jaguar, would have migrated to areas where food was more readily available (Stokes and Stokes 1986).

Tables 11.1 and 11.2 give the distribution of the faunal assemblage from dated contexts with and without the removal of the Terminal Classic A6 floors and fill data. These contexts are removed in Table 11.2 because they contain both refuse deposited after A.D. 890 and the animals that were attracted to the refuse for food and shelter. For instance, 54,651 mammal elements (91 percent, 3,894.78 g) come from the room floors at the top of Structure A6.¹ Showing two tables allows for the acknowledgment of this bias. As a note, raw counts are used in these tables instead of amount per volume excavated because of the differences in excavated contexts.

Burials may have little soil if sealed, whereas units of varying sizes would have more. This mostly intrusive material causes quite a difference in the site patterning. Instead of the great increase in faunal usage at Caracol during the Late Classic, Table 11.2 suggests another story.

Table 11.1. Caracol Fauna by Dated Contexts

Period	Count	Percent	Weight (g)
Late Preclassic	1,479	2.2	451.51
Early Classic	888	1.3	338.95
Late Classic	3,471	5.2	841.56
Terminal Classic	61,427	91.3	5,798.73
Site total	67,265	100	7,430.75

Table 11.2. Caracol Fauna by Dated Contexts after A6 Floor/Fill Removal

Period	Count	Percent	Weight (g)
Late Preclassic	1,479	18.2	451.51
Early Classic	888	11.0	338.95
Late Classic	3,471	42.9	841.56
Terminal Classic	2,260	27.9	1,759.05
Site total	8,098	100	3,391.07

Based on the faunal data it appears that Caracol was already quite efficient in providing meat to households and importing luxury products such as marine fish. There is a decline in utilization of meat during the Early Classic. This may be real or a bias of the data sample. For instance, if there are more structures found from the Late Preclassic than the Early Classic, then the data set may reflect this in total amount of bone recovered. Or, if the disposal of animal remains from the Early Classic was used as fill in the later construction phases of buildings, then this material may not be associated with dated contexts and not applied to the overall patterning at the site. The data from other material remains will help determine which is the most logical explanation. Currently, Arlen Chase (personal communication 2001) believes that there are not enough Early Classic structures excavated at this point.

The spike from Early to Late Classic is logical given the increase in population levels by this point. The proposed defeat of Tikal initiated a florescence of Caracol that was seen in the construction of the majority of plaza groups, causeways, and terraces throughout the city (A. F. Chase and D. Z. Chase 1998). The expansion brought many of the smaller nearby centers within Caracol's polity, and the causeways integrated them within the greater Caracol social fabric. The increase of all faunal material shows the ability of Caracol to provide for its inhabitants both in large game and imports from the sea. A slight decline during the Terminal Classic matches a decline in population levels as people began to leave the city through A.D. 1000 (Chase and Chase 2000).

To ensure that the patterns in fauna representation over time are not restricted to a portion of the population, divisions into broad socioeconomic groups are applied, following models by Chase and Chase (Chase and Chase 1987; D. Z. Chase and A. F. Chase 1994). The faunal assemblage is divided among the epicenter (the central locus of administrative and ceremonial activities), the core (residential in nature and outside of the administrative and royal structural complexes), and the termini areas at the end of the causeways (large administrative plazas). Causeway termini, approximately 6 to 8 km away from the epicenter (see Figure 11.1), are not residential in function but probably served as regional administrative centers for the area (Chase and Chase 1996). Based on architectural investment alone, the epicenter and the causeway termini can be classified as elite, likely royal, whereas the core contains households of all socioeconomic strata but can be averaged to the middle majority of Caracol's populace.

Figure 11.2 highlights that the majority of faunal remains can be found in the epicenter. This is significant since only 26 percent of the total 147 discrete excavation areas or operations were located in the epicenter, but remains from the epicenter represent 88 percent of the total site faunal assemblage. In contrast, 65 percent of excavation areas were from the core, but

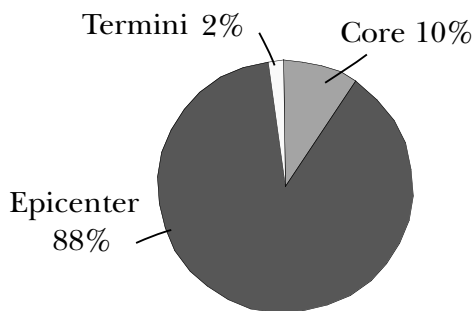
these represent only 10 percent of the total assemblage from just 37 residential groups. It is therefore unlikely that excavation strategies are responsible for the difference in quantities recovered from different site areas.

More likely, some differences are the result of variability in recovery context (see Emery chapter 2 for additional discussion). From the evidence collected so far, the best preservation of bone occurs in sealed environments such as cache vessels with lids, structural fill, and floors sealed by other floors. Degree of preservation within tombs depends on whether the tomb remained sealed or was opened through partial collapse. Protection from the elements (including water, acidic humus soils, plant roots that can burrow through bone) is crucial to bone preservation. Most often excavations in the epicenter are conducted on large structures with only a small covering of soil and then structural fill. Tombs are generally still sealed and have very little debris that might hinder the preservation of included animals, although temperature variability may be a factor. In contrast, the core residential plazas often contain open or partially collapsed tombs with lots of debris from the surrounding environment and are subject to rain and heat, a very poor condition for bone survival. Of course, another reason for recovery differences may be that inhabitants of

the epicenter were eating and using the majority of the animals brought into Caracol. Further testing is being conducted using multiple lines of evidence such as stable isotope testing on human remains (Chase et al. 1998) and my own research to understand the dietary habits of different socioeconomic groups (see Teeter 2001).

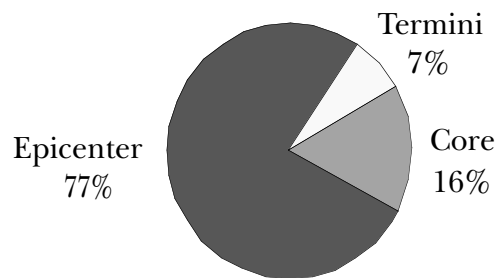
Christine White of the University of Western Ontario is researching information on the diet and nutrition of elite and nonelite Caracol Maya through stable isotope analysis on human bone. White's analysis is helping us to understand what portions of the Caracol diet were maize vs. meat and how dietary patterns were distributed throughout the site (Chase et al. 1998). Early results are finding evidence of meat consumption in all parts of the city through time. However, not surprisingly, the largest diversity in diet is found in the epicenter, showing unequal access to food resources. This was found in the collagen-apatite spacings interpreted by Chase et al. (1998) and seen most dramatically in the faunal remains discussed more fully below.

Figure 11.3 divides the modified faunal remains by epicenter, core, and termini. The unmodified bone is not figured because it follows the same trend as for bone overall (Figure 11.2), since 99.2 percent of the total faunal assemblage is unmodified. Therefore, patterning



Site Area	Pieces	Weight(g)
Core	2,544	1,200.87
Epicenter	81,700	11,053.88
Termini	519	246.24
TOTAL:	84,763	12,500.99

Figure 11.2. Distribution of all animal bone by site area.



Site Area	Pieces	Weight(g)
Core	161	199.76
Epicenter	580	948.82
Termini	13	87.18
TOTAL:	754	1,235.76

Figure 11.3. Distribution of modified animal bone by site area.

shows that the majority of unmodified bone is found in the epicenter. However, the modified animal bone (Figure 11.3), largely found in sealed contexts, is a little more evenly distributed across Caracol.

Besides differences in the amounts of faunal material between the epicenter and outlying areas, there are also significant differences in species represented between the city areas. Table 11.3 presents a list of identified species found at

the site, and Table 11.4 shows the distribution of animal remains in the city by order. Table 11.5 presents the distribution of taxa orders by context. The “other” category used in this table refers to material found in poor context, including structural fill, collapse, and surface finds. Species identifications were limited to bone from primary contexts and all fish and modified bone to better understand what behaviors might be represented. Even with this restriction more

Table 11.3. Identified Vertebrate Species from Caracol, Belize

Taxon	Common Name	Taxon	Common Name
Dasyatidae	Stingray, unidentified	<i>Buteo</i> sp.	Hawk, unidentified
Ariidae	Sea catfish family	<i>Micrastur semitorquatus</i>	Falcon, collared forest
<i>Epinephelus striatus</i>	Grouper, Nassau	<i>Meleagris ocellata</i>	Ocellated turkey
<i>Caranx latus</i>	Jack, horse-eye	<i>Gallus gallus</i>	Chicken, domestic
<i>Lutjanus</i> sp.	Snapper, unidentified	Phasianidae	Quail, unidentified
<i>Haemulon sciurus</i>	Grunt, blue-striped	<i>Columba flavirostris</i>	Pigeon, red-billed
<i>Sphyrna</i> sp.	Barracuda, unidentified	<i>Zenaida</i> sp.	Dove, unidentified
<i>Sparisoma viride</i>	Parrotfish, stoplight	<i>Amazona</i> sp.	Parrot, unidentified
Total fish	197 (54.90 g)	<i>Tyto alba</i>	Barn owl, common
<i>Rhinophrynus dorsalis</i>	Frog, Mexican burrowing (Uo)	Strigidae	Owl family
<i>Bufo</i> sp.	Toad, unidentified	<i>Momotus momota</i>	Motmot, blue-crowned
<i>Rana</i> sp.	Frog, unidentified	<i>Ramphastos sulfuratus</i>	Keel-billed toucan
Total amphibian	2,716 (64.14 g)	<i>Cotinga amabilis</i>	Lovely cotinga
<i>Dermatemys mawii</i>	River turtle, Central America	<i>Cyanocorax yncas</i>	Jay, green
Kinosternidae	Mud, Musk turtle family	<i>Cyanocorax morio</i>	Jay, brown
<i>Rhinoclemmys areolata</i>	Turtle, furrowed wood	Total bird	4,079 (255.17 g)
Gekkonidae	Gecko family	<i>Didelphis</i> sp.	Opossum, unidentified
<i>Basiliscus vittatus</i>	Basilisk, striped	<i>Philander opossum</i>	Opossum, gray four-eyed
<i>Ctenosaura similis</i>	Iguana, spiny-tailed	<i>Chironectes minimus</i>	Opossum, water
<i>Anolis</i> sp.	Anole, unidentified	<i>Marmosa robinsoni</i>	Opossum, Robinson’s mouse
<i>Ameiva festiva</i>	Lagartija Parda	<i>Caluromys derbianus</i>	Opossum, C. Am. woolly
<i>Lepidophyma flavimaculatum</i>	Night lizard, yellow-spotted	<i>Cryptotis</i> sp.	Shrew, unidentified
<i>Boa constrictor</i>	Boa constrictor	<i>Micronycteris megalotis</i>	Bat, Brazilian small-eared
Colubridae	Colubrid family	<i>Carollia brevicauda</i>	Bat, short-tailed
<i>Bothrops asper</i>	Fer de lance	<i>Sturnira lilium</i>	Bat, yellow-shouldered
Total reptile	1,006 (284.22 g)	<i>Artibeus lituratus</i>	Bat, big fruit-eating
		<i>Centurio senex</i>	Bat, wrinkle-faced

Continued on next page

Table 11.3. Identified Vertebrate Species from Caracol, Belize (continued)

Taxon	Common Name	Taxon	Common Name
<i>Natalus stramineus</i>	Bat, Mexican funnel-eared	<i>Canis familiaris</i>	Dog, domestic
<i>Dasypus novemcinctus</i>	Armadillo, nine-banded	<i>Procyon lotor</i>	Raccoon
<i>Sylvilagus</i> sp.	Rabbit, unidentified	<i>Nasua narica</i>	Coati, white-nosed
<i>Sciurus</i> sp.	Squirrel	<i>Puma concolor</i>	Mountain lion, puma, cougar
<i>Orthogeomys hispidus</i>	Pocket gopher, hispid	<i>Lepardus pardalis</i>	Ocelot
<i>Heteromys desmarestianus</i>	Mouse, Demarest's spiny pocket	<i>Lepardus wiedii</i>	Margay
<i>Ototylomys phyllotis</i>	Rat, big-eared climbing	<i>Panthera onca</i>	Jaguar
<i>Sigmodon hispidus</i>	Rat, hispid cotton	<i>Tapirus bairdii</i>	Tapir, Baird's
<i>Agouti paca</i>	Paca	<i>Tayassu pecari</i>	Peccary, white-Lipped
<i>Dasyprocta punctata</i>	Agouti, Central American	<i>Odocoileus virginianus</i>	Deer, white-tailed
<i>Urocyon cinereoargenteus</i>	Fox, gray	<i>Mazama americana</i>	Deer, red Brocket
		Total mammal	59,925 (7,790.46 g)

Table 11.4. Distribution of Taxa Orders across Caracol, Belize

Order	Epicenter		Core		Terminus	
	No.	Weight (g)	No.	Weight (g)	No.	Weight (g)
Fish	173	46.43	24	8.47	0	0.00
Amphibian	2,647	60.02	65	3.99	4	0.13
Reptile	438	148.03	258	60.32	310	75.87
Bird	3,926	214.92	130	33.94	23	6.31
Mammal	57,454	6,753.50	2,296	897.04	175	139.92
Site total	64,638	7,222.90	2,773	1,003.76	512	222.23

Table 11.5. Distribution of Taxa Orders by Context at Caracol, Belize

Identification	Burial		Cache		Floor		Other	
	No.	Weight (g)	No.	Weight (g)	No.	Weight (g)	No.	Weight (g)
Fish	46	16.68	102	23.49	24	9.50	25	5.23
Amphibian	79	5.02	0	0.00	2,637	59.12	0	0.00
Reptile	584	144.61	18	2.30	403	136.50	0	0.00
Bird	1,173	99.67	392	17.21	2,512	137.32	0	0.00
Mammal	3,541	1,470.57	60	8.36	56,168	6,053.77	156	257.76
Site total	5,423	1,736.55	572	51.36	61,744	6,396.21	181	262.99

than 80 percent of the total assemblage was included. There are many interesting trends in these tables that can be examined further.

Fish use at Caracol provides a good example of specific environmental exploitation. For example, although the Macal River lies 15 kilometers away from the city epicenter and would have provided an abundance of fish, no river fish have yet been recovered from excavations. However, evidence for the importation of fish from the Belizean coast has been modest (197 elements) but intriguing. The majority of these fish derived from coral reef areas, and their importation would have been costly, requiring logistical planning. Because their presence begins in the Late Preclassic, a well-developed trade network must have been in place by this point (see Masson this volume for additional discussion). Although only a small amount of fish remains were recovered in the city, their presence is not incidental, based on the stable isotope analysis on human remains, which shows the presence of fish in the diet of elite residents (Chase and Chase 1999). Because of difficulties bringing fish into Caracol, it is doubtful that they ever constituted a major part of the dietary regimen, but the archaeological distribution of these remains suggests that fish were eaten by an affluent segment of the Caracol population both in the epicenter and core. No fish were found at the causeway termini groups, although those groups likely have strong elite ties.

The presence of amphibian remains at Caracol is restricted to frogs and toads. Almost the entire collection (99 percent) was recovered from excavations into trash deposited in the rooms on top of Structure A6. This context dates to after A.D. 890, with a buildup of faunal remains and trash as a result of owl and human contributions (discussed further below). Outside of this context the small portion that is left comes from floor contexts in Structures B19 and B21. This may be indicative of food, but with no cut marks or cooking indications it is hard to tell anything conclusive from only two examples.

The representation of reptiles in the Caracol archaeological record does not reflect changes

in the environment over time. Overall, reptile use does increase over time, but it decreases as the city is abandoned. Turtles, iguanas, and boas can all live commensally with humans, and the increase in human population would have increased their available food at Caracol. The recovery of turtles highlights the use of riverine environments, since some of the turtle species (e.g., the Central American River turtle) were not likely found in the city but may have been obtained from the Macal River. Turtles were found most frequently in upper-class groups throughout the city (epicenter, core, and terminus). Iguana and snakes may have contributed to the diet at Caracol, but their presence in only a few contexts makes forming conclusions about their role difficult.

Many of the birds identified from the Caracol faunal assemblage prefer more open land with forest patches, including the ocellated turkey, quail, and barn owl. These birds offer the best glimpse at the surrounding environment of Caracol during its occupation. Far from being denuded of trees, Caracol's larger building clusters were likely surrounded by residential plaza groups connected by agricultural terraces and kitchen gardens with fruit and nut trees. The aesthetic use of trees is also likely, but speculative, as is the argument for a "king's forest" similar to feudal Europe, where royals could hunt for protected wild game (Pohl 1981).

Bird remains were recovered largely from epicentral floors. Significant numbers were found in dated contexts from the Late Preclassic, with a drop in use during the Early Classic. This decline then is followed by a sharp increase to 35.7 percent by the Late Classic. The next augmentation in use during the Terminal Classic period matches northern Belize Maya cities, where an increased reliance is seen on the use of birds and smaller animals. Ocellated turkeys (*Meleagris ocellata*) are responsible for the majority of identified species on floors. Additionally, quail (Columbiformes) and songbirds (Passeriformes) were restricted to the epicenter. Based on the limited evidence, it seems that turkey and other birds represented only a small proportion of Caracol residents' diet.

The presence of mammals in dated contexts through time shows an ever-increasing amount of remains from the Late Preclassic to the Terminal Classic, with the majority from the Terminal Classic. The large augmentation between the Late and Terminal Classic periods matches other northern Belize Maya cities, where an increased reliance is seen in the use of smaller animals. However, this great increase is likely also owing to the preservation of the final Caracol occupation and in particular, the largely intrusive A6 floor remains.

Opossums, bats, armadillos, shrews, rodents, tapir, peccary, and deer are found predominately on floors. Among these represented mammals the majority of the smaller animals (i.e., mouse opossums, shrews, rodents, and bats) were recovered from A6. If the epicenter total is considered without the remains from the Terminal Classic A6 floors, almost half of the epicenter total is taken away but still represents the majority of mammal remains (53 percent) over the entire city. It is interesting that rabbits, carnivores, and artiodactyls continue to dominate epicentral contexts even after the removal of A6 floor materials.

Similar to birds, the mammal data overall suggest some level of restriction on the use of many mammals for food. The representation of opossum, margay, jaguar, raccoon, tapir, and coati on floors is minimal, with little significance as food. It should be noted, however, that even a small amount of tapir would contribute more meat than a half dozen rabbits and was restricted to Structures B4 and B6 in the epicenter.

Good evidence for meat resources derives from rabbit, the third most abundant mammal from floor contexts. However, its presence at Caracol is highly restrictive, being found in only eight structures (B4, B6, B19, B20, B24, B25, B34, and B64), all within several hundred meters of each other.

A similar restriction to the northeast portion of the epicenter (if we don't consider A6 floors) is seen with the *Agouti paca* and *Dasyprocta punctata*. They are restricted to B19,

B25, and B118. Likewise, *Urocyon cinereoargenteus* (gray fox) was recovered only in Structures B4, B23, and B64.

As a food, dog is never the most abundantly represented but is still a staple of the Maya from the Formative to the Postclassic (Pohl 1990:159; Wing 1981:25). At Caracol dogs are well represented but restricted in recovery to Structures B4, B5, B6, B19, B25, B64, and, on the Central Acropolis, Structure A39. A fourth of the recovered dog assemblage was worked. It is likely that the remaining contexts represent food refuse and that dog formed a small part of the elite diet.

Peccaries are considered one of the three top meat sources for the Maya (Sharer 1994: 440). At Caracol, however, peccary was limited to the epicenter, based on floor remains being recovered in the B ball-court floor and Structures B21, B24, B64, and D18 in the South Acropolis. The majority of the elements are teeth and not likely representative of food. Since peccary bones are strong and a good choice for bone working, it may be that bone was utilized further after the meat was removed and will be found modified.

The most important meat source has been saved for last. Two species of deer are found at Caracol, the white-tailed and smaller red brocket deer. Although deer availability and use during the Classic period has been questioned, its significance from the Formative through the Spanish periods cannot be denied (Pohl 1985b). At Caracol it is the most abundant species found—mostly in the epicenter, but two fragments were found in Structure C11 of the Los Tabanos group. Clearly deer formed a large part of the epicentral diet. Deer was also often found modified. Like the peccary, deer remains demonstrate the complete utilization of animals. It is difficult to accurately assess how much deer or other meat might have been eaten within a complex society such as Caracol because leftovers may have been completely recycled.

To further look at subsistence activities, faunal remains have been recovered from two types of refuse contexts at Caracol. One, located in

Structure A6, is de facto refuse deposited over a century or more (Chase and Chase 2000). Located in the two central and side rooms, it was a greasy, black soil that appeared to have been periodically burned. Of the faunal remains from Caracol, 71 percent were recovered in this structure. Unfortunately, 87 percent ($n = 52,613$) of this material is divided among rodents, mouse opossums, and shrew. Archaeological sites provide an excellent habitat for these creatures, as well as a food supply, shelter, and potential traps (Falk and Semken 1998:304). Their presence in the trash deposit is likely the result of animal activity, including owl roosting and carnivore scavenging during the abandonment of these rooms, and not direct human activity.

Excavations at some of the epicentral residential courtyards revealed an additional type of refuse. Provisional trash was a short-term deposit not cleaned from the courtyard before the group was abandoned (Chase and Chase 2000). More than a half dozen examples of this type of refuse area have been identified. Most are Terminal Classic (see Pendergast chapter 15 for additional discussion of this type of refuse), such as Structure B64 and the "Barrio" residential group (located within the northeastern area of the epicenter). Often deer are found in these situations; however, Structure B64 is extremely diverse and includes deer, peccary, rabbit, and snapper.

Unfortunately, refuse in the core areas has not been located. This may be owing to a lack of general preservation or refuse disposal. Diane and Arlen Chase (2000) have suggested that with such a high population density, a more formal garbage disposal system would have been in place at Caracol. Shaw (1985:7) showed evidence for this possibility when she found only low numbers of fish remains from Colha, until a single pit feature was found to contain 1,274 bones of fish and turtle remains. She believes that fish were likely buried quickly to reduce the heavy smell of decomposition. A similar practice may have been to collect and remove refuse from the residential areas to a

yet-undiscovered locale. But although preservation or refuse practices are likely factors in identified patterns, White's stable isotope analysis supports meat in the core population's diet through time (Chase et al. 1998). Therefore, it is likely that the Caracol diet included more animal meat than current data suggest.

CEREMONIAL USE OF FAUNA

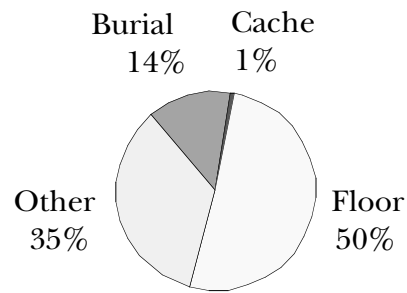
Animals also played an ideological role for the Maya. Miller and Taube (1993:118, 148) write that monkeys were patron gods of art, writing, and calculating. People born under the time of "1 Monkey" were likely to be artists or scribes. Ethnographically, Mary Pohl (1983) has described modern-day rituals that include the sacrificing of a bull and a pig. From the ethnographic, historic literature, and zooarchaeological data it is possible to reconstruct how animals were used in rituals and how changes in their accessibility affected their symbolic and economic value. For example, what effect did habitat destruction have on forest animals incorporated into ceremonial practices as Caracol continued to expand over time? The data suggest a number of alternatives. It is possible that the Caracol population modified its ceremonial activities in response to stresses on animal resources. This stress may have caused the population to reevaluate the higher cost of animals for public and private ceremonies and at times to make substitutions of more readily available animals. The alternative may be that the higher cost of rarer animals increased their symbolic and/or ceremonial value and that these animals continued to be used by the elite. The archaeological faunal record shows which animals were preferred in burials and caches through time. If certain animals became more costly but were still used, there should be a change from more widespread use to a restricted presence in higher socioeconomic groups. If a choice of substitution was preferred, then over time there will be a gradual replacement of individual animals that do not tolerate human populations, to more commensal species used within burials and

caches. The abundance of faunal material excavated from primary contexts provides a unique opportunity to study the relationship between ideology and subsistence strategies.

Ceremonial activities are most readily identified in two contexts, burials and caches. Burials at Caracol are most often found in cysts (a prepared area with clear outlines, marked either by soil changes or stones), crypts (areas with formal walls and roof but not much larger than necessary for their contents), tombs (formal construction larger than necessary for their contents), and chultuns (subterranean pits carved in bedrock), and the burials may include offerings of meat or even the entire animal (Chase and Chase 1987:57). Purposefully buried objects, or caches, generally consist of a container, such as a lidded urn or bowl, filled with an offering and buried in front of or within a building. Because caches are often sealed at Caracol, the preservation can be extremely good, allowing archaeologists to recover seeds, cloth, and even string (D. Z. Chase and A. F. Chase 1998).

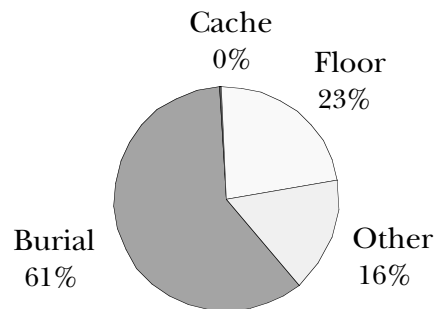
Figure 11.4 shows how faunal remains separate into contexts, with the majority of bone being recovered from floors (50 percent) and mostly midden material. Also, a significant percentage of bone (14 percent) was recovered from burials. Since the majority of the floor material is from small animals, calculating percentages by weight instead of number of specimens (NISP) helps reduce some skewing. In this method the weight percentage for the “other” context category is higher since the majority is heavier deer bone recovered from structural fill on Caana.

The modified bone appears to be radically different from the rest of the assemblage. Figure 11.5 shows that burials are most likely to contain modified bone—generally awls, needles, pins, scoops, tubes, inscribed and carved pieces (such as Figure 11.6, showing a hieroglyphic text carved on a long bone found within a Late Classic tomb in a core residential group), and occasionally figurines. Figure 11.7 shows carved deer-antler figurines recovered from an



Context	Pieces	Weight(g)
Burial	4,964	1,695.15
Cache	693	86.58
Floor	73,143	6,384.52
Other	5,963	4,334.74
TOTAL:	84,763	12,500.99

Figure 11.4. Distribution of Caracol animal bone by context.



Context	Pieces	Weight(g)
Burial	598	745.42
Cache	3	2.06
Floor	104	284.98
Other	49	203.3
TOTAL:	754	1,235.76

Figure 11.5. Distribution of modified animal bone by context.

Early Classic tomb within the epicentral structure D16 (in the South Acropolis). It is interesting to note that within caches only three worked pieces of bone have been found: a shaped fragment of burned bone found in a pit

under the north doorway of Structure B19, located at the top of Caana; a hieroglyphically inscribed pin fragment from within a subadult burial pit within Structure B19; and a renotched stingray tail spine in Structure B118, where the sides were so worn that new cuts had to be made.

Dog teeth are a favorite raw material for jewelry at Caracol, with canines often pierced through the root for wearing as a pendant. Research has revealed that dog canines were widely used for jewelry throughout the Maya area (Clutton-Brock and Hammond 1994:825; Hamblin 1984:114). Having conferred with other colleagues, I am convinced that much of what has been identified in the Maya area as jaguar canine is actually dog, based on their large size. When teeth from both are compared, one can see that jaguar teeth are almost twice as large, but most archaeologists have not seen them together to realize this difference. I recommend a second look at all large mammal tooth identifications, paying close attention to overall shape rather than size. All large cat canines have a rounder cross section than dog canines, which are more oval. I have found that only 1 of about 322 modified teeth recovered from Caracol is jaguar, whereas 310 teeth are from dog. The only other jaguar remains from the site are a single phalanx from a Terminal Classic floor in Structure B6; the claws and a third phalanx of a single cat found with a burial of a single adult within Structure B20, on top of Caana, dating to A.D. 537; and the claws of a single cat found within an elite tomb in a very large structure at a group called "Saraguate." These phalanges likely represent the former presence of the jaguar skin, possibly used as a mat, cape, booties, or gloves. The infrequency of jaguar remains and their elite ceremonial contexts are consistent with other interpretations that the jaguar was an animal reserved for rulers as a symbol of their power (Coe 1988:233; Miller and Taube 1993:102; Pohl 1983).

In addition to canines, dog premolars were also utilized for jewelry. In a Late Preclassic burial in front of Structure B34, within the



Figure 11.6. Long-bone shaft with hieroglyphic inscription. Photo courtesy of Caracol Archaeological Project.

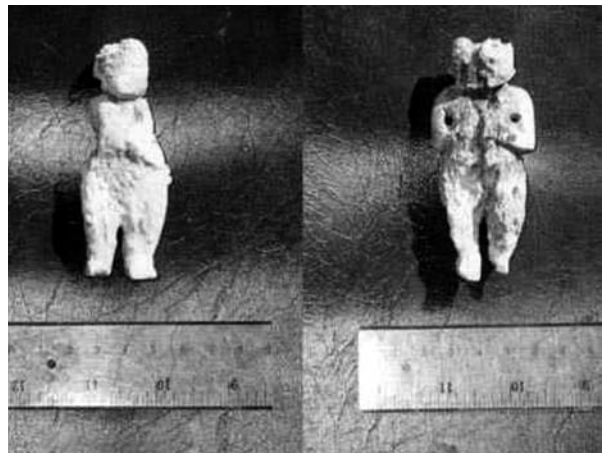


Figure 11.7. Deer antler figurines from an Early Classic tomb. Photos by author.

North Acropolis, a person was buried with jewelry made from 299 fourth premolars and 79 large mammal long bones drilled and used as

separators for the beads (Figures 11.8 and 11.9). The beads and spacers formed part of the jewelry worn by the interred woman; the beads formed anklets, and the spacers fit with shell and jadeite beads to form a mantle. This collection of jewelry required a minimum of 99 individual dogs.

