A Discernment of Prey Selection by the Ancient Maya:

White-tailed deer (*Odocoileus virginianus*) Pest, Prey or Domesticate.

Submitted Sept. 15, 2017 in partial fulfilment of conditions for award of the degree PhD Archaeology

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Abstract: This thesis investigates the demographics of paleo-populations of white-tailed deer (*Odocoileus virginianus*) as a means of testing the hypothesis that this species was domesticated or managed as a vital cultural and economic resource by the ancient Maya in Mesoamerica. To do so it employs a set of standardized bone measurements derived from a modern population and compares them with 1100 deer bone samples recovered by archaeologists from Maya sites dating from 450 B.C. to the late 16th century. These measurements were also applied to modern white-tailed deer specimens representing a discrete population from south eastern Florida of know age, and sex, for use as a baseline. The recorded measurements were used for side by side comparisons and to generate log ratios testing population stature and sexual dimorphism represented in the archaeological materials.

Changes in deer stature and mortality profile over time are examined and tested against standard methods for the detection of herd management strategies, that may potentially reveal deer domestication or resource management. Pathologies common to white-tailed deer are identified and their potential for assessing the ontological age of mature deer is investigated. The results show variations in white-tailed deer stature over time and space, suggesting dynamic alterations in prey selection that may be reflective of changes in Maya social complexity.

Acknowledgements

The work presented is the cumulation of four years of research and more of preparation, all of which would have been quite impossible without the cooperation and contributions of multiple institutions, colleagues, and personal associations. I also am grateful to the many friends and colleagues for assistance rendered, rants listened to, and wine offered. At the top of that list are my sister Kari Stewart, dear friends James Curnow, and Ruth Woods, without you, I would have never made it through. Colleagues and co-conspirators too numerous to name, but Dr Holly Miller and Tom Fowler you're tops.

University of Nottingham: special thanks to my supervisors, Dr Naomi Sykes and Dr Hannah O'Regan, for their direction and patience. In many cases the selection of a research topic is directed by one's academic supervisor. In this case, it was the topic under investigation that directed my selection of mentors, as the methodologies developed during the "Fallow Deer Project' were an essential springboard for this research, as was their expertise working with osteological materials. However, the archaeology of the Americas is well outside the expertise of either and it must have taken some degree of fortitude for them venture into a field of unfamiliar literature. They have my deepest thanks.

The Florida Museum of Natural History and its Environmental Archaeology Project FLMNH-EAP: Associate Curator Dr Kitty F. Emery for granting me access to the museum's collections, resources and negotiating permissions with the stakeholders, on my behalf a process too intricate for me to even contemplate; additional thanks for critique of the previous version of this document. To Mr Irv Quitmyer Collections Manager FLMNH-EAP, for providing the necessary tools, support and numerous useful suggestions. My gratitude to the FLMNH-EAP staff for making me welcome, and special thanks to Sophie McGraw UF for help documenting the measurement process, and Nicole Cannarozzi UF, for assistance in photographing relevant specimens.

FLMNH Mammal Centre: Dr David Reed Curator and Dr Verity Mathis Collections Manager for granting me access to additional Cervidae specimens for study.

The Museum of Vertebrate Zoology MVZ at Berkeley, special thanks to Chris Conroy MVZ Curator for granting me permission to use the museum's collections for photography.

Dr Walter R. T. Witschey Longwood University, for the creation of a custom map based on the Electronic Atlas of Ancient Maya Sites.

Stakeholders: Dr Elizabeth Graham UCL, Dr David Pendergast UCL. Dr Arthur Demarest Vanderbilt U, Vanderbilt Petexbatun Regional Archaeology Project. Dr Takeshi Inomata and Dr Daniela Triadan U Arizona, Aguateca Archaeology Project. Dr Charles Golden Brandeis U, Dr Andrew Scherer Brown U, Sierra Del Lacondón Regional

Archaeology Project. Dr Robert J. Sharer, Copan Acropolis Project. Dr Antonia Foias Williams College, Dr Kitty Emery UF, Dr Erin Thornton Washington State U, Motul de San Jose Archaeology/Ecology Project. Dr Susan deFrance UF, Dr Craig A. Hanson Tulane, Dr Ashley Sharpe STRI, Petra Cunningham-Smith UF, Arianne Boileau UF, Dr M. Charlotte Arnaud Université Paris, Panthéon Sorbonne, without their generous contributions this effort would have failed.

Permissions for archaeological research granted by: Instituto Nacional de Antropología e Historia Mexico (INAH). The National Institute of Culture and History (NICH) The Belize Institute of Archaeology. Instituto de Antropología e Historia de Guatemala, Ministerio de Cultura y Deportes (IDAEH), and the Instituto Hondureño de Antropología e Historia (IHAH).

Any errors or misrepresentations found within are the fault of this author and do not reflect on my collaborators who made their best efforts to insure the accuracy of the information and data provided.

A special nod to the Office of U.S. Senator Dianne Feinstein for assistance in releasing my 2014 research funding.

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Chapter 1 Introduction:

Animal domestication is a topic of considerable interest in archaeology and very nearly the raison d'être for zooarchaeology to exist as a discipline (Zeuner, 1963; Bökönyi, 1969; Meadow,1989; Budiansky, 1992; Clutton-Brock, 1994; O'Connor, 1997; Zeder and Hesse, 2000; Ucko and Dimbleby, 2008). That substantial body of literature has primarily focussed on Eurasian domesticates e.g. cattle, sheep, horses, goats, and pigs, as those species are central to questions about economic systems, dietary traditions, religious practices, and political organization for an overwhelming portion of human societies investigated by archaeologists (Levine,.1999; Larson et al. 2005; Outram, 2009; Zeder, 2011, 2012; Russel, 2012; Ottoni et al. 2012; Arbuckle et al. 2014). In the Americas, domestication has been more focused on plants (Freitas et al. 2003; Smith, 2006; Perry et al. 2007; Pickersgill, 2007). However, there is growing interest in the New World domestication of camelids (Gallardo and Yacobaccio, 2005; Mengoni-Goñalons and Yacobaccio, 2006; Cartejena et al. 2007) turkeys (Speller et al. 2010; Thornton et al. 2012) and dogs (Morey and Wiant, 1992; Valdez-Azúa, 2000; Larson et al. 2012; Stahl, 2012, 2013; Valdez-Azúa et al. 2013; Blick et al. 2016).

A singular qualification for status as a domesticate is human management of reproduction if not actual dependence on human intervention for reproductive success. With some exceptions, domestic animals share a common social organization (herd) and reproductive strategy (hareem) whether these are ancestral strategies or a product of domestication is not clearly understood (Mignon-Grasteau et al. 2005). DNA evidence suggests the initiation of animal domestication occurred in several different regions of Eurasia (Luikart et al. 2001; Bruford et al. 2003; Sultana et al. 2003; Pederosa et al. 2005; Zeder, 2011) and presumably under a variety of cultural impulses (O'Connor, 1997; Terborgh, 2000; Terrel et al. 2003; Wing, 2013).

A common theme in the study of domestic animals is the perceived economic value of the species studied. However, many animal species in different places and at various times have been intimate cohabitants in human settlements (Niemenen and Helle, 1980; Erickson, 1997; Weinstock, 2000; Baskin, 2000; Maher et al. 2011; Driscoll et al. 2012; Stahl, 2012, 2013). Recent papers have implicated human agency in the translocation of deer to new environments during the Neolithic (Carden et al. 2012; Daujat, 2013; Vigne et al. 2016; Stanton et al. 2016; Valenzuela et al. 2016) indicating the relationship between these deer populations and the human communities fostering them were more complex than caloric value. To disregard these relationships is to

ignore the beliefs of the ancient peoples we seek to understand. With these issues in mind, this thesis tests the hypothesis white-tailed deer (*Odocoileus virginianus*) were domesticated by the Pre-Columbian Maya or managed as a vital economic and cultural resource.

In 1982 Pohl and Feldman posited women produced vital material contributions to Maya economic and social institutions through animal husbandry, that Maya women were active rather than passive participants in those institutions. *'. . . y crían otros animales domésticos, de los cuales dan el pecho a los corzos, con lo que crían tan mansos que saben írseles al monte jamás, aunque los lleven traigan por los montes y crían en ellos.'* (Landa, 1566) 'and they raise other domestic animals, and let deer suck their breast, by which means they raise them and make them so tame that they never go into the woods although they take them and carry them through the woods and raise them there' (Tozzer, 1941: 127) cited in (Pohl and Feldman, 1982: 305).

In the single passage quoted above Landa (1566: 57) appears to designate deer as a domesticated animal or at least one that was common in Maya households. The proposed domestication of white-tailed deer, hereafter described as WTD, roused considerable interest among those engaged in Maya studies as the species is abundantly represented in faunal assemblages and contrary to the expectations for a wild animal species, appears to become more abundant in relationship to expanding human populations in the region (Masson and Peraza-Lope, 2008). The Landa (1566) quote is regularly cited in papers on Maya faunal assemblages (Hammond, 1991; 1999; Clutton-Brock and Hammond, 1994; Nickels, 2008; Montero-Lopez, 2009; Foreman, 2011; Götz, 2013).

The abundance of WTD remains in Pre-Columbian faunal assemblages throughout North America has also drawn comment, Noble (1985: 139), citing Champlain (1612), proposes WTD were domesticated or managed by the Neutral Iroquois during the early colonial period, based on comments from early chronicles and the overwhelming abundance of deer bone excavated at Neutral Iroquois village sites. Deer domestication by the Neutral was explored using faunal analysis. Noble and Crerar (1993) asserted variations in the mortality profile and sex ratios show evidence for herd management strategies. Those claims have recently been countered by Needs-Howarth and Hawkins (2016). However, the proposal to examine WTD demographics for evidence of herd management strategies is both useful and long overdue (Smith, 1974; Compton, 1999; Stewart and Finlayson, 2000; Pavao-Zuckerman, 2000, 2007).

The primary goal of this thesis is an exploration of the hypothesis WTD were domesticated by the ancient Maya. To do so it employs a set of standardized bone measurements derived from a modern WTD population and compares them with deer bones samples recovered by archaeologists from Maya sites dating from 450 B.C. to the late 16th century. The archaeological material is assessed for species, age at death, and sex. Changes in deer stature and mortality profile over time are examined and tested against standard methods for the detection of herd management strategies indicating animal domestication or resource management using osteometrics and logarhythmic size index scaling LSI (Meadows, 1999; Cartajena et al. 2007; Arbuckle et al. 2014). Before presenting any methods or results, a brief overview of Maya civilization and previous investigation of WTD among Maya faunal assemblages is offered as framing for the questions pursued in this thesis.

1.2 Maya Civilization:

The Maya were just one of many ancient civilizations that thrived in the Americas prior to European contact. John Lloyd Stephens's reported discovery of stone temples in the Honduran jungles in 1836 fired the imaginations of 19th century scholars steeped in antiquarian ideas of a Golden Age (Morley, 1946; Evans, 2010; Frimmer, 2010) and while the allure of 'a lost Maya civilization' has not dimmed (Gallencamp 1985; Simmons, 1995), it has been regularly reappraised. The ancient Maya were and remain among the most frequently published and widely read topics in archaeology (Fash, 2001; McKillop, 2004; Coe, 2005; Sharer and Traxler, 2006; Huston and Inomata, 2009). Early investigations focussed on temples, palaces, and art (Thompson, 1960; Kubler, 1962) while mid and late 20th century efforts decrypted the significance of hieroglyphic [logo-phonetic] texts relating to dynastic lineages and pre-historic events (Proskouriakoff, 1960; Schele and Freidel, 1990; Martin and Grube, 2008).

Mayan archaeology has undergone many changes since its beginnings in the late 19th century, among those is an increasing sophistication of technique and methodology. Early ideas of an isolated philosopher/astronomer priesthood as described by Thompson (1956), have given way to the recognition these monumental stone structures represent the core of complex and thriving urban centres. Ecological investigations have progressed from simply listing the plant and animal species recovered from trenches, to integration in research design; resource management is now at the core of attempts to understand how Maya civilization functioned (Cluttton-Brock and Hammond, 1994; Teeter and Chase, 2004; Sabloff, 2012; Foias and Emery, 2015).