Referring in part to Table 11.5, we can see a number of interesting trends. Large mammals, making up a large portion of the diet, were rarely placed in burials or caches unless modified in the form of jewelry or tools. Instead, smaller animals such as birds, reptiles, stingray, and fish were offered. For instance, in Structure A3 a tomb contained 13 quail (*Odontophoridae*) as a burial offering to a young woman. Often these ceremonially offered animals are whole



Figure 11.8. Beads made from dog premolars found in a Late Preclassic tomb. Photo by author.



Figure 11.9. "Spacers" found with the above beads in a Late Preclassic tomb. Photo by author.

and seem to have been chosen for reasons other than sustenance in the underworld. The fishes, lovely cotinga, and stoplight parrotfish seem to suggest that beauty may have been a factor in the decision to place them in the burial. However, it could also be that the more readily available lovely cotinga was an economic substitute for the quetzal found farther south.

Excavation and analysis seem to indicate that cache vessels were extremely restrictive as to contents. Although epicentral caches contained almost no modified bone, they generally contained stingray. Stingrays are found on sandy bottoms among sea-grass beds, lagoons, and reefs. They have large thick "wings" that are used to swim and help locate shellfish buried in the sand. For protection stingrays have one or two tail spines, which whip up and over their body as they lie almost motionless in the sand (Humann 1995:389). Their tail spines are often found in Maya burials and caches; it is believed they may have functioned as perforators in bloodletting ceremonies (Borhegi 1961; Chase 1991; Miller and Taube 1993:46).

At least 50 tail-spine elements are represented at Caracol, found in 13 locations, both in royal tombs and in simple burials from the core. They were recovered from 8 caches, 12 burials, and on 2 structure floors (Table 11.6). They must have been prized and hard to come by, considering that one spine found in a floor context was so worn down that no barbs were left. Furthermore, notches were carved along the edges to make it functional again. Although isolated tail spines are most frequently found at Caracol, three caches and a child's burial included spines and vertebrae or cranial elements. This evidence shows that Caracol imported and utilized the entire stingray, not just the spines as many authors assume (e.g., Borhegi 1961; Hamblin 1984). More direct ethnographic evidence of stingray use is found in Diego de Landa's writing of 1566:

There is another fish on this coast which they call *ba*, broad and round, and good to eat, but risky to kill or come against. It also does not go into deep water, but

swims in the shoals, where the Indians hunt it with bow and arrow; but if they are careless in their walking, or step on it in the water, it comes up at once with its long narrow tail, and gives such a wound with a saw it carries that it cannot be removed without greatly enlarging the cut, the teeth being set backwards as in the sketch here given. These small saws the Indians use to cut themselves with in their sacrifices to the evil one, and it was the office of the priest to have them. Thus they had many very fine ones, for the bone is white and curiously shaped like a saw, so sharp and pointed that it cuts like a knife. [quoted in Tozzer 1941:98]

Table 11.6. Number of Instances and Distribution of Stingray Spines across Caracol, Belize

Site area	Burial	Cache	Floor	Total
Epicenter	9	8	2	19
Core	3	0	0	3
Total	12	8	2	22

The presence of stingray and other sea fish supports a long history of trade between Caracol and the coast for marine material. This is seen in the existence of a substantial shellworking industry. *Strombus gigas*, among other shell species, was imported from the Belizean coast as raw material for manufacturing ornaments and other finished goods (Cobos 1994). Shell is denser than fish bone, survives much better in the humid rainforest environment than bone, and is found in large quantities in shell workshops. The trade that kept a steady flow of shell coming into the city from the Late Preclassic through the Late Classic era also provided opportunities for fish to be imported. Besides shell and fish, a few crab claw fragments have also been found at Caracol in the epicenter and core areas. Stark and Voorhies (eds. 1978:300) argue that when an item is unlikely to survive archaeologically, suites of commodities should

be looked for together rather than individual examples. Three littoral resources (shrimp, clam, and fish) can be interpreted in terms of a suite of possible coastal exports. Of course this idea relies on ethnographic observations, but it is possible that shrimp and other crustaceans that may not survive archaeologically were also being imported with the crab, shells, and fish.

CONCLUSIONS

The importance of animals in the daily life of the Maya cannot be overstated. This chapter has highlighted briefly some of my research on subsistence and ceremonial activities at Caracol based on faunal analysis. Teeter (2001) further explores and incorporates some of the ethnographic, iconographic, and archaeological data concerning the subsistence and ceremonial use of animals. Although the sample size of Caracol's faunal assemblage is extraordinary, frustration abounds with the lack of good floor representation for the core and terminus areas. Perhaps recycling of bone for tool and jewelry manufacture causes some of the bone recovery patterns. This would explain the high numbers of bone objects made from large mammal long-bone elements. Brian Hayden and Aubrey Cannon (1984) have demonstrated the extent of recycling that the modern Highland Maya use. One can only assume that this was likely in the past.

There does not seem to be a change in the use of mammals in ceremonial or subsistence contexts through time (see Tables 11.1 and 11.2). With the increase in population sizes at Caracol, deer and other large mammals continued to be available and are seen in burials throughout the city. There does not appear to be a shift from mammals found in the general Caracol area to smaller animals over time, as witnessed in the Yucatán (Hamblin 1984; Wing and Steadman 1980). The majority of Caracol burials are dated to the Late Classic, the most highly structured and populated time. However, animals and offerings are found in even simple burials within the core. This suggests that some method of animal management may have existed during

this time. Deer, rabbit, turkey, dog, peccary, and coati were easily tamed and could be raised in the household, providing a great source for meat and tool production. However, many of these animals are not found in great numbers at Caracol. Preservation, disposal patterns, and recycling have been offered as possible reasons for this absence. There is no doubt, however, that the majority of Caracol inhabitants enjoyed meat and animal resources from the surrounding environment and abroad from the city's beginning to its abandonment.

The presence of bone artifacts was found throughout the city, whereas bone detritus was highly restrictive and provides evidence that bone workshops existed. These specialized workshops were created by the Late Classic and were found in Structures B88, B108, B118, and "Barrio." This specialization suggests that time for the general populace was better spent doing tasks other than making bone tools and jewelry at the household level. Other bone-working evidence was found in Structures A6 and B64, dating to the Terminal Classic, and suggests a conversion to the household production of bone artifacts before the city was abandoned.

Excavations at Caracol have provided an incredible database to explore changes in the relationship between subsistence and ceremonial activities over long periods. They have also provided enough small-scale data to compare households and socioeconomic status. It is a tribute to the faunal research conducted through the 1980s and 1990s that many of the issues raised and discussed then can now be explored further by new faunal research in Mesoamerica as presented in this volume.

Acknowledgments. The foundation of this chapter was presented at the 62nd Annual Meeting of the Society for American Archaeology in Nashville, Tenn. The final product, however, is a revision made possible by long hours of editing and comments by Arlen and Diane Chase, Richard Leventhal, Kitty Emery, Norbert Stanchly, Tom Wake, and Marillyn Holmes. Initial fieldwork on what has become my dissertation started when I joined the Caracol Archaeological Project in 1989 and began learning about Caracol fauna from June Morton, the Maya field crew, and the endless series of biologists brought to work in the region with Bruce and Carolyn Miller. This research was made possible through the generous support and funding from the Caracol Archaeological Project, UCLA Friends of Archaeology, UCLA Department of Anthropology, and J. F. Wilken. Identifications of faunal material were made with collections from the UCLA Cotsen Institute of Archaeology Zooarchaeology Laboratory, UCLA Dickey Collection, and the Florida Museum of Natural History. Invaluable help and guidance with these identifications were provided by Tom Wake, Elizabeth Wing, and David Steadman. Finally, I must thank Venice and Daniel Teeter, Amy Morris, and the staff of the Belize Department of Archaeology, especially John Morris and David Griffith, whose support was always there when I needed it most.

NOTE

1. Many of the references to specific data sets are not shown in the chapter tables but are available in my dissertation (Teeter 2001).

12

Vertebrates in Tikal Burials and Caches

Hattula Moholy-Nagy
University of Pennsylvania Museum

More than half of the large collection of vertebrate remains recovered by the Tikal Project of the University of Pennsylvania Museum come from caches, burials, and other special deposits. By the beginning of the Classic period, specialized material assemblages, including unmodified and worked bone, can be defined for monument caches, structure caches, chamber burials, crypt burials, and other kinds of burials. The vertebrate fauna included in these special deposits is both local and exotic, including much of marine origin.

Caches and burials associated with the elite have the potential to enhance our understanding of sociopolitical developments. During the course of the Late Preclassic and Classic periods the relative emphases given to caches and burials suggest that there may have been important changes in the nature of rulership at Tikal.

Excavations by the Tikal Project of the University of Pennsylvania Museum recovered a large sample of vertebrate remains. The collection includes more than 30,500 unworked, mostly fragmentary, bones and teeth, more than 5,700 of which were identified as human, as well as nearly 1,200 artifacts and over 500 pieces of debitage. Bone was found in all areas of Tikal, in all kinds of recovery contexts, and from the entire span of occupation from the Early Middle Preclassic to the Early Postclassic period. There is, however, considerable unevenness in distribution. More than 26,500 items, or almost 87 percent of the recovered sample, came from Tikal's epicenter, primarily from the monumental architecture of Group 5D-2, which was the civic-ceremonial heart of the city during most of its occupation (Carr and Hazard 1961; Coe 1990: 916–939; Puleston 1983: Figure 21). Approximately 17,000, or almost 56 percent, came from caches, burials, and other special deposits of problematical function. About 25,600, or approx-

imately 84 percent, date to the Classic period (Figure 12.1; Table 12.1).

Table 12.1. Tikal Chronology (after Coe 1990: Chart 1; Culbert 1993: Table 1)

Period	Date	Ceramics
Early Postclassic	A.D. 950	Caban
Terminal Classic	A.D. 869	Eznab
Late Late Classic	A.D. 692	Imix
Early Late Classic	A.D. 554	Ik
Early Classic	A.D. 250	Manik
Terminal Late Preclassic	A.D. 150	Cimi
Late Late Preclassic	A.D. 1	Cauac
Early Late Preclassic	350 B.C.	Chuen
Late Middle Classic	600 B.C.	Tzec
Early Middle Preclassic	800 B.C.	Eb

Much of the material culture recovered from Tikal burials and cached offerings is associated with its elite and, therefore, can contribute information about the social and political history of Tikal. Furthermore, offerings from burials and caches are usually in a better state of preservation than materials from secondary contexts, referred to here as general excavations. When the caches and burials from Tikal are analyzed with regard to type, recovery

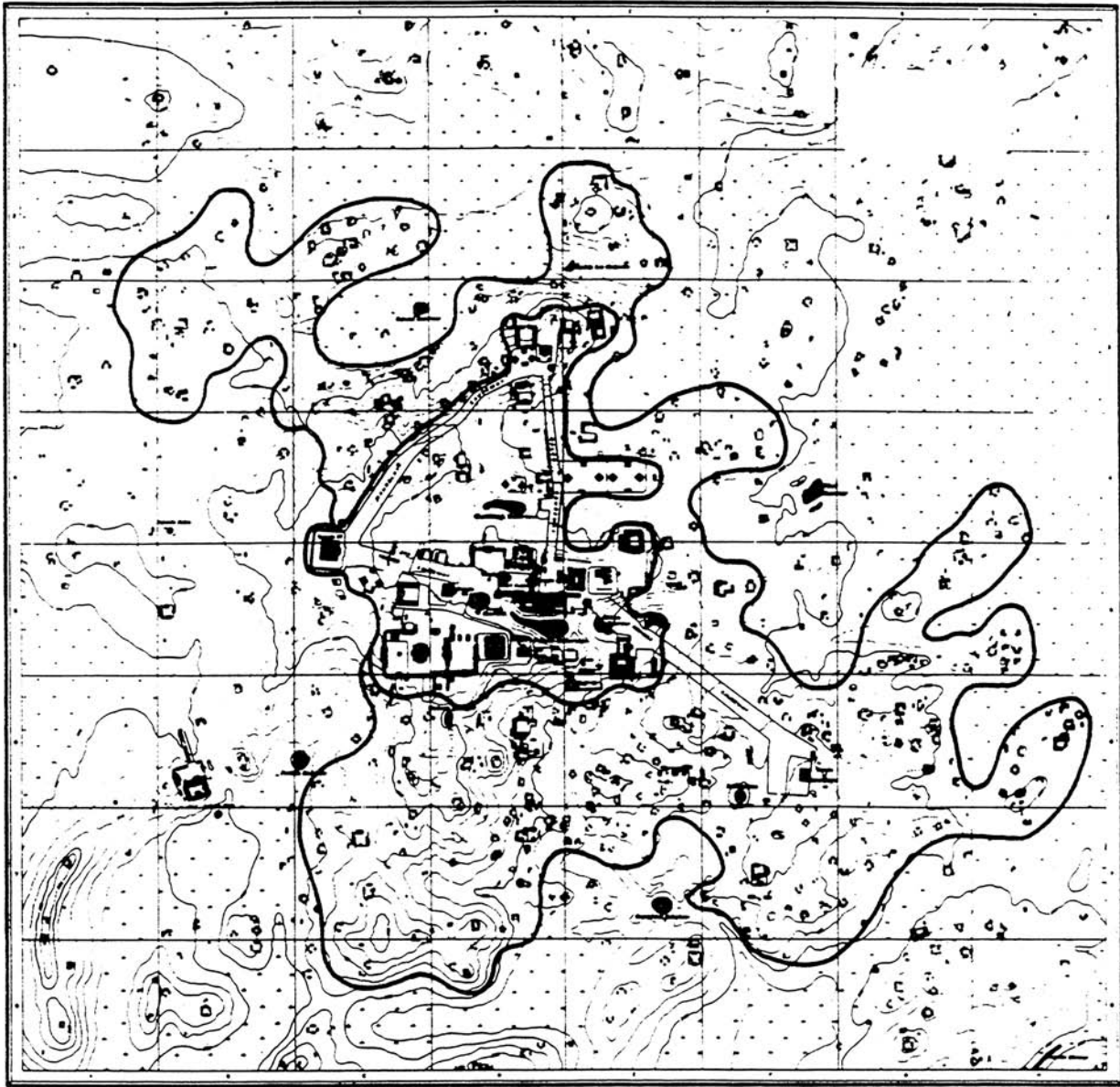


Figure 12.1. Map of Tikal showing the Epicentral, Central, and Peripheral Areas (after Puleston 1983: Figure 21). Group 5D-2, the North Acropolis and Great Plaza, is at the convergence of three causeways in the Epicenter.

context, content, and date, they provide data that contribute to a broader understanding of Tikal's material culture.

CONTEXTS AND DISTRIBUTIONS OF BURIALS AND CACHES

Contexts

By the beginning of the Early Late Preclassic period, if not before, rank society was securely es-

tablished at Tikal, manifested in sumptuary grave goods, monumental public architecture, and cached offerings placed in these temples and shrines. This tradition of burial offerings and structure caches associated with the elite was maintained until the end of the Late Classic period. During the Late Preclassic, chamber and crypt burials ("tombs") furnished with greater quantities of pottery and other goods appear. Contexts of the elite offertory tradition of the

Early Classic period also include monument caches placed with carved and plain stone stelae and structure caches placed with range structures ("palaces") and in chamber and crypt burials. Other kinds of burials, thought to be mainly those of commoners, are found from the Early Middle Preclassic into the Terminal Classic periods.

Besides burials and caches, vertebrates were also recovered from problematical deposits,

defined by the Tikal Project as special deposits of uncertain function. Some problematical deposits appear to be offerings and burials in a tradition distinct from that of the elite, but they are not well understood. They will not be reviewed here, although it should be noted that they occur during the entire span of permanent and sporadic occupation and precede and postdate offerings in the elite tradition (Figures 12.2 and 12.3).

Figure 12.2. Tikal caches and miscellaneous problematical deposits by period.

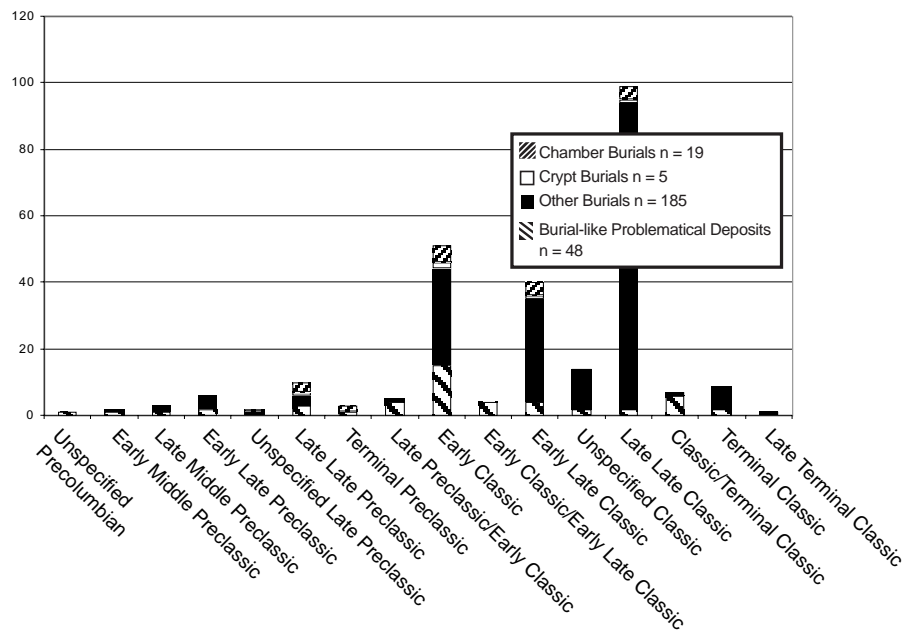
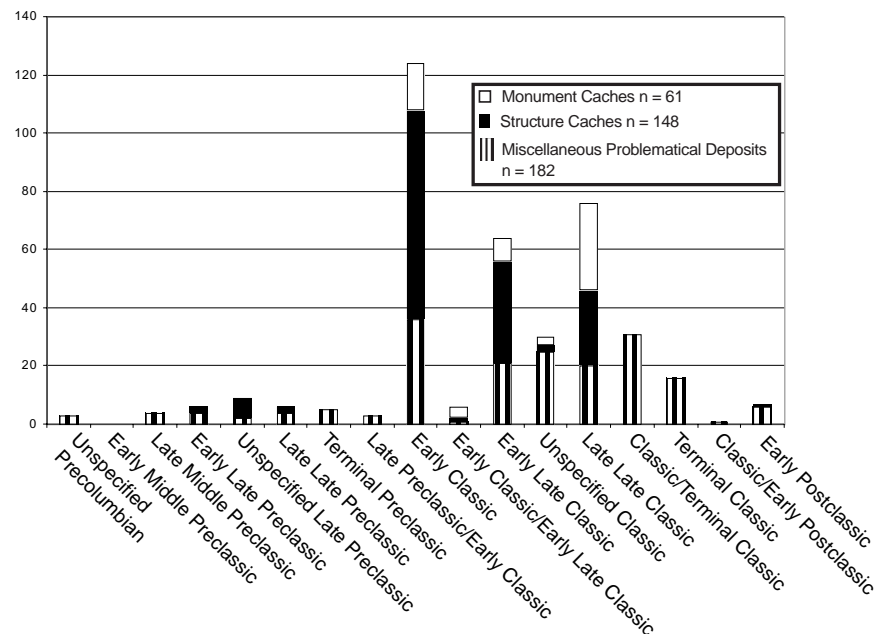


Figure 12.3. Counts of all Tikal burials and problematical burials by period.



The vertebrate sample discussed here includes fishes, amphibians and reptiles, birds, mammals, and humans (Table 12.2). I have also included bone artifacts from these special deposit contexts because the Maya themselves often used worked and unworked materials for

the same purpose, as functional equivalents. In the case of stingray spines (*Dasyatis* sp.), for example, unworked and elaborated spines, as well as imitations made from mammal bone, may all occur in the same offering.

Table 12.2. Database Codes and Names of Vertebrates Found in Tikal Caches and Burials

Vertebrate Class and Code	Scientific Name	Common Name
Fishes		
G06	<i>Dasyatis say*</i>	Stingray
G07	<i>Dasyatis</i> sp.*	Stingray
G08	<i>Diodon</i> sp.*	Spiny puffer
G09	<i>Diodon</i> cf. <i>hystrix*</i>	Spiny puffer
G10	<i>D. hystrix*</i> or <i>D. holocanthus*</i>	Spiny puffer
G13	<i>Galeocerdo cuvieri*</i>	Tiger shark
G16	<i>Pristis</i> sp.*	Sawfish
Reptiles and Amphibians		
I08	<i>Bothrops atrox asper</i>	Fer-de-lance
I09	<i>Bothrops</i> sp.	Fer-de-lance
I10	cf. <i>Bothrops</i> sp.	Fer-de-lance
I12	<i>Bufo</i> cf. <i>marinus</i>	Cf. giant toad
I14	<i>Trachemys scripta ornata</i>	Painted turtle
I22	<i>Crocodylus acutus*</i> or <i>C. moreleti</i>	Crocodile
I23	<i>Crocodylus</i> sp.	Crocodile
I26	<i>Crotalus</i> cf. <i>durissus</i>	Rattlesnake
I28	<i>Ctenosaura similis similis*</i>	Black iguana
I30	<i>Dermatemys mawei*</i>	River turtle, <i>blanca</i>
I32	<i>Drymarchon corais melanurus</i>	Related to indigo snake
I48	<i>Spilotes pullatus mexicanus</i>	Racer family
I55	Viperidae	Viper family
Birds		
H02	<i>Meleagris ocellata</i>	Ocellated turkey
H08	<i>Ara macao</i>	Scarlet macaw
H18	<i>Buteo magnirostris</i>	Roadside hawk
H30	<i>Cissilopha sanblasiana</i>	Black and blue jay
H31	<i>Colinus nigrogularis</i>	Black-throated quail
H38	<i>Cotinga amabilis</i>	Brightly colored cotinga
H41	cf. <i>Cyanocorax yncas</i>	Green jay
H46	<i>Glaucidium brasilianum</i>	Ferruginous pygmy owl
H51	<i>Habia</i> sp.	Probably ant tanager
H57	<i>Icterus</i> sp.	Oriole
H63	<i>Nyctidromus albicollis</i>	Parioque bird

Continued on next page

Table 12.2. Database Codes and Names of Vertebrates Found in Tikal Caches and Burials (continued)

Vertebrate Class and Code	Scientific Name	Common Name
H67	<i>Oryzoborus funereus</i>	Thick-billed seed finch
H76	<i>Pharomachris mocinno*</i>	Quetzal
H78	<i>Podilymbus podiceps</i>	Pied-billed grebe
H80	<i>Cyanocorax morio</i>	Brown jay
H83	<i>Sarcorhamphus papa</i>	King vulture
H85	<i>Turdus albicollis</i> or <i>T. nudigenis</i>	Nonmigratory thrush
Other Mammals		
J07	<i>Ateles geoffroyi</i>	Spider monkey
J12	<i>Canis familiaris</i>	Dog
J22	<i>Agouti paca</i>	Spotted cavy
J27	<i>Dasypus novemcinctus</i>	Armadillo
J42	<i>Panthera onca</i>	Jaguar
J43	<i>P. onca</i> , possibly <i>Puma concolor</i>	Jaguar, possibly cougar
J44	probably <i>P. onca</i>	Probably jaguar
J92	<i>Odocoileus virginianus</i>	White-tailed deer
Humans		
J52-J73	<i>Homo sapiens sapiens</i>	Human

Note: Names bearing an asterisk are not found at Tikal today.

This presentation will be qualitative because of the uninformed manner in which the sample was processed in the field laboratory (Moholy-Nagy 1998).

Spatial Distribution

During the Classic period, Tikal developed a concentric settlement pattern centered on Group 5D-2. Evidence of elite activities is concentrated in this structure group. Few offerings are found beyond a radius of about 2.5 km from its center, a distribution pattern characteristic of many types of durable remains recovered from the site. The scarcity of vertebrates on the peripheries of large sites has also been observed at Copán (Webster and Gonlin 1988) and Caracol (Teeter this volume) and may in large part result from factors of preservation.

CACHES

The term *cache* is used here to designate a votive offering. In effect, Tikal Project archaeol-

ogists restricted this term to offerings made by persons on the uppermost levels of the social hierarchy. Caches were recovered from various contexts: under plain and inscribed stone stelae; from shrines, temples, and range structures; and as part of the burial offerings of persons of high social rank.

The contents of structure caches placed in temples, range structures, and elite burials more closely resemble one another than they do the contents of offerings placed with monuments. Accordingly, I will discuss caches as two groups.

Structure Caches

Excavations recovered 148 structure caches, of which 67 include vertebrate remains. The different parts of the occasional two-part and four-part caches deposited during the Classic period have been counted here as individual offerings. Structure caches are overwhelmingly from the Epicenter, principally from the monumental mortuary temples of the North Acropolis of

Group 5D-2 (Table 12.3). Eleven caches come from the Central Area and 12 from the Peripheries, including 1 from the Minor Center of Navajuelal and 10 from the Minor Center of Uolantun (Puleston 1983: Figure 1).

Table 12.3. Tikal Structure Caches by Site Area and Date

	Epi-center	Center	Peripheries	Total
Early Postclassic	1	—	—	1
Late Classic	23	2	1	26
Early Late to Late Classic	2	—	—	2
Early Late Classic	30	5	—	35
Early to Late Classic	1	—	—	1
Early Classic	62	4	6	72
Late Preclassic	4	—	5	9
Early Late Preclassic	2	—	—	2
Total	125	11	12	148

Structure caches include more kinds of offerings and more diverse vertebrate and invertebrate fauna than monument caches, with the maximum diversity and the largest number

of caches found during the Early Classic period (Figure 12.4). The stone, shell, and bone offerings in caches are usually unworked, whereas the same materials in burials tend to be worked into artifacts.

The earliest known vertebrate remains in structure caches are of unspecified Late Preclassic date and consist of the remains of humans and dogs. Although human remains, usually skulls or phalanges but occasionally an entire individual, continue to occur until the end of the Early Late Classic period, dogs lose their importance during the Early Classic. Animals thought to have been used for food, such as white-tailed deer, peccary, or ocellated turkey, are very rare in caches and burials at all times, a situation that contrasts notably with their predominance among vertebrate remains from general excavations (Moholy-Nagy 1998).

Bird bones, often of small, brightly colored species, are found as early as the beginning of the Early Classic. Rodents, which may indicate offerings of food, also appear at this time.

Fishes, birds, and reptiles are all offered during the Early Classic and Early Late Classic periods and are often deposited whole. Bone artifacts are occasionally included during this period.

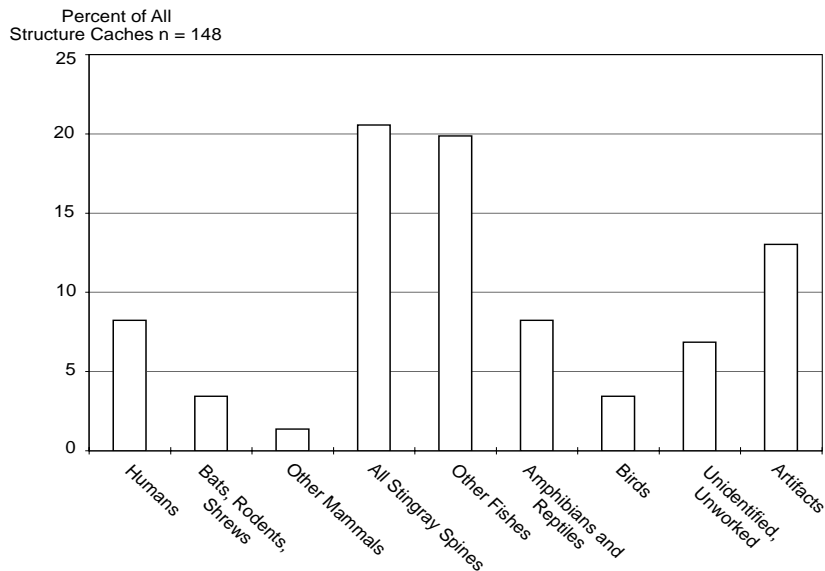


Figure 12.4. Percentage of occurrences of vertebrates in structure caches.

Fish remains consist predominantly of stingray spines, widely assumed to have been used for bloodletting. Often these are carved or otherwise worked, and sometimes real spines are accompanied by false ones of terrestrial animal bone. A shark tooth comes from an Early Classic cache in a range structure. During the transition from the Early Classic to the Early Late Classic, pufferfish (*Diodon* sp.) spines make an appearance. Barbs from the snouts of sawfish (*Pristis* sp.) first occur during the Early Late Classic. The only cached vertebrate remains from the terminal Late Classic period are the nose barbs of an unusually large sawfish.

Both local and exotic species are among the reptiles favored for structure caches during Early and Early Late Classic times. Most of the turtles are *blancas* (*Dermatemys mawei*), a riverine animal that had to be brought to Tikal. Other reptiles include painted turtles (*Trachemys scripta ornata*), crocodiles (*Crocodylus acutus* or *C. moreleti*), venomous snakes such as rattlesnakes (*Crotalus* cf. *durissus*) and fer-de-lance (*Bothrops atrox asper*), and nonvenomous snakes such as racers (*Spilotes pullatus mexicanus*), and a relative of the indigo snake (*Drymarchon corais melanurus*).

As in the case of mammals, the avian species in caches and burials may not have been sources of food. Black and blue jays (*Cissilopha sanblasiana*), quails (*Colinus nigrogularis*), cotingas (*Cotinga amabilis*), pygmy owls (*Glaucidium brasilianum*), king vultures (*Sarcorhamphus papa*), scarlet macaws (*Ara macao*), and unspecified finches, large passerines, and hummingbirds have been identified to date.

Small cutout figures of standing humans referred to as "a 'Charlie Chaplin' type of figurine" by J. Eric S. Thompson (Thompson 1939: 1), a form usually found in marine shell, are made of other materials such as bone and jade only during the Early Classic period. A well-made bone pin or awl with a knob handle was placed in an Early Late Classic cache. Fake stingray spines may have been offered only during the Early Classic and Early Late Classic periods.

Monument Caches

Of the 61 excavated caches found with carved and plain stone monuments, 21 include unworked vertebrate remains. Many of Tikal's stone monuments and nearly two-thirds of its monument caches were placed in Epicentral Group 5D-2. Only one cache, found with a carved stela of Early Classic date, is from the Central Area. Five monument caches are known from the peripheries. Two of these are associated with late Early Classic carved monuments, and three caches were found with plain stelae. The type of stone from which the plain monuments are made, as well as their spatial arrangement (Jones 1969), date them to the Early Late Classic period. This is the time of a hiatus, between A.D. 557 and 682, during which we have no dates inscribed on monuments (Jones and Satterthwaite 1982:121–124; Moholy-Nagy 2003a).

Caches were placed with stelae at Tikal; none have yet been found with the accompanying altars. Offerings had been placed with approximately half of the carved stelae (17 of 37; reported in Jones and Satterthwaite 1982) and approximately half of the plain ones (40 of 79; Carr and Hazard 1961). Early stone monuments and their caches were broken up and displaced during prehispanic times (Coe 1990:926) so that the oldest known, securely dated offerings are from the beginning of the Late Early Classic Manik 3A Ceramic Complex (A.D. 378–485) (Coe 1990:742). They include the earliest with vertebrate remains. The latest known cache, from terminal Late Classic period Stela 11, did not include any fauna. Monument caches are most numerous and diverse during the Early Classic period. Plain stone monuments were erected during the hiatus; however, accompanying monument caches are rare, and the only vertebrate remains they include are human. The scarcity and reduced inventories of these monument caches are a striking contrast to the contemporary structure caches and chamber burials, which are not reduced in either numbers or offerings (Moholy-Nagy 2003a). Monuments and caches once again become numerous during the Late Late Classic,

but they have disappeared altogether by the Terminal Classic, along with the elite they commemorate.

Monument caches have a limited faunal component (Table 12.4; Figure 12.5), as well as a simplified inventory of other durable items,

Table 12.4. Number of Occurrences of Vertebrates in Tikal Special Deposits

Number of Occurrences	Total No. Defined	Humans ^a	Bats, Rodents, Shrews	Other Mammals	All Stingray Spines	Other Fishes	Amphibians and Reptiles	Birds	Unidentified, Unworked	Artifacts
Chamber burials	19	8	3	6	13	2	2	5	3	7
Crypt burials	5	1	1	—	2	1	—	1	—	—
Other burials	185	14	8	7	5	—	7	2	9	15
Burial-like problematical deposits	48	19	14	19	7	8	15	13	23	22
Monument caches	61	18	2	—	—	2	4	—	3	—
Structure caches	140	12	5	2	30	29	12	5	10	19
Other problematical deposits	182	19	17	8	12	10	8	5	17	9

^aOnly as retainers or sacrifices.

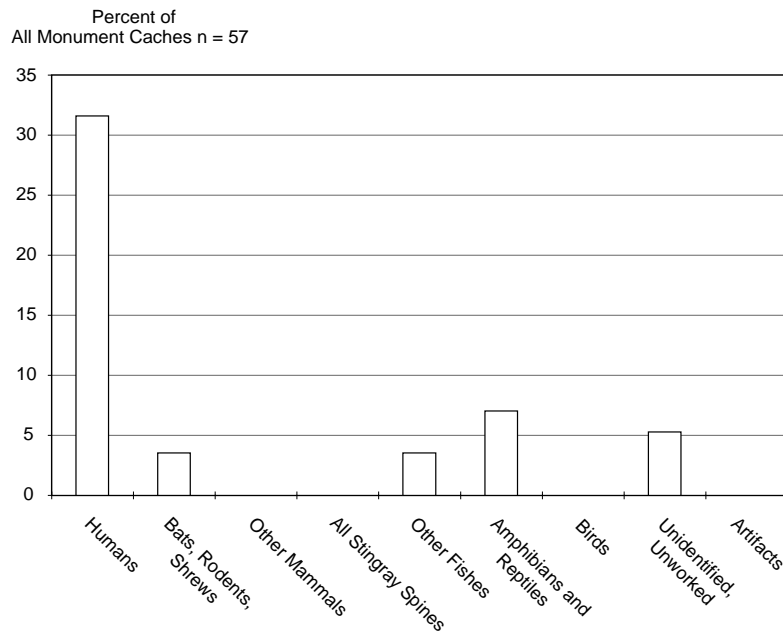
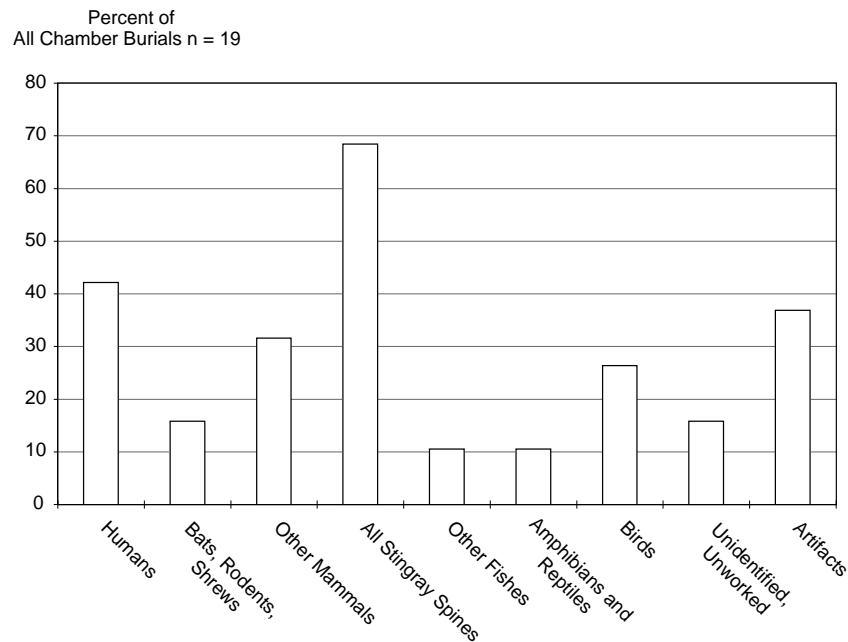


Figure 12.5. Percentage of occurrences of vertebrates in monument caches.

Figure 12.6.
Percentage of occur-
rences of vertebrates
in chamber burials.



such as pottery vessels or ceremonial lithics, compared to coeval structure caches. Human remains are included in monument caches from the Early into the Late Classic periods. After the end of the hiatus there is a reappearance of vertebrae of unidentified fishes and venomous snakes, which were occasionally present in the Early Classic. These small vertebrae preserved in caches and burials are often found aligned, indicating that the entire animal was deposited. Besides fishes and snakes, the occasional remains of rodents suggest the inclusion of offerings of food. After ca. A.D. 735 humans are the only vertebrates present. Overall, marine materials other than shells are very rare in monument caches; the absence of stingray spines is especially striking.

BURIALS

I have assumed here that the conspicuously different amount of labor and goods invested in Tikal's graves and offerings is a reliable indicator of the social rank of their subjects when they were alive (Binford 1971). The size and construction of the grave usually correlate well with the quantity and quality of the burial offerings, although the relationship is certainly not invariable. For this analysis I divided what

is essentially a continuum of repository types into three categories: chamber burials ($n = 19$) and crypt burials ($n = 5$), considered to be, respectively, of rulers and lesser elite (Blanton 1999:140), and all other burials ($n = 182$), which are thought to be of commoners.

Chamber Burials

Fourteen chamber burials of the total of 19 excavated by the Tikal Project occur in Group 5D-2, which functioned as the necropolis of Tikal's most powerful persons during most of its occupation. Group 5D-2 has the earliest and latest known examples of such burials, which date from the Late Late Preclassic to the terminal Late Classic periods. The contents of the latest burial had been disturbed in antiquity, so its original assemblage of offerings is unknown. There is one Late Late Classic chamber burial in the adjacent elite residential structure group, Group 5D-10, one of late Early Classic date in Group 7F-1 in the Central Area, and three at Uolantun that span the Late Late Preclassic to Early Classic periods. Like the outlying monument and structure caches, the Central and Peripheral Area chamber burials predate the Late Classic.

Retainers occur in eight chamber burials, dating from the Late Late Preclassic through the Early Classic periods (Table 12.4; Figure 12.6).

The femur of a quail (*Colinus nigrogularis*) was identified in a Late Late Preclassic burial, and a tentatively identified turkey femur (*Meleagris ocellata*), perhaps an offering of food, is dated to the Early Classic. Other identifications are of whole birds, and all are of the Early Classic period. They include snail kites (*Rothramus sociabilis*), a quetzal (*Pharomachris mocinno*), scarlet macaws (*Ara macao*), green jays (cf. *Cyanocorax yncas*), pygmy owls (*Glaucidium brasilianum*), and a probable ant tanager (*Habia* sp.). Stucco fragments from an Early Late Classic chamber burial carry traces of feathers, thought to be part of a now-vanished headdress.

The only reptiles identified in chamber burials are a crocodile and a set of five large, complete turtle shells (carapace and plastron) from Burial 10 of the Early Classic period. Two of the turtle shells are of *blancas* (*Dermatemys mawei*), and two are of painted turtles (*Trachemys scripta ornata*). One could not be identified. The crocodile is either *Crocodylus moreleti*, which is found in the area today, or *C. acutus*, which is not.

Nonhuman mammal remains are uncommon. Fluffy, dark material is associated with some of the human skeletons in three chamber burials of the Late Preclassic, terminal Preclassic, and Late Classic periods. It has not been identified but suggests the remnants of pelts used to wrap the bodies. Worked and unworked deer phalanges (nearly all *Odocoileus virginianus*) occur in the Early Classic and Early Late Classic periods. Mittens and boots of jaguar paws (*Panthera onca*) (e.g., as illustrated in Culbert 1993: Figure 81) are offered only in burials of the Early Late and Late Late Classic. Rodent bones are found at all periods.

Bone artifacts, some of very high technical and esthetic quality, occur at all times, with a peak in quantity, craftsmanship, and diversity during the Late Late Classic period. They include Late Late Preclassic polished and perforated clasps for *Spondylus* bead bracelets and Early Classic minor sculptures of humans carved in the round. A spectacular set of bone artifacts of the Late Late Classic period com-

prised objects decorated with elaborate incised scenes, hieroglyphic texts, bone tweezers with shell overlays, and several uninscribed objects of animal long bone inlaid with shell and pyrite (Triak 1963).

Worked and unworked stingray spines occur at all periods.

Crypt Burials

Five graves were encountered that were larger than most other graves yet were neither as large nor as well furnished as chamber burials. Only one, of Early Late Preclassic date, is from Group 5D-2. One is from the adjacent Group 5D-11, the Central Acropolis, thought to have been the residence of Tikal's Classic period rulers, and three are from the Central Area. One of those from the Central Area is of Early Late Classic date; the others are Early Classic.

With the exception of the Early Late Classic burial, Burial 132, faunal offerings are sparse (Figure 12.7). None of the burials included nonhuman mammals, reptiles or amphibians, bone artifacts, or retainers, although five human phalanges are included in Burial 132. This burial also included two large pottery dishes set rim to rim, within which were found items typical of contemporary structure caches, such as fish vertebrae, stingray spines, rodents, several birds, and a large quantity of small marine shells. The birds were identified as roadside hawk (*Buteo magnirostris*), oriole (*Icterus* sp.), parioque bird (*Nyctidromus albicollis*), thick-billed seed finch (*Oryzoborus funereus*), brown jay (*Cyanocorax morio*), nonmigratory thrush (*Turdus albicollis* or *T. nudigenis*), and an unspecified flycatcher.

Other Burials

Burials of other types ($n = 182$) are frequently found in residential structure groups. Approximately 58 percent ($n = 105$) come from the Central Area, 57 of these from the eastern shrines of Plaza Plan 2 structure groups thought to have been the residences of prosperous commoners or, possibly, lesser elite (Becker 1999). Types include simple graves, graves with covering

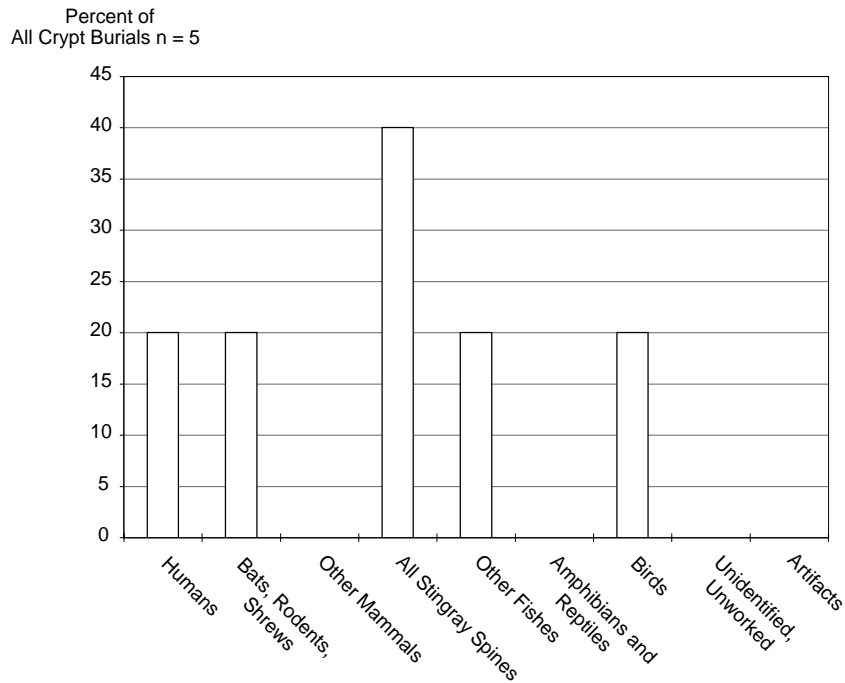


Figure 12.7. Percentage of occurrences of vertebrates in crypt burials.

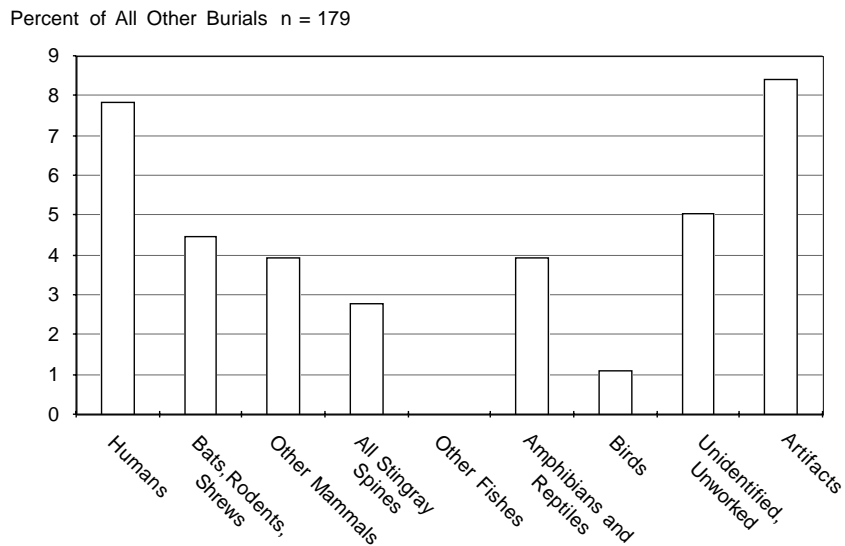


Figure 12.8. Percentage of occurrences of vertebrates in other burials.

stones, graves lined with stones, graves cut into bedrock, burials without discernible graves, and burials in large pottery vessels and in chultuns.

Multiple burials, extra human remains such as skulls or phalanges, unworked vertebrates, and bone artifacts are known from these burials, but they are rare (Figure 12.8).

Stingray spines occur sporadically from the Early Late Preclassic into the Early Late Classic but have not been identified for the Late or Terminal Classic. An unworked animal tooth, perhaps from a dog, comes from a burial that could be dated to the general Late Preclassic period. A complete spider monkey (*Ateles geoffroyi*) accompanied an Early Classic chultun burial; worked and unworked deer phalanges date from the Late Preclassic into the Late Classic; and armadillo platelets (*Dasypus novemcinctus*), perhaps part of an artifact, are Late Classic. Giant toads (*Bufo* cf. *marinus*), black iguana (*Ctenosaura similis similis*), and nonvenomous snakes are rare but apparently intentional inclusions in Late Classic burials. Extra human remains and bone artifacts are as early as the Early Late Preclassic, and rodents, which may indicate offerings of food, appear during the Early Classic. These three classes of materials continue into the Terminal Classic period.

The earliest bone artifacts from this group of burials are ornaments and date to the Late Late Preclassic: two sets of bone clasps for multi-strand *Spondylus* shell bead bracelets, and a carved ring tentatively identified as an ear spool. Of Early Classic date are fake stingray spines; large, well-made ladles; and a set of seven spotted cavy (*Agouti paca*) femora with one end cut off. Plain tubes made of animal long bones occur from the Early Classic through Late Classic periods, apparently only with males. Late Classic artifacts include single bones incised with glyphs. A set of four short bone pins and a perforated tube, probably a whistle, accompanied a person of elevated social rank buried during the Terminal Classic.

SUMMARY AND CONCLUSION

Overall similarities among the offerings in caches and burials indicate their ritual function; overall differences indicate specialized contexts of use and social correlates (Table 12.4). By Early Classic times distinctive assemblages of offerings, including materials of vertebrate origin, specific to structure caches, monument

caches, and elite and nonelite burials are well established.

The relative importance of elite caches and burials appears to have fluctuated during the course of Tikal's permanent occupation. During the Late Preclassic, structure caches are quite modest, whereas elite burials increase in the quantity and richness of offered goods until at least the middle of the Late Late Classic period. Great emphasis is placed on caches during the Early Classic. They become more numerous and include quantities of precious materials such as jade and marine shell, as well as local and exotic vertebrates. Besides temples, caches are now also placed beneath carved and plain stone stelae in chamber and crypt burials and with elite range structures. Structure caches reach a plateau in number and richness of offerings that lasts throughout the Early Late Classic, the period of the long hiatus in monumental inscriptions, but decline noticeably by the middle of the Late Late Classic. During the hiatus fewer kinds of durable goods appear in the rare monument caches associated with plain stelae. The Late Late Classic is characterized by an increased number of stone monuments and associated caches and an escalation in monumental construction. After ca. A.D. 735, however, monument caches become quite standardized, almost perfunctory compared to offerings of earlier times, and there is a marked decline in the number and contents of structure caches. There are more offerings of problematical nature; that is to say, there are more offerings that depart in some readily observable way from what is referred to here as an elite tradition of structure caches. Chamber burials may have reached a zenith in richness of offerings with Burial 196, interred around the middle of the Late Late Classic period. Uncertainty remains, however, because the contents of the latest known chamber burial from Group 5D-2 are unknown.

The goods and labor invested in the burials of the elite, particularly the chamber burials of Tikal's rulers, may be taken as indicators of the personal wealth and control of labor that these

persons once held, and the contents and contexts of caches strongly suggest the material accompaniments of religious rituals. The differing emphasis on caches and burials over time may have arisen from changes in the nature of rulership. The Late Preclassic rulers appear to have been autocrats. The great importance of caches during the Early Classic and Early Late Classic periods suggests the development of social or religious values that may have placed some constraints on rulers (Blanton 1999:152–153), constraints that remained in force until after the hiatus. During the succeeding Late Late Classic period rulers may once again have become increasingly powerful, until they vanish from the record.

The contents of Tikal burials and caches show more similarities with than differences from those from contemporary sites elsewhere

in the Maya lowlands (e.g., Coe 1965; Hall 1989; Maxwell 1996; Ricketson and Ricketson 1937; Smith 1950). It would, however, be of great interest to see if other lowland sites also show changes in the relative importance given to burials vs. caches similar to those we can observe at Tikal.

Acknowledgments. I thank Kitty Emery for the invitation to contribute to this volume and Kitty, Norbert Stanchly, and Marilyn Beaudry for helpful comments on earlier versions of this chapter. We would know next to nothing about the use of vertebrates at Tikal without the faunal identifications made by Kent V. Flannery, Steven M. Goodman, Robert Rush Miller, Karen Mudar, Raymond A. Paynter, Anne Meachem Rick, Mary Pohl, Sylvia Scudder, L. C. Stuart, Elizabeth Wing, and their associates.



PART 5

Zooarchaeology from the Borders of the Maya World

A Vertebrate Archaeofauna from the Early Formative Period Site of Paso de la Amada, Chiapas, Mexico

Preliminary Results

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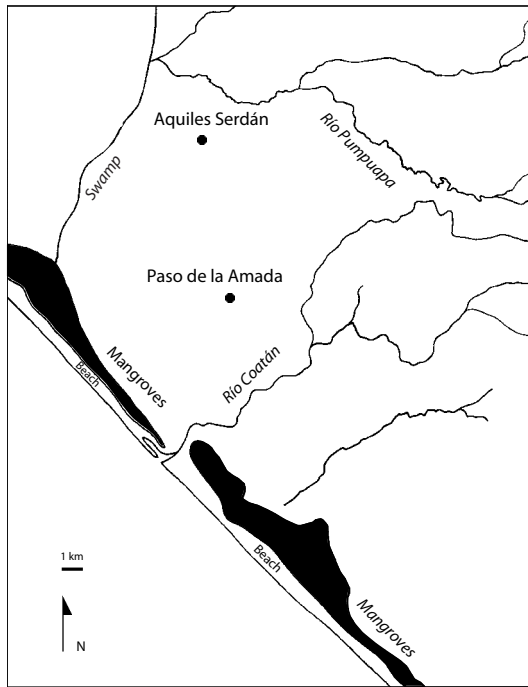
Recent archaeological excavations at Paso de la Amada, Chiapas, Mexico, have recovered an impressive amount of well-preserved vertebrate faunal remains. Analysis of highly diverse redeposited midden material from a high-status structure (Mound 1), dominated by Cherla phase (1100–1000 B.C.) ceramics, is presented here. Primary analytical foci include preliminary determination of diet-based status measures for future comparison to other areas of the site, subsistence focus, and paleoenvironmental reconstruction.

This chapter revolves around the identification and analysis of vertebrate faunal remains recovered at a residential platform mound at the site of Paso de la Amada, Chiapas, Mexico. I determine the vertebrate resource focus at Paso de la Amada during the Cherla phase and then compare this collection to the only other reported contemporaneous faunal assemblage in the region, Aquiles Serdán (Blake, Chisholm, Clark, and Mudar 1992; Flannery and Mudar 1991), only 15 km away. The results of this analysis and comparison provide insight into what the local environment was like, the dynamics of vertebrate food acquisition, and the level of dependence on hunting as it relates to agricultural production during the Cherla phase in the Mazatán region of Soconusco.

PASO DE LA AMADA

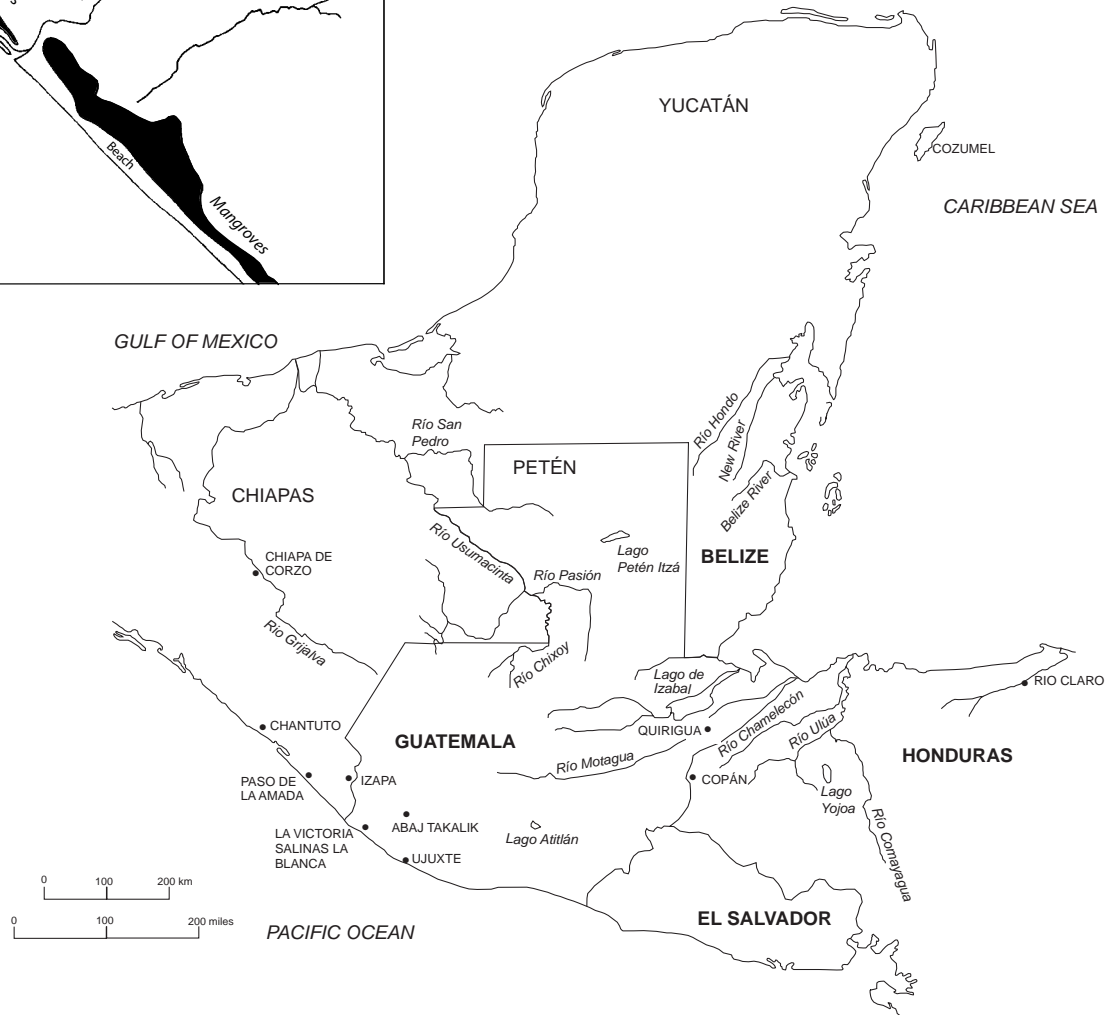
The site of Paso de la Amada is located in the southernmost part of Mexico on the Pacific

coastal plain of Chiapas (Figure 13.1). This area of Chiapas and a small adjoining portion of Pacific coastal Guatemala is often referred to as Soconusco (Voorhies 1989). The plain on which the site sits slopes gently to the southwest, toward the Pacific Ocean, away from the piedmont bordering the highlands and volcanoes. The coastal plain is dissected by three main rivers and is bounded to the northwest by a large freshwater swamp and to the southwest by mangrove swamps and estuaries. The site itself is located on the coastal plain 7 km east of the Pacific Ocean and the modern estuary at the mouth of the Río Coatán and 5 km south of the swamp of Pampa la Cantileña (see Figure 13.1 inset). Local wetlands and forests were probably more extensive in prehistoric and even recent historic times than they are today after several decades of modern drainage for the expansion of large-scale agriculture (Blake 1991; Blake, Chisholm, Clark, and Mudar 1992; Clark and Blake 1994; Coe 1961; Coe and Flannery 1967).



BELOW: Figure 13.1. Map of sites locations mentioned in the text. Map by K. Emery.

LEFT: Paso de la Amada. Inset by T. Wake.



The site of Paso de la Amada was first discovered, mapped, and excavated by Jorge Fausto Ceja-Tenorio in 1974. Ceja-Tenorio found evidence of the Barra, Ocos, and Cuadros phases (Ceja-Tenorio 1985) when he tested Mounds 1 through 5. The site was occupied between

approximately 1850 and 950 B.C. and is characterized by a series of low natural undulations spread over an area of approximately 50 ha. These low mounds are interspersed with old stream channels, some of which still flood in the rainy season (Blake et al. 1995; Clark 1991).

Some of the higher areas of the site are artificially constructed mounds built on slightly elevated land during the prehistoric occupation of the site (Lesure 1997, 1999). Mound 1 is one such artificial feature. Sometime between 1350 and 1200 B.C., during the Cherla ceramic phase, a dense refuse deposit containing predominantly Cherla phase artifacts was quarried from somewhere in the surrounding area and heaped up to form a platform more than 1 m in height and approximately 20 m in diameter. Stratigraphic levels dominated by Cherla phase ceramic artifacts included Lots (natural levels) 9, 10, and 11.

The site was investigated again during the mid and late 1980s by John Clark, Michael Blake, and a number of others (Blake, Chisholm, Clark, and Mudar 1992; Blake, Chisholm, Clark, Voorhies, and Love 1992; Clark et al. 1994; Hill et al. 1998; Lesure 1997). One of their major finds was a series of house floors in Mound 6, including the remains of a dumbbell-shaped structure with low walls (Blake, Chisholm, Clark, and Mudar 1992). Excavations at the site continued intermittently through the 1990s under the direction of Clark, Blake, and Lesure (Clark et al. 1994; Lesure 1997). These excavations involved further testing and trenching of a number of the other mounds at the site, including more work on Mound 1 and Mound 7. Hill et al. (1998) report the oldest excavated formal Mesoamerican ball court (Mound 7) at Paso de la Amada.

Subsistence at Paso de la Amada

Isotopic analysis of human bone recovered from Paso de la Amada clearly shows that the individuals examined were consuming C₃ plants, most likely maize, but not at the levels seen later, during the Formative period in the region (Blake, Chisholm, Clark, Voorhies, and Love 1992). Carbonized maize cupules and bean cotyledons (*Phaseolus* sp.) have been identified in material excavated from Mound 32 (Chris Attarian, personal communication 1998), further confirming the presence of domesticated agricultural products during the Cherla

phase (Blake, Chisholm, Clark, and Mudar 1992). Reconstruction of Early Formative period subsistence at Paso de la Amada and in the broader Soconusco regions suggests that agricultural products were an important part of the diet but not necessarily a staple (Blake, Chisholm, Clark, and Mudar 1992; Blake, Chisholm, Clark, Voorhies, and Love 1992).