To the Enlightenment era mind, creation of monumental art and architecture presumed an elite class directing a larger class of non-elite labour, while postulating a ruling class actively warding its privilege and entitlements. This concurred with observed social hierarchy of the time and still fits within modern ideas of economic organization (Feinman, 2016). Questions remain as to the nature of separation between Maya rulers and their 'subjects'. The means by which the elite negotiated their status is just as important as the monuments proclaiming it, and the motivations of farmers and artisans supporting the social organization that defines Maya civilization are of equal value. Analysis of animal remains is a key method for answering who had primary access to which resources, both local and exotic, and how that access was negotiated (Pendergast, 1992; Joyce, 2004; Emery et al. 2013; Götz and Stanton, 2013). Zooarchaeology is an increasingly visible discipline in determining how ancient economies functioned, recent publications demonstrate a growing ability to tackle big picture problems about the Ancient Maya using faunal data (Emery, 2004b; Götz and Emery, 2013).

Apart from the characteristics of all Mesoamerican civilizations, a hierarchal social structure, monumental architecture, a number system, and a roughly approximate calendar, the ancient Maya shared a fairly standardized writing system quite distinct from other Mesoamerican cultures, though similarities are present (Joyce, 2004: 3-5).

1.3 Temporal frame:

The chronology of Maya civilization spans roughly 3000 years, during which it developed from simple agricultural settlements into the complex web of city states found by the Spanish in 1517. Evolution of this social complexity does not necessarily mirror that of the Fertile Crescent though similarities (especially during the 19th and early 20th centuries) are frequently described. The term 'City States' is a relic of that early estimation; in more recent publications these allied urban centres are described as polities; though their organization appears to be fluid through time and space (Sharpe and Emery, 2015: 280).

The terminology for Mesoamerica's chronology is inclusive of the Maya cultural region with one notable exception. The period witnessing introduction of agriculture and establishment of sedentary communities is described as the Preclassic among the Maya and as Formative for the rest of Mesoamerica; though these two terms are sometimes used interchangeably. In Table 1-1 the Formative Period refers to Olmec culture, which was influential if not foundational for all of Mesoamerica civilizations.

The standard chronology is rooted in the 'cultural evolution' paradigm, and while most archaeologists are mindful of the theoretical contradictions, readers less familiar with Maya archaeology can mistake these descriptions as factual. The units of time described in the table below are not absolute, being based on the appearance of distinct cultural traits at each site. The interpretation of these units by researchers may differ, and their co-incidence with the Gregorian calendar fluctuates (Joyce, 2004: 15). An exception to this framing is the Middle Classic Period, which appears in the literature reviewed for this research to have been dismissed as a distinct period of cultural development but remains embedded in the literature as a chronological framing (Henderson, 1997: xvii). New understandings and interpretations of Maya cultural development are on-going, but sequence remains relevant within the established literature.

Maya Chronology

1697 AD	Spanish Conquest of Nojpeten
1541 AD	Spanish Conquest of Yucatan
1517 AD	Spanish arrive in Yucatan
1350-1500 AD	Late Postclassic Period
1000-1300 AD	Early Postclassic Period
850-950 AD	Terminal Classic Period
650-800 AD	Late Classic Period
450-600 AD	Middle Classic Period
250-400 AD	Early Classic Period
150-200 AD	Terminal Preclassic Period
BC 450-100 AD	Late Preclassic Period
BC 750-500	Middle Preclassic Period
BC 1000-700	Early Preclassic Period
BC 2600-1200	Formative Period
BC 11,000-2600	Archaic Period

Table 1-1 Derived from Hammond (1991) Henderson (1997).

Date assessment: increasingly Maya archaeology uses Bayesian models to calibrate carbon 14 dates and ceramic typologies though these methods are not particularly fine grained (Beramendi-Orosco et al. 2009; Ramsey, 2009; Inomata et al. 2014). More specific is application of inscription dates found on stone monuments or, more rarely, polychrome ceramics when such inscriptions are available, and if

stratigraphy can be directly linked to those artefacts. Linking faunal remains to these objects is difficult, with dedicatory caches of animal bones in structures with inscriptions being the exception. Other ritual deposits show varying levels of stratigraphy, but these are rarely directly associated with residential deposits or inscribe dates. Animal bones are frequently recovered in architectural fill rendering accurate dating difficult (Carr, 1996; Emery, 1999; Emery et al. 2013). Notable exceptions to this pattern are sites at Ceren, El Salvador which was buried under volcanic ash in 550 A.D. and Aguateca, Guatemala which suffered a catastrophic fire and abandonment in 850 A.D. (Brown and Sheets, 2000; Inomata and Stiver, 1998).

1.4 Geography:

Occupying an area that includes the modern Mexican states of Yucatán, Tabasco, Quintana Roo, Campeche, Chiapas, as well as the nation states of Guatemala, Belize, portions of Honduras, and El Salvador, the western highlands are predominantly volcanic or igneous soils, while the lowland area is dominated by karst limestone, a diversity of ecological systems including mountain pine and oak woodlands to tropical forests of several types, savanna, and mangrove swamps are present in this region (Marshall, 2007; Götz, 2013).



Figure 1-1 source www.gograph.com/clipart/maya-high-culture-area-map-gg70967465.html

Geology impacts hydrology, soil fertility, and the nutrient yield of vegetation for humans and animals living there. Understanding the geology is also useful for tracking

the migrations of people and animals using stable isotopes such as strontium (Price et al. 2002; Bently, 2006; Sykes, 2006; Thornton, 2011).

The Maya were the southern-most of the Mesoamerican cultures straddling the divide between Central America and the North American Continent. The prehistoric communities of Central America represent a separate culture sphere; while there is evidence of trade and cultural exchange between the Maya and communities south, the most notable influences in the literature associate the Maya with the Olmec civilization of the Gulf Coast and the Teotihuacán Empire of Central Mexico (Götz, 2013).

1.5 Theoretical models:

A fundamental model that has been used for assessing the importance of WTD relative to Maya Civilization is optimal foraging theory (Clutton-Brock and Hammond, 1994; Masson, 2004; Sharpe and Emery, 2015), and while often usefully applied to archaeological materials, some assumptions of this model have been usefully critiqued (Smith et al. 1983; Gremillion, 2002). As a basic premise of optimal foraging theory, preferred prey choice presumes a hierarchal ranking based on the greatest calorie return relative to effort expended on capture of a particular prey species. Such ranking is often described as primary, secondary, and tertiary prey selection. The largest mammals in the region are tapir (*Tapirus bairdii*) and manatee (*Trichechus manatus*), which both occur in Maya faunal assemblages though neither is abundantly represented (Masson, 1999; Masson and Peraza-Lope, 2008). More frequently identified in these assemblages are WTD, brocket deer (*Mazama* sp.), peccary (*Tayassuidae* sp.), and dogs (Canis lupus familiaris). Other vertebrate and invertebrate species are also abundant in these archaeological assemblages, though representation is variable across time and geography (Hammond et al. 1979; Carr, 1985, 1996; Pohl, 1985, 1995; White et al. 2001; Emery and Thornton, 2008; Sharpe et al. 2014; Sharpe and Emery, 2015).

Food production: The Maya were an urban civilization and archaeologists from Gordon Child (1936) until the present have proposed that urban communities are incompatible with subsistence patterns dependent on naturally occurring communities of plants and animals (Reed, 1959; Dumond, 1961; Maisels, 1993; Zeder, 1998, 2012). That premise is the root idea supporting the invention of animal and plant domestication as a global phenomenon and farming as a requirement for civilization.

Managing animal reproduction: There are two acknowledged domestic animals in Maya archaeology. The Mexican turkey *(Meleagris gallopavo)* found in Maya assemblages as early as the late Preclassic (Thornton et al. 2012; Thornton and

Emery 2016) is an intrusive species in the Maya culture area, the region's native variety is the ocellated turkey *(Meleagris ocellata)*. Domestic turkeys are usually dependent on human protection if not provisioning. A second acknowledged domestic species are dogs (*Canis lupus familiaris*), participants in the original human migration into the Americas. Two types of dogs appear in Maya faunal assemblages (Hammond, 1999; Forman, 2011), and historical accounts describe several types of dogs in the Americas maintained for assistance in battle, the hunt, as guards, as food, and for pelage (Blick et al. 2016). The *Techichi,* a smaller edible type, is described by Landa (1566), who notes these animals were frequently castrated for fattening. This type is common in Maya archaeology, whether the type was specifically bred for consumption is not fully understood (Clutton-Brock and Hammond, 1994: 824; Forman, 2011: 37). Isotope study indicates that dogs (omnivorous scavengers) had a C^4 signature comparable to human remains, indicating a diet rich in maize, while the dog bones recovered from dedicatory caches are reported by White et al. (2001) to have a distinctive C^4 signature that may indicate deliberate feeding with maize. Masson (1999b) has proposed WTD were also provisioned (fattened) on maize. Deer bones have also been the subject of isotope analysis for C^4, the results indicate some WTD posses elevated C^4 ratios, but not others, and show no significant change in the percentage of WTD diets over time (White et al. 2001a; White et al. 2001b).

While the origin of the *Techichi* is unknown, maintenance of the type argues for human management of these animals' reproduction. The Spaniards also recorded the practice of castrating native camelids by Andean communities specifically as a means of controlling reproduction (Markemann and Valle Zárate, 2010; Hyland, 2014). None of the literature reviewed has suggested management of deer reproduction by the Maya. If the Maya practiced castration of deer either as a means of controlling reproduction or fattening the animal prior to consumption, evidence for this practice may be visible in the bones as a series of non-metric traits as described in zooarchaeology's literature for identifying castrates (Uerpmann, 1973; Davis and Davis, 1987; Davis, 2000). *Relacion de la Cosas de Yucatan* is unique in designating deer as a domestic animal (Landa, 1566: 57), while other portions of the same document and other Chronicles of the same period assume deer in the Americas occupy the same social/economic status as in Europe, i.e. the legitimate prey of elite hunting or as objects of tribute to elite households.

Hunting: Presumed as the foundational subsistence strategy for human settlement across the globe, hunting is a regularly viewed as a precursor to animal management (Lee and Devore, 1968; Reitz and Wing, 2008). The assumption that WTD and hunting can be addressed solely via optimal foraging theory fails to consider the cultural contexts deer occupied in Maya society. The Maya used several methods, stalking, pursuit with dogs, use of traps such as spring pole snares or pits dug in the ground, game drives both as small cooperative groups and as community wide activities (Mandujano and Rico-Gray, 1991; Carr, 1996: 252; Corona and Vasquez, 2012; Contreas-Moreno et al. 2015). Each of these methods has its own technology, and social construct. Indeed, cross-cultural analysis of hunting shows different methods of prey procurement are never devoid of cultural meaning (Cartmill, 1996: 197; Sykes, 2014b). A degree of selectivity in prey choice could be assumed for each method. Garden-hunting is an opportunistic strategy employed both to defend crops and supplement peasant diets (Peres et al. 2010; Clinton and Peres, 2011). Such a strategy may have lacked some or all the ritual and social restrictions associated with other forms of hunting. Modern ethnography reports Maya hunters distribute meat along lines of kinship (Narajo et al. 2004; Santos-Fita et al. 2012). Hunting is a male activity, and of sufficient social status to prompt farmers to carry disabled firearms into agricultural fields even though no game can be taken (Jorgenson, 1995).