A number of broad anthropological assumptions are associated with the advent of prehistoric agriculture, including sedentism and incipient social complexity (Blake, Chisholm, Clark, and Mudar 1992; Blake, Chisholm, Clark, Voorhies, and Love 1992; Kent 1989). It is clear that both were occurring at Paso de la Amada. What is unclear, however, is the level of dependence on agricultural products at the site. Agriculturalists in the humid tropics of South America and New Guinea depend largely on plant products, both wild and domestic, as staple food sources (Griffin 1989; Kensinger 1989; Kent 1989; Rosman and Rubel 1989; Vickers 1989). These same authors show that the tropical populations they studied also view hunting as important to the diet and to the maintenance of social structure at various levels (Griffin 1989; Kensinger 1989; Kent 1989; Rosman and Rubel 1989; Vickers 1989). The relative importance of obtaining locally available vertebrate resources at Paso de la Amada is determined by assessing the number and frequency of wild vs. domestic species at the site and comparing these findings to earlier and later assemblages from the region. Cultural implications of the vertebrate diet are also discussed in the conclusions.

CHRONOLOGY

Little is known about the Soconusco region prior to the Late Archaic period. The recently excavated site of Cerro de las Conchas has yielded radiocarbon dates ranging from 5500 to 4500 B.C., huge amounts of estuarine shellfish remains, and a wide variety of lower estuarine vertebrate species (Voorhies 2000; Voorhies et al. 2002; Wake 2000a). More is known about the Late Archaic Chantuto period beginning approximately 4650 B.C. and lasting to roughly

1800 B.C. (or as recent as 1500 B.C.; Barbara Voorhies, personal communication 2000), where people continued to intensively exploit estuarine environments. Ceramics appear abruptly and apparently without antecedents in the refined and well-developed Barra phase (1550–1350 B.C.). It is often presumed that agriculture is coincident with the beginning of the ceramic tradition in this region (Blake, Chisholm, Clark, and Mudar 1992). The ceramic chronology progresses through the Locona phase (1350–1250 B.C.), the Ocos phase (1250–1100 B.C.), to the Cherla phase (1100–1000 B.C.), and on to the Cuadros (1000–900 B.C.) and Jocotal (900–850 B.C.) phases (Blake, Chisholm, Clark, and Mudar 1992).

PREVIOUS ARCHAEOFAUNAL STUDIES

Focused study of archaeological assemblages in Soconusco began with Drucker's 1947 archaeological survey of the northern part of Chiapas (Drucker 1948:166; Michaels and Voorhies 1989). At the time, his discovery of the Chantuto shell mounds was important because it was only the second area where aceramic and ceramic deposits were present in the same stratigraphic section. Drucker (1948) considered this occurrence integral to the understanding of the transition from a preceramic to an early ceramic horizon or, as he saw it, from mobile hunter-gatherers to settled farmers (Drucker 1948:166; Michaels and Voorhies 1989). However, Drucker provided no information on subsistence practices or other ecological aspects.

Inspired by Robert Braidwood's multidisciplinary approach in the Middle East (Braidwood and Howe 1960; Braidwood and Reed 1957; Flannery 1965; Reed and Braidwood 1960), archaeological research with a much stronger ecological interest appeared in the Ocos area of Pacific coastal Guatemala in the early 1960s. Michael Coe's (1961) excavations at La Victoria and Shook's (1965) survey in Pacific coastal Guatemala set the stage for later regional approaches to the examination of subsistence, settlement, and cultural development.

Coe and Flannery (1964) first discussed the role of ecology, subsistence, and specific microenvironments in local archaeological inquiry. Interest in human ecology and changing subsistence patterns through time in Mesoamerica expanded rapidly, as evidenced by the Tehuacan Valley Project (Byers 1967). A series of authors addressed human settlement patterns and relationships with different aspects of the Tehuacan Valley environment through regional and temporal analysis of animal (Flannery 1967) and plant (Cutler and Whitaker 1967; Kaplan 1967; Mangelsdorf et al. 1967; Smith 1967; Stevens 1967) remains from various contexts. The emphasis in the Tehuacan report, however, is clearly on plants (five chapters) and their role in past human subsistence, with animals treated as secondary (one chapter).

Michael Coe and Kent Flannery (1967) directed their research at Salinas la Blanca along lines similar to Byers and crew in the Tehuacan Valley, including the recruitment of Paul Mangelsdorf (1967) to examine maize remains that they recovered. Although much of their work focused on settlement patterns, chronology, and ceramic seriation, the authors highlight the role of environment and subsistence in the cultural evolution of the lower Río Naranjo basin. Follett's (1967) analysis of the fish remains recovered from Salinas la Blanca represents the first detailed zoological analysis of vertebrate remains from archaeological contexts in this part of Central America. Coe and Flannery (1967:13) listed the larger mammals and reptiles from the "Ocos Transect," a strip of the coast bounded on the west by the Suchiate River, the east by Pampa la Morena, and extending inland roughly 15 km. Since this transect is relatively close to Paso de la Amada, it is useful for comparative purposes. Coe and Flannery (1967) conclude that casual collecting of animals was far more important than active hunting and that fishing was the only vertebrate exploitation activity focused enough to draw individuals away from farming.

Archaeological research in Pacific coastal Mexico and Guatemala continued through the

1970s into the 1980s, with noteworthy discoveries such as those at Abaj Takalik (Graham 1977, 1979; Graham et al. 1978), various New World Archaeological Foundation projects, and other projects (Shook and Hatch 1979). Relatively little attention was paid, however, to questions concerning the role of vertebrate animals in subsistence. Even with the notice served by Coe and Flannery (1967), apparently little attention was paid to the purposeful discovery or recovery of vertebrate faunal remains in Pacific coastal Mexico and Guatemala during this era. In the 1970s Barbara Voorhies (Voorhies 1976) undertook the only substantive investigations with a strong environment and subsistence bent at the northern end of Soconusco. Her study of large shell mounds at Isona de Chantuto and surrounding sites indicated, among other things, the importance of animal resources in regional settlement systems and shifting patterns of exploitation through time. The development of relatively stable resources such as those found in estuarine systems was clearly important in the aceramic Late Archaic period and developing sedentism in Soconusco and throughout Central America (Stark and Voorhies 1978; Stark and Voorhies, eds. 1978; Voorhies 1976, 1978). During this period interest and inquiry into such questions largely shifted to the Valley of Oaxaca (Flannery 1976, 1986), where much of the published research was begun in the late 1960s. Other than Voorhies (1976) and Hudson et al. (1989), no analyses of archaeological faunal assemblages excavated from Soconusco during the 1970s and the early 1980s are available.

During the late 1980s archaeological inquiry into the evolution of Formative period society along the Pacific coast of southern Mexico and Guatemala was reinvigorated. Hudson et al. (1989) examined regional subsistence patterns from the Archaic to the Protohistoric periods in Soconusco. Further research into the late Archaic Chantuto people was conducted, emphasizing the role of estuarine systems and resource scheduling (Michaels and Voorhies 1989; Voorhies et al. 1991). Farther south and east of Soconusco, excavations were conducted at El

Mesak, Guatemala, by Mary Pye and Arthur Demarest (1991), where it was established that estuarine resource exploitation produced the greatest portion of animal protein at the site (Wake 1990; Wake and Hyland 1989).

Also during this period Michael Love (1989, 1990, 1991, 2002) conducted a regional survey in the Río Naranjo drainage and excavated the site of La Blanca, whose vertebrate faunal assemblage is reported elsewhere (Wake and Harrington 2002). At the same time that Love was excavating at La Blanca, others began more intensive research in the Mazatán region of southern Chiapas (Blake 1991; Blake, Chisholm, Clark, and Mudar 1992; Blake and Clark 1992; Clark 1991; Clark and Blake 1989, 1994). Analysis of contents from a trash pit excavated at Aquiles Serdán identified two important facets of the overall pre-Cuadros phase (the Cuadros phase being much more maize dependent) subsistence pattern: estuarine resources and early maize cultivation (Flannery and Mudar 1991). Blake, Chisholm, Clark, Voorhies, and Love (1992) further investigated Early Formative period relative dietary contributions in the region by examining stable isotope ratios in human bones. They found a focus on estuarine resources and "a minimal reliance on maize agriculture" (Blake, Chisholm, Clark, and Mudar 1992:92). Whereas some authors (e.g., Ambrose and Norr 1992) fault the analytical methods of Blake, Chisholm, Clark, and Mudar (1992) and of Blake, Chisholm, Clark, Voorhies, and Love (1992), the original investigators stand behind their conclusions (Chisholm et al. 1993). Their ideas are supported by the currently available vertebrate faunal data (Flannery and Mudar 1991; Wake 1990; Wake and Harrington 2002).

In sum, comparatively little is known about vertebrate exploitation in Pacific coastal Chiapas, Mexico, and adjacent Guatemala in any period, especially the Formative. Although the available literature forms a good foundation, there is much more that can be learned from available samples, such as those from Paso de la Amada.

ANALYTICAL METHODS

The faunal assemblage recovered from Mound 1 is quite large, numbering well over the 3,563 specimens reported here. Because of the size of the assemblage, and various other constraints, this report focuses on vertebrate faunal remains from the Lot 11 levels of seventeen 2-m² units of Mound 1. The term *Lot* refers to a given natural stratigraphic level defined by the excavators in the field. Lot 11 represents one of the least mixed stratigraphic components of Mound 1. Artifacts from these units are dominated by Cherla phase ceramic sherds, with minimal admixture of earlier Locona and Ocos sherds, and date the assemblage to somewhere between 1350 and 1200 B.C. (Lesure 1995; Wake 1997). The aggregated vertebrate specimens reported here, therefore, represent animal remains deposited during roughly a 100-year period, the Cherla ceramic phase. Lots 9 and 10, directly above Lot 11, also correspond to the Cherla phase and yielded vertebrate faunal samples even larger than Lot 11 which have yet to be analyzed.

Sediments excavated from Mound 1 were passed through 4-mm mesh screens in the field. The importance of using relatively small mesh screens at this site cannot be overlooked. The numerous diagnostic small vertebrate remains recovered using relatively fine screens has yielded an assemblage that provides a far more accurate picture of both the Cherla phase natural environment and the role of small vertebrates in the local subsistence system. Many of the most common fish and amphibian remains, for example, would have passed through larger screens. An important subfossil specimen of a rare amphibian (*Dermophis mexicanus*) would certainly have been missed without the use of finer screens (Wake et al. 1999). Various authors have discussed screen-size-based sampling biases (e.g., Grayson 1984; Lyman 1994a). It will suffice to say that this report is yet another example of the utility of small-gauge screens.

The Lot 11 vertebrate faunal remains have been sorted by class and weighed. A representative sample of the fish and all of the Lot 11

amphibians, reptiles, and mammals have been examined in detail. Birds are reported by Steadman et al. (2003).

Because of the great number of fish specimens, only the Lot 11 ichthyofauna represented by Units F9 and H8 have been analyzed in detail. These units were selected as representative of the general Mound 1 Cherla phase fish fauna, since they had relatively average amounts of specimens for all the units represented and are from different parts of the mound.

Individual unit-level bags were sorted by vertebrate class by the staff and volunteers of the UCLA Zooarchaeology Laboratory. Each class was then identified one at a time in order to limit confusion. In the course of identifying each specimen, sorters noted other data, including skeletal element, side, portion, weight, and taphonomic characteristics such as fragmentation, gnawing (carnivore and rodent), burning, cut marks, or other obvious modification.

The Paso de la Amada vertebrate archaeofauna is measured using NISP (number of identified specimens) and MNI (minimum number of individuals) counts. The NISP measure is a straight count of all the identified bone specimens representing a given taxonomic category. The MNI is a derived determination of the minimum number of individual animals represented in the sample at hand. The MNI determinations here are based on counts of the greatest number of paired elements from either side (left or right) of a given taxon or the number of unique skeletal elements represented, whichever is greater. Size of individual skeletal elements is also used in the determination of MNIs here. For example, when two specimens representing one side of a specific paired skeletal element of a given taxon might suggest the presence of a minimum of two individuals, a much larger or smaller specimen representing the opposite side would indicate the presence of another individual animal. Where MNIs are determined for a given taxon, the skeletal element used and relative size are identified. Although each of these counts (NISP and MNI) has its inherent problems (e.g., Grayson 1984;

Table 13.1. Identified Fish from Paso de la Amada, Mound 1, Lot 11

Scientific name	Common Name	NISP	MNI	Weight
<i>Elasmobranchiomorphii</i>	Shark or ray	2	—	0.22
<i>Lepisosteus tropicus</i>	Tropical gar	44	1	10.86
<i>Elops affinis</i>	Machete	2	1	0.17
<i>Arius</i> sp.	Sea catfish	900	40	151.08
<i>Centropomus</i> sp.	Snook	31	5	9.58
Carangidae	Jacks	6	—	0.52
<i>Lutjanus argentiventris</i>	Amarillo snapper	2	1	0.13
<i>Lutjanus</i> sp.	Snapper	29	3	5.96
<i>Eugerres</i> sp.	Mojarra	4	3	0.39
Gerreidae	Mojarras	2	—	0.16
<i>Haemulon macracanthus</i>	Bigspine grunt	2	1	0.76
<i>Pomadasys</i> sp.	Grunt	1	1	0.19
Haemulidae	Grunts	5	—	0.79
Sciaenidae	Drums	1	1	0.05
<i>Cichlasoma</i> sp.	Cichlids	38	6	2.90
<i>Mugil</i> sp.	Mullet	4	1	0.32
<i>Dormitator latifrons</i>	Pacific fat sleeper	55	19	2.70
Eleotridae	Sleepers	350	—	15.37
<i>Sphoeroides</i> sp.	Pufferfish	1	1	3.40
<i>Osteichthyes</i>	Bony fish	311	—	33.92
Total		1,790	84	239.47

Lyman 1994a; Ringrose 1993), together they provide a fairly accurate representation of the relative abundance of the different identified animals present in the overall assemblage.

THE FAUNA

Fish

The Lot 11 vertebrate faunal remains are dominated by fish. The fish, in fact, are so numerous and diverse that only a subsample (Units H9 and F8) has been examined closely. Twenty taxonomic categories are represented, with eleven genera and five species identified (see Table 13.1 for NISP and weight data). The most common identifiable elements are from sea catfish, known locally as bagre (*Arius* sp.; MNI = 40, based on proximal right pectoral spines), and the Pacific fat sleeper, known locally as sambuco (*Dormita-*

tor latifrons; MNI = 19, based on numbers of vertebra no. 1, atlas). Another 350 vertebrae (15.37 g) represent the family Eleotridae (sleepers), bringing the total eleotrid NISP to 405 (18.07 g).

The next most common fish are tropical gar, known locally as armado (*Lepisosteus tropicus*; MNI = 1); cichlids, referred to as mojarra, (*Cichlasoma* sp.; MNI = 6, based on left premaxillae); snook, commonly known as robalo (*Centropomus* sp.; MNI = 5, based on left dentaries); and snapper, locally known as huachinango (*Lutjanus* sp.; MNI = 4, based on right dentaries). Most of the more numerous fish taxa are represented by head bones (the syncranium, including both the neurocranium and the branchiocranium) and vertebrae. The gar are represented mostly by dermal ossicles or scutes, but many vertebrae and head bones are present as well. Many of the gar specimens are charred or appear altered by heat.

I have purchased roasted gar on a stick in various local markets in coastal Chiapas and Guatemala. A stick is inserted into a fresh gar. The fish is then placed in or over a fire, cooking the meat within the armored sleeve and causing a great deal of discoloration to the individual scutes. Once roasted, a gar's bony armor can be easily peeled off in large chunks (e.g., as in Follett 1967:129), uncovering their tasty flesh.

The more common fish taxa are followed by a smattering of other species including bigspine grunt (*Pomadasys macracanthus*; MNI = 1); mullet, referred to locally as lisa (*Mugil* sp.; MNI = 1); mojarra (*Eugerres* sp.; MNI = 3, based on two large right premaxillae and one small left premaxilla); machete (*Elops affinis*; MNI = 1); and pufferfish (*Spherooides* sp.; MNI = 1, a large left premaxilla). Jacks (Carangidae), grunts (Haemulidae), and drums (Sciaenidae) are represented by specimens identified to their respective families.

Amphibians

Amphibians are present in the Lot 11 assemblage in relatively low numbers (Table 13.2). Anurans (the frogs and toads) dominate the amphibians numerically. Toads (*Bufo* sp.) dominate all of the amphibians, with 20 specimens and 3 individuals represented. One true frog (*Rana* sp.) is identified. The anurans could easily be intrusive, since some species are well known as burrowers (Campbell 1998). Some authors (Hamblin 1981; Kennedy 1982) have argued that toads may have been used in ritual ceremonies, since they appear so often in later Formative sculpture and ceramic representations at sites including, but not limited to, Abaj Takalik, Copán, Cozumel, Izapa, and Quirigua.

Reptiles

Reptiles are well represented in the Lot 11 fauna, making up 10 percent of the overall collection. Turtles dominate the reptile subassemblage numerically, and snakes, followed by lizards, are the next most common (Table 13.2). By weight the turtles dominate, followed by crocodiles, and then snakes and lizards. There are 22 taxonomic categories represented, with 11 genera and 5 species identified. The lizards

and turtles are the most diverse, with three genera each represented. Snakes are represented by three families and one genus and species. Crocodilians are represented by a single genus and species. In terms of MNIs lizards (Iguanidae) dominate, with five individuals, followed by four mud turtles (*Kinosternon* sp.). At least one crocodile (*Crocodylus acutus*) is represented, which could probably provide as much meat as all of the other reptiles combined.

The most prevalent turtles are casquitos, mud turtles of the genus *Kinosternon*, most likely *Kinosternon scorpioides*, the local subspecies of which is *Kinosternon s. cruentatum* (Iverson 1992). Most of the *Kinosternon* elements are burned (charred to a black color and sometimes charred and calcined), especially the plastron fragments. The burning could indicate roasting or possibly trash disposal. Emydid turtles, the larger pond and river turtles, are present but are much less common. One coracoid of a sea turtle (cf. *Chelonia*) is also identified.

Snakes are the next most common reptile group. Colubrid snakes are the most common in the assemblage, as they are today in Chiapas. The one identified snake species, the indigo snake (*Drymarchon corais*), is extremely fast, aggressive, and is known to eat venomous snakes such as the fer-de-lance (*Bothrops asper*). A number of indigo snake vertebrae recovered from Lots 9, 10, and 11 (Cherla phase) of Mound 1 have been modified by grinding the dorsal and ventral surfaces flat, possibly for use as beads. Many of the snake vertebrae are burned.

Lizards are well represented in Lot 11, although their remains are highly fragmented. Specimens representing large iguanids, either green iguanas (*Iguana iguana*) or black iguanas (*Ctenosaura similis*), dominate the lizard bone assemblage. Both species are identified by various cranial elements but are difficult to differentiate postcranially. A single crested lizard (*Coritophanes* sp.) is also present. Most of the lizard elements are either charred or appear to have been heated in some fashion, as indicated by discoloration and delamination of the surface bone.

Crocodilians are represented by relatively few, but some rather large, elements. Crocodile

Table 13.2. Identified Amphibians and Reptiles from Paso de la Amada, Mound 1, Lot 11

Scientific Name	Common Name	NISP	MNI	Weight
Amphibia				
<i>Bufo</i> sp.	Toad	20	3	1.79
<i>Rana</i> sp.	True frog	1	1	0.12
Anura	Frogs and toads	4	—	0.36
<i>Dermophis mexicanus</i>	Tepalcua (Lot 10)	1	1	0.50
Amphibia subtotal		26	5	2.77
Reptilia				
<i>Crocodylus acutus</i>	Crocodile	4	1	71.76
Crocodylidae	Caiman/crocodile	15	—	9.75
<i>Chelonia</i> sp.	Sea turtle	1	1	10.13
<i>Kinosternon</i> sp.	Musk turtle	116	4	77.47
<i>Rhinoclemmys</i> sp.	Painted turtle	1	1	0.26
Emydidae	Larger turtles	7	—	32.55
Testudines	Turtles	15	—	7.11
<i>Coritophanes</i> sp.	Helmeted lizard	1	1	0.10
<i>Ctenosaura similis</i>	Black iguana	8	2	2.63
<i>Iguana iguana</i>	Green iguana	2	1	0.54
<i>Iguana/Ctenosaura</i>	Iguana	57	2	9.49
Lacertilia	Lizard	13	—	1.29
Boidae	Boas	1	—	0.08
<i>Drymarchon corais</i>	Indigo snake	3	1	2.65
Colubridae	Nonvenomous snakes	109	—	23.97
Viperidae	Pit vipers	1	—	0.70
Serpentes	Snakes	2	—	0.36
Reptilia	Reptiles	1	—	1.45
Reptilia subtotal		357	14	252.30
Total Amphibia and Reptilia		383	19	255.10

(*Crocodylus acutus*) has been positively identified, and caimans (*Caiman crocodilus*) are probably present as well, since they do turn up in other Cherla phase levels (9 and 10) of Mound 1. Virtually all of the 19 crocodilian specimens are charred or appear to have been heated to some degree, similar to the lizard remains. Crocodilians, because of their relatively large size, could have provided a substantial amount of dietary protein and may have been a relatively highly ranked prey item.

Mammals

Lot 11 of Mound 1 has yielded a diverse mammal fauna, composing 25 percent of the level's collection. Twelve species and 14 genera have been identified, representing 6 orders (Table 13.3). The carnivores are the most diverse, with four families and four genera represented. Artiodactyls and the rodents are both represented by three genera, the other orders by a single genus.

In terms of NISP rodents dominate, followed by armadillos and rabbits. This bias

Table 13.3. Identified Mammals from Paso de la Amada, Mound 1, Lot 11

Scientific Name	Common Name	NISP	MNI	Weight
<i>Didelphis marsupialis</i>	Common opossum	8	2	6.01
<i>Didelphis</i> sp.	Opossum	1	1	0.39
<i>Dasypus novemcinctus</i>	Nine-banded armadillo	105	3	34.92
<i>Urocyon cinereoargenteus</i>	Gray fox	2	1	1.28
<i>Canis familiaris</i>	Domestic dog	9	1	8.31
<i>Canis</i> sp.	Dog	13	2	10.76
<i>Nasua narica</i>	White-nosed coati	3	1	9.55
<i>Mustela frenata</i>	Long-tailed weasel	1	1	0.37
Felidae	Cat	1	—	0.56
Carnivora	Carnivore	4	—	1.20
<i>Tayassu tajacu</i>	Collared peccary	7	2	14.60
<i>Odocoileus virginianus</i>	White-tailed deer	26	2	103.62
<i>Mazama americana</i>	Red Brocket deer	1	1	0.42
Cervidae	Deer family	1	—	1.75
Artiodactyla	Even-toed ungulates	8	—	18.08
<i>Orthogeomys grandis</i>	Giant pocket gopher	46	3	16.40
<i>Oryzomys</i> sp.	Rice rat	3	2	0.15
Cricetidae	Mouse	4	—	0.12
<i>Agouti paca</i>	Paca	1	1	0.69
Rodentia	Rodents	69	—	5.37
<i>Sylvilagus floridanus</i>	Eastern cottontail	68	4	25.74
Leporidae	Rabbit	1	1	0.45
Unidentified mammalia				
Mammalia, small		20	—	3.17
Mammalia, medium		103	—	31.87
Mammalia, large		775	—	323.08
Mammalia		110	—	26.82
Total		1,390	28	645.68

probably results from the large numbers of small rodent bones and individual armadillo dermal ossicles. By weight, however, the artiodactyls clearly dominate, followed by armadillos, carnivores, and lagomorphs.

Rabbits dominate in terms of MNI, with four individuals, followed by three giant pocket gophers and three armadillos. Two collared peccaries and two white-tailed deer are represented. Any one of the artiodactyls would probably provide as much meat as all the rabbits, gophers, and armadillos combined. Therefore, the artiodactyls most likely represent highly ranked prey items (Bayham 1979; Broughton 1994, 1999).

Marsupials are represented by nine common opossum (*Didelphis* cf. *marsupialis*) elements, from at least two individuals. Roughly half of the opossum specimens are burned, suggesting that these animals were included in the overall Paso de la Amada diet.

Armadillos (*Dasypus novemcinctus*) are the only representatives of their order (Xenarthra) at this site. Dermal ossicles are distinctive and are the most common armadillo specimens. Postcranial bones are present and some bear cut marks. Most of the armadillo scutes and bones are burned. The high degree of charring seen in the scutes could be the result of cooking arma-

dillos in their armored skins directly over a fire, in a fashion similar to current gar (*Lepisosteus*) cooking practices. It is possible that another armored vertebrate, such as an armadillo, could be roasted in its shell as well.

Carnivores are the most diverse vertebrate order at Paso de la Amada, Mound 1, Lot 11. They are represented by four families: Canidae (dogs), Procyonidae (raccoons), Mustelidae (weasels), and Felidae (cats). Two canid species are present: domestic dogs (*Canis familiaris*) and gray foxes (*Urocyon cinereoargenteus*). The other carnivore families are represented by a single species each: the coati (*Nasua narica*, Procyonidae), the long-tailed weasel (*Mustela frenata*, Mustelidae), and an undetermined cat (Felidae). Most of the dog bones are burned, as are the coati and the cat.

The presence of carnivore remains begs the question of whether they were included in the diet or represent activities other than subsistence. At other slightly later sites in the region, such as La Blanca (Wake and Harrington 2002), Chiapa de Corzo (Flannery 1969), and elsewhere (Burleigh and Brothwell 1978; Wing 1978), dogs appear to have been included in the diet. At Ujuxte, even more recent than La Blanca, dogs represent an important contributor to all of the mammal remains and may have been the most reliable source of mammal protein at that site (Wake 2000b). Dogs, however, although present at Paso de la Amada, occur in relatively low numbers and in much lower relative frequencies than they do at later sites in the region. Although dogs may have been consumed at Paso de la Amada, they do not appear to have been the most important source of mammal protein, as they are in later Formative period sites in the region.

The artiodactyls are represented by three species from two families. White-tailed deer (*Odocoileus virginianus*) are the most common numerically and by weight. Collared peccaries (*Tayassu tajacu*), although less common, equal the deer in terms of MNI, with two individuals represented. One tooth is tentatively identified as brocket deer (*Mazama americana*) because of its distinctive enamel surface texture and den-

tine lakes. Most of the artiodactyl bones are burned or charred.

Rabbits are well represented at Paso de la Amada as well. Cottontails (Genus *Sylvilagus*, most likely *floridanus*, based on seven cranial specimens) dominate the overall mammal assemblage numerically, with four individuals represented and 68 elements identified. A number of the rabbit bones are burned or charred.

Rodent remains are common and will probably turn out to be the most diverse mammal order at the site. Many of the bones identified simply as rodent represent mice and rats and will be subjected to more detailed analysis to determine if further identification will provide more fine-grained environmental data. So far, giant pocket gophers (*Orthogeomys grandis*), rice rats (*Oryzomys* sp.), cotton rats (*Sigmodon hispidus*), and a paca (*Agouti paca*) have been identified in the Paso de la Amada mammal assemblage. Giant pocket gophers (*Orthogeomys grandis*) dominate the rodents in terms of numbers, weight, and individuals (MNI = 3). This gopher species is quite large (up to 1 kg), and many of the gopher bones are burned, suggesting that they were consumed. Ceja-Tenorio (1985) mentions that giant pocket gophers are still consumed by local inhabitants. It is likely that many more rodent species will be represented at Paso de la Amada as the Lot 11 remains are analyzed in greater detail.

SUMMARY

Although fish clearly dominate the overall assemblage numerically, reptiles and mammals contributed a considerable amount of protein to the diet of the Cherla phase inhabitants of Paso de la Amada. Crocodiles, peccaries, and deer, the largest aquatic and terrestrial vertebrates present at the site, were probably the most highly ranked prey, since they would provide the greatest amount of meat for the labor expended (e.g., Bayham 1979; Broughton 1994, 1999). As large vertebrates, however, they were probably not as common, nor encountered as often, as the smaller, more numerous vertebrates such as rabbits, gophers, turtles, lizards,

snakes, and various fish. The smaller, more commonly encountered reptiles and mammals, especially in combination with fish, probably represented more dependable, staple protein resources than the larger vertebrates.

COMPARISON WITH AQUILES SERDÁN

As it stands, the Paso de la Amada Mound 1, Lot 11 faunal assemblage can be readily compared to the vertebrate remains identified by Kent Flannery and Karen Mudar (1991) and discussed by Blake, Chisholm, Clark, and Mudar (1992) from a Cherla phase trash pit at Aquiles Serdán. Aquiles Serdán, 15 km to the north and west of Paso de la Amada, was excavated using techniques and screen sizes similar to Blake's (Blake, Chisholm, Clark, and Mudar 1992).

Flannery and Mudar identified five families of fishes, with three genera and two species. The dominant fish at this site are mojarras (*Cichlasoma trimaculatum*; MNI = 171) and catfish (*Arius* sp.; MNI = 97), followed by gar (*Lepisosteus tropicus*; MNI = 15) and some marine fishes (Lutjanidae, snappers and Scaridae, parrotfish). Blake, Chisholm, Clark, and Mudar (1992) did not state which elements Flannery and Mudar (1991) used in their MNI determinations.