Ethnographic and iconographic research suggest that the Maya followed specific codes of conduct while hunting, and believed in an Animal Guardian Spirit that protected/oversaw wild animals, and regenerated them when appropriate ritual was followed (Brown, 2005). Ritual caches of animal bones in cave shrines and monumental structures are attributed to this belief (Brady and Rodas, 1995; Emery, 2004a; Brown and Emery, 2008). The cultural significance of deer in Maya society is indicated as deer and maize are mythically linked by the personification of the Hero Twins. According to the Popol Vuh, the hero twin *Hun Hunapu* is associated with maize and his sons *X-Balam-Que* (Jaguar-deer) and *Xbalnque* (Blowgun) personify the hunt (Goetz and Morley, 1950). Deer, turtles, peccary, and dogs, all figure prominently in the Maya creation stories (Tedlock, 1996). Deer are also associated with sun and rain (Foreman, 2011: 34), and with the annual renewal *Cuch* ceremony (Pohl, 1981). The mythical equivalency of deer with maize, sunlight, and rain, may have been key markers of Maya cultural identity (Pohl, 1995).

1.6 Deer Domestication:

The question of deer domestication by the Maya is intriguing for several reasons. Aside from dogs, the first occurrence of animal domestication in Eurasia was roughly 9000 B.C., while the initial Maya settlements began to be established around 2000 B.C. If the Maya did manage WTD as a domesticate, initiation of that relationship would be considerably closer to the present day and possibly more visible in the archaeology than the primary domestication of sheep or goats in Eurasia. On the other hand, if WTD were always a wild species, the premise that wild animals cannot interface with urban civilization by their own agency could be reconsidered. The evolution and sustainability of ancient tropical civilizations is another factor to be considered. Modern nation states in tropical regions struggle with sustaining their resource base; as WTD appear to have been an important species for the Maya, understanding how these animals impacted and interacted with this civilization has potential real-world application (Allen et al. 2003; Emery, 2007: 184).

Identifying evidence for early animal domestication within archaeology is not an easy task, as is clear from the extensive literature on the subject for Eurasia (Zeder, 2000, 2006, 2011, 2012; Russell 2012). Evidence for early stage animal domestication in Eurasia has relied on recognizing the presence of species outside of their native range, and reduction in population stature compared to the wild progenitors (Arbuckle et al. 2014); WTD however are endemic to the Maya culture area. Zooarchaeological representation and in particular, the relative frequencies of species, is something that can be explored, as shifts from broad spectrum exploitation to a focus on particular species have been suggested as early domestication traits (Davis 1982). This kind of representation analysis for WTD has been achieved by Emery (2007) showing a progressive increase in the percentage of WTD harvested by the Maya from the Preclassic to the Late Classic. The literature suggests this trend accelerated until the end of the Terminal Classic. ‘WTD may have been less available or less valuable during this period . . . there is no zooarchaeological evidence of extinction or extirpation of faunal during this period’ (Emery, 2007:192). In the Postclassic period, the pattern of WTD exploitation appears to resume (Emery, 2007: 189-190).

Contrary to expectation, therefore, WTD ‘wild animals’ appear to become more frequent in tandem with growing human population and the development of increasing cultural complexity among the Ancient Maya. However, other common prey species become less visible in the archaeological record during the Late Preclassic and Early

Classic periods. Together, these opposing trends suggest that the WTD may have been classified as something other than mere 'prey' (Carr, 1996; Emery, 2007). To determine what relationship might have existed between people and WTD requires analysis beyond simple zooarchaeological representation. Emery (2004a) and Sharpe and Emery (2015) have pushed representation analyses further by considering them not only across time but also by site type, social ranking, as well as comparisons between allied and competing polities (Emery, 2003b; 2004b, 2007a; Emery and Brown, 2012; Sharpe et al. 2014; Sharpe and Emery, 2015). While these studies have enabled greater understanding of the socio-political significance of WTD, more thorough understanding of human-deer relationships requires more detailed analysis (White and Schwarcz, 1989; Powis et al. 1999; White et al. 2001b; Tykot, 2002; Allen, 2009; Freidwald, 2010.

Eurasian studies of domestication are increasingly turning to demographic analysis, with sex and age biased mortality being attributed to herd management strategies, and changes in population stature to human intervention in reproduction or nutrition (Arbuckle et al. 2009; Payne, 1973; Payne and Bull, 1988; Zohary et al. 1998; Reitz and Wing, 2008). Carr (1996) agrees that the determination of demographic profiles is key in determining whether prey selection can be attributed to herd management or to cultural paradigms, but at the time of her seminal paper no single Maya faunal assemblage displayed sufficient skeletal representation of WTD to adequately address the question (Carr, 1996: 257). Except in the case of salvage operations, excavators usually explore discrete periods in the sediment record (Joyce, 2004: 18). The preservation of cultural resources, pending advancements in analytical methods and new technologies is a necessary prohibition/caution, but restricts the creation of large faunal assemblages or those with sufficient chronological depth to easily observed changes in stature, morphology, or deposition patterns.

While substantial assemblages of WTD are now available, identifying their age and sex is not straightforward, as within the readily available literature for WTD there are few standards by which demographics can be assessed. Purdue (1983b) provides information concerning long bone fusion but this has a maximum predictable age of 38 months for this species. For dental ageing, the standard reference is Severinghaus (1949) which provides details of dental eruption up to the age of 20 months, and details of dental wear tentatively up to 10 years. However, not only is Severinghaus (1949) outdated and in need of revision, but Maya patterns of nutrient extraction and curation of animal bones eliminate all but a few of the intact deer mandibles that would be

required for dental age assessment (Brown and Emery 2008). Only the morphology of the frontal bone and pelvis for WTD are identifiable to sex and neither skeletal element is well represented in Maya faunal assemblages (Pohl, 1985: 136; Carr, 1996: 257). WTD are sexually dimorphic, with males typically 25-35% larger than females (Miller et al. 2003). However, this species varies in stature over both time and space (Purdue, 1987a; 1987b; Purdue and Reitz, 1993). Individual variation should be considered, but relevant details of any particular animal's life are seldom available within archaeological contexts. While understanding there are exceptions, NISP data assumes each skeletal element is best understood to represent a single individual. Determining either sex or age of an animal represented by a single skeletal element especially as these are often fragments, requires both training and the use of comparative collections. Two fairly recent osteometric studies have examined WTD. Soto-Toral (1998) tested for representation of male and female deer using length and breadth of the glenoid facet with limited results. A more exhaustive approach was taken by James (2013) applying a range of osteometrics derived from Von Den Driesch (1976) testing the identification of WTD against Brocket deer (*Mazama* sp.) specimens from assemblages at Mayapan.

Given that demographic studies would appear to be the lynch-pin upon which zooarchaeological arguments of domestication, or any inferences of human-animal relationships, can be hung, there is a pressing need to investigate this in relation to WTD. Without such explorations, it seems unlikely that questions of whether or not WTD were domesticated will ever be answered. For this reason, my thesis will investigate paleo-population demographics of WTD harvested by the Ancient Maya using osteometric comparisons, size index scaling via log ratios, and faunal analysis, testing for changes in stature related to anthropogenic alterations of the environment, evidence of prey selection by age or sex, using analysis of epiphysis fusion to determine age at death, and metric comparison for evidence of sexual dimorphism.

1.7 Thesis outline:

Having introduced the question under investigation and the paradigms supporting the hypothesis of WTD domestication in the introduction, it is time to outline the content and structure of this document. WTD are a species of considerable importance in the archaeology of the Americas and the proposition they might have been domesticated by indigenous societies has attracted investigation by several scholars over the past 30 years with results that have thus far failed to prove or deny this species was domesticated. This indicates there are gaps in our knowledge about WTD,

or that standard methods of faunal analysis are too coarse for such investigations. With this in mind, the measurements selected were expanded beyond the standard canon of osteometric measurements published by Von Den Driesch (1976). As the research is largely methodological, employing multi-scalar analysis (from desk-based synthesis, to detailed consideration of both modern and ancient collections) these chapters are subdivided with each set of procedures presented in turn.

Chapter 2 Methods: describes both the qualitative and the quantitative methods selected for this analysis, with emphasis on the measurements selected, and detailed descriptions of their origin and recording, with the intention of facilitating both independent verification of my results and further study in the demographics of WTD represented in archaeology. New measurements devised during this research and a table designed to tally maximum possible age via epiphysis fusion are described.

Chapter 3 Materials: first describes the modern reference collections accessed during this research as they were identified in museum records, followed by an independent assessment of the age for the specimens from Florida via analysis of the dentition and epiphysis fusion. The second portion of the chapter describes the archaeological assemblages investigated. Published NISP data for the assemblages under investigation are compared to data sheets provided to this research from site excavations, comparing the NISP from both sources in terms of taxonomy and cultural periods represented in the assemblages. The quantity and taxonomy of each of the archaeological samples recorded for this project are then presented as NISP with a brief overview of the site's significance to Maya studies.

Chapter 4 Querying the Question: follows with a syncretic analysis of WTD as represented in the archaeological literature, first in terms of how this species is represented in faunal assemblages, then applying that data to questions about abundance through time and primary access to WTD as a dietary/cultural resource. The chapter then turns to available literature elucidating the ecology of WTD. However, they are not the only Cervidae native to the Maya culture area. Two sympatric species of brocket deer are also present in the region. It is vital to ground this discussion in what species were available to the Maya and how the attributes of these animals would shape whether human–animal relationships were endogamous or exogamous. Beyond presence, this section outlines the reproductive strategies, social behaviour, foraging habits, and environmental requirements of all three species.

Chapter 5 Baseline Study: continues to develop the methodological component of the thesis, presenting the WTD from the reference collection available at FLMNH-EAP, and testing specimens of known age and sex and how those qualities are manifested in osteological materials. Thereby expanding the means that may be applied to assessment of the archaeological materials.

Chapter 6 Morphology: further expands my methodology by identifying species' specific morphology for two of the three Cervidae species native to the Maya culture area, as well as demonstrating nonmetric traits in WTD bone morphology that I hypothesise to be age related.

Chapter 7 The Artefacts-Looking for Sex: organizes the assemblages by geographic region, Given the fragmentary nature of the deer bones in storage and the relatively small sample size of most assemblages, I use the four modern specimens from Big Cypress Preserve in Florida selected as the Standard for direct comparisons, and to produce a log ratio analysis of the archaeological assemblages, before testing the archaeological materials for species, age and sex, plotting the osteometrics derived from those samples against the modern specimens, to identify the age and sex of animals represented in those assemblages. Finally, the chapter compares the stature of WTD from each archaeological site using the Mean generated from the log ratios of each assemblage.

Chapter 8 Analysis of Cervidae Stature: proceeds with the analysis of archaeological samples using log ratio data segregated by cultural period with the intention of determining if variations in WTD stature are regional or diachronic. The second section returns to the topic of identifying which deer species are present in the faunal assemblages, exploring trends in species' stature that could be conflated with animal domestication.

Chapter 9 Discussion: challenges the idea urban civilization is inherently destructive of natural ecosystems; discusses the current limitations for assessing the age at death of mature ungulates and how this hampers the exploration of animal domestication. A synthesis of the innovations designed during this research to mitigate the limits of standard methods is presented. The summation of my results offers a discussion of how changes in WTD stature identified in my analysis might be related to changes in the organization of Maya civilization.

Chapter 10 Conclusions: compares my results to several papers describing WTD stature across time and space, addressing how the results of my work conflict with previous studies about WTD stature and the possible causality of that contradiction. The cultural role of WTD among the Maya is briefly summarised, and finally presents alternative interpretations of the results that may support the hypothesis WTD were domesticated or at least commodified.

The next chapter presents the core methods selected for this research which are foundational to my expanded methodology in Chapters 5 and 6.

Chapter 2 Core Methods:

In a fashion similar to human societies, animal species evolve in concert with both their environment and population history, participating in a race for reproductive success. As such no two species are identical in every way, and it is an over simplification to assume one species of deer can serve to illustrate the anatomy and evolution of all deer. As the illustrated descriptions in *Measurement of Animal Bones* specific to Cervidae are limited to crania and cervical vertebrae (Von Den Driesch, 1976: 36-37 and 68), while descriptions of the limb bones are general to quadrupeds, it was essential to plan what measurements would be recorded, but also to remain flexible enough to account for variations between regional deer populations and species as these were unknown qualities.

2.1 i Terminology:

As the methods and measurements used require description, so does the language and terminology employed. In this thesis, *collection* refers to the curated reference materials housed within a museum, *specimen* denotes an individual animal present in those collections. *Assemblage* means all or a distinctively quantified portion of the faunal materials recovered in excavations at a single site, and *sample* refers to a single skeletal element recovered by excavation. *Modified* artefacts describe clear evidence for human manipulation of the observed materials in this document, but do not distinguish between butchery marks and manufacture of tools or ornaments since neither process can clearly be attributed to prey selection by the Maya. As measurement is essential to science, so is consistency in language, while some interpretations of Maya culture have changed, the nomenclature has been retained with a few changes in spelling. An exception to this is the 'historical period' during which European powers and economic interests began to intrude on the political, economic, and spiritual life of indigenous communities. There does not appear to be a consistent terminology in use as much of the archaeological investigation for the Maya and literature so derived is focussed on pre-contact communities. In this document 'Historic Era' refers to post-contact communities as European record keeping in the form of church registries intruded into many post-contact settlements (Pendergast, 1993).

2.1 ii Recording of archaeological materials:

Modern Maya ritually curate the bones of wild game taken by hunters; evidence that this ceremonial practice is persistent from at least the Late Classic Period into the present day has been documented (Brown, 2005; Brown and Emery, 2008). Dispersal of

deer bone to different ritual and economic zones of any settlement may further reduce the likelihood of encountering individuals represented by more than one skeletal element. The faunal samples presented in Chapter 7 represent the materials spared by taphonomy, selected for curation and export, and then selected for recording in this study. As the artefacts in this project are biased by several levels of curation, species and mortality profiles in any assemblage are best deferred to a particular excavation's faunal analyst, since they would be aware of both the full contents of the faunal assemblage and the contexts from which the samples were derived.

Measurements for samples present in the selected assemblages were recorded in sequence individually; some assemblages were limited to a single tray, others were stored in several pasteboard boxes. Each sample deemed suitable for recording was assigned a sequential test number, with each site receiving a unique number series including an abbreviation of the site name.

As part of access to their collections collections, Kitty Emery (curator of collections) and/or faunal analysts provided this research with Excel documents recording faunal materials from each site. When available, these documents offered original catalogue numbers, provenance, and the analysts original identifications including species, element, sample description/condition, and sex and age when possible. In many cases catalogue numbers were written on the sample making it possible to directly match the sample in hand with the original recording. In a few cases the original catalogue number was a mismatch for the skeletal element described within the documents provided, possibly resulting from the transcription of handwritten notes to digital media. In all cases where zooarchaeological analysis documents were available, the original description was retained and supplemented with the measurements taken along with my descriptions (see digital appendix III). A more concise version is present in my field notes see appendix B. Also measured and recorded were all brocket deer (*Mazama* sp.), samples listed as Cervidae, and any samples listed as artiodactyls that in my judgement were likely to represent deer. When available, original catalogue numbers were retained in my data sheets to facilitate independent verification of results; catalogue numbers include the site abbreviation as the first characters in the sequence, and my test numbers include this information as the last characters of the sequence.

Primary destruction of skeletal bone for nutrient extraction is often implied for zooarchaeological samples, distinguishing such from taphonomic destruction is

sometimes possible but was deemed unnecessary in this study. However, the dearth of intact long bones does present serious limitations in determining WTD stature. A partial solution to this handicap is the refitting of broken deer bones when I estimated the resulting measurement was well within the +-3mm consistent with instrument error. Refits are recorded in both my field notes (appendix B) and within my sample descriptions in Chapter 7.

2.1 iii Log-ratios:

The measurements of any two animals will rarely coincide, even among domesticates of uniform, genetic heritage, age, sex, and provisioning. Though the measurements of any one skeletal element will vary greatly from other elements in the body, skeletal growth for individuals is thought to be symmetrical. Within archaeological collections, animal bones are generally disarticulated, and specific skeletal elements are likely to be recovered from different areas of a site or be unrepresented in an assemblage. Leaving archaeology with a great deal of material, and few ways to quantify the artefacts in a fashion that yields useful information (Albarella, 2002: 52).

In these circumstances, a statistical method may offer the best option for understanding the living animal from which these artefacts derived. Log ratios are such a method, based on the premise that the limbs and organs of an organism will be proportional to each other. In this project, the technique applies metrics from the limb bones of at least one complete skeleton representing the species to be investigated. The metrics are segregated into planes of measurement and then averaged per measurement plane. The resulting ratios can then be applied as proxy to the disarticulated bones recovered by excavation using a log scale (Meadows, 1999; Albarella et al. 2009; Sykes et al. 2011b). The log ratios are the product of the artefact's measurement and the Mean measurements of the specimens selected as the standard i.e. the measurement of change between individual data points. These log ratios indicate the variance between the artefact's measurements and the standard. The size of the scale limits the dispersal to create patterns of artefact size in the histograms subsequently generated.

To use this method a standard set of measurements derived from WTD (*Odocoileus virginianus*) of known sex and age was required. To discern differences between individual variation and sexual dimorphism, specimens used for the standard needed to represent both male and female adults of this species. A second concern was selection of skeletal elements likely to be present in the assemblages; it was decided to

use measurements from the ten limb bones-scapula, humerus, radius, ulna, metacarpal, femur, tibia, calcaneus, astragalus, and metatarsal following Albarella et al. (2009) and Sykes et al. (2011b).

The measurements of four adult WTD, one male and three females from Big Cypress Preserve were selected as representative specimens. note that these were provided by Emery (curator) and Quitmyer (CM) from the EAP comparative collections of which they are a portion.

Standard's Mean per Skeletal Element

	GL	GLC	Bp	BFp	Dp	DC	SD	SDt	SDs	Bd	Dd	BT	HT	HTC	BFd
Humerus	193.07	175.28	44.21			52.29	17.37			35.95	36.92	33.66	26.62	20.09	
Radius	209.37		34.62	32.42	19.93		11.99			30.43	23.49				
Metacarpal	204.41		28.03		20.19			13.14		24.67	16.68				26.45
Femur	234.5	227.0	54.33			23.81	19.15			48.58	64.24				
Tibia	278.5		50.3		54.5		18.0			32.2	25.13				
Metatarsal	241.0		24.19		27.0			15.74	15.4	27.14	17.1				28.49
	GLl	Dl	Lcc	Bp	GLm	Dm	Bd								
Astragalus	37.55	20.6	30.33	22.38	34.93	19.33	22.45								
	GL	GB	GD	Bc	Dc										
Calcaneus	83.49	22.1	27.75	11.37	19.47										
	HS	DHA	LD	SLC	ASG	GLP	LG	BG							
Scapula	179.98	171.87	98.66	21.6	15.31	37.7	26.44	27.63							
	GL	LO	DPA	SDO											
Ulna	255.0	50.71	33.48	33.41											

Table 2-1 Mean measurements derived from the Standard.

Measurements of the female specimens for each skeletal element were averaged to produce a Mean measurement; this was then calculated with the measurements of the male specimen to produce the Mean. A single Mean was then selected from each element per anatomical plane, and then calculated as in Table 2-2 below. The Total Mean becomes the Standard, and calculated as *=log 10(sample measurement/Standard measurement) the sum is multiplied by 100* to produce the ratio used in the histograms that follow.

anatomical plane	scapula	humerus	radius	ulna	metacarpal	femur	tibia	astragalus	calcaneous	metatarsal	Total mean
length	179.98	193.07	209.37	255	204.81	234.5	278.5	37.56	84.02	240.89	191.77
breadth	27.64	44.21	34.62		27.96	54.33	50.3	22.45	22.01	24.08	34.18
depth	26.44	52.29	19.94	33.41	19.61	23.81	54.51	20.61	28.01	27.32	30.60

Table 2-2 Mean of measurements from the Standard per anatomical plane.

As per Meadows (1999) and Sykes et al. (2011b) phalanges should not be used in size scale indexing because identification of phalanges per limb is an ongoing challenge in zooarchaeology: it is often difficult to determine if they derive from the forelimb or hind limb. For this project, log ratios have been used to generate histograms comparing the metric baseline with the archaeological materials for discerning trends that can be interpreted as sexual dimorphism and age cohort (Meadows, 1999).

2.1 iv Skeletal development:

WTD bones observed in the Maya faunal assemblages were frequently represented by fragments, rendering attempts to assess the age at death of any individual problematic. Mortality curves differentiated by sex and age class are frequently applied to identification of herd management strategy, and consequently proof of animal domestication. Epiphysis fusion is frequently used for age assessment of juvenile and sub-adult animal bones, but is of limited use for determining the age of adult specimens (Hambleton, 1998: 108; Needs-Howarth and Hawkins, 2016: 8). This presents a significant limitation for accessing mortality profiles when intact dentition is limited or absent. Table 2-3 was devised as an effort to clarify the mortality profile represented in the archaeological assemblages to be described in Chapter 7 and is rigorously applied to these assemblages in Chapter 7. A key assumption of this design is that the cortical bone of older animals is more resistant to biological destruction in sediment (Lyman, 1987). Most of the skeletal elements recorded are long bones, defined as a shaft of cortical bone surrounding a medullary cavity with an articulating structure at each end. The mechanics of bone growth are detailed in several sources including White (2000) and O'Connor (2000). Fusion of these articulating structures to the bone's shaft occurs at predictable stages of the animal's life. Following Table 3-3 in the next chapter, skeletal elements in this table below are grouped in age categories based on the predicted age of epiphysis fusion. This design is possibly more efficient for demonstrating the mortality profile than a textual description.

Table 2-3 lists the bones recorded from the reference collection, and is designed to account for the dissolution of incompletely fused epiphysis among archaeological materials that might be destroyed by taphonomic processes while not depressing the maximum possible age class. The numerals under each description identify the number of samples that match the criteria, no bone should be counted twice. Skeletal elements that fuse completely at a young age, astragali, glenoid and 2nd phalanx, need especially careful consideration as they may represent older animals, because complete skeletons are represented in Table 2-3 above the mature cohort represented is inflated.

Period		
Modern		
WTD	Species	
0	distal 2nd phalanx	< 5 months
0	humerus shaft only	
8	prox. metacarpal	≥ 6 months
8	prox. metatarsal	
97	prox. 2nd phalanx	
22	astraglus	
22	scapula	
9	distal humerus	
9	prox. Radius	
0	distal 1rst phalanx	< 14 months
4	tibia shaft only	
6	femur shaft only	
9	unfused ulna	
7	unfused calcaneus	
0	distal radius	≥ 20 months
0	distal metacarpal	
0	distal metatarsal	
6	distal tibia	
97	prox. 1rst phalanx	
2	prox. Femur	
13	fused ulna	
15	fused calcaneus	
13	complete metacarpal	≥ 30 months
14	complete metatarsal	
0	prox. Humerus	
4	distal femur	
2	prox tibia	
13	complete humerus	≥ 38 months
12	complete femur	
11	complete tibia	
403	Total	

Assessed age by element fusion

Table 2-3 Template for discerning age categories present in archaeological assemblages. The numerals below each description demonstrate the number of samples matching the criteria.

2.1 v Equipment:

Previous versions of this section used the writer's drawings of roe deer (*Capreolus capreolus*) skeletal elements, because there were noticeable variations in bone morphology between WTD and the original roe deer specimens, these have been replaced with photographs taken by this author at the Museum of Vertebrate Zoology University of California at Berkeley. Except when otherwise noted photos were taken by this author with my personal camera (Sanyo Vpc-e1500tp 14.0Mp), photos of the measurement process were taken by Sophie McGraw UF also using my camera. Photographs of specimen phalanges, metatarsals, and radius, were taken at a later date by Nicole Cannarrozi UF environmental archaeology laboratory using a Canon EOS RebelT2i/ EOS 550D, and generously provided by FLMNH-EAP and FLMNH Mammal Centre.