The species representation at Aquiles Serdán is similar to Paso de la Amada in that cichlids and catfish are conspicuous, and some estuarine and marine families are represented. At Paso de la Amada, however, the dominant fish taxa are reversed. Catfish clearly dominate in terms of MNI at Paso de la Amada, and fewer cichlids are present. Sleepers (Eleotridae), the second most abundant fish at Paso de la Amada, are not represented at Aquiles Serdán. Follett (1967) identified a spotted sleeper (*Eleotris picta*) at Salinas la Blanca, a slightly later site directly adjacent to the estuary at the mouth of the Río Naranjo, 30 km south of the Río Coatán. The fish fauna at Paso de la Amada, although less numerous overall (for the moment), is taxonomically much richer. Estuarine and marine fish species are much more common and diverse at Paso de la Amada.

Like Paso de la Amada, Aquiles Serdán provides evidence of various reptiles, including turtles, crocodilians, iguanas, and snakes. Although exact numbers and MNIs for these taxa are not provided, the general similarities to the Paso de la Amada fauna are apparent. Iguanas, both green and black, are represented at both sites. Likewise, *Kinosternon* dominates the turtle remains at both sites.

Flannery and Mudar (in Blake, Chisholm, Clark, and Mudar 1992; Flannery and Mudar 1991) identify *Pseudemys grayi* and *Dermatemys mawii* at Aquiles Serdán. These identifications are confusing for a variety of reasons. First of all, *Pseudemys grayi* is no longer a valid taxonomic name and as such does not appear on range maps in recent publications (Iverson 1992). The correct name for sliders in Soconusco is currently *Trachemys scripta grayi* (Iverson 1992: 208).

The identification of *Dermatemys mawii* at Aquiles Serdán is potentially very interesting, but it is also suspect because no mention is made of the key characters used to determine the species, it is unsupported by illustrations, and it is far outside its known historic range. The current range limits of *Dermatemys* are 300 km to the north and east, in the lowlands of the Atlantic slope drainages (Iverson 1992:97). If the specimens do represent *D. mawii*, then they must have been imported. The claim that the *Dermatemys* specimens may represent an imported drum is unsubstantiated (Blake, Chisholm, Clark, and Mudar 1992:141). No mention is made of any modification, such as holes or shaping, that might lead to such a conclusion. It is also frustrating that MNIs for most of the reptile species are presented as "several," and NISP counts are not provided, at least by Blake, Chisholm, Clark, and Mudar (1992).

Nine genera and species of mammals are also identified from Aquiles Serdán. Although giant pocket gophers are the most common (MNI = 9), artiodactyls (deer and peccary, MNI = 6) dominate the assemblage in terms of potential meat contribution. Dogs (MNI = 3) and rabbits (MNI = 4) are represented in num-

bers similar to Paso de la Amada (see Table 13.3). Like Paso de la Amada, no strictly forest species are identified at Aquiles Serdán.

CONCLUSIONS

Historical accounts of Soconusco around the turn of the nineteenth century depict the region as swampy with heavily forested higher ground. Few species that prefer closed canopy primary tropical forest environments are represented at Paso de la Amada. Only two specimens represent primary tropical forest species: one brocket deer (*Mazama americana*) tooth and one paca (*Agouti paca*) tooth. No primary forest species such as tapirs (*Tapirus bairdii*), monkeys (*Ateles* or *Alouatta*), agoutis (*Dasyprocta*), or four-eyed opossums (*Philander*) are yet identified at Paso de la Amada (e.g., Emmons 1990; Reid 1997). The low frequency of such species suggests that the area surrounding Paso de la Amada may not have been heavily forested or at least that hunters were not exploiting forest environments.

The identified fauna does suggest the exploitation of a variety of microenvironments, ranging from coastal estuaries and mangrove swamps to freshwater marshes and drier savannas, and possibly field edges. The majority of the fish species represented in Mound 1 are found in brackish water estuarine habitats. Most of the turtles are found in fresh and slightly brackish water swamps. The iguanas are edge oriented, with green iguanas (*Iguana iguana*) commonly found consuming foliage or sunning in trees or bushes, and black iguanas (*Ctenosaura similis*) found near cover on the ground. Most of the mammal species at Paso de la Amada are broad-ranging generalists that prefer areas of mixed microhabitats, especially where edges of various vegetation zones come together with more open areas (such as deer, peccaries, rabbits, and gophers). The species identified at Paso de la Amada represent a number of different local microhabitats. The overall vertebrate assemblage exhibits the kind of diversity one might expect if hunting were taking place in rivers, swamps, and perhaps in

and around cleared and cultivated areas, similar to Linares's (1976) concept of garden hunting.

The similarities between these two faunal assemblages (Paso de la Amada and Aquiles Serdán) suggest opportunistic hunting and exploitation of varied microenvironments during the Cherla phase in the Mazatán region. The relative frequencies and range of species represented at both sites are consistent with Coe and Flannery's (1967) conclusions at Salinas la Blanca: inhabitants engaged in collecting and opportunistic acquisition of higher vertebrates, perhaps at the individual level. Although hunting appears to have emphasized potentially high-ranked species such as deer, peccaries, or crocodiles, a broad range of species is represented at Paso de la Amada, Aquiles Serdán, and other Early to Middle Formative period sites in the region. The relatively low MNI counts for large vertebrates and diversity of species represented at these two sites do not suggest highly organized hunting. Fishing was probably the only animal protein procurement activity that could consistently draw groups of people away from farming (e.g., Coe and Flannery 1967). The variation in the two fish faunas, however, has two plausible explanations: either different aquatic habitats were available near these two sites, or the fishing focus was not the same. A more estuarine focus is evident at Paso de la Amada, a predominantly freshwater focus at Aquiles Serdán. At this time I lean toward an environmental explanation. Aquiles Serdán probably had a stronger focus on freshwater fish species because it lay close to a freshwater swamp and had more restricted access to estuarine species than Paso de la Amada simply because it was farther from the coast.

The two Cherla phase assemblages compared above exhibit a wide array of species and lack of focus on any particular vertebrate. Domestic dogs are present at Paso de la Amada but are not numerous. A stronger focus on larger species, such as dogs and deer, is seen in Middle and Late Formative period vertebrate faunal assemblages from sites such as Salinas la

Blanca, La Blanca, and Ujuxte (Coe and Flannery 1967; Hudson et al. 1989; Wake 2000a, 2000b; Wake and Harrington 2002). These same sites exhibit evidence of a stronger dependence on agricultural staples such as maize (Blake, Chisholm, Clark, and Mudar 1992; Love 1989, 1990, 1991, 2002).

The inhabitants of Paso de la Amada may have been some of the earliest people in Mesoamerica to construct a ball court and potentially chiefly houses (Blake 1991; Blake and Clark 1992; Hill et al. 1998). However, they do not exhibit the vertebrate exploitation strategy seen at later Formative period sites with monumental architecture in the region, such as La Blanca and Ujuxte (Blake, Chisholm, Clark, and Mudar 1992; Wake 2000b; Wake and Harrington 2002). The overall Cherla phase vertebrate exploitation pattern bears strong similarities to those of modern tropical agriculturalists that do not focus on domesticated animals or agricultural products as reliable staples (Griffin 1989; Kensinger 1989; Kent 1989; Linares 1976; Rosman and Rubel 1989; Vickers 1989). The wide array of vertebrate species present at Paso de la Amada suggests that the inhabitants could not rely entirely on agricultural production and found it necessary to buffer against unreliable availability of food by opportunistically hunting and collecting a variety of vertebrate species.

FUTURE RESEARCH

Once the remaining fish and bird remains from Lot 11 and the other Cherla phase levels, Lots 9 and 10, are identified and analyzed, thorough comparison between Paso de la Amada and Aquiles Serdán can be made. The faunal assemblages from these two sites will then serve as a comparative baseline for the Mazatán region—and the whole of Soconusco, at least for the Cherla phase. Cherla phase faunal remains have been recovered from the site of El Varal, closer to the coast, and can eventually be incorporated into a regional perspective as well.

Once a comprehensive study of Cherla phase dietary patterns is completed, those findings can then be compared to faunal assemblages representing earlier periods in the Mazatán region (Wake 2000a) and later periods at La Blanca (Wake and Harrington 2002), Ujuxte (Wake 2000b), and farther south at El Mesak (Wake 1990). We will then have a better understanding of the role vertebrates played in agricultural intensification, population growth, and the development of complex social hierarchies in the region.

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All identifications were verified by the author using the comparative osteological collections housed in the UCLA Zooarchaeology Laboratory, the UCLA Department of Biology's Dickey Natural History Collection, the Los Angeles County Museum of Natural History, the UC Berkeley Museum of Vertebrate Zoology, and the California Academy of Sciences. A current list of the UCLA Zooarchaeology Laboratory comparative collection holdings is available on the World Wide Web at <http://www.sscnet.ucla.edu/ia/zcollection.htm>.

Human Use of Animals in Prehispanic Honduras

A Preliminary Report from the Lower Ulúa Valley

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Zooarchaeological analyses from sites in the Lower Ulúa Valley, Honduras, are used to provide a broad outline of human use of animals in the region. A history of zooarchaeological analysis in the Ulúa Valley and surrounding areas provides a comparative profile of animal use to highlight recent faunal information gathered from the site of Puerto Escondido. Here, broad horizontal excavations of the Loma 2 occupation area by the VIRU project recovered assemblages from both domestic and ritual contexts dated to the Middle Formative to Early Classic periods.

The lower Ulúa River Valley—an extensive riverine zone on the Caribbean coast of Honduras (Figure 14.1) that is characterized by greater biodiversity and agricultural potential than almost any other region of Mesoamerica—was the focus of important early archaeological research (e.g., Gordon 1898; Popenoe 1934; Stone 1940, 1941; Strong et al. 1938). Beginning in the 1950s, a hiatus of nearly 30 years ensued before intensive research resumed in the 1970s (Hase-mann et al. 1977; Henderson 1984; Kennedy 1981). On the one hand, this means that the absolute scale of research lags behind that in other areas of the Maya world, and considerable effort has had to be expended simply to provide general environmental reconstruction (Pope 1984, 1986, 1987) and to establish a sufficiently refined chronological scale (Beaudry-Corbett et al. 1993) to begin to address questions of social and economic organization. On the positive side, the late blooming of extensive study of sin-

gle sites has offered the opportunity to integrate approaches to categories of data, including fauna, that would have been ignored by excavators of the 1950s and 1960s.

The present essay is the first attempt to sketch the general outlines of human use of animals in the region. Because it draws on extremely limited samples, we refrain from proposing interpretations of the development of human-animal relations over time or of overall subsistence strategies. Instead, we focus here on providing a basis for general comparison with other regions of the Maya world, for which the lower Ulúa Valley provides a significant comparative case. By contrasting the composition of older curated collections with those from our ongoing project, our discussion here also illustrates the difference that integrating the recovery of faunal remains into research strategies makes at even the gross level of descriptive inventories.

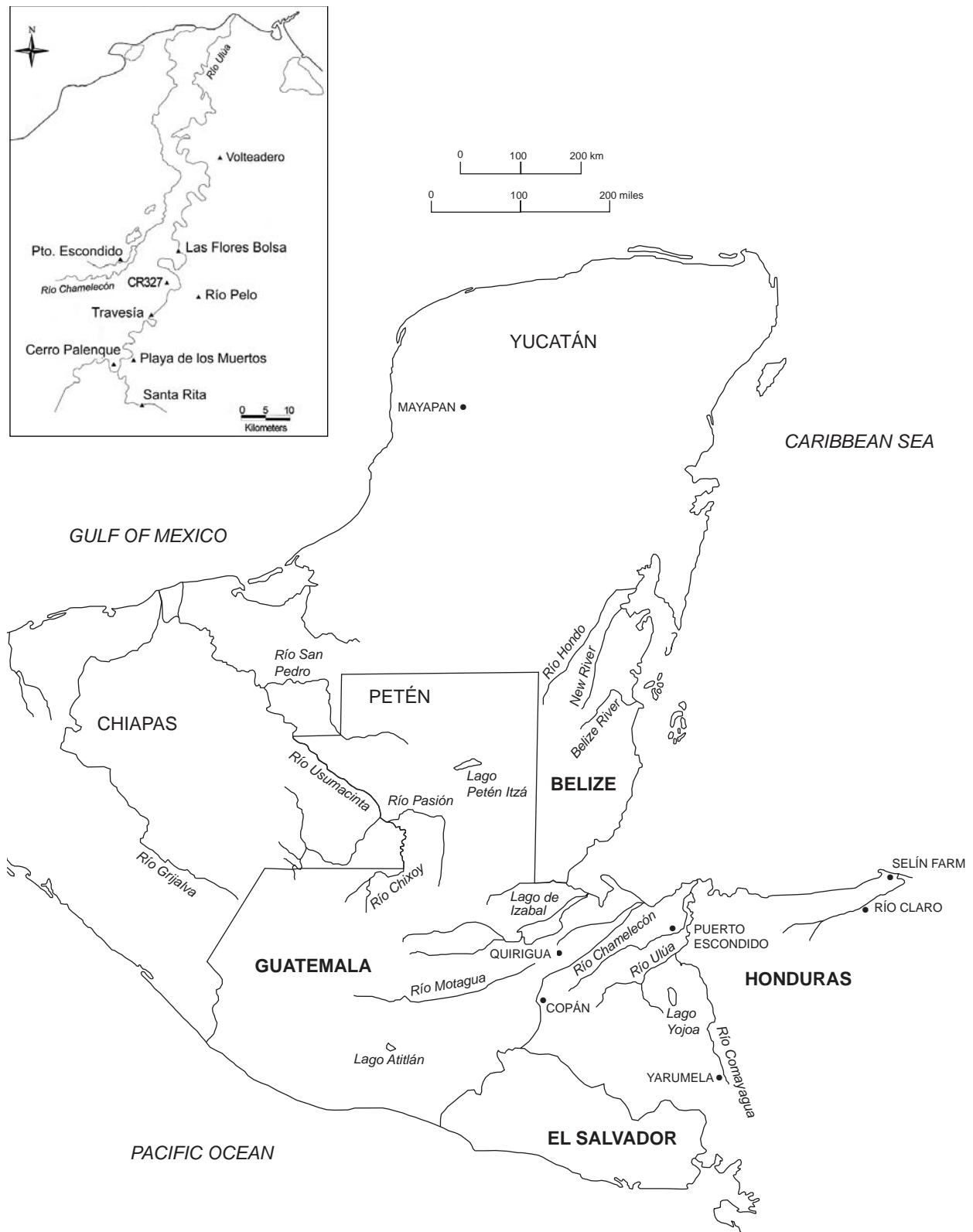


Figure 14.1. Map of eastern Mesoamerica, showing sites and regions mentioned in text. Inset: Lower Ulúa Valley. Main map by K. Emery. Inset by J. Henderson.

The general environmental situation of the lower Ulúa Valley is pertinent to the potential utility of the data presented here as a comparative example. The most extensive discussion of this topic has been presented by Kevin Pope (1984, 1986, 1987). He noted that the riverine regime in the valley produced highly productive soils, matched in the Maya world only by those of the lower Usumacinta (Pope 1987:95). The range of habitats he described for the pre-Columbian valley included extensive gallery forest, true rainforest, monsoon forest, wet and dry swamp forests, palm swamp, savanna, marsh, mangrove swamp, littoral forest, and subtropical moist forest, with interspersed lakes providing even more habitat diversity (Pope 1987:100). Assemblages from sites in the lower Ulúa Valley, then, can be expected to exhibit a high diversity of resources exploited, with Caribbean marine species, waterfowl, tropical riverine species, and both lowland and upland terrestrial species available within a radius of approximately 70 km from the valley center.

Pope (1987:112–118) argued that Classic period land use in the valley was not driven by constrained population expansion. Noting that “with the exception of the avoidance of poor soils, there was little attraction to settle on the best soils,” he described the Classic period settlement as characterized by “intensive use of alluvial and colluvial fan and upland soils, requiring high labor inputs, with less intensive use of northern gallery forest, abandoned levee, and tributary plain soils” (Pope 1987:115). Pope suggested that the lack of evidence for intensive use of the most productive soils for subsistence farming could have reflected the monopolization of the best soils for large-scale agriculture of crops like cacao, which was a major commercial crop in the region at the time of the Spanish invasion. He suggested that such commercial use of the best soils could have been combined with an avoidance of flood-prone settlement locations and a dependence on some form of redistribution, resulting in the observed patterns of settlement.

Pope’s analysis assumed that unless there were some constraining factors, population

would normally expand and maximize agricultural potential. Empirically, however, that does not seem to be the case in the Late Classic lower Ulúa Valley. We suggest that the high soil fertility and habitat diversity of the lower Ulúa Valley were among the factors that allowed a large agricultural population to live in rural farming settlements in situations of relative affluence, as measured by the diversity of household possessions, including exotic material and luxury items (cf. Smith 1987:319–320). We note that this relatively high standard of living is not accompanied by a high degree of sociopolitical centralization; we characterize the Classic period valley as a landscape of wealthy independent farming households. This socioeconomic and sociopolitical context makes sites in the lower Ulúa Valley potentially of great interest for comparison with more stratified areas of the Maya world, particularly those (like parts of northern Belize) where the resource environment was originally somewhat similar. Comparisons of our data with those generated from sites in these environmentally similar, but sociopolitically different, regions could highlight the degree to which human-animal relations are affected by social stratification. In our view the maintenance of less stratified society in the Classic period lower Ulúa Valley is the result of deliberate practices that reinforced more heterarchical social forms (cf. Joyce and Hendon 2000). We suggest that comparison between different zones in the Maya world can illuminate the kinds of diverse relationships between social management and the environment to which Kirch (1997) has recently drawn attention, and we view our contribution as a step toward facilitating that goal.

ANIMAL REMAINS IN THE LOWER ULÚA VALLEY: A PRELIMINARY OVERVIEW

Early Data

Most early projects undertaken in Honduras did not report the existence, much less the composition, of faunal assemblages. In some cases,

however, collections from such early research were preserved. The utility of these collections is severely limited by questions about recovery methods, which are usually not documented. Nonetheless, these collections can begin to provide useful information concerning the general range of species represented in different settlements and through time. Table 14.1 presents a checklist of species from a variety of sites excavated prior to the work of the Proyecto Valle Inferior del Río Ulúa (VIRU), beginning in 1993, which for the first time incorporated systematic collection and identification of faunal remains into the investigation of sites in the lower Ulúa River Valley.

Material excavated at the sites of Playa de los Muertos, Santa Rita, and Las Flores Bolsa in 1936 (Strong et al. 1938) was curated at the Peabody Museum, Harvard University, without undergoing analysis until 1993. Field notes from the work at these sites (Strong 1936) document excavation techniques. The excavations proceeded in arbitrary 25-cm levels, with alternate shoveling and hand troweling; artifacts were recovered by hand, with no use of screens. At Las Flores Bolsa the notes explicitly indicate that some material (at least plain body sherds) from levels that produced animal bones was not retained but simply counted and discarded. Only 65 percent of the faunal remains curated at the Peabody were precisely labeled with site and intrasite context (Fox 1994). Before being curated, the bones had not been completely cleaned, nor had fragments been rejoined, tasks undertaken by John G. Fox. Fox (1994) then employed the collections of Harvard's Museum of Comparative Zoology to identify the species represented. Although Fox summarized frequencies for the species identified at these three sites, only the presence and absence of species is used here because of the probability that these samples are not quantitatively representative of the original excavated assemblages nor of the faunal remains deposited at the site.

The three sites all were located along river levees (Figure 14.1 inset). Santa Rita, farthest south, was on the bank of the Comayagua or Humuya River, which enters the valley from

mountains directly to the southeast. Apart from a small component dating to the Middle Formative not represented in the curated faunal remains, occupation at Santa Rita continued from the initial Late Classic through the Terminal Classic period (ca. A.D. 550–950; Joyce 1987). Playa de los Muertos (Kennedy 1981; Popenoe 1934) was located farther downstream on the Ulúa River, above its confluence with what was then its major tributary, the Chamelecón River (see Pope 1984, 1986). The excavations of Strong et al. (1938) produced faunal remains from both late Middle Formative (ca. 500–300 B.C.) and Late Classic (ca. A.D. 650–850) components at Playa de los Muertos. Las Flores Bolsa, located even closer to the Caribbean, and below the ancient confluence of the Chamelecón and Ulúa rivers (Pope 1986:66–69), yielded evidence of occupation from the later Late Classic through the Early Postclassic (ca. A.D. 750–1050; Joyce 1987). Although the sample sizes are very small, the curated collection thus spans the range of occupation from the later Middle Formative through the initial Early Postclassic.

Because the three sites include components from different periods, it is also important to examine differences in the use of animals over time. Deer, peccary, medium and large mammal, and unidentified bird bones were recognized in the Formative period levels from Playa de los Muertos. The earliest Classic period levels at Santa Rita produced evidence of the use of deer, peccary, canid, and small and medium mammals. The later Late Classic levels at Playa de los Muertos, Santa Rita, and Las Flores Bolsa yielded deer, canid, opossum, and small, medium, and large mammal bones, along with the only evidence of fish in the sites Fox analyzed. The disappearance of peccary from the assemblage is noteworthy. The Terminal Classic and Early Postclassic levels from Santa Rita and Las Flores Bolsa continued the pattern, with deer, canid, opossum, and small and medium mammal bones represented. In addition, these late components featured the only examples of tapir, turtle, and turkey bones in the collection.

Overall, the assemblage from Las Flores Bolsa was most diverse, consisting of identified

Table 14.1. Comparative List of Species from Sites in Northern Honduras

	Playa de los Muertos	Santa Rita	Las Flores Bolsa	Volteadero (YR-162) and CR-327	Cerro Palenque	Río Pelo	Puerto Escondido (CR-372) Op 2	Cajón Project	Río Claro H-CN-12	Selín Farm H-CN-5
Large mammal (probably deer)	x	—	—	—	—	—	x	—	—	—
Deer (<i>Odocoileus</i> sp.)	x	x	x	x	x	x	x	x	x	x
Deer (<i>Mazama americana</i>)	—	—	—	—	—	—	x	—	—	x
Tapir (<i>Tapirus bairdi</i>)	—	—	x	—	—	—	—	—	—	x
Manatee (<i>Trichechus manatus</i>)	—	—	—	—	—	—	—	—	—	x
Medium mammal	x	x	x	—	—	—	—	—	—	—
Peccary (<i>Tayassu</i> sp.)	x	x	x	—	—	x	x	x	—	x
Dog (<i>Canis</i> sp.)	—	x	x	—	x	—	—	—	—	—
Felid	—	—	—	—	—	—	x	—	—	—
Jaguar (<i>Felis onca</i>)	—	—	—	—	—	—	—	—	—	x
Howler monkey (<i>Alouatta</i>)	—	—	—	—	—	—	—	—	—	x
Otter (<i>Lutra longicadis</i>)	—	—	—	—	—	—	—	—	—	x
Porcupine (<i>Coendu</i> sp.)	—	—	—	—	—	—	—	—	—	x
Small mammal	—	x	x	—	—	—	x	—	—	—
Agouti (<i>Dasyprocta punctata</i>)	—	—	—	x	—	—	—	x	—	x
Paca (<i>Agouti paca</i>)	—	—	—	—	—	—	—	—	—	x
Armadillo (<i>Dasypus novemcinctus</i>)	—	—	—	—	—	—	x	x	—	x
Opossum (<i>Didelphis marsupialis</i>)	—	—	x	—	—	—	—	x	—	—
Rabbit (<i>Sylvilagus</i> sp.)	—	—	—	x	—	—	x	x	—	—
Turtle	—	—	x	x	x	x	x	x	—	x
Iguana (Iguanidae indeterminate)	—	—	—	—	—	—	—	x	—	x
Caiman (<i>Caiman crocodylus</i>)	—	—	—	—	—	—	—	x	—	—
Crocodilian	—	—	—	—	—	—	—	—	—	x
Lizard	—	—	—	—	—	—	x	—	—	—
Bird	x	x	—	x	—	x	x	—	—	—
Turkey (<i>Meleagris</i> sp.)	—	—	x	—	—	—	—	—	—	—
Fish	—	x	—	x	—	x	x	—	—	—
Crab (crustacean)	—	—	—	—	x	—	x	—	—	—
<i>Nephronaias</i> sp.	—	—	—	—	x	—	—	x	—	—
<i>Pachychilus</i> sp.	—	—	—	—	x	—	x	x	—	—

Sources: Hirth and Coskren 1989:29–31 (Cajón region); Joyce 1985:139, 150, 155, 161, 166, 213, 219, 224 (Cerro Palenque); Pope 1986:151 (Volteadero [YR-162] and CR-327); Wonderley 1991:155 (Río Pelo); Fox 1994 (Playa de los Muertos, Santa Rita, and Las Flores Bolsa); Healy 1983, 1984 (Río Claro, Selín Farm); Glew 1997 (Puerto Escondido [CR-372]).

deer, peccary, canid, opossum, turtle, tapir, and turkey, as well as general large, medium, and small mammal bones. As noted above, most of the diversity was introduced by the late components at the site. If this is not merely a reflection of differential preservation, it might suggest that late inhabitants at this site—located at the northern extreme of the area with the densest documented Late Classic settlement and close to the beginning of lower, marshy, and mangrove habitats—exploited a wider range of nondomesticated animals. In contrast, the assemblage from Playa de los Muertos was the least diverse, with only deer, peccary, unidentified bird, and medium and large mammals represented. The absence of canids (likely domestic dog) may reflect a real absence of dogs from the region until after the Formative period, a point we return to below. The assemblage from Santa Rita, a Classic period site with a brief Terminal Classic occupation, was also dominated by deer, peccary, and canid bones, with an unidentified small mammal, fish, and bird also present. The absence of fish bones from most of these assemblages, all from riverine sites, is an obvious contradiction most likely to be understood as a reflection of collection techniques, not the actual absence of the use of fish. In this regard it should be noted that the Early Postclassic burial from Las Flores Bolsa that included the remains of the turkey reported here also contained a copper fishhook, an indirect indicator of the practice of fishing, despite the absence of fish bones in the curated collection.

Expressing caution about projecting trends from the assemblage, because of uncertainties concerning collection and curation, Fox (1994) noted the following apparent tendencies over time:

1. a gradual decline in the proportion of deer and other large mammals, with the sharpest decline between the Late Classic and the Terminal Classic to Postclassic;
2. a gradual increase in the proportion of canid and other medium mammals (possibly all canid bones);
3. the presence in the Early Postclassic assemblage of a non-native bird, the turkey, which was likely introduced through exchange with the Yucatán Peninsula or Belize.

More Recent Projects

When systematic archaeological research resumed in the lower Ulúa Valley in the 1970s, the first generation of projects regularly reported the recovery of faunal remains. None of these projects employed a zooarchaeology specialist, so only the largest or most distinctive species were identified. Whereas some of these overlap with the species represented in the earlier curated collections, others expand the range of animals represented from the valley (see Table 14.1). In the Late Formative to Early Classic period sites Volteadero (YR-162) and CR-327, Pope (1986:151) recognized deer but also agouti and rabbit. Such small mammals are extremely important parts of faunal assemblages, whose differential preservation and identification is a crucial issue, especially in the New World tropics (Stahl 1982, 1992). Both of these sites were, like Playa de los Muertos, Santa Rita, and Las Flores Bolsa, located on river levees. In fact, YR-162 was not far from the original location of Las Flores Bolsa, whereas CR-327 was located on a channel of the major tributary of the Ulúa River, the Chamelecón. Because the excavations that produced these faunal remains were limited in scope and dictated by the goal of exploring and dating ancient sediments, the context of deposition is unclear, but they illustrate that the range of species that can be expected in the region is broader than that represented in curated collections from early excavations.

A sealed primary deposit of Late Formative date at Río Pelo, on the east flank of the valley, some 90 m above the valley floor, produced remains of peccaries, deer, birds, turtles, and fish. Wonderley (1991:155), the excavator, interpreted the deposit as the material residue of a single event, presumably a feast.

Excavations at Cerro Palenque, a large settlement dating to the Terminal Classic, produced relatively few faunal remains (Joyce

1985:376–377). Nonetheless, the excavations at this site also expand the inventory of species (Table 14.1). In addition to the expected deer, the in situ refuse at this site produced remains of turtles, crabs, riverine bivalves, the important riverine gastropod *Pachychilus* (Healy et al. 1990), and dogs. Because excavations at Cerro Palenque were intended to clarify the use of presumed residential areas through wide-area exposures, contextual information is more certain for these remains. Notably, there are strong indications of nonsubsistence use of deer and canids. These animals are represented in public spaces—the area of the Terminal Classic ball court and the plaza of the Late Classic component of the site—by elements (deer teeth and lower limbs, canid teeth) that were likely not the result of subsistence use. Recovery of the radius, ulna, and metatarsals of a deer associated together suggests that faunal remains in these areas did not result from butchering. In situ domestic refuse, in contrast, took the form of limited sheet middens abutting house and lot walls and contained the more ephemeral remains of bivalves, gastropods, and turtle (likely a reflection of the culinary use of riverine resources), as well as deer long-bone fragments and a cut scapula. We return to the importance of considering nonsubsistence use of animals in this region in the conclusion of this chapter.

Zooarchaeological Analysis in the Proyecto VIRU

Beginning in 1993, research in the valley increasingly emphasized investigation of residential sites located on alluvial soils on the valley floor. Here long-term residential stability produced a series of sites dubbed “lomas,” which consist of accumulated architectural remains and associated domestic debris (interspersed in deep levels with riverine deposits). Excavation of a series of loma sites in the central part of the valley was designed to document long-term changes in household economy in the region.

Puerto Escondido (CR-372), comprising four lomas located near a tributary of the Río Chamelecón, has produced the longest sequence of occupation, beginning in the Late Archaic or

very Early Formative and continuing through the Terminal Classic period (Henderson and Joyce 1998, in press). Analyses are still in progress, but the faunal remains from the excavation of deposits from Loma 2, spanning the range from Middle Formative through Early Classic (Operation 2), have been identified by Christopher Glew (1997). These specimens—some 677 pieces from well-documented archaeological contexts (Table 14.2)—constitute the largest set of data on human use of animals available at present from the lower Ulúa region.