2.1 vi Osteometrics:

This section documents not only the measurements taken but provides a visual recording of the placement and angle at which the callipers were held as data was collected. *Inter worker variation* is an issue when assessing raw data from other sites (Sykes et al. 2011b: 56). Any scientific enquiry depends on results being reproducible. The detail presented here intends to facilitate testing of the results presented in this document. In general, the measurements to be taken are GL (greatest length), Bp (greatest breadth proximal), Dp (greatest depth proximal), Bd (greatest breadth distal), Dd (greatest depth distal). SD (smallest diameter) 'in whatever plane diameter is smallest' (Davis, 1996: 597); additional measurements for specific skeletal elements are included and referenced with the images below.

The following section describes the selected skeletal elements, their metrics, and specific angles used to record these measurements for the purpose of independently verifying the results derived in this study of WTD. The Fallow deer project as described by Sykes et al. (2011a) compiled osteometric measurements that might be used to assess changes in fallow deer (*Dama dama*) across time and geographic distance and published them in a public data base http:/www.fallow deer project.net/home. Those measurements became the foundation of the work presented here. As per Sykes et al. (2011a) this author used the methods published by Angela Von Den Driesch (1976) and developed further by including the methods of other scholars (Davis, 1996; Popkin et al. 2012) who had designed independent measurements to address their own specific questions; these measurements are not species specific and were expanded upon

following Purdue (1983a, 1983b, 1987a, 1987b), Purdue and Reitz (1993), Jacobson (2003), Wolverton (2008), Wolverton et al. (2007), and Wolverton et al. (2009) for measurements previously used to test WTD stature and species morphology.

Additional measurements were devised late in this research to account for morphological difference observed between archaeological samples. All recorded specimens of WTD, brocket deer (modern specimens and archaeological samples) examined within the collections of the FLMNH-EAP and FLMNH Mammal Centre were subjected to osteometric analyses.

The measurements of unfused bones deserve comment. Standard practice in zooarchaeology records the articulating structures of long bones only if they display fusion to the diaphysis. This practice correctly assumes that unfused bones will vary in morphology and dimensions from fully fused reference specimens, resulting in unnecessary confusion when comparing those metrics with the measurements of the archaeological samples. My original research plan was limited to creation of a set of standard measurements to be used for size-index-scaling, and therefore unfused proximal and distal articulating structures of specimens in the reference collection were not recorded or measured. The unfortunate consequence is an incomplete record for sub-adult specimens in the FLMNH-EAP reference collection, and this becomes obvious with the lack of sub-adult males represented in the Baseline Study.

2.2 The Measurements

This section shows the measurements recorded and the details of that recording for the reference collections and the archaeological assemblages. The images presented here were digitally manipulated to clarify where and how measurements have been recorded as inter-worker variation in technique can hamper independent verification of results. A brief description follows each image. All measurements were taken with a set of Vernier Callipers connected by USB cord to the writer's laptop, or on hand operated osteometrics board, both instruments provided by the FLMNH curation team for the duration of my visit. For specimens from the FLMNH reference collection, skeletal elements were selected from the right-side limb except when one or more elements were unavailable for measurement, in which case the left side limb bones were recorded.

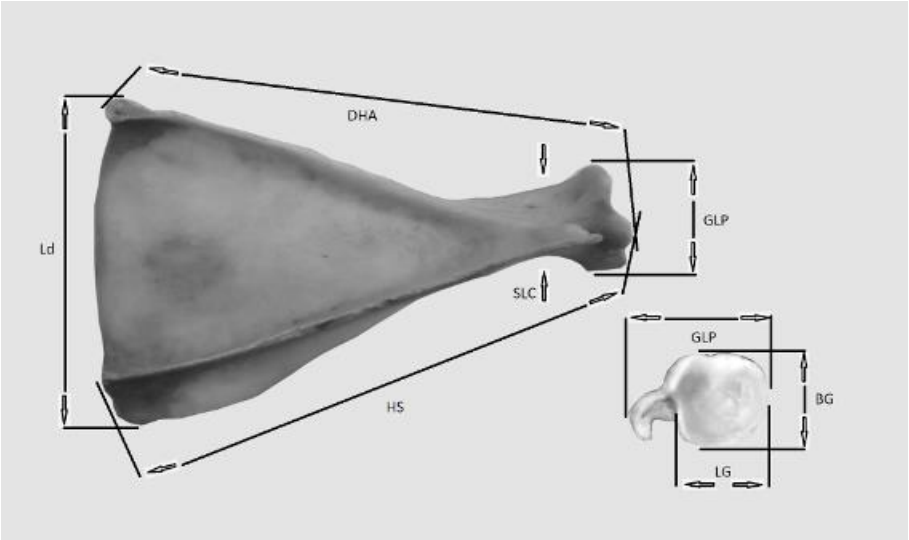


Figure 2-1 Scapula: specimen MVZ31118 from the Museum of Vertebrate Zoology (photo taken by author) and used with permission of MVZ.

HS (height of the scapular spine), from the proximal anterior margin of the scapula to the most distal point on the glenoid lip. DHA (diagonal height) from the posterior proximal corner to the most distal point of the glenoid lip. SLC is described in the original text as a length measurement (Von Den Driesch 1976: 74-75). Not shown is the measuring of the Ld, HS, and DHA, as these measurements are sufficiently straight forward. Figure 2-2 below shows the process for measuring GLP length of the glenoid process, BG breadth of the glenoid facet, and LG length of the glenoid articular surface, the last measurement is taken from the inner lip of the glenoid fossa using the reverse side of the callipers, in younger individuals the lip of the fossa is indistinct and especially difficult to measure.



Figure 2-2 Glenoid: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

Measuring the glenoid facet of the scapula, left GLP, centre LG, right BG

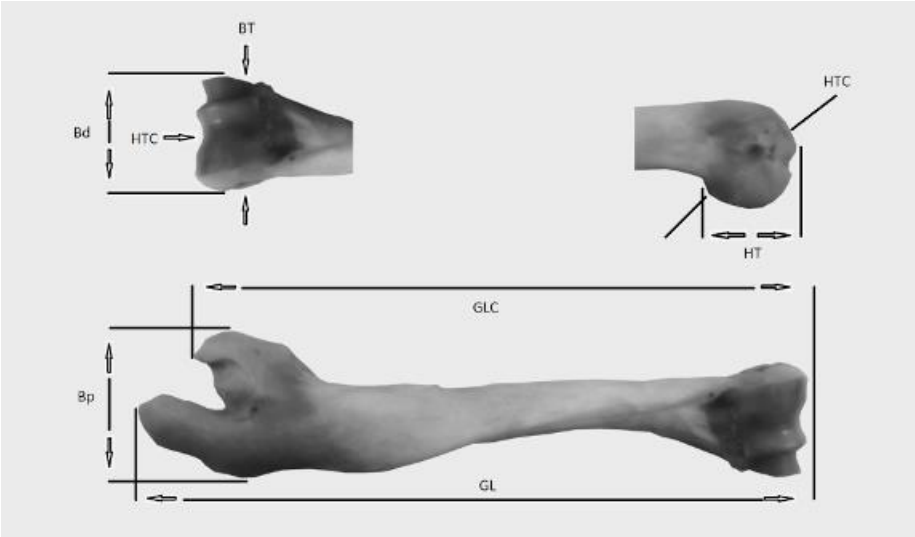


Figure 2-3 Humerus: specimen MVZ31118 from the Museum of Vertebrate Zoology (photo taken by author) and used with permission of MVZ.

Humerus GL (greatest length), GLC (greatest length from the caput), Bp greatest (breadth of the proximal articulation), Von Den Driesch (1976: 76) specifies Dp only for canids, in this study depth of the humeral head is listed as DC as per the description of the femoral head (Von Den Driesch, 1976: 84). Not shown is the SD width of the smallest diameter (Davis 1996), as this feature was found on a diagonal angle from the sagittal plane and not easily shown in photos taken at right angles.

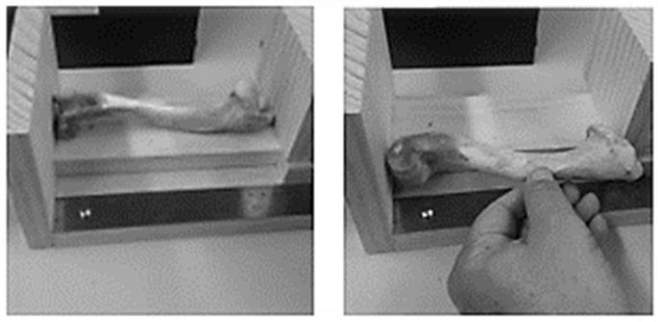


Figure 2-4 Humerus length: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

Ideally an osteometric-board may have an aperture approximately three inches in diameter in each terminal panel to accommodate the regular bumps and protrusions of skeletal morphology when measuring the length of a long bone. As the instrument, available at FLMNH-EAP did not include this feature, careful manipulation of the bone was required for measuring GLC, see right side image above.

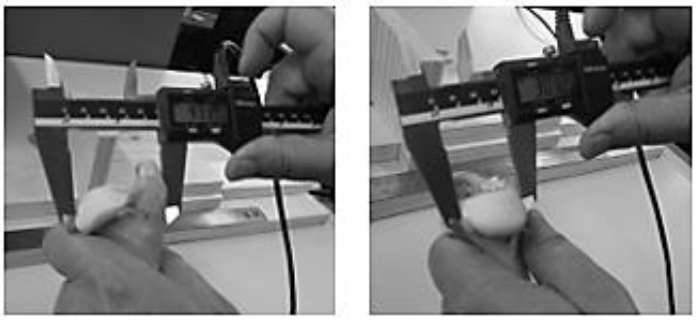


Figure 2-5 Proximal humerus: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

Measuring the proximal humerus, on the left DC (depth of the humerus head), on the right Bp (proximal breadth).

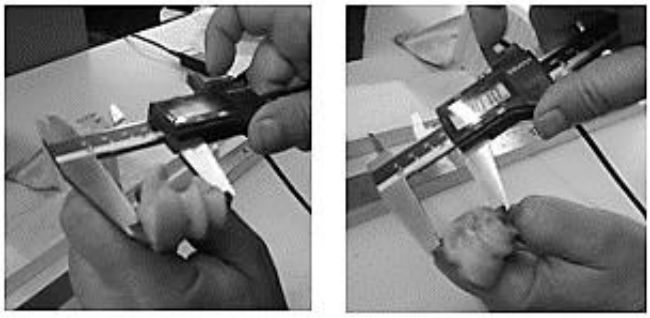


Figure 2-6 Distal humerus: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

Measuring the distal humerus breadth, on the left (Bd), right (BT) The medial side of trochlea has a depression that should be used for measuring the BT (Von Den Driesch 1976: 76).



Figure 2-7 Trochlea: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

Measuring distal humerus depth, on the left HT (height of the trochlea), on the right HTC (height of the trochlea constriction) from Popkin et al. (2012: 1778). The

HTC measurement above was found especially useful with young deer as other osteological features may not be sufficiently preserved to facilitate accurate measurement.

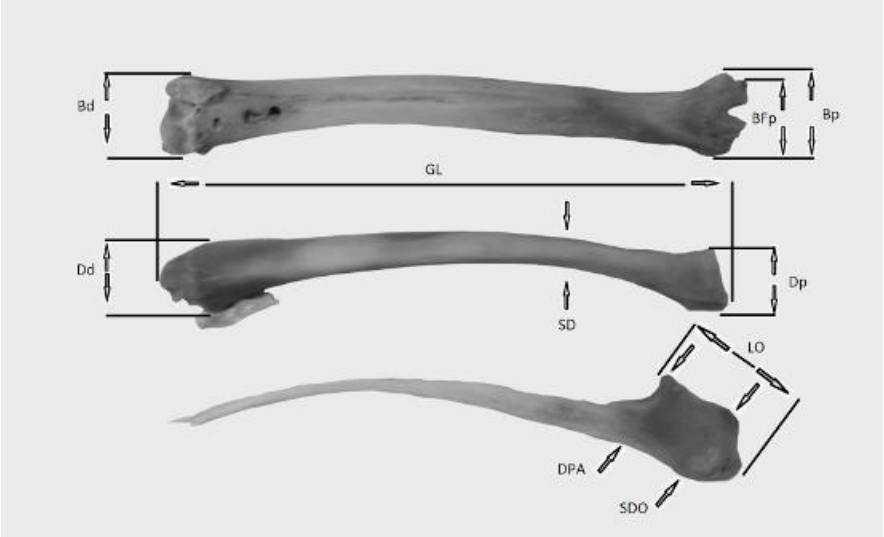


Figure 2-8 Radius and ulna: specimen MVZ32031 from the Museum of Vertebrate Zoology (photo taken by author) and used with permission of MVZ.