Loma 2 at Puerto Escondido produced evidence for exploitation of a diverse array of animals, including white-tailed and brocket deer, peccary, small felid, rabbit, bird, armadillo, lizard, turtle, crustacean, fish, and riverine gastropod. Puerto Escondido, like Las Flores Bolsa, is located near the northern edge of the densely occupied central sector of the valley; the diversity of the animal remains at the two sites suggests that ease of access to contrasting marsh and mangrove habitats fostered a pattern of exploitation of a wider range of wild animals than in communities located farther south.

The excavated area of Loma 2 included steam baths and stone cyst tombs, facilities dedicated to life-cycle rituals and probably other community ceremonies. The excavated contexts reflect these special uses in the presence of carnivore and felid bones likely to have figured in ritual, such as the radius of a large carnivore associated with a stone cyst that probably originally contained a human burial. Remains of deer and other large mammals, rabbits, birds, lizards, crustaceans, and fish found in refuse pits may reflect feasting or household consumption.

Remains of white-tailed deer, rabbit, turtle, and crustacean, along with those of large mammals and other animals that cannot be identified more specifically, occurred in deposits of all the periods sampled by the Operation 2 excavations, from Middle Formative through Early Classic. Deer bones are most common in Late Formative contexts, declining in the Early Classic period. Fish remains are abundant beginning in the Late Formative, suggesting that

their absence in the early curated collections discussed above reflects the field practices of early excavators. Brocket deer, birds, armadillos, and lizards appear in Late Formative deposits, and their exploitation continued through the Early Classic. Unidentified carnivore remains occur in a few Middle Formative and Early Classic contexts; small felids and peccaries appear in small numbers only in the Early Classic.

Puerto Escondido provides the first basis for a quantitative comparison of the differential in-

tensity of use of animals in the lower Ulúa Valley on the basis of the entire excavated assemblage from a single site. We draw attention to the relatively high proportion of non-mammal remains (turtles, lizards, bird, fish, and crustaceans), which together accounted for 20 percent of the collection. Slightly less than 58 percent of the collection was securely identified as mammals, with a large proportion (approximately 22 percent) of indeterminate identification. The 3:1 ratio of mammals to other animals, although still indicating that mammals were the

Table 14.2. Frequencies of Fauna Represented at Puerto Escondido (CR-372), Operation 2

	Number of Identified Specimens (NISP)	Relative Frequency (based on NISP)	Number of Identified Elements
Large mammal (probably deer)	88	13	2
Deer (<i>Odocoileus</i> sp.)	6	0.9	1
<i>Odocoileus virginianus</i>	80	11.8	56
<i>Mazama americanus</i>	4	0.6	4
Peccary (<i>Tayassu</i> sp.)	3	0.4	3
Small felid	1	0.1	1
Small mammal	2	0.3	—
Small rodent	2	0.3	2
Large carnivore	1	0.1	1
Medium carnivore	1	0.1	1
Small carnivore	1	0.1	1
Armadillo (<i>Dasypus novemcinctus</i>)	2	0.3	2
Rabbit (<i>Sylvilagus</i> sp.)	10	1.5	8
Turtle	8	1.2	4
Lizard	17	2.5	6
Bird	29	4.3	23
Fish	42	6.2	8
Crustacean	41	6.0	—
<i>Pachychilus</i> sp.	—	—	—
Mammal	162	23.9	—
Small-medium animal	12	1.8	—
Large animal	16	2.4	—
Indeterminate	147	21.7	—

Source: Glew 1997. NISP frequencies do not control for a variety of factors that affect their utility as measures of taxonomic abundance, but they have the advantage of facilitating comparison, especially with lowland Maya faunal assemblages, analyses of which have emphasized NISP counts (Emery 1997:84–90).

largest part of the assemblage, is a much lower proportion than in previously excavated, curated collections from the valley (Fox 1994). The ratio of identified large mammals to small-to-medium mammals (approximately 6:1), although suggesting that large mammals made up the majority of the animals exploited, again documents a much stronger presence of small mammals than noted in early excavations.

DISCUSSION

The range of species identified in the assemblage excavated at Puerto Escondido is not markedly different from that reported in analyses of early curated collections and nonspecialist reports from more recent excavations in the valley. Most notably, Puerto Escondido produced the first secure identifications of brocket deer (*Mazama americana*) and armadillo. Other species reported elsewhere in the valley are apparently absent from the site: tapir, canid, agouti, and opossum. We cannot rule out the possibility that elements from these species may be among the large and small mammals that could not be further identified. Opossum and agouti, in particular, are quite likely to be represented among the small mammals. But the rarity of tapirs in other collections (a single example from Las Flores Bolsa) may reflect a real rarity of this animal in the region during the period of intensive pre-Columbian occupation.

The presence at Puerto Escondido of an element from a small felid, and potentially of other felids (reflected in the summary as large and medium carnivores), although unprecedented in the curated collections and recent excavations, is not unique. Doris Stone (1941:75) reported a complete skeleton of a small feline at the site of Travesía, located within 15 km of Puerto Escondido. As at Travesía, it is likely that the presence of elements from carnivores, and in particular from a feline, reflect nonsubsistence use of animals. Indeed, one of the major issues in understanding patterns of use of animals in the valley is accounting for the nonsubsistence use of faunal remains, which occur as worked artifacts and as probable items of costume.

Variation in the use of animals over time is evident both at the level of the site and on the scale of the valley as a whole (Table 14.3). Fox (1994) noted a steady decline in white-tailed deer and other large animals from the Middle Formative through the Terminal Classic, a pattern we also note at Puerto Escondido over the more restricted span from the very Late Formative through Early Classic. Fox suggested that there were sharp declines between the Formative period and Early Classic and between the Late Classic and Terminal Classic. The timing of the decline of white-tailed deer at Puerto Escondido supports this assessment. At Puerto Escondido we can clearly relate the proportional decline in the presence of white-tailed deer between the Late Formative and Early Classic to a diversification of species exploited. The apparent absence from Puerto Escondido of canid bones may lend support to the suggestion that dogs were not exploited until sometime in the Classic period. This possibility will be addressed in ongoing analysis of Early to Middle Formative assemblages from Puerto Escondido.

Regional comparison

Although the diversity of faunal assemblages within the lower Ulúa Valley is obviously high, even taken as a whole, the fauna reported from the valley are more limited than those reported from neighboring areas to the east. The Cajón regional project excavated at a number of sites along the Sulaco and Humuya rivers, southeast of the Ulúa Valley. The preliminary report (Hirth and Coskren 1989:29–31) notes a familiar range of species (Table 14.1): white-tailed deer, peccary, armadillo, agouti, opossum, rabbit, turtle, and riverine bivalves and gastropods, but also iguana and caiman. The iguana and caiman represent distinctive elements missing from the excavated and analyzed samples. It is possible that regional differences in subsistence are reflected in these variations.

Such an interpretation is inescapable when the lower Ulúa Valley assemblages are compared to those excavated by Paul Healy farther east along the Caribbean coast (Healy 1983, 1984). There the fauna from Selín Farm reflect

occupation throughout the equivalent of the Classic period (ca. A.D. 300–1000). The exceptionally rich representation of ocean fish and shellfish at this site could reflect differential

preservation and identification. The greater specificity of identification of birds, reptiles, and amphibians also may be attributed to the abilities of the faunal analyst. Nevertheless, the

Table 14.3. Animal Use through Time in the Lower Ulúa Valley

Period	Playa de los Muertos	Santa Rita	Las Flores Bolsa	Puerto Escondido
Middle Formative	White-tailed deer	—	—	White-tailed Deer
	Peccary	—	—	Rabbit
	Bird	—	—	Turtle
	—	—	—	Crustacean
	—	—	—	Carnivore
Late Formative	—	—	—	White-tailed deer
	—	—	—	Rabbit
	—	—	—	Turtle
	—	—	—	Crustacean
	—	—	—	Fish
	—	—	—	Brocket deer
	—	—	—	Bird
	—	—	—	Armadillo
Early Classic	—	White-tailed deer	—	White-tailed deer
	—	Peccary	—	Rabbit
	—	Canids	—	Turtle
	—	—	—	Crustacean
	—	—	—	Fish
	—	—	—	Brocket deer
	—	—	—	Bird
	—	—	—	Armadillo
	—	—	—	Lizard
	—	—	—	Felid
	—	—	—	Carnivore
	—	—	—	Peccary
Late Classic	White-tailed deer	White-tailed deer	White-tailed deer	—
	—	Canids	Canids	—
	—	Fish	Opossum	—
Terminal Classic to Early Postclassic	—	—	White-tailed deer	—
	—	—	Canids	—
	—	—	Opossum	—
	—	—	Tapir	—
	—	—	Turtle	—
	—	—	Turkey	—

inventory of medium to large mammals is clearly distinct (Table 14.1). Brocket deer, very rare in the lower Ulúa Valley, is present in addition to the more common white-tailed deer. The much less well-preserved faunal remains from the Río Claro site, dating to the Postclassic, nevertheless included brocket deer as well. Healy (1984) suggests that the Classic period inhabitants of this coastal zone practiced a mixed subsistence regime, which was replaced by more reliance on maize agriculture in the Postclassic. The presence on the northeast Caribbean coast of brocket deer, tapir, jaguar, howler monkey, and otter suggests that the terrestrial environment exploited was unlike that of the contemporary lower Ulúa Valley.

Tapirs and brocket deer are among a group of species reported in sites farther east that continue to be rare or absent from excavated contexts in the lower Ulúa Valley. Along with howler monkey, otter, porcupine, iguana, and crocodilians, these species may reflect proximity to less disturbed forest environments in the vicinity of sites in the Sulaco River drainage investigated by the Cajón Project, and near the north coastal Selín Farm site. The implication would be that the central Ulúa Valley was more extensively cleared during the period represented by the major dated samples: from the late Middle Formative through the Terminal Classic.

Nonsubsistence Uses of Animals in the Ulúa Valley

The discussion of faunal remains in the preceding pages has for the most part deferred the central question of the use made of these animals and the degree to which any of the assemblages we discuss can be treated as typical of everyday subsistence activities. This question is critical for the employment of faunal remains in dietary reconstructions. Our data suggest that good contextual information will be crucial to the interpretation of faunal assemblages in the valley. In this concluding section we would like to draw attention to contextual information that suggests ways in which fauna may have been introduced

into sites in the valley for reasons other than everyday subsistence. Three special contexts for faunal remains are amply documented in the sites discussed here: the consumption of animals in feasts to mark specific events, the use of animals in ceremonies, and the use of bone as a raw material in secondary industries.

The faunal assemblage from Río Pelo was interpreted by its excavator as representing a single event, probably a feast (Wonderley 1991:155). This assessment drew on the depositional context of the fauna and the associated artifacts. Without that information the presence of peccary, white-tailed deer, turtles, birds, and fish might be taken as a profile of general subsistence at the site. With that contextual information we can suggest the possibility that other, similarly diverse, faunal assemblages might reflect unusual consumption practices. In Operation 2 at Puerto Escondido our highly diverse Late Formative and Early Classic assemblages are associated with a number of unusual architectural features, including stone cyst tombs and evidence of steam bathing. Other artifacts present include a high number of small pottery candeleros and ceramic ear spools. It is possible that rather than providing a profile of common subsistence practices for the site during these periods, the fauna reported reflect the cumulative repetition of feasts associated with life-cycle rituals (see Joyce 2000).

More generally, the use of animals in ritual may introduce specific species otherwise not present in a site. Fox (1994) noted that the turkey identified at Las Flores Bolsa, included in an Early Postclassic burial along with 22 obsidian blades and a copper fishhook, could be compared to practices in the Maya lowlands of Mexico and Guatemala, where turkeys were most common in ceremonial deposits (Pohl 1983:101). He drew attention to the use of turkeys in the Late Postclassic as items of tribute and ceremonial consumption (Wing 1981:22). Fox identified the left humerus, left and right distal femurs, left and right proximal tibiosaurus, left distal tibiosaurus, left distal tarsometatarsus, one vertebra, and five unidentified

fragments of a single female turkey, with the assistance of Robert Paynter of the Ornithology Department of the Museum of Comparative Zoology, Harvard University. He suggested that the presence of elements of legs from both sides of one bird was consistent with the original contents being an entire turkey, under the assumption that other elements originally present were lost in the process of original collection or in subsequent curation. There is some support for this in the unpublished papers at the Smithsonian Institution. In his personal journal W. D. Strong first mentions this burial (A-12) on Monday, February 3, 1936, describing it as found by one of the intermittent visitors to the site, who had assisted in straightening the rear wall of the excavation on Friday, January 31. Strong notes that looters had already removed some of this burial on Monday before he arrived and completed the excavation. Nonetheless, contrary to Fox's interpretation, we suggest that this deposit originally contained only part of the turkey. A sketchbook included in the Smithsonian archives contains drawings of the burials completed by Strong and A. V. Kidder II. The sketch of Burial A-12 shows the pot containing the turkey bones as intact, although crushed, with the opening abutting the in situ cranium of the burial. Although these sketches are all undated, references to their production in the contemporary journal make clear that no drawing was made of Burial A-12 by the end of work on Friday, since Strong describes working on documenting Burials A-9 through A-11. The total removal of Burial A-12 is recorded on Monday, so the drawing must have happened that day, although Strong does not explicitly mention it. The photographic record of the expedition also indicates a discontinuity between the documentation of Burials A-9, A-10, and A-11 and that of A-12. If these arguments are correct, then the absence of any major elements other than those that might represent two turkey legs and a wing could be attributed to patterned use of part of the bird as a food offering. Slightly later Postclassic drawings in the Dresden Codex of turkey tamales consumed in feasts show drum-

sticks protruding from vessels whose contents are identified in accompanying captions as turkey tamales (Bricker 1991).

The bone of a small felid present at Puerto Escondido may, like the entire feline skeleton recorded at Travesía, have been used in ceremony. Specific elements of animals otherwise useful for food may be introduced to archaeological deposits through their use in costume and regalia, as is suggested for deer and canid elements identified at Cerro Palenque. Red staining of specific elements at Santa Rita (left distal radius of deer, late Classic) and Las Flores Bolsa (left maxilla of opossum, lumbar vertebrae of two probable *Canis*, lateral right mandible of *Canis*, the last definitely Late Classic) may suggest the same nonculinary use of these bones (Fox 1994). The prominence of dogs in the latter instances suggests that the presence of dogs in faunal assemblages in the lower Ulúa Valley may, like the presence of turkey, owe more to the selection of this animal for ceremonial consumption than to an everyday importance. It is notable, in this regard, that all the canid remains from Cerro Palenque were also from nondomestic deposits.

Finally, at least some of the unmodified animal bones present in these sites can be considered likely raw material for production of tools and ornaments, based on the presence of worked bone in the same sites. Christopher Glew (1997) noted evidence of modification on 3 of the 677 bones recovered from CR-372 Operation 2. Two deer bones showed signs of cut marks that appeared to be decorative, and one rabbit tibia was polished on both ends and the shaft. It is beyond the scope of this chapter to report systematically on the assemblage of fauna from Early and Middle Formative deposits at CR-372 Operation 4, but worked bone tools and costume ornaments recovered in these deposits suggest the variety of artifacts for which animal bone provided the raw material. Seven bone artifacts were recorded, three apparently tools, the rest ornaments. Two of the tools were picks or awls, whereas the third had a notched end similar to ethnographically documented weaving tools. Ornaments included

remains of two bone tubes, possibly ear spools, an incised and red-pigmented fragment, and a fragment worked in the form of a figurine. The identifiable bone used for all of these artifacts was from deer, suggesting that in some cases the presence of deer bones may be a result not of subsistence use but of secondary industries.

CONCLUSION

Our review of the limited information available concerning faunal use in the lower Ulúa Valley leads us to make two concluding points. First, we draw attention to the diversity of specific faunal assemblages across space and through time within this region. This diversity is easily overlooked if primary attention is given to the most common or largest animals. The diversity of faunal assemblages in the region supports other analyses of artifacts that show there is no single profile that applies to sites within the region. We thus caution categorically against taking any single site in this region as an adequate proxy for the area as a whole. Highly diverse and decentralized practices produced each of these assemblages.

Second, we note the extreme importance of control of the context of deposition for the interpretation of reported faunal assemblages in the area. Although we have not discussed issues of site-formation processes, these are, of course, foremost in assessing the significance of faunal remains from these sites. But equally important, we insist, is that framing the investigation of the use of fauna in terms of a broad spectrum of uses, ranging from everyday subsistence through specific ritual practice, is critical to understanding the composition of these assemblages.

Although these concerns limit our ability to generalize about human-animal relations in the region, we can draw attention to specific issues suggested by analyses to date. These issues constitute research questions for ongoing analysis of faunal collections excavated during our current research project. Foremost among these is continuing assessment of the apparent ten-

dency for white-tailed deer to decline in importance over time, noted both at Puerto Escondido and in Fox's (1994) study of collections from Santa Rita, Playa de los Muertos, and Las Flores Bolsa. If the apparent pattern of sharp declines between Late Formative and Early Classic and between Late Classic and Terminal Classic continues to hold, we suggest that it might bear a significant relation to clearance of land in the central valley. Emery (1997, 1999, this volume) notes a similar shift away from deer and other large mammals to smaller game and aquatic resources in Belize and the Petén, but not in the Petexbatún region, where dietary use of species shifts vary little through time and deer and other large mammals remain important. Isotopic analysis of white-tailed deer bone in the Petexbatún shows no change in the importance of corn in deer diets, suggesting that there was no intensification of land clearance for farming in that region.

A second question posed by faunal analyses to date is the nature and timing of the use of dogs. If continued analysis of faunal remains from Formative period sites fails to identify canid bones, then we suggest that it may be possible to consider the introduction and use of dogs as a specific cultural practice of the Classic period. Careful attention to contextual evidence for nonsubsistence use of dogs should help clarify whether dogs were introduced as an item employed in specific ceremonies starting in the Classic period.

Finally, special attention should be given to the issue of fauna absent from the valley samples, which may reflect difficulty of access to forest environments. Information available at present would support either the interpretation that forest environments were generally disrupted during the Classic period or that they were intact only in the extreme northern edge of the valley. Study of faunal remains from sites in a wider range of geographic locations within the valley should provide information to assess whether either or both of these factors are relevant to explain the differences in assemblages from the valley and from regions to the east.

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PART 6

Discussing New Perspectives on Maya Zooarchaeology

Where's the Meat?

Maya Zooarchaeology from an Archaeological Perspective

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Having lived through, and been a participant in, the days in which a laundry-list presentation of faunal identifications was as far as what is now known as zooarchaeology extended, I am extremely pleased to be part of an endeavor that attests so forcefully to the fact that those days are far behind us. My contribution in these pages stems from my participation as a discussant in the symposium that gave rise to this volume, but as those who have the stamina to read on will discover, this chapter is very far from a standard discussant's volume summation. I am decidedly an excavator rather than a faunal analyst; therefore, neither at the time of the symposium nor in preparing this chapter did I have the temerity to comment specifically on the data and conclusions presented in the chapters that make up this work. As I am sure will be true of all readers, however, I am struck by the very considerable progress toward resolving persistent and pernicious problems in faunal analysis in the Maya world that is in evidence on all sides in the volume. Having wrestled with the field facet of the problems for more than four decades, I set out some time ago to formalize my observations on some factors that may affect Maya faunal analyses, and out of that endeavor came my involvement in this volume.

Given this chapter's history one might see the verbiage that follows as a tramp down history lane, a journey along roads that no longer need to be traveled, and happily that image is in one sense correct. If, as was largely true

when I set down the germ of what appears here, my series of caveats had no positive response from the world of zooarchaeology, my contribution would seem rather out of place in this volume. As the preceding chapters eloquently demonstrate, however, today's zooarchaeologists are responding to dire warnings such as mine with great effect. They are doing so sometimes by posing new questions and sometimes by utilizing new analytical methods, and the results of their efforts are singularly impressive. In very considerable measure, in fact, the innovative solutions to direct protein quantification offered by today's Maya zooarchaeologists go a very long way toward setting aside the concerns that I express here. I continue to feel, however, that the problems inherent in ancient Maya faunal resource utilization need to be kept before us as reminders of how fraught with pitfalls the reconstruction of past practice can be. It is for that reason that I present, as a type of reminder with which to close this excellent volume, a field-based historical perspective on Maya zooarchaeology.

MAYA ZOOARCHAEOLOGY THEN AND NOW

I find great cause to rejoice at seeing, in place of the tabulations that were once thought to be virtually all it was necessary to say about faunal remains, the variety of approaches to the characterization of ancient dietary resource utilization that marks this volume. Every element in

such variety offers a means of putting flesh on the bones of data, as all readers who have progressed this far cannot fail to recognize. If there is a single characteristic that blends the chapters of this volume into a coherent whole, it is that they show unmistakably that the practice of zooarchaeology is no longer seen as a kind of science-focused end in itself, a sort of capsule attachment to excavation reporting. Instead it has come to be viewed both by its practitioners and by the broader archaeological community as one of the many windows on the past through which very real light is shed, not just on food habits but on social process. The same message is conveyed by a number of recent studies of material from individual sites, including those in joint efforts that unite faunal analyses (Emery 1999; Shaw 1999) with botanical, paleopathological, and bone chemistry studies (White 1999b). Witness the variety within this volume, link it with the growing body of multifaceted studies of human skeletal remains, and you sense the ever-broadening spectrum of approaches to the faunal component of ancient Maya diet that marks today's archaeology.

In addition to the specifics of the picture of Maya faunal resource utilization that this volume places before us, the work constitutes a very convincing demonstration of the value of bringing the methods of science to bear on human activities wherever possible. As the writers quite clearly show, however, the scientific data must be tempered by knowledge of the history of the society on which the data bear; that is, the faunal data cannot be allowed to stand alone as indicators of the past but rather should be one of many threads that, once the conflicts among them have been resolved, can be woven into a tapestry. Nowhere is this more true than in the study of the ancient Maya, where problems such as poor preservation, frequent inadequacy of sampling at both the regional and the site level, uncertainty regarding environmental change from past to present, data destruction by looters, and absence of ancient pictorial and documentary evidence, to name but a few, often

seem to raise insurmountable barriers in the way of meaningful conclusions. No greater barrier exists, though, than the Maya environment itself. The tropics, a world in which the term *plethora* can be applied in its proper meaning to vegetation, impose on the excavator a problem for which no solution can be devised: anyone who seeks to assess the degree of midden perturbation over time must recognize, but cannot quantify, the impact of the thousands of roots that have penetrated the deposit (see Emery, chapter 2 this volume; Stanchly this volume). Roots, the omnipresent enemy of the excavator, have spent the centuries rearranging midden contents, often demonstrably moving ceramic and other dating evidence from the top to the bottom of the deposit, and in many cases they have wrenched out masses of material and deposited them elsewhere when great trees have fallen. The conditions that the lush vegetation of the tropics have placed before the excavator fall far short of providing ideal, or even workable, conditions for many kinds of zooarchaeological studies. In times past, this barrier, as well as the others I have named, have combined with the paucity of data from controlled excavation to give rise to an urge to lend great weight to raw data. The urge seems, in turn, to have driven a goodly number of researchers to omit consideration of a complex of factors that can create a very wide gulf between reconstructed diet and reality. The work set forth in this volume takes a number of significant steps toward rectification of that omission, but, still, as we cross the bridge that now spans the chasm, it is well to keep in mind how broad and deep the space beneath us can be.

The gulf affects several critical aspects of ancient Maya diet, including faunal resource exploitation, species preference, minimum number of individuals (MNI) represented, and amount of edible meat available to individuals and to the community as a whole. The problems inherent in assessment of these matters combine with uncertainties regarding population estimates and difficulties in chronological control to raise very serious issues regarding

the reliability of the information on which we rest reconstructions of ancient Maya diet. My observations bear on that ancient diet alone, but I suspect that they may be equally applicable to other societies with generally similar food resources, similar community structures, and similar approaches to garbage disposal.

It is readily apparent that any list of fauna that provides the absolute minimum of information can have every semblance of an acceptable basis for calculation of all the abovementioned aspects of diet. It has been less readily apparent to many, however, that the figures can be grossly misleading in many circumstances and of more limited value than one might think even in the most restricted temporal and spatial contexts. It is a relatively simple matter to identify factors that have the potential of distorting the relationship between an archaeological faunal sample and the realities of ancient diet and of conferring on faunal figures a seriously misleading quality. As is so often true in archaeology, however, the ability to quantify the effects of such factors with enough precision to allow us to bring a reconstruction of the past plausibly near to the facts of the past has come only when the amassing of data has been joined to the perspective of a new generation of analysts.

MAYA MIDDEN DEVELOPMENT AND THE USE OF MNI DATA

If counting and other manipulations of data are confined to a single midden of demonstrably short span, MNI figures seem at first glance quite likely to provide a reasonable measure of species preference and/or resource exploitation efficiency and to constitute a solid foundation for computations of edible meat quantities. I will focus my attention on the latter issue in a moment; let us turn first to what MNI may mean in most "standard" Maya midden contexts.

Midden-Structure Association

The initial matter to be addressed in an assessment of the significance of MNI is the relation-

ship of Maya middens to the structures they abut, which in large part reflects the mechanisms involved in the composition of the deposits. Whereas a one-to-one primary association between a refuse deposit and domestic activity in a household has long been seen as irrefutable, there is now ample evidence that the relationship between a midden and an associated building is far more complex than once believed and, hence, far less clear. Because middens have almost universally been taken to be in primary association with the structures alongside which they are found, they have been perceived as the repositories of information on the time of construction and period of use of the buildings, as well as on the activities that characterized that period. In fact, however, there are clearly three classes of association: the midden can indeed be primary to the structure; it can be a secondary deposit from a neighboring and related building beside an abandoned residential (or other) unit in a group; or it can be a secondary deposit brought from a greater distance. In the best of circumstances it may prove possible to adduce taphonomic information as a means of sorting among the classes of association by addressing the deposition history of the units, but in the Maya world the best of circumstances rarely exists, and it is therefore of prime importance that the excavator be aware of the distinctions among the three classes.

The first class of midden-structure association is the one that, on grounds of the principle of what biologists and others have unfortunately come to call *parsimony*, one should assume in the absence of evidence to the contrary. Here the link between midden data and residents' dietary preferences is unequivocal, although as we are about to see, the chronological aspect of the matter may not be clear at all. In the second association class, which is most likely to be identifiable on the basis of the condition of the building face against which the midden lies, the effect on the link between the consumers and the foodstuffs consumed will be nil if one can identify the structures in a group as elements in a multiunit extended-family residential compound and if

one accepts the premise, which with good luck may be supported by archaeological data, that the refuse originated within the group. It is in the third class, potentially impossible to identify unless the worn condition of ceramics suggests transport over some distance, that the link between the midden data and the builders and users of a structure is severed, and the information will have only a rather tenuous value at the community level. In all three association classes, however, there is an additional factor that calls into question the utility of the midden information as an indicator of dietary practice throughout the use span of a structure.

The Process of Refuse Accumulation

Although it has long been assumed that refuse accumulated in a dump beside a structure's platform was consistently a feature of Maya household life, evidence from excavations at Altun Ha (Pendergast 1979, 1982, 1990a) and Lamanai (Pendergast 1981a, 1981b, 1984, 1985, 1990b, 1992) that permits comparison of dates of building construction and principal use with dates of midden contents demonstrates that middens encountered alongside structures represent only the last stage of occupation and use of the buildings (Pendergast 1995). The Altun Ha and Lamanai data show that from the picture of Maya communities as malodorous in the extreme, we are now constrained to move to a focus on refuse disposal procedures for which evidence has emerged from many other southern Maya lowlands sites, although the data have not generally been assessed as what they are. Where we are not able to move, however, is to a clear understanding of how one is to set about reconstructing dietary practice or other aspects of the zooarchaeological picture in times earlier than the period that the middens represent.

Middens encountered in association with structures that remained in use until Terminal Classic times are not what they once seemed to be—evidence of perpetual Maya slovenliness—but in fact are one of the products of a breakdown of community services that was a feature

of the disintegration of southern Maya lowlands Classic political and social structure. To a degree, therefore, they had the same quality that has marked accumulated masses of green bags on the sidewalks of communities that have suffered partial, and mercifully temporary, breakdowns in one area of service. This is not to say that garbage was never allowed to accumulate around buildings before Classic society was well on its way into decline; rather, it is to say that prior to the decline the removal of such material must, judging by the evidence, have been a regular feature of community maintenance. The lone seeming exception to the rule occurred when a building was drawing very close to its time of abandonment or had reached that state (Pendergast 1979); in this circumstance the structure might have been seen as a fitting site for a refuse deposit, although such an approach was far from universal.

It is an unhappy fact of Maya archaeology that Classic period waste-management practices have confronted the excavator with essentially the same problem that a garbologist (Rathje 1984) faces, which is the potential of extensive mixture of material from a variety of widely separated sources. The potential arises because the Maya had the eminent good sense—in many but certainly not all Classic period communities—to view their larger construction efforts, and indeed many smaller ones as well, as sanitary landfill sites. Into the core of structures, together with soil, stone, and other components, went masses of garbage that not only reduced the amount of quarrying of pristine core material required but also ended up in spots conveniently out of sight and smell. The ceramics associated with midden deposited in such circumstances may give a clue to the time of deposition, although the potential for inclusion of earlier sherds is obviously strong; but in no case of which I am aware is it possible to sort a core midden mass out into refuse lots from individual dwellings. Hence although core midden may provide a general picture of species consumption in Classic, or even earlier,

times, it cannot provide the sort of household consumption and utilization data that are essential to a characterization of diet as well as class- and status-based differentiation as regards access to faunal resources.

Hear Diego de Landa in a maddeningly brief description of a sixteenth-century Maya town center that raises, albeit indirectly, the topic of community cleanliness, behind which one can obviously see refuse disposal: "In the middle of the town were their temples with beautiful plazas, and all around the temples stood the houses of the lords and priests, and then [those of] the most important people. Thus came the houses of the richest and of those who were held in the highest estimation nearest to these, and at the outskirts of the town were the houses of the lower class" (Tozzer 1941:62). In what is, for a Spaniard bent on changing the Maya way of life, almost a paean of praise, the absence of mention of garbage strewn amidst the beauty is surely significant. One could argue, of course, that de Landa was so fully inured to the visual and olfactory quality of garbage-strewn cityscapes in his homeland that he would never have thought to comment on such a matter in the Maya setting. Surely, though, in the frame of an attempt to demonstrate the Maya need for Christianity and European tutelage, one could expect references to the filth and degradation of native city life, and their absence is therefore all the more surprising.