Measurement points for the radius and ulna, as the osteometrics-board on site lacked an aperture in either panel, taking a GL (greatest length) for the single fused radius and ulna in the reference collection was not possible. However, minus fusion to an intact ulna, the radius GL (greatest length) was easily taken with the osteometrics-board on site (see below).

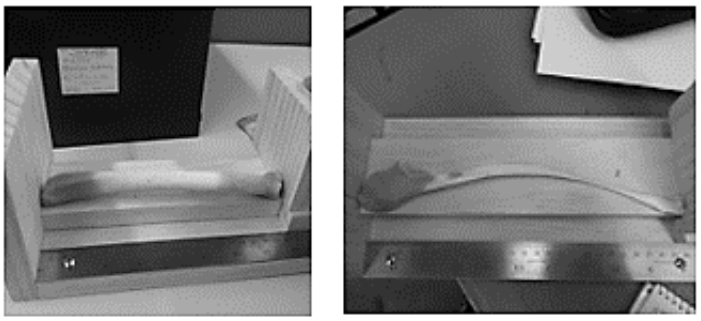


Figure 2-9 Radius length: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

Measuring the proximal radius, on the left Bp (proximal breadth), centre BFp (proximal breadth of facet), right Dp (proximal depth). The SD (smallest diameter) on the radius for WTD examined was found on the transverse plane - anterior to posterior - below the proximal articulation.



Figure 2-10 Proximal radius: from FLMNH-EAP (photo by Sophie McGraw). Used with permission of FLMNH-EAP.

Measuring the distal radius, on the left Bd (distal breadth), right Dd (distal depth).

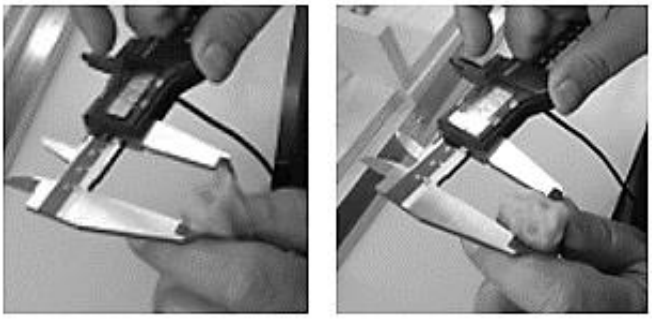


Figure 2-11 Distal radius: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

Measuring the ulna, on the left DPA (depth of anconaeus process), centre, LO (length of the olecranon), right SDO (depth of the olecranon) per Von Den Driesch (1976: 78-80).



Figure 2-12 Olecranon: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

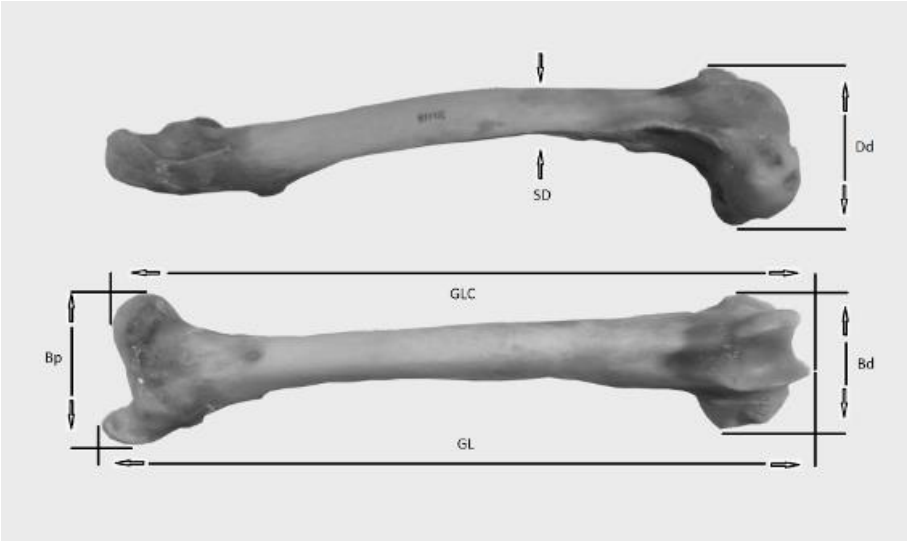


Figure 2-13 Femur specimen MVZ31118 from the Museum of Vertebrate Zoology (photo taken by author) and used with permission of MVZ.

Measurement points of the femur: like the humerus the femur presents two length measurements, either of which can be used for comparisons. As was the case for the humerus, taking the GLC (greatest length of the caput) measurement with the osteo-board available required careful manipulation to achieve consistent measurements.

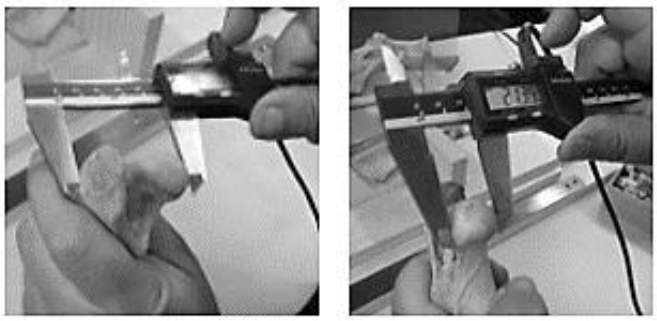


Figure 2-14 Proximal femur: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

Measuring the proximal femur, on the left Bp (proximal breadth), on the right the DC (greatest depth) of the caput/femoral head.

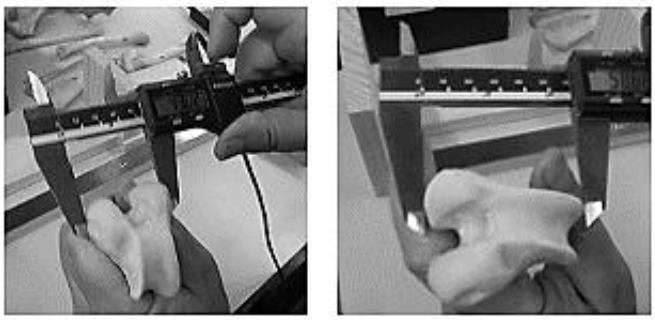


Figure 2-15 Distal femur: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

Measuring the distal femur, on the left Bd (distal breadth), on the right Dd (distal depth).

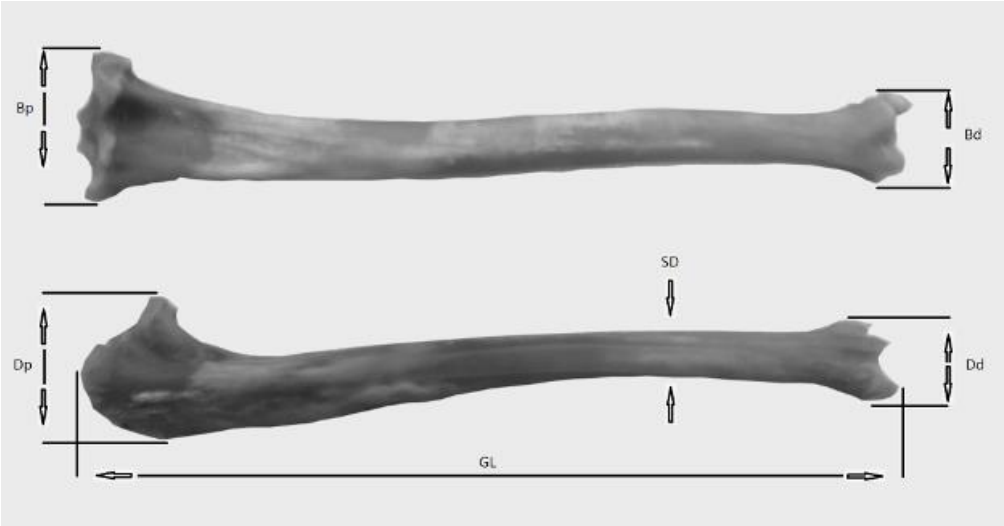


Figure 2-16 Tibia: specimen MVZ31118 from the Museum of Vertebrate Zoology (photo taken by author) and used with permission of MVZ.

Measurement points for the tibia, The SD (smallest diameter) of the tibia was found on the transverse plane per Figure 2-16 above.

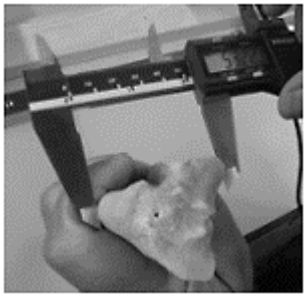


Figure 2-17 Proximal tibia: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

The proximal end of the tibia is quite large and in some cases exceeded the depth of the callipers, making measurement from right angles impossible. The Bp

(proximal breadth) is taken medial to lateral on the posterior surface (not shown), Dp (proximal depth) should be taken at right angles anterior to posterior. Because the osteoboard was not available during this part of data collection; I used digital callipers, as the proximal dimensions of this skeletal element regularly exceeded the depth of the instrument's blades, it was necessary take the measurement at a diagonal angle as in Figure 2-17 above. This is an important consideration for anyone attempting to duplicate my measurements. Distal measurements below in Figure 2-18 were less complicated, on the left Bd (distal breadth), while the right side shows the Dd (distal depth).

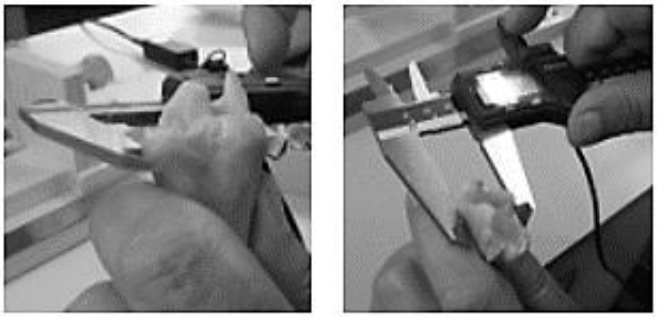


Figure 2-18 Distal tibia: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

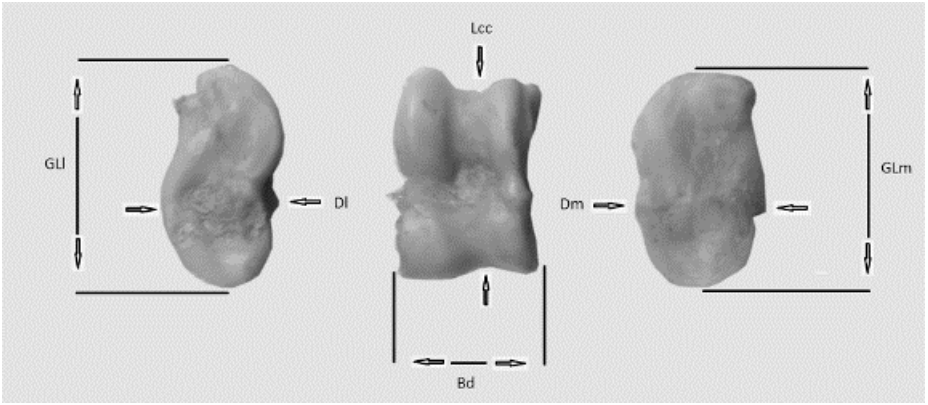


Figure 2-19 Astragalus: specimen MVZ31118 from the Museum of Vertebrate Zoology (photo taken by author) and used with permission of MVZ.

The astragalus: these measurements are straight forward and need no detailed instructions. GLl (greatest length lateral), GLm (greatest length medial), Bd (greatest breadth distal), Dl (greatest depth lateral), Dm (greatest depth medial) per Von Den Driesch (1976) p 88. Also included is Purdue's ASLEN (1983) with a special note this measurement does not appear in Von Den Driesch but has been used by several American scholars (Purdue, 1983; Wolverton et al. 2007; Jacobson, 2003; Densmore, 2009). This measurement is reportedly useful when archaeological samples have been damaged along the medial or lateral length (pers. com. Wolverton 2015). The

designation has changed with each scholar based on their research needs; for my research, the length of the central constriction is labelled Lcc (Length of central constriction).

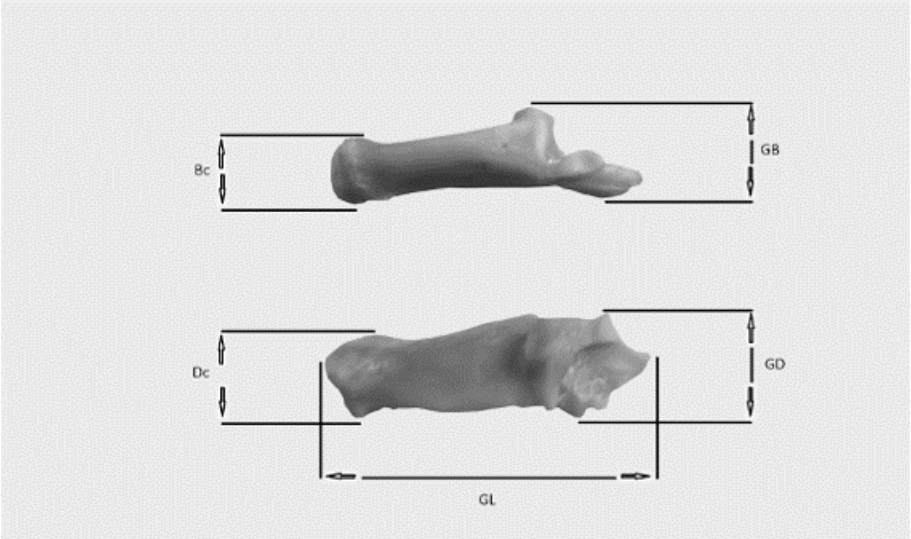


Figure 2-20 Calcaneus: specimen MVZ31118 from the Museum of Vertebrate Zoology (photo taken by author and used with permission of MVZ).

Measurement points for the calcaneus, greatest length, greatest breadth per Von Den Driesch (1976: 90), greatest depth per Purdue (1987b: 3).



Figure 2-21 Calcaneus length: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

Measuring the calcaneus, on the left GL (greatest length), centre GB (greatest breadth), right GD (greatest depth).



Figure 2-22 Caudal calcaneus: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

On the left side, Bc (caudal breadth), right side Dc (caudal depth) are original measurements designed for this research, taken anterior of the rugose surface attaching the Achilles tendon to the calcaneus, as such it is a stress point engaged in locomotion. The measurement appears to be sensitive to chronological age (see Figure 5-17), and may offer evidence of mechanical overload.

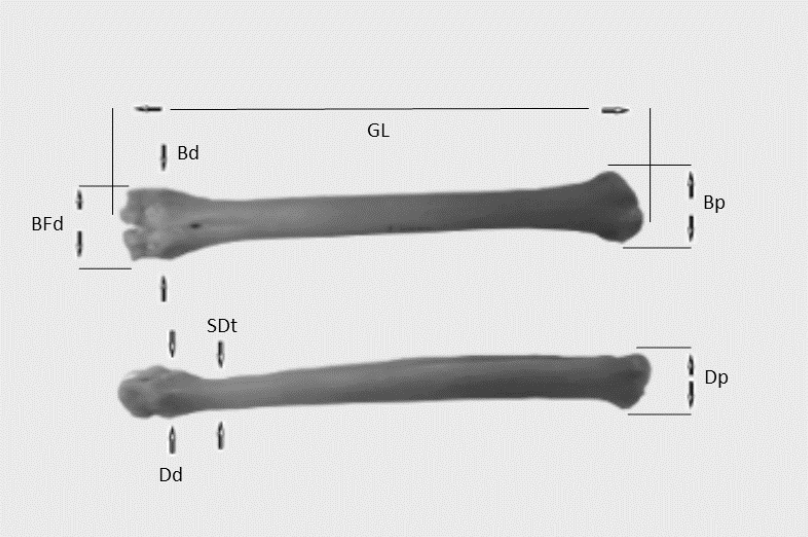


Figure 2-23 Metacarpal: specimen MVZ 31118 from the Museum of Vertebrate Zoology (photo taken by author) and used with permission of MVZ.

Metacarpal measurement points, in this research metacarpals and metatarsals were found to vary in morphology, original measurements were created to specify the plane on which the smallest diameter was found. The SDt (smallest diameter transverse) is taken anterior to posterior on the transverse plane, while the SDs (smallest diameter sagittal) is taken medial to lateral.

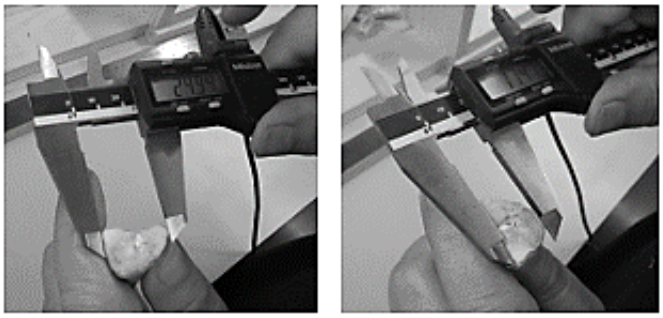


Figure 2-24 Proximal metacarpal: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

Measuring the proximal metacarpal, on the left Bp (proximal breadth) right side shows measurement of Dp (proximal depth).



Figure 2-25 Distal metacarpal: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

Measuring the distal metacarpal, on the left BFd (breadth of the distal facet) is taken on a diagonal. Centre panel the Bd greatest (distal breadth), right side panel Dd greatest (distal depth) were both taken at the distal epiphysis line of this element.

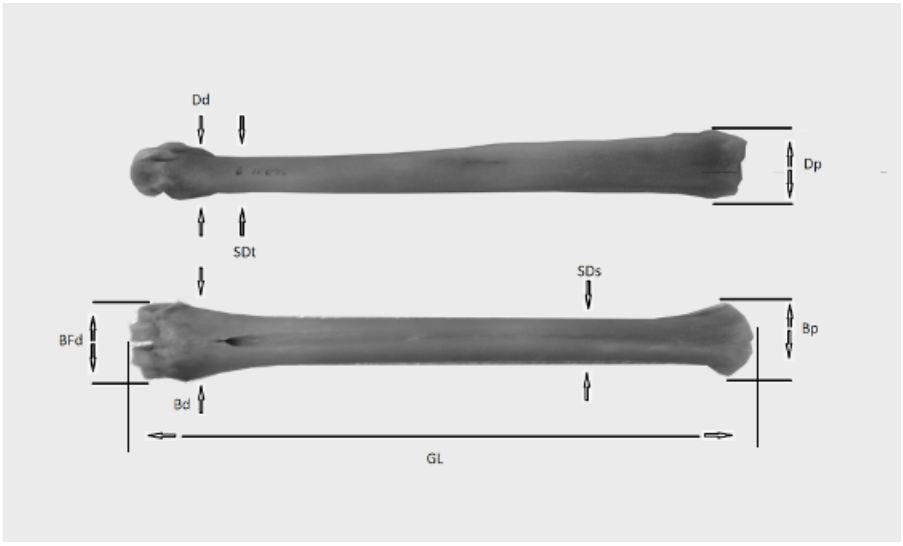


Figure 2-26 Metatarsal: specimen MVZ31118 from the Museum of Vertebrate Zoology (photo taken by author) and used with permission of MVZ.

For the metatarsals, the same measurement points apply as for metacarpals except for the smallest diameter; in older WTD specimens, the smallest diameter was on the sagittal plane, medial to lateral and roughly one third below the proximal articulation. For clarity in the data sheets these were recorded as SDt (smallest diameter transverse) and SDs (smallest diameter sagittal). While applied to all specimens from the reference collection, this innovation was devised late in the data collection process and was specified to plane for very few of the archaeological assemblages.

While WTD metacarpals consistently presented the smallest diameter SD on the transverse plane (anterior to posterior) 5 to 8mm superior to the distal epiphysis. The metatarsals presented a more complicated morphology, with the smallest diameter varying in anatomical plane and location on the shaft SDs (medial to lateral). Below in Figure 2-27 the left side shows the SDt (smallest diameter transverse), on the right SDs (smallest diameter sagittal) was on the upper third of the metatarsal shaft.

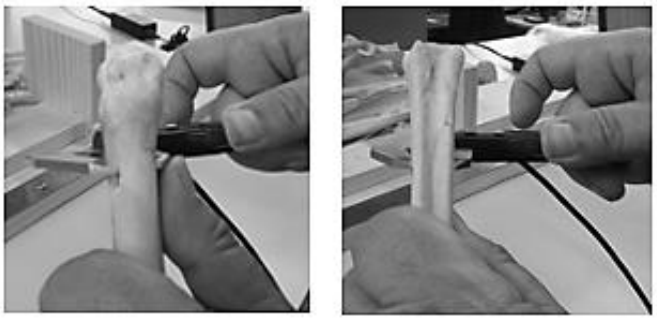


Figure 2-27 Smallest diameter of the metatarsal: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

The intent of the reference collection study was creation of standard measurements that could be used in size index scaling; for that only the ten limb-bones listed in measurements presented above were required. Since a preliminary search for WTD osteometrics had returned no results, the metric data collected during this research is to be added to Nottingham's deer bone data-base, an open access digital resource to facilitate additional work on this species using osteometrics. Based on the exceptional completeness of the skeletons in the reference collection, it was decided at the beginning of field work in Florida that measurements of additional skeletal elements should be included in the data collection.

- Measurements of mandibular teeth: the molar row as per Driesch (1976: 56), as well as the length and breadth measurements for each molar tooth m1, m2, m3.

- Measurements of the acetabulum: LA, length of the acetabulum, LAR length of the acetabulum on the rim (Von Den Driesch, 1976: 83).
- Measurements of the antler burrs: proximal and distal circumference (Von Den Driesch, 1976: 36),
- Measurements of the Phalanx: GL, Bp, Dp, SD, Bd, and Dd, for the proximal and intermediate phalanx (Von Den Driesch, 1976: 96).

The addition of phalanx measurements yielded interesting results as there were variations in morphology of the phalanges between WTD and the two populations of brocket deer tested, hinting at environmental adaptation and possibly species diffusion. These morphologies are described in Chapter 6.

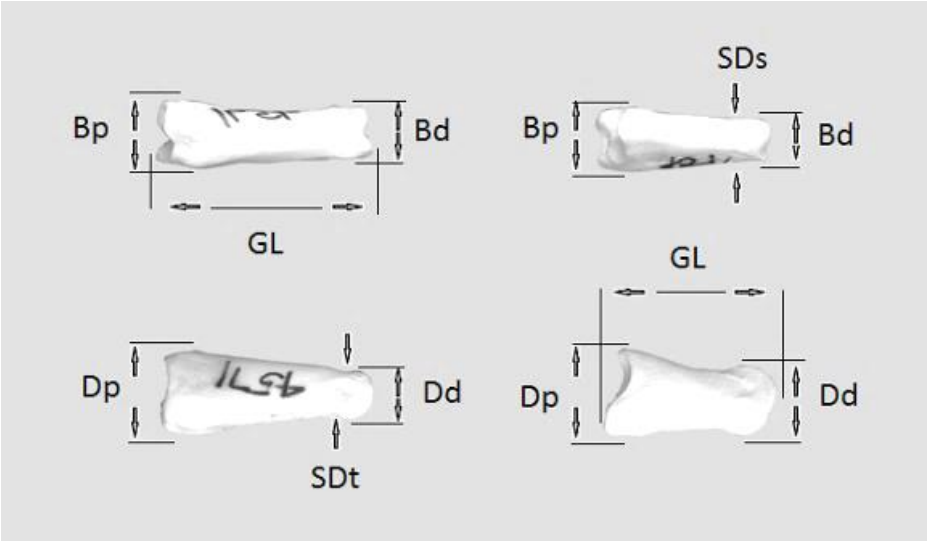


Figure 2-28 1st and 2nd phalanges: specimen FLMNH Z: 4571 from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Nicole Cannarrozzi and used with permission of the FLMNH-EAP.