In combination with the archaeological evidence, de Landa's description suggests that throughout the times in which Maya cities flourished, they remained clean because the removal of the detritus of living was managed by community governments. It was only when maintenance of such service was beyond the ability, or beyond the concern, of dwellers in the fracturing Terminal Classic Maya cities of the southern Maya lowlands that the accumulation of masses of refuse began to be a permanent feature of the residential environment. Because of this the adequacy of the middens as sources of information on Classic diet is open to serious question.

The Effects of Cultural Context on Midden Data

The nature of the cultural context in which most middens were deposited creates a high potential for significant skewing of both MNI and species-preference data. Two factors produce such a potential. The first is that any administered mechanisms for resource exploitation are very likely to have been less efficient in the period of social disintegration than they were previously, simply because administrative attention and energy were most probably focused on propping up an increasingly threatened political structure. In any such situation the authority required for the maintenance of resource exploitation systems is one of the central elements under siege, and the weakening of such authority tends to lead to greater individual or small-group action in the harvesting of faunal resources. There are, of course, fundamental questions regarding the relative efficiency of governmental vs. individual systems of resource exploitation, but in polity terms it is the centralized system that wins the efficiency competition, and it is the dissolution of such a system that is very likely to result in a new pattern of intrapolity resource recovery.

The second factor that may have skewed midden data is that the system of resource distribution is highly likely to have been afflicted with even greater inefficiency than characterized the exploitation system, particularly as regards provision of major game to city-center consumers, because sanctions against retention of game by the hunter were no longer enforceable. Resources that would earlier have been apportioned on social and political grounds would, in circumstances of the decline of central authority, come at least in part to be distributed on the basis of individual hunting skills and access to game. Such an increase in poaching as a reflection of administrative turmoil and the loosening of bonds over the middle and lower classes is well documented elsewhere, as, for example, in medieval England (Birrell 1982: 15; Grant 1991: 133–172), and there is every good reason to believe that it would have characterized the

Terminal Classic southern Maya lowlands world as well. The result is that Terminal Classic elite city dwellers' midden data have a higher probability of failing to reflect the meat preferences and consumption patterns of their Classic period ancestors than do the data from peripheral areas of the city and from smaller outlying communities. Unfortunately this is not a testable hypothesis, for obviously unless Classic preference and consumption patterns can be reliably established, no comparisons between them and the patterns of Terminal Classic times will be possible.

A further and equally serious question regarding MNI arises from the very considerable likelihood that at no time in Maya prehistory did a single family have access to an entire animal of any appreciable size as a food resource. The aggregate quantity of bone of cervids and other large species shows that such forms were an important food resource but suggests that they were never superabundant. Combined with their high meat yield, this factor is very likely to have made distribution of cuts from large species among a good many families the norm. As a result MNI counts may be extremely misleading, especially if they involve middens that are in fairly close proximity and/or are associated with structures that appear to represent the same economic level. Broad distribution of chops, upper and lower leg portions, pelvis-region cuts, ribs, and other edible portions of a large animal might produce an MNI of more than 50 within a small area of the site, or indeed over a fairly wide area, when only a single creature was involved. This factor has the potential of distorting the importance of large species in a community's diet by several thousand percent, unless a meaningful site-wide MNI determination, usually an impossibility owing to massive intrasite variation in sample quality and quantity, can be made.

An additional distorting factor in MNI calculations exists in the differential distribution of meat resources within the community. Evidence from Altun Ha shows that large-species MNI figures from middens associated with elite residences are higher than those from middle-class

and lower refuse dumps; the difference, which appears to be substantiated by isotopic data (White et al. 2000) and is surely understandable as one of the perquisites of power, can be a significant producer of perturbation in the picture of community consumption of various species. An exaggerated picture of the community importance of large species will be highly likely to emerge if elite midden data outweigh those from other contexts, and an underestimate of this aspect of resource exploitation will occur if elite midden data are minimal or absent. It is obvious that identification of the social status of midden data sources can reduce the problem, but it cannot eliminate it; only if the sample from all social classes is approximately equal, a condition difficult to assess and in any case often impossible to achieve, can a balanced picture of relative species importance be derived from the data.

Using MNI figures as a basis for calculating available quantity of meat is also potentially inaccurate as the result of the activities of the domesticated dogs that made up part of the population of every Maya community. As do other early writers (Tozzer 1941:143), de Landa gives us a very small view of the roles of dogs in Maya life, both pleasant and unpleasant (Tozzer 1941:203, 143, 145, 192). Such accounts, plus dog remains in some special contexts, such as a tooth offering from Actun Polbilche (Pendergast 1974:76, 77, Plate 10), attest to the presence of significant numbers of canines among the Maya. However, no archaeological data exist that would permit quantification of the importance of dogs as an agency for alteration of the faunal record. This is surely the result of generally nonhonorific treatment of the canine dead; disposal of the remains is very likely to have taken place off-site and may have been quite casual in nature.

In many settings outside the Maya world the effects of canine activity on a faunal assemblage can be, and have been, assessed. In this sphere, as in so many others, however, the tree-ridden Maya environment erects major barriers in the way of such assessment. In order to judge the impact of any activity, human, canine, or other,

on a faunal assemblage—or on a ceramic or lithic sample—one must be able to operate in circumstances where the deposits being studied have been minimally perturbed by agents other than the ones with which the study is concerned. Combined with the paucity of evidence regarding the number of canines rooting about at any point in a Maya community's history, the tropical environment makes any attempt to assess the impact of dogs on midden deposits a dangerous one at best and more likely to lead off the trail to the truth in many more cases than not.

The significant impact of canine activity as regards MNI counts does not stem from transportation of faunal material from one locus to another, although dogs' propensity for selecting large bones to carry from place to place is undeniable. Relocation of such material might reduce the protein intake figure for one household and increase it for another, but because this activity was random and surely pervasive, it will not affect calculations above the individual family level. The significant product of canine presence lies in dogs' selection of bones for chewing and ultimate destruction. In the absence of data on canine preference in the circumstances likely to have attended Maya garbage disposal, we cannot judge the relative effect of such activity on large as opposed to small bones, but it is clear that the potential for reduction of MNI counts for major meat-providing species exists. The likelihood that assessment of total available meat quantities will fall below real figures is commensurately high.

The Uses of MNI Data

Although we have seen that several factors, individually or in combination, make MNI figures subject to major distortion, it can be argued that we have no other starting point but such figures for any sort of calculation of available edible meat. True, but with such a base point, the calculations are clearly fraught with potential for error. The question of how one determines edible meat yield has received much attention, but it appears that no one has addressed the fundamental fact that the definition of usable animal

products very frequently broadens as the number of animals diminishes. This is the very reverse of the Tucson situation depicted by Rathje (1984:17–20), which is explainable as the product of the combination of two characteristics of modern North American society. First, as Rathje (1984:17) notes, hoarding in advance of times of expected shortage will be pervasive, given the ready availability of huge supplies of meat; second, disposal of large quantities of the hoarded meat will occur because modern standards define meat as inedible after a very limited number of days, no matter how protective the storage may have been.

In ancient Maya society the occurrence of the Tucson phenomenon was surely an impossibility, given both the limited availability of meat resources and the standards of edibility that naturally exist in such circumstances. It remains true, however, that a society blessed with a relative plenitude of deer or any other large meat animal may be less inclined to use every bit of the creature than one that is forced to struggle for such a food supply. It is in this connection that determination of edible meat quantity becomes exceedingly difficult. If the ancient Maya enjoyed a steady, comparatively high supply of deer, their conception of economical and socially acceptable utilization of the resource may have fallen well short of total consumption of the animal—but we can only know the supply level from MNI counts, and hence we are on very shaky ground in attempting to assess cultural attitudes toward meat use. Here, too, formidable barriers are erected in the way of knowledge acquisition by the Maya handling of refuse. Body-part and fragmentation analysis can certainly provide data on degree of utilization, but except in the broadest, and hence least meaningful, sense the meaning of such data cannot be determined unless household-midden associations can be specified, and as we have seen, the Maya have left us with conditions of deposition that make such specification shaky or impossible in all but a limited number of circumstances.

Households and Time

Even if all of the foregoing factors are ignored, as indeed they have been in a good many past faunal studies, insurmountable problems arise when one attempts to convert MNI and edible meat figures into some sort of picture of ancient diet. It is here that control of context arises as a primary obstacle that comprises two factors: actual number of consumers per household and real time span represented by any refuse deposit. No unshakable conclusion can be drawn regarding the first of these matters, although an average family size of 5.6 individuals has been widely used for calculations of population since the pioneering work of Haviland (1965:19, 1969:429, 1972), and it serves as well as any other for purposes of this discussion. As to the time required for deposition of a midden, it is obvious that neither ceramics nor any absolute dating method will, even if the materials are the best available, come close to providing the precision required if we are to do real time-factored animal protein intake calculations.

A very simple formula illustrates the several problems to which I have alluded:

$$n \times e = k / (p \times t) = x$$

In the formula, n = MNI; e = edible meat weight (kg) of the species in question; k = total kilograms of meat available to the household; p = number of persons per household; t = time required for accumulation of the midden; and the product x = kilograms of meat per person per year.

If we hold all factors other than t constant, and introduce entirely expectable variation in the value of that factor, we produce very interesting results in the value for x . The variation in t used below is wholly realistic in that it is far below the discrimination capability of any dating method now in use and light years away from the dating potential in any midden.

$$n = 8, e = 80, p = 5.6, t = 10$$

$$8 \times 80 = 640 / (5.6 \times 10) = 11.4$$

$$n = 8, e = 80, p = 5.6, t = 25$$

$$8 \times 80 = 640 / (5.6 \times 25) = 4.57$$

$$n = 8, e = 80, p = 5.6, t = 40$$

$$8 \times 80 = 640 / (5.6 \times 40) = 2.86$$

There is no question that in the best of circumstances, given our present methods of chronological control and the dating problems that beset all middens, any value for t within, or even well beyond, the range used above is possible. Because t is essentially an uncontrolled variable in the context of this sort of calculation, its effects alone are sufficient to destroy the value of animal protein intake estimates. Introduction of variation in n , e , and possibly in p , as well, will obviously produce a confidence level so low as to demolish the calculations as a reflection of reality. Of course, calculations of the percentage of animal protein in ancient Maya diet are by no means the only possible or useful end product of zooarchaeological studies. They have, however, loomed large in past work, and they continue to be a matter of concern for many archaeologists, both biologically focused and otherwise. It therefore seems wise to invoke the realities of such dietary studies as limiting factors that should urge great caution whenever one seeks to recreate the ancient Maya table.

CONCLUSION

As I said at the outset, this chapter is no attempt at a summary of where zoological studies stand in today's archaeology as opposed to where they stood when I began excavations in the Maya area some 43 years ago. Any such summary would show how much higher the new stance is than the one it replaces, and there is no question that the higher one goes, the farther one can see. In my view, however, the risk remains that along the way upward the climber may disregard some of the stumbling blocks in the path. The number of pitfalls in the calculation of animal protein intake per person in an

ancient Maya community is daunting; the obstacles are, in fact, so formidable that no degree of precision high enough to warrant attention to the figures can be achieved, even in the best of circumstances. In fact, however, faunal data are eminently usable—as the contents of this volume so eloquently make clear—as long as one employs them with sufficient caution, asks cogent questions, and constantly seeks new approaches to the answers. We have suffered long from the failure to perceive the very extreme limitations that are imposed on reconstructions of ancient diet by our imprecise controls over all of the variables involved; the work presented here shows that our suffering is at or near an end, even though resolution of some aspects of the problems I have discussed above may remain beyond our grasp. The question before the excavator is whether or not changes in field methods commensurate with those in the world of analysis can help to resolve the problems of assessing Maya faunal

resource utilization. I wish that I could posit a simple solution, such as very careful attention to the dates of middens studied, coupled with an attempt to locate refuse dumps that result from activity in times earlier than the Terminal Classic. Obviously, however, the degree to which such a solution proves possible will depend entirely on the nature of the site and its individual components, the percipience of the excavators, and the luck of the draw. I argue only that we must keep all of the exigencies of Maya midden data use firmly in mind and to the fullest extent possible shape our field research, our analyses, and our conclusions accordingly. If we are to strive to determine the importance of meat, or indeed of any other foodstuff, in ancient Maya cookery, we must proceed with the caution of a chef plagued by failing memory; we need to check the ingredients over thoroughly and weigh them with great care, lest the dish emerge as something quite different from what we intended.

Maya Zooarchaeology from a Zooarchaeological Perspective

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Zooarchaeology has a great deal to contribute to a better understanding of ancient Maya culture. Animals were an integral part of the Maya economy and beliefs. Our understanding of these important aspects of Maya life increases with the application of new and improved techniques and the integration of faunal data with other archaeological information. Particularly important avenues of research are those concerned with the environment and the impact of cultural change on it, human management of natural resources and particularly animal resources, and the roles played by animals in sacred and political institutions.

Maya zooarchaeology holds the promise of insight into ancient Maya thought, economy, social structure, and environments. Animals were an integral part of Maya culture and were associated with socially stratified urban centers in both sacred and secular contexts. The Maya people produced great artworks, many of which portray animals endowed with symbolic meanings. Fueling these cultural achievements were complex and diverse systems of agriculture supplemented by foods from animal sources. Progress has been made in understanding many of these facets and how they relate to animals in the economy and beliefs of Maya culture. An important publication produced in the 1980s in memory of Dennis Puleston includes papers primarily concerned with the diverse agricultural systems adapted

to the different environmental conditions and meeting subsistence needs within the Maya realm (Flannery 1982). Now, slightly more than two decades later, this volume on Maya zooarchaeology is devoted to the better understanding of the many roles animals play in complex Mayan society.

METHODS ALLOWING INVESTIGATION OF SOME OF THESE ISSUES

During the past few decades methods in zooarchaeology have improved greatly and continue to make it possible to address ever more complex questions. These advances in methods come from research in many parts of the world, as well as from techniques developed in other fields. Both means can be applied to zooarchaeological investigations in new and imaginative ways. These improvements include simple procedures, such as refined recovery methods, and complex ones requiring sophisticated equipment and specialized knowledge.

The recovery of material is one of the most important techniques and is fundamental to the success of the analysis that follows. Sebastian Payne (1972) demonstrated the biases to the faunal record caused by sieving with coarse-gauge screens that lose small animal remains. All sites will not have remains of small animals; even so, each site needs to be tested for such remains. Many small remains of fishes and

snails cannot be seen until the matrix is washed and examined under magnification. Bulk samples need to be taken for recovery of insect, parasite, and plant remains. Many of the smaller animals recovered this way are species with restricted environmental requirements that make them good environmental indicators, although they were not necessarily food items.

More precise contextual information, taphonomic data, and soil descriptions accompany better recovery methods (Scudder et al. 1996; Stanchly this volume). All of these lines of investigation clarify the nature of the zooarchaeological sample. Contextual information is essential for distinguishing among faunal assemblages associated with people of different social status, as well as between deposits of sacred or secular nature. Characteristics of the soils such as pH and phosphate levels can indicate conditions of organic preservation. In the absence of organic remains these markers may indicate the presence of human refuse. This is but one part of the taphonomic investigations that trace all of the changes to the deposit that modify its integrity (Stanchly this volume). In addition to evidence from the soil of low pH conditions likely to dissolve bone, other environmental factors can change the zooarchaeological deposit. Important among these is the presence of dogs (*Canis familiaris*) so frequently documented in Mesoamerican sites. They are well known to consume refuse and to either entirely or partially destroy bone (Walters 1985). Evidence for such biases should be considered before comparisons are made between sacred deposits, which may have been buried and out of reach for dogs and scavenging animals, and secular ones, exposed to this kind of destruction. Destruction of organic material is not even for all materials; plant remains tend to be more fragile than bone, and bone is usually less resistant to deterioration than shell. Such differences in preservation must be kept in mind when integrating data from organic deposits.

Despite the problems of differential preservation, integrating data from vertebrates, inver-

tebrates, and plants holds the potential for holistic interpretation of past lifeways. It may never be possible to determine the relative importance of plants and animals in the lives of the Maya; however, if ridged fields, fruit tree cultivation, and wood types used in construction can be established, zooarchaeological research may provide data on the animals associated with these domesticated environments. This helps to distinguish between animals caught in the wild and those tended in such domestic settings. Such integration of data sets is usually beyond the expertise of a single scholar and requires truly interdisciplinary research. All archaeology is multidisciplinary in that many types of materials are studied, and biological and ethnographic information is examined; but an interdisciplinary approach implies the integration of these different lines of evidence for a better understanding of all aspects of past ways of life.

New scientific methods are brought to bear on understanding the Maya past. Several of these, such as stable isotope analysis (White et al. this volume) and GIS (geographic Information systems) (McKillop and Winemiller this volume), are tools used to great advantage in this volume. Other techniques such as trace mineral analysis of bone; incremental analysis of shells, teeth, and otoliths; improved dating methods; and DNA analysis are proving to be valuable adjuncts to traditional zooarchaeological research.

Normal ranges must be established in order to interpret the result of these techniques. For example, incremental growth structures can be used to determine the seasons during the year when hard clams (*Merccenaria* spp.) were gathered (Quitmyer et al. 1997). In the south hard clams grow fastest during the winter, when water temperatures are cool, whereas in the north cold-water temperatures in the winter are limiting, and summer water temperatures promote fast growth. This research can be applied to other organisms, but local growth patterns and limiting factors affecting growth must be determined

before interpretation of archaeological material is possible. Similarly, all other methods must be ground-truthed before they can be applied to archaeological materials and valid interpretation made.

CONCERNS IN MAYA ARCHAEOLOGY AMENABLE TO INVESTIGATION THROUGH ZOOARCHAEOLOGY

Of all the New World states, the Maya afford us perhaps the greatest opportunities for understanding the evolution, operation, and demise of a complex society. No other New World state offers us such a variety of complementary data sets, including eyewitness reports preserved as ethnohistorical documents, hieroglyphic texts that span some 600 years, regional settlement pattern data, linguistic reconstructions, subsistence data, and architectural evolution (Marcus 1983:482).

The Maya region is rich in monumental architecture and evidenced large-scale landscape changes through terracing, ridged fields, and canal construction. Animal remains, therefore, are rarely considered. Yet animals provided essential nutrients to the diet, were the focus of feasting events, and were metaphors for agricultural fertility (Pohl 1990). Two general topics are particularly important in the light of Mayan zooarchaeology: human ecology in the diverse Maya area and domestication and control of animals.

The Maya area is not ecologically uniform. Low and highland elevations and a five-fold range in annual rainfall have significant effects on the vegetation and fauna the land will support. Aquatic animals living in rivers, estuaries, the Gulf of Mexico, the Caribbean, and the Pacific also add to the diversity of available resources. These different ecological settings require diverse adaptations in agricultural enterprises (Flannery 1982). Landscape modifications, such as slash-and-burn agriculture, ridged fields, and drained wetlands are part of agricultural systems. All change the environ-

ment for wild, tamed, and domestic animals. Second-growth forest and expanded ecotones may enhance conditions for some animals such as the white-tailed deer (*Odocoileus virginianus*), at the same time diminishing preferred habitats for forest-dwelling animals such as monkeys (*Alouatta palliata* and *Ateles geoffroyi*). Flexibility in the food quest is documented by the range of species represented in different faunal assemblages (Carr 1986a; Emery, chapter 2, this volume; Hamblin 1984; Pohl 1990; Stark 1987). This diversity reflects adaptations for exploitation of local resources. Despite these differences, though, certain animals stand out as particularly important to Maya civilization. This importance extends well beyond subsistence into the realm of ceremony, sacrifice, and ritual.

The emergence of elite power and city-state development is linked to economic success in production of surpluses. Intensification of agricultural systems provided many of the staples that supported this stratified society. A part of the reaffirmation of power was feasting, and animals were central to this activity (Pohl 1990). One of the functions of feasting was political negotiation between elites. Animals also played a key role in ritual and ceremonial sacrifice. "In their fertility rituals, the Maya used animals as metaphors for elements in their environment such as earth, rain, and sun. . . . They sacrificed animals during the performance of their agricultural rites" (Pohl 1990:163).

An integral part of the economic system is the dispersal of commodities (Marcus 1983; Pohl 1990; Stark 1987). Reef fishes, marine shells, macaws (*Ara* spp.), and turkeys (*Meleagris gallopavo*), along with other commodities such as salt, cotton (*Gossypium* sp.), and cacao (*Theobroma cacao*), were trade items (Hamblin 1984; Stark 1987). Trade of whole animals or their parts can reveal the flow of goods between regions and indicate the social or political alliances forged (Marcus 1983). Finds of animal remains outside their normal range can mean that either they were transported or the environment changed. Distant transport of resources is suggested by

the presence of the remains of marine fishes, which constitute a major portion of faunas, from the sites of Lubaantún and Colha, located over 20 km from the coast (Wing 1975). Parrotfishes (Scaridae), surgeonfishes (Acanthuridae), and tuna (Scombridae) are represented at the Cuello site, located even farther from the coast (Wing and Scudder 1991).

Commodities exchanged and shared within a region are less easy to document than those exchanged between distinct ecological zones. Shared carcasses within a community have been demonstrated by matching right and left elements of a single individual white-tailed deer based on size and morphology of the matched pairs (Zeder and Arter 1996). Such an analysis is most successful when animal remains from an entire site are available.

Changing patterns in the exploitation of animals from an early village society, through a ranked society, state organization, and finally to the collapse of the Classic Maya civilization can reveal the place of animals in a society evolving from an egalitarian to a stratified one. Animals are also sensitive to overexploitation, indicating some of the stresses that led to the collapse of the Classic Maya (Emery, chapter 6, this volume; Masson this volume).

The knowledge of control of agricultural production in various ecological settings sufficient to produce surpluses essential for the development of the Classic Maya social organization also has implications for zooarchaeology. Mesoamerican state-level societies are often used as examples of economies that depend on agriculture in the absence of domestic animals. This is basically true in comparison with economies reliant on pigs (*Sus scrofa*), sheep (*Ovis aries*), goats (*Capra hircus*), cattle (*Bos taurus*), and chickens (*Gallus gallus*). However, different degrees of control may result in equally reliable access to animals. Zooarchaeological investigation of the control of animals and acquisition of diverse wild resources serves as an important complement to studies of Maya agricultural diversity and to the Maya world as a whole (White et al. this volume).

Luring animals to the produce of a garden where they may be more easily caught, termed *garden hunting*, was proposed by Linares (1976) as an explanation for the assemblage of animals from sites in Panama. The animals attracted to the garden plot and subject to hunting are white-tailed deer, collared peccary (*Tayassu tajacu*), and agouti (*Dasyprocta punctata*). All three of these animals frequent second-growth habitats, eat cultivated crops, and are found in disproportionately great numbers in archaeological faunal assemblages. Linares's concluding remark is that "garden hunting was analogous to, and may have even substituted for, actual animal domestication" (Linares 1976: 348). The criteria for recognizing garden hunting in archaeological remains are the presence of animals often attracted to garden crops and the relatively great abundance of those species in the faunal assemblage (Neusius 1996). White-tailed deer and collared peccary are among the most abundant land mammals, other than the domestic dog, reported from most Mayan sites during all cultural periods. Both are commonly found raiding gardens today. Although this is not proof that garden hunting was practiced in the past, it does suggest that possibility among other procurement strategies (Shaw 1991).

Other, more active management strategies may explain the relatively great abundance of deer and peccary in Maya sites. Corrals were probably used to control the movement of a variety of animals until they were needed. Ethnohistoric documentation, architectural features, and the age distribution of peccary on Cozumel Island suggest that they were kept tame and easily accessible (Hamblin 1984:133). White-tailed deer need a great quantity of forage and thus are difficult to maintain in corrals, although they might have been kept in pens temporarily in anticipation of ceremonial occasions (Pohl 1990; Pohl and Feldman 1982; White et al. this volume). Illustrations show representations of deer with ropes around their necks and tied prior to ritual sacrifice (Pohl 1981). Ethnohistoric accounts describe women suckling fawns that grew up tame (Pohl 1990).

Another way to manage animals is through land management. Burning old milpas and savannas produces salty ash and encourages growth of fresh nutritious sprouts that attract game (Pohl 1990). It may have been through such means of environmental management that the abundance of choice animals was indirectly controlled.

Animals that are found outside their normal range may have been kept as captive tame animals. This is the nature of the evidence for the control of tame macaws and other parrots (Psittacidae) and for the transport and occasional taming of ocellated turkey (*Meleagris ocellata*) on Cozumel Island (Hamblin 1984). The Lacandón Maya keep stingless bees (Meliponidae) for honey and wax and to make a sacred ceremonial drink. Ceremonial rites associated with beekeeping have considerable antiquity in the Yucatán (Schwarz 1948:143–153). Studies of insect remains from archaeological contexts may provide more details about ancient Maya beekeeping and how it fits into ceremonial life.

Domestication is one of the closest associations between humans and another species. Of the domestic animals, dogs were the most important in the Maya region. Dog remains are present in most Maya sites, often in special contexts indicating some ceremonial significance. Maya women reared and nurtured dogs for tribute and renewal ceremonies (Pohl and Feldman 1982). Maize was fed to dogs, which is borne out by isotopic studies of dog bones (White et al. this volume). Dog teeth were modified by holes drilled through the roots of canines and carnassials (Hamblin 1984:114). Dogs are associated with human burials in the Maya region, as elsewhere in Mexico. They were believed to help their masters' souls cross a great underworld river (Hamblin 1984:117). Thus, they were imbued with special powers and held an important place in Maya life.

The other domestic animal of the pre-Columbian Maya was the turkey. The ocellated

turkey is native to the Maya area and is found in most Maya faunal assemblages. In a few Maya deposits the domesticated form is also present (Hamblin 1984). It was introduced to the Maya area from northern Mexico. Turkey also played a part in ritual and sacrifice.

Both domestic and tamed animals appear to play important roles in the sacred and political life of the Maya. Their place in subsistence may be secondary. Food for the common people appears to have come more from aquatic sources, composed of a variety of turtles and fishes, rather than an equal share of managed animals (Carr 1986a). Class distinction in access to meat and the reservation of domestic and managed animals for elite people in the society and on special ritual occasions are other interesting avenues for zooarchaeological exploration.

CONCLUSIONS

The array of Maya uses and beliefs about animals is incredibly rich. Zooarchaeologists now have the archaeological and analytical tools to better understand the full implications of the animal remains associated with different contexts throughout the Maya world. As is demonstrated by this volume and others to come, zooarchaeologists have important things to say about ancient Maya life. Zooarchaeologists are increasingly becoming full-fledged members of archaeological teams ready to integrate data from all sources and are making substantial contributions to our understanding of Maya culture.

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Appendix:

Taxonomic List of Important Mesoamerican Species Mentioned in *Maya Zooarchaeology*

NOTE: Numbers following faunal names represent page numbers in this volume.

Common Name	Taxonomy	Species
Cotton 143, 145	<i>Gossypium</i> sp. 48, 117, 141, 151, 251	—
Cacao 117, 141, 156, 225, 251		<i>Theobroma cacao</i> 251
Red mangrove 58–60, 63, 64, 66, 67, 70, 71, 74, 77–80, 99, 112, 148, 209, 221, 225, 228, 229		<i>Rhizophora mangle</i> 58, 65, 67, 70, 79
Ants 41, 152	Order Hymenoptera	—
Termites 41, 152	Order Isoptera	—
Stingless bees	Meliponidae 253	—

Molluscs

(following Morris 1973; Andrews 1969; and Vokes and Vokes 1983; with some modifications)

Common Name	Taxonomy	Species
Molluscs 3, 5, 7–9, 11, 21, 29, 84, 125, 130, 136, 137	Mollusca 11, 27, 31, 49, 50, 51, 86, 125, 130, 131	
Freshwater Bivalves 134		
River clam 86	Unionidae: <i>Nephronaias</i> spp. 125–127, 129–139, 227	<i>Nephronaias calamitarium</i> 128 <i>Nephronaias goascoranensis</i> 128 <i>Nephronaias ortmanni</i> 128 <i>Nephronaias yzabalensis</i> 128 <i>Nephronaias sphenorhynchus</i> 128, 129
	Unionidae: <i>Psoroniaias</i> spp. 86	<i>Psoroniaias percompressus</i> 128 <i>Psoroniaias quadratus</i> 128 <i>Psoroniaias semigranosus</i> 128, 134
	<i>Elliptio</i> spp.	<i>Elliptio sphenorhynchus</i> 128, 129
Freshwater mussel 125, 129, 130	Unionidae	<i>Proptera alata</i> 130, 131 <i>Actinonaias carinata</i> 129, 130 <i>Unio bivaie</i> 129, 130
Dyson's cyclotus		<i>Neocyclotus dysoni</i> 85
Helicina		<i>Helicina amoena</i> 85
Freshwater Gastropods 51, 57, 65, 66, 69		
Jute 57, 67, 71, 78, 86, 125	<i>Pachychilus</i> sp. 57, 64, 65, 67, 68, 69, 70, 72, 77, 125, 129, 130, 132, 133, 134, 137, 138, 139, 227, 230	<i>Pachychilus glaphyrus</i> 86 <i>Pachychilus indiorum</i> 86, 130 <i>Pachychilus polygonatus</i> 71 <i>Pachychilus pyramidalis</i> 71
Apple snail 85, 125		<i>Pomacea flagellata</i> 20, 86, 125, 129, 130, 134, 137, 138
Edible (Roman) snail		<i>Helix pomatia</i> 130

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Common Name	Taxonomy	Species
Marine Bivalves 57		
Ark shells	Arcidae: <i>Arca</i> spp. (64), <i>Arcinella</i> (64), <i>Barbatia</i> (64), <i>Arcopsis</i> (64), <i>Anadara</i> (63)	—
False mussels	Dreissenidae	<i>Mytilopsis</i> spp. 64, 69
Purse shells	Isognomonidae	<i>Isognomon</i> spp. 64 <i>Isognomum alatus</i> 65
Pearl oysters	Pteriidae 51	—
File shells	Limidae 50	—
Thorny oysters	Spondylidae: <i>Spondylus</i> spp. 29, 46, 49, 50, 51, 52, 125, 202	<i>S. americanus</i> <i>S. princeps</i>
Cat's paws	Plicatulidae: <i>Plicatula</i> spp. 64	—
Oysters	Ostreidae: <i>Ostrea</i> spp. 64	<i>Ostrea lurida</i>
	Ostreidae: <i>Crassostrea</i> spp. 64	<i>Crassostrea rhizophorae</i> 65–67, 69, 70 <i>Crassostrea mangle</i> 66
Mangrove oyster 66	Ostreidae	<i>Crassostrea rhizophorae</i> 64–67, 69, 70
Crassatellas	Crassatellidae: <i>Crassinella</i> spp. 63	—
Lucines	Lucinidae: <i>Lucina</i> spp. 63, 65, 66, 67	<i>Lucina pectinatus</i> 69
	Lucinidae: <i>Parvilucina</i> sp. 64	—
	Lucinidae: <i>Anodonta</i> spp. 63	—
	Lucinidae: <i>Codakia</i> spp. 63, 65, 66	<i>Codakia orbicularis</i> 69 <i>Codakia orbiculata</i> 69
Jewel boxes 69	Chamidae: <i>Chama</i> spp. 64, 78	<i>Chama macerophylla</i> 66, 67, 69
	Chamidae: <i>Echinochama</i> spp. 64	—
	Chamidae: <i>Pseudochama</i> spp. 64, 78	<i>Pseudochama radians</i> 65, 67, 69
Cockles	Cardiidae: <i>Americardia</i> spp. 63	—
Hard-shelled clams	Veneridae: <i>Mercenaria</i> spp. 63, 66	<i>Mercenaria campechiensis</i> 63, 65, 250 <i>Mercenaria mercenaria</i> 66, 250
	Veneridae: <i>Chione</i> spp. 57, 63, 65, 66, 67	<i>Chione cencellata</i> 69 <i>Chione granulata</i> 69
	Veneridae: <i>Tivela</i> spp. 63	—
Tellins	Tellinidae: <i>Tellina</i> spp. 63	—
Faust tellin	Tellinidae: <i>Arcopagia</i> spp. 64	—
Macomas	Tellinidae: <i>Macoma</i> 63	—
Gari shells	Sanguinolariidae: <i>Asaphis</i> spp. 64	—
Basket clams	Corbulidae: <i>Corbula</i> spp. 63	—
Marine Gastropods		
Keyhole limpets	Fissurellidae: <i>Fissurella</i> spp. 64	—
	Fissurellidae: <i>Diodora</i> spp. 64	—
Pearly top shells	Trochidae 63	—
Top shells 71, 78	Trochidae: <i>Cittarium</i> spp. 64	<i>Cittarium pica</i> 65
	Trochidae: <i>Tegula</i> spp. 64	—

Common Name	Taxonomy	Species
Star shells	Turbinidae: <i>Astraea</i> spp. 63	—
Nerites	Neritidae: <i>Nerita</i> spp. 63	—
	Neritidae: <i>Neritina</i> spp. 64, 65, 66, 67	—
Periwinkles	Littorinidae: <i>Littorina</i> spp. 64	—
False cerith	Potamididae	<i>Batillaria minima</i> 66, 67, 69
Swamp snails	Hydrobidae: <i>Truncatella</i> spp. 64	—
Modulus	Modulidae: <i>Modulus</i> spp. 63, 65, 66, 67	<i>Modulus carchedonius</i> 66
Horn shells	Potamididae: <i>Batillaria</i> spp. 63	<i>Batillaria minima</i> 66, 67, 69
Horn shells	Cerithidea: <i>Cerithium</i> spp. 63, 64, 65, 66, 67	—
Strombs	Strombidae: <i>Strombus</i> spp. 63, 65, 66, 67, 125, 155	<i>S. pugilis</i> 57, 65, 69
Queen conch 112	"	<i>S. gigas</i> 57, 62, 65, 69, 71, 73, 190
Hawk-wing conch	"	<i>S. raninus</i> 65
Milk (ribbed) conch	"	<i>S. costatus</i> 65
Hoof shells	Hipponicidae: <i>Hipponix</i> spp. 63	—
Moon shells	Naticidae: <i>Natica</i> spp. 63	—
Moon shells	Naticidae: <i>Polinices</i> spp. 63	—
Trumpet shell	Cymatiidae: <i>Charonia</i> spp. 64	<i>Charonia variegata</i> 65
Rock or dye shells	Muricidae: <i>Murex</i> spp. 63	—
Rock shells or dogwinkles	Thadididae: <i>Thais</i> spp. 64	—
Wide-mouthed rock shell	"	<i>Purpura patula</i>
Dove shells	Columbellidae	<i>Columbella mercatoria</i> 63, 65, 66, 67
Nassa mud snails	Nassariidae: <i>Nassarius</i> spp. 63	—
Mud conch (West Indian crown conch) 65	Melongenidae 63	<i>Melongena melongena</i> 65
Tulip shells	Fascioliidae: <i>Fasciolaria</i> spp. 63	—
Olive shells	Olividae: <i>Oliva</i> spp.	—
Chank shells	Xancidae: <i>Xancus</i> spp., <i>Turbinella</i> spp. 63	<i>Xancus angulata</i> 65
Vase shells	Vasidae	<i>Vasum muricatum</i> 65
Harp shells	Harpidae: <i>Morum</i> spp.	—
Common marginella	Marginellidae	<i>Prunum apicinum</i> 63
	Marginellidae: <i>Hyalina</i> spp. 64	—
Cone shells	Conidae: <i>Conus</i> spp. 63	—
Bubble shells	Acteonidae: <i>Bulla</i> spp. 63	—
Salt marsh snails	Ellobiidae: <i>Melampus</i> spp. 64	<i>Melampus coffeus</i> 69

Other Invertebrates

Common Name	Taxonomy	Species
Hard corals	Phylum Cnidaria [Coelenterata] 50	—
Red coral 50, 51, 52	Class Anthozoa	<i>Tubastrea coccinea</i> 51, 52
Sea fan	Anthozoa: Gorgoniidae 49, 50, 51, 53	—
Finger (stag-horn) coral 79	Order Scleractinia: Poritidae 77	—
Star coral	Order Scleractinia: Faviidae 78	—
Rose coral	Order Scleractinia: Trachyphylliidae (or Faviidae) 78	—
Sponge	Phylum Porifera 50, 51	—
Crabs	Order Decapoda: Section Brachyura 85, 103, 106, 112, 190, 227	—
Shrimp	Order Natania 190	—
Sea star	Class Asteroidea: Ophidiasteridae 49, 50, 51, 52	—
Brittle star	Class Ophiuroidea: Ophiocomidae 50, 51, 53	—
Sea urchin	Class Echinoidea: Echinometridae 50, 64	<i>Echinometra lucunter</i> 49, 50, 51, 53

Chondrichthyes/Osteichthyes

Common Name	Taxonomy	Species
Cartilaginous fishes 113	Chondrichthyes (Elasmobranchiomorphi) 49, 50, 215	—
Tiger shark	Carcharhinidae 114	<i>Galeocerdo cuvieri</i> 196
Sawfish	Pristidae: <i>Pristis</i> sp. 196, 199	—
Rays 103, 112, 215	Order Rajiformes 114	—
Stingray 103, 106, 112, 113, 189, 200–204	Dasyatidae: <i>Dasyatis</i> sp. 85, 182, 196	<i>D. say</i> 49, 51, 52, 196
Eagle rays	Myliobatidae: <i>Aetobatus</i> sp. 85	—
Vertebrates 109, 112, 125, 130, 131, 136, 182, 196, 198–203, 212	Vertebrata	—
Bony fish	Osteichthyes 104, 109, 111, 113, 114, 118, 215	—
Tropical gar 85	Lepisosteidae	<i>Lepisosteus tropicus</i> 215, 219, 220
Lady fish	Elopidae: <i>Elops</i> spp.	—
Machete	Elopidae 114	<i>Elops affinis</i> 215, 216
Tarpons 112	Elopidae [was Megalopidae]: <i>Megalops</i> sp. 114	—
Bonefishes	Albulidae	<i>Albula vulpes</i> 114
Catfish 20, 102, 112, 113, 114, 115, 116, 119, 130	Siluriformes: Ictaluridae 85, 104, 109, 111, 114, 118, 130	—
Sea catfish	Ariidae: <i>Arius</i> sp. [was <i>Galichthyes felis</i>] 113, 114, 118, 119, 162, 170, 171, 173, 182, 215, 220	—

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Common Name	Taxonomy	Species
Ray-finned fish	Order Perciformes 111, 113, 114, 118	—
Toadfishes 85, 111, 118	Batrachoididae: <i>Opsanus</i> sp. 114	—
Batfishes 114	Ogcocephalidae	—
Needlefishes 113	Belonidae: <i>Strongylura</i> sp. 114	—
Snook	Centropomidae: <i>Centropomus</i> sp. 114, 162, 170, 171, 215	—
Swordspine snook	"	<i>C. ensiferus</i> 164
Groupers 169	Serranidae: <i>Mycteroperca</i> sp. 159, 162, 170, 173	—
	Serranidae: <i>Epinephelus</i> sp. 114, 159, 161, 162, 165, 170, 172, 173	—
Snowy grouper	"	<i>E. niveatus</i> 162
Warsaw grouper	"	<i>E. nigritus</i> 164
Rock hind	"	<i>E. adscensionis</i> 164
Nassau grouper	"	<i>E. striatus</i> 164, 182
Jewfish	"	<i>E. itajara</i> 162, 164, 173
Red hind	"	<i>E. guttatus</i> 162, 164
Speckled hind	"	<i>E. drummondhayi</i> 162, 164
Yellowedge grouper	"	<i>E. flavolimbatus</i> 162, 164
Cobia	Rachycentridae 170	<i>Rachycentron canadus</i> 162, 170, 171
Jacks 113	Carangidae 114, 215, 216	—
Crevalle jack	"	<i>Caranx hippos</i> 159, 162, 163, 169, 170, 171, 173
Yellow jack	"	<i>Caranx bartholomaei</i> 163, 170
Blue runner	"	<i>Caranx crysos</i> 163, 170
Horse-eye jack	"	<i>Caranx latus</i> 163, 182
Pompanos	Carangidae: <i>Trachinotus</i> sp. 170	—
Snappers 113, 169	Lutjanidae: <i>Lutjanus</i> sp. 114, 159, 161, 162, 170, 172, 173, 182, 215, 220	—
Blackfin snapper	"	<i>L. buccanella</i> 163
Silk snapper	"	<i>L. vivanus</i> 167
Red snapper	"	<i>L. campechanus</i> 167
Dog snapper	"	<i>L. jocu</i> 163, 167
Cubera snapper	"	<i>L. cyanopterus</i> 167
Mutton snapper	"	<i>L. analis</i> 167
Lane snapper	"	<i>L. synagris</i> 167
Schoolmaster	"	<i>L. apodus</i>
Gray snapper	"	<i>L. griseus</i> 163, 167
Yellow snapper	"	<i>L. argentiventris</i> 215
Mojarras	Gerreidae: <i>Eugerres</i> sp. 215, 216	—
Striped mojarra	"	<i>E. plumieri</i> 164
Irish pompano	"	<i>Diapterus auratus</i> 164

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Common Name	Taxonomy	Species
Yellowfin mojarra	"	<i>Gerres cinereus</i> 170, 171
Grunts	Haemulidae: <i>Haemulon</i> sp. 170, 171, 215	—
Sailor's choice	[was Pomadasyidae]	<i>H. parrai</i> 164
Bluestriped grunt	"	<i>H. sciurus</i> 164, 182
White grunt	"	<i>H. plumieri</i> 164
Bigspine grunt	"	<i>H. macracanthus</i> 216
sheepshead	Sparidae	<i>Archosargus probatocephalus</i> 114
Pinfish	Sparidae: <i>Lagodon</i> sp. 114	—
Porgies	Sparidae: <i>Calamus</i> sp. 162, 170, 171	—
Grass porgy	"	<i>C. arctifrons</i> 163
Sheepshead porgy	"	<i>C. penna</i> 163
Pluma porgy	"	<i>C. pennatula</i> 163
Drums 113	Sciaenidae 114, 215, 216	—
Freshwater bass	Centrarchidae: <i>Micropterus</i> spp. 114	—
Cichlids (mojarras)	Cichlidae: <i>Cichlasoma</i> sp. 215	<i>Cichlasoma trimaculatum</i> 220
Blanco	Cichlidae	<i>Petenia splendida</i> 85
Mullet	Mugilidae: <i>Mugil</i> sp. 114, 215, 216	—
Barracudas 112	Sphyraenidae: <i>Sphyraena</i> sp. 159, 161, 162, 170, 172, 173, 182	—
Great barracuda	"	<i>S. barracuda</i> 113, 114, 163, 166
Guaguanche	"	<i>S. guachancho</i> 163, 166
Wrasses 113	Labridae 114	—
Puddingwife		<i>Halichoeres radiatus</i> 164, 170
Hogfish		<i>Lachnolaimus maximus</i> 162, 170, 171
Stoplight parrotfish	Scaridae: <i>Sparisoma</i> sp. 109, 159, 161, 162, 171, 172, 189, 220, 252	<i>Sparisoma viride</i> 155, 164, 170, 172, 182
Redtail parrotfish	"	<i>S. chrysopteron</i> 164, 168
Redfin parrotfish	"	<i>S. rubripinne</i> 168, 170
Redband parrotfish	"	<i>S. aurofrenatum</i> 164, 168
Parrotfish	Scaridae: <i>Scarus</i> sp. 159, 161, 162, 170, 172	—
Queen parrotfish	"	<i>S. vetula</i> 163, 169
Rainbow parrotfish	"	<i>S. guacamaia</i> 169
Midnight parrotfish	"	<i>S. coelestinus</i> 169, 170
Blue parrotfish	"	<i>S. coelurus</i> 169
Princess parrotfish	"	<i>S. taeniopterus</i> 169
Pacific fat sleeper	Eleotridae 215, 220	<i>Dormitator latifrons</i> 215
Spotted sleeper	Eleotridae 215, 220	<i>Eleotris picta</i> 220
Surgeonfishes	Acanthuridae: <i>Acanthurus</i> sp. 170, 171, 252	—
Doctorfish	"	<i>A. chirurgus</i> 164
Blue tang	"	<i>A. coeruleus</i> 164

Common Name	Taxonomy	Species
Mackerels	Scombridae 114, 252	—
Pacific flounder	Pleuronectidae	<i>Hippoglossus stenolepis</i> 161
Leatherjackets	Balistidae: <i>Balistes</i> sp. 170	—
Queen triggerfish	"	<i>B. vetula</i> 163
Gray triggerfish	"	<i>B. capriscus</i> 163
Puffers	Tetraodontidae: <i>Sphoeroides</i> sp. 215, 216	—
Spiny puffers	Diodontidae 114	<i>Diodon</i> cf. <i>hystrix</i> , <i>holocanthus</i> 196, 199

Amphibians and Reptiles (after Lee 1996)

Common Name	Taxonomy	Species
Amphibians	Amphibia 105, 106, 109, 196, 203, 232	—
Mexican caecilian	Caeciliidae	<i>Dermophis mexicanus</i> 214, 217
Frogs and toads 103, 106, 110, 111, 112, 117, 118, 216	Anura 217	—
Mexican burrowing frog	Rhinophrynidae	<i>Rhinophrynus dorsalis</i> 182
True frogs	Ranidae: <i>Rana</i> spp. 85, 182, 216, 217	—
True toads	Bufo: <i>Bufo</i> spp. 182, 216, 217	—
Giant toad	Bufo: <i>Bufo</i> spp. 182, 216, 217	<i>Bufo marinus</i> 85, 196, 204
Reptile	Reptilia 111, 112, 119, 125, 189, 196, 198, 203, 217, 220, 232	—
Crocodile	Crocodylidae: <i>Crocodylus</i> sp. 85, 97, 103, 106, 107, 110, 111, 112, 116, 117, 118, 119, 196, 202, 217, 219, 227, 233	—
American crocodile	Crocodylidae	<i>C. acutus</i> 199, 202, 216, 217
Morelet's crocodile	Crocodylidae	<i>C. moreletii</i> 199, 202
Caiman	Crocodylidae	<i>Caiman crocodylus</i> 217, 227
Lizards 103, 105, 106, 216, 217, 219, 227, 229, 230, 232	Squamata (suborder Sauria)	—
Gekkos	Gekkonidae 182	—
Iguanas 103, 112, 118, 184, 216, 227, 233	Iguanidae	—
Green (common) iguana	Iguanidae	<i>Iguana iguana</i> 111, 216, 217, 221
Spiny-tailed or black iguana	Corytophanidae [was Iguanidae]	<i>Ctenosaura similis</i> 182, 196, 204, 216, 217, 221
Crested lizard	Corytophanidae: <i>Coritophanes</i> sp. 216, 217	—
Striped basilisk	Corytophanidae	<i>Basiliscus vittatus</i> 182
Anole	Polychrotidae: <i>Anolis</i> sp. 182	—
Middle American Ameiva (Lagartija parda)	Teiidae	<i>Ameiva festiva</i> 182
Yellow-spotted night lizard	Xantusiidae	<i>Lepidophyma flavimaculatum</i> 182

Common Name	Taxonomy	Species
Turtles 20, 27, 84, 97, 103, 105, 106, 107, 109, 110, 111, 112, 116, 117, 119, 130, 184, 186, 216, 219, 226, 227, 228, 229, 230, 231, 232, 233, 253	Testudines 86, 108, 118, 130, 217	—
Central American river turtle	Dermatemydidae	<i>Dermatemys mawii</i> 86, 182, 196, 199, 202, 220
Mud and musk turtles	Kinosternidae 182, 216	—
Mud turtles	Kinosternidae: <i>Kinosternon</i> spp. 86, 108, 109, 216, 217, 220	—
Red-cheeked mud turtle	"	<i>K. scorpioides</i> 216
Northern giant musk turtle	"	<i>Staurotypus triporcatus</i> 86, 108
Pond turtles	Emydidae: <i>Pseudemys</i> sp. 105, 108–110, 117, 118	—
Common slider/painted turtle	Emydidae	<i>Trachemys scripta</i> [was <i>Pseudemys grayi</i>] [was <i>Chrysemys scripta</i>] 86, 196, 199, 202, 220
Furrowed wood turtle	Emydidae: <i>Rhinoclemmys</i> sp. 217	<i>Rhinoclemmys areolata</i> 182
Hard shelled sea turtles 111, 112	Cheloniidae 217	—
Green sea turtle	Cheloniidae	<i>Chelonia</i> sp. 217
Snakes	Order Squamata (suborder Serpentes) 85, 103, 105, 106, 109, 110, 111, 112, 117, 118, 201, 216, 217, 220	—
Indigo snake	Colubridae 182	<i>Drymarchon corais</i> 196, 199, 216, 217
Tropical rat snake	Colubridae	<i>Spilotes pullatus</i> 196, 199
Vipers	Viperidae 196, 217	—
Fer-de-lance	Viperidae	<i>Bothrops atrox asper</i> 182, 196, 199, 216
Tropical rattlesnake	Viperidae	<i>Crotalus durissus</i> 196, 199
Boa constrictor	Boidae 217	<i>Boa constrictor</i> 182

Aves

Common Name	Taxonomy	Species
Birds 105, 106, 109, 110, 112, 117, 119, 125, 189, 196, 198, 203, 222, 226, 227, 228, 229, 230, 232, 233	Aves 108, 111, 118	—
Pied-billed grebe	Podicipedidae	<i>Podilymbus podiceps</i> 197
King vulture	Cathartidae	<i>Sarcoramphus papa</i> 197, 199
Hawks	Accipitridae: <i>Buteo</i> sp. 182, 196, 202	—
Roadside hawk	Accipitridae	<i>B. magnirostris</i> 196, 202

Common Name	Taxonomy	Species
Collared forest falcon	Accipitridae	<i>Micrastur semitorquatus</i> 182
Snail kite	Accipitridae	<i>Rosthramus sociabilis</i> 202
Great currasow	Cracidae	<i>Crax rubra</i> 85
Black throated bobwhite (quail)	Phasianidae [was Odontophoridae] 118	<i>Colinus nigrogularis</i> 184, 196, 199, 202
Domestic chicken	Phasianidae	<i>Gallus gallus</i> 182, 252
Common turkey	Meleagrididae	<i>Meleagris gallopavo</i> 19, 31, 226, 227, 228, 232, 234, 251
Ocellated turkey	Meleagrididae	<i>Meleagris ocellata</i> [was <i>Agriocharis ocellata</i>] 19, 85, 182, 184, 196, 202, 226, 227, 228, 232, 234, 251, 253
Pigeons	Columbidae: <i>Columba</i> sp.	—
Red-billed pigeon	Columbidae	<i>C. flavirostris</i> 182
Doves	Columbidae: <i>Zenaida</i> sp. 182	—
Macaws	Psittacidae: <i>Ara</i> sp. 251	—
Scarlet macaw	Psittacidae	<i>Ara macao</i> 196, 199, 202
Parrots	Psittacidae: <i>Amazona</i> sp. 182, 253	—
Barn owl	Tytonidae	<i>Tyto alba</i> 182
Feruginous pygmy owl	Strigidae 182	<i>Glaucidium brasilianum</i> 196, 199, 202
Pauraque (nightjar)	Caprimulgidae	<i>Nyctidromus albicollis</i> 196, 202
Hummingbirds	Trochilidae 199	—
Quetzal	Trogonidae	<i>Pharomachris mocinno</i> 197, 202
Blue-crowned motmot	Momotidae	<i>Momotus momota</i> 182
Keel-billed toucan	Ramphastidae	<i>Ramphastos sulfuratus</i> 182
Lovely cotinga	Cotingidae	<i>Cotinga amabilis</i> 182, 189, 196, 199
Flycatchers	Tyrannidae 202	—
Black and blue jay	Corvidae	<i>Cissilopha sanblasiana</i> 196, 199
Jays	Corvidae: <i>Cyanocorax</i> sp. 182, 196	—
Green jay	Corvidae	<i>C. yncas</i> 182, 196, 202
Brown jay	Corvidae	<i>C. morio</i> [was <i>Psilorhinus morio</i>] 182, 197, 202
Perching birds	Passeriformes 184, 199	—
Nonmigratory thrush	Turdidae: <i>Turdus</i> sp.	<i>T. albicollis</i> or <i>T. nudigenis</i> 197, 202
Orioles	Icteridae: <i>Icterus</i> sp. 196, 202	—
Ant tanager	Thraupidae: <i>Habia</i> sp. 196, 202	—
Finches	Fringillidae 199	—
Thick billed seed finch	Fringillidae	<i>Oryzoborus funereus</i> 197, 202

Mammalia (following Emmons 1997, with some modifications)

Common Name	Taxonomy	Species
Mammals	Mammalia	
Opossums 117, 185, 226, 228, 231, 232, 234	Didelphidae 218	—
Common opossum	Didelphidae	<i>Didelphis marsupialis</i> 85, 118, 182, 218, 227
Four-eyed opossums	Didelphidae: <i>Philander</i> sp. 85, 182, 221	—
Gray four-eyed opossum	Didelphidae	<i>P. opossum</i> 182, 218
Water opossum	Didelphidae	<i>Chironectes minimus</i> 182
Robinson's mouse opossum	Didelphidae	<i>Marmosa robinsoni</i> 182, 185, 186
Central American woolly opossum	Didelphidae	<i>Caluromys derbianus</i> 182
Shrews	Soricidae: <i>Cryptotis</i> sp. 182, 185, 186, 203	—
Armadillo 20, 97, 104, 109, 117, 119, 152, 185, 229, 230, 231, 232	Dasypodidae	<i>Dasypus novemcinctus</i> 85, 108, 118, 183, 197, 204, 218, 227, 230
Brazilian small-eared bat	Phyllostomidae	<i>Micronycteris megalotis</i> 182
Short-tailed bat	Phyllostomidae	<i>Carollia brevicauda</i> 182
Yellow-shouldered bat	Phyllostomidae	<i>Stunina lilium</i> 182
Big fruit eating bat	Phyllostomidae	<i>Artibeus lituratus</i> 182
Wrinkle-faced bat	Phyllostomidae	<i>Centurio senex</i> 182
Mexican funnel-eared bat	Natalidae	<i>Natalus stramineus</i> 183
Carnivores 17	Carnivora	—
Weasels	Mustelidae 97, 108, 109, 117, 118, 219	—
Long-tailed weasel	Mustelidae	<i>Mustela frenata</i> 218, 219
Otter	Mustelidae	<i>Lutra longicaudis</i> [was <i>L. annectens</i> , sometimes genus <i>Lontra</i>] 227
Raccoon 117, 185	Procyonidae 219	<i>Procyon lotor</i> 85, 118, 183
Coati	Procyonidae	<i>Nasua narica</i> 183, 185, 191, 218, 219
Kinkajou	Procyonidae	<i>Potos flavus</i> 152
Canids 97, 103, 108, 109, 117, 226, 228, 231, 232, 234, 244	Canidae 105	—
Domestic dog	Canidae	<i>Canis familiaris</i> 19, 31, 39, 40, 41, 84, 85, 101, 105, 106, 109, 110, 141-158, 183, 186, 191, 197, 218, 219, 221, 227, 228, 229, 235, 250, 252, 253
Gray fox	Canidae	<i>Urocyon cinereoargenteus</i> 85, 183, 185, 218, 219
Jaguar 19, 179	Felidae	<i>Panthera onca</i> [was <i>Felis</i>] 85, 183, 185, 188, 197, 202, 227
Cougar	Felidae	<i>Puma concolor</i> [was <i>Felis</i>] 183, 197, 227
Margay	Felidae	<i>Felis wiedii</i> [or <i>Leopardus</i>] 85, 183, 185

Common Name	Taxonomy	Species
Ocelot	Felidae	<i>Felis pardalis</i> [or <i>Leopardus</i>] 85, 183
Mantled howler monkey	Cebidae	<i>Alouatta palliata</i> 227, 233, 251
Black howler monkey	Cebidae	<i>Alouatta pigra</i> 221, 233
Spider monkey	Cebidae	<i>Ateles geoffroyi</i> 197, 204, 221, 251
Manatee	Order Sirenia: Trichechidae 85, 112, 113, 116	<i>Trichechus manatus</i> 227
Tapir	Tapiridae 113, 117, 152, 185, 226, 228, 231, 232	<i>Tapirus bairdii</i> 85, 97, 111, 118, 183, 221, 227
Peccary 84, 97, 103, 105, 113, 117, 122, 148, 152, 185, 186, 191, 226, 228, 229, 231, 232, 233	Tayassuidae: <i>Tayassu</i> sp. 85, 111, 218, 227, 230	—
White lipped peccary	Tayassuidae	<i>T. pecari</i> 19, 118, 183
Collared peccary	Tayassuidae	<i>T. tajacu</i> 19, 219, 252
Domestic pig	Suidae	<i>Sus scrofa</i> 252
White-tailed deer	Cervidae	<i>Odocoileus virginianus</i> 19, 31, 86, 87, 91, 92, 95, 103, 108, 109, 110, 111, 113, 117, 118, 130, 141-158, 183, 185, 186, 191, 197, 202, 218, 219, 221, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 245, 251, 252
Red brocket deer	Cervidae	<i>Mazama americana</i> 19, 85, 103, 108, 109, 110, 113, 117, 118, 130, 141-158, 183, 185, 186, 191, 218, 219, 221, 226, 227, 228, 229, 230, 231, 232, 234, 245
Cattle	Bovidae	<i>Bos taurus</i> 252
Goat	Bovidae: Caprinae	<i>Capra hircus</i> 252
Sheep	Bovidae: Caprinae	<i>Ovis aries</i> 252
Rodents 41, 105, 106, 109, 111, 112, 117, 119, 185, 186, 198, 203, 214, 218, 219, 230	Rodentia 108, 118	—
Squirrels 85	Rodentia: <i>Sciurus</i> sp. 183	—
Giant pocket gopher	Geomyidae	<i>Orthogeomys grandis</i> 218, 219
Hispid's pocket gopher	Geomyidae	<i>Orthogeomys hispidus</i> [was <i>Heterogeomys</i>] 85, 183
Desmarest's spiny pocket mouse	Heteromyidae	<i>Heteromys desmarestianus</i> 183
Big eared climbing rat	Muridae 85	<i>Otodylomys phyllotis</i> 183
Rice rats	Muridae: <i>Oryzomys</i> sp. 218, 219	—
Cotton rat	Muridae [was Cricetidae] 218	<i>Sigmodon hispidus</i> 183, 219
Mice	Muridae: <i>Peromyscus</i>	—
Porcupine	Erethizontidae: <i>Coendu</i> sp. 227, 233	—
Spotted cavy /paca	Agoutidae [was Dasyproctidae]	<i>Agouti paca</i> [was <i>Cuniculus paca</i>] 29, 84, 85, 97, 101, 103, 105, 183, 185, 197, 204, 218, 219, 221, 227

APPENDIX

Common Name	Taxonomy	Species
Agouti 113	Dasyproctidae	<i>Dasyprocta punctata</i> 85, 101, 103, 105, 111, 118, 183, 185, 221, 227, 231, 252
Rabbits and hares	Leporidae 106, 109, 130, 183, 185, 186, 191, 229, 231, 232	—
Rabbits	Leporidae: <i>Sylvilagus</i> sp. 85, 130, 218, 219, 227, 230	—
Cottontails	Leporidae	<i>S. floridanus</i> 108, 218, 219

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