The smallest diameter of the 1st phalanx (proximal phalanx) for WTD occurs on the transverse plane at the distal end of the shaft; in red brocket deer (*Mazama americana*) the smallest diameter is different (see chapter 6). For the 2nd phalanx (intermediate phalanx) it appears on the sagittal plane also at the distal end of the diaphysis in both species. These measurements and their orientation appear to be consistent across all age and sex cohorts of the WTD specimens tested.

Measurements of the 1st phalanx and 2nd phalanx below in Figure 4.29: the left panel shows measurements of the GL (greatest length), the centre panel shows measurements of the Bp greatest (breadth proximal), right side shows Dp greatest (depth proximal).



Figure 2-29 Phalanges proximal measurements: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

Below Figure 2-30 shows distal measurements of the 1st phalanx, on the left SDt (smallest diameter transverse) as described above, the centre panel Bd (distal breadth), and the right-side panel shows the Dd (distal depth).



Figure 2-30 Phalanges distal measurements: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

The 2nd phalanx SD (smallest diameter) appears on the sagittal plane at the distal end of the shaft, and is recorded as SDs.

All recorded specimens of WTD and brocket deer (modern specimens and archaeological samples) examined within the collections of the FLMNH-EA were subjected to osteometric analyses using the methods outlined above. The raw metric data are provided in Digital Appendix II (modern data) and III (archaeological data). Pending permission of the stakeholders, both will be added to Nottingham's deer bone data-base, an open access digital resource to facilitate additional work on this species using osteometrics.

2.3 Synopsis:

The skeletal elements to be investigated are described along with the methods selected for testing, osteometric comparison, and size index scaling/log ratios. Detailed descriptions and the origin of each measurement follow the figures. The process of

recording metric data from archaeological assemblages has been described along with terminology used to distinguish reference materials from archaeological artefacts. Previous testing of roe deer bones present in Nottingham's zooarchaeology laboratory showed depth measurements to be more variable between individuals than breadth measurements for the same element. Not all measurements recorded in the data sheets for this project are described above: the ASG for the scapula was not observed among the archaeological materials and showed no clear trends among the reference specimens that could be related to the topic investigated, therefore its description is not included. Measurements for smaller bones, i.e. patella, fibula, small carpal, and tarsal bones, were excluded as they are uncommon in many assemblages, and because use of such measurements may skew the ratios for size index scaling. Unfused phalanges and acetabulum in the archaeological assemblages were excluded. New measurements devised during the later stages of data recording have been described and are further explored in the Chapter 5 and Chapter 6 for evidence of ontological change and species variation.

It is genuinely hoped that the measurements above and details regarding their application described in this section will be of value to additional research. The order-of-operations is crucial in recording osteometric data; it is further suggested these measurements be taken three times sequentially and then averaged to reduce instrument error. All mammalian skeletal anatomy is roughly analogous, but evolution is not a linear process effecting all members of a species equally and it does not produce adaptations that are uniformly superior. A chief characteristic of WTD described in the literature is their ability to colonize diverse environments and discern forage with the highest nutritional value, and this is discussed in Chapter 4 (Geist, 1971; 1998; Miller et al. 2003).

Having described the core methodology, the next chapter describes the modern reference collection used as a metric baseline in this research and the archaeological assemblages that are the primary subject of my thesis.

Chapter 3 Materials:

As is the case for methods in the previous chapter a detailed description of the materials is required. It took me very nearly a year to locate relevant collections and secure permission to investigate the materials required for this study, but early in 2013 Maya faunal collections suitable for this research were identified at Universidad Autóma de Yucatán and at the University of Florida in Gainesville. Unfortunately, due to a lapse in my funding, investigation of these collections was delayed for 14 months. During that interval, the opportunity to work with the collections in Merida Yucatán was awarded to another researcher. However, the collections at the Florida Museum of Natural History Environmental Archaeology Project (FLMNH-EAP) remained available thanks to a data sharing agreement negotiated by my academic supervisor Dr Naomi Sykes and FLMNH-EAP's Associate Curator Dr Kitty F. Emery. I arrived in Gainesville knowing there was a sizable collection of Maya fauna at the museum but the content of those assemblages, the quality of preservation, and which collections would be accessible were unknown. Likewise, even though the public webpage listed a considerable number of modern WTD specimens, descriptions of the skeletal elements present for these specimens were unavailable prior to my arrival.

The FLMNH-EAP in Gainesville is the source for many journal articles concerning Maya faunal studies and the possibility of WTD domestication by the Maya (Wing and Scudder, 1991; Pope et al. 2001; Web et al. 2007). The FLMNH-EAP does not own all the resident collections of faunal material, some are on loan, and others are curated there for the benefit of researchers in various departments and institutions. Dr Emery, Associate Curator, facilitated obtaining permission for my study with these stake holders (see acknowledgements), and permission to access the museum facilities. The department's Collections Manager Mr Quitmyer provided me with access to the museum's digital archives for modern WTD specimens prior to my visit and much of the equipment used to record the measurements. Original osteometric data was collected from November 2014 through April 2015.

3.1 Reference materials

To reconstruct the demographic profiles of archaeological whitetail deer assemblages and understand whether size variations are linked to sex, age or environmental factors, it is useful first to develop baseline data, composed of individuals of known age and sex (Nieminen and Helle, 1980; Payne and Bull, 1988; Albarella et al. 2009; Sykes et al. 2011a; White, 2000). Differences between

populations also need to be considered since morphologies and stature can vary across geographies and time (Purdue, 1987b; Purdue and Reitz, 1993; Jacobson, 2003; Wolverton et al. 2007; Sykes et al. 2011), though predictors of population differences - such as Bergmann's rule - should be used with caution (Giest, 1998).

While comparative collections of known-history domestic animals are relatively common, held in museums around the world, the same is not true for wild animals since these are generally collected through hunting expeditions which, by definition, capture animals that are unknown to the collector. Sex and age estimates of culled individuals are often made at the kill-site by stalkers, as this is an important element of deer management (Knight, 2001; Cain, 2015); however, such records are not always reliable, especially age estimations since accurate age assessment is predicated on reference to a limited number of known-aged animals.

A further problem is where osteological collections of WTD exist, they are limited by size – often represented by just one or two individuals. Many of the laboratories working with Maya materials contain one or more WTD specimens for teaching and comparative identification, use of a single specimen is not ideal but would not be fruitless (Meadow, 1999: 288). Richard Purdue has also studied and written on WTD in American archaeological journals, and authored several papers focused on WTD osteometrics (1983a; 1983b, 1987a, 1987b). Unfortunately, those articles reported synthetic results rather than the raw data collected. A search for published data on WTD bone metrics produced no results. Thus, a preliminary step for this project was to study a population of this species containing individuals of known age, sex, and the creation of a metric baseline for comparison with archaeological samples from excavated Maya sites. The need for such a study has been pressing for some time (Carr, 1996). Deer populations in Mexico and Central American are under considerable pressure from hunting and habitat loss, and some species are classified as endangered. Obtaining sufficient animals native to the region of diverse age and sex for archaeological study was considered a questionable proposal.

The mammal collection of the Museum of Vertebrate Zoology University of California at Berkeley provided access to additional WTD skeletons for photographing the skeletal elements necessary to illustrate species morphology. Four relatively complete skeletons representing two WTD subspecies were present in the MVZ collection, one male, one female and two unsexed specimens. The male specimen MVZ98889 *(Odocoileus virginianus truei)* derives from El Salvador's department of

San Miguel. The female MVZ32031 and the unsexed specimens MVZ31118 and MVZ321107 *(Odocoileus virginianus covesi)* were from Cochise County in Arizona. These specimens were assessed for skeletal completeness, state of bone fusion and, when possible, dental wear.

However, the reference collections from FLMNH-EAP are the sole source for metric data collected for this research and were accessed from November 2014 through April 2015, specimens were selected based on place of origin, skeletal completeness, known sex and age. The fortuitous occurrence of a sizable reference collection of modern WTD within the same institution as the archaeological assemblages can hardly be overstated. Digital records of the modern reference collection list 93 individuals. In most cases sex, species and date of collection are the limits for the public web page. No metric data were previously available.

EANHM id#	location	sex	age	date	side	Scapula	Humerus	Radius	Ulna	Metacarpal	Pelvis	Femur	Tibia	Astragalus	Calcaneus	Metatarsal	Phalnges 1	Phalanges 2	Mandible	Burr Cp
z:4576	Collier City	F	2	1985	R	P	P	P	P	P	P	P	P	P	P	P	NA	NA	P	NA
z:4571	Collier County	M	3.5	1985	R	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
z:4703	Collier County	F	3.5	1985	L	P	P	P	P	P	P	P	P	P	P	P	P	P	NA	NA
z:4711	Collier City	M	1.5	1985	L	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
z:4579	Collier County	M	1.5	1985	R	P	P	P	P	P	P	P	P	P	P	P	P	P	P	NA
z:4580	Collier County	F	4	1985	R	P	P	P	P	P	P	P	P	P	P	P	P	P	P	NA
z:4573	Collier County	F	5	1985	R	P	P	P	P	P	P	P	P	P	P	P	P	P	P	NA
z:4574	Collier County	F	3	1985	R	P	P	P	P	P	P	P	P	P	P	P	P	P	P	NA
z:4572	Collier County	F	2.5	1985	R	P	P	P	P	P	P	P	P	P	P	P	P	P	NA	NA
z:4578	Collier County	M	2	1985	L	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
z:4577	Collier County	M	1	1985	L	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
z:4700	Collier County	F	2	1985	R	P	P	P	P	P	P	P	P	P	P	P	P	P	P	NA
z:4708	Collier County	F	1	1985	L	P	P	P	P	P	P	P	P	P	P	P	P	P	P	NA
z:4581	Collier County	F	2	1985	R	P	P	P	P	P	P	P	P	P	P	P	P	P	P	NA
z:4702	Collier County	F	2.5	1985	L	P	P	P	P	P	P	P	P	P	P	P	P	P	P	NA
z:4709	Collier City	F	2	1985	R	P	P	P	P	P	P	P	P	P	P	P	P	P	P	NA
z:4705	Collier County	F	3.5	1985	R	P	P	P	P	P	P	P	P	P	P	P	P	P	NA	NA
z:2850	Clay County	F	3.5	1979	R	P	P	P	P	P	P	P	P	P	P	P	P	P	P	NA
z:2773	Clay County	F	1.5	1979	R	P	P	P	P	P	P	P	P	P	P	P	P	P	NA	NA
z:4569	Collier County	F	NA	1985	R	P	P	P	P	P	P	P	P	P	P	P	P	P	P	NA
z:4567	Liberty County	F	NA	1985	R	P	P	P	P	P	P	P	P	P	P	P	P	P	P	NA
z:3590	Marion County	M	NA	1981	R	P	P	P	P	P	P	P	P	P	P	P	P	P	P	NA

Table 3-1 Reference specimens using the museum's catalogue numbers, assessed sex, age, and the skeletal elements present during data recording (P=present and NA=not available).

WTD are known to vary in stature geographically and chronologically (Purdue, 1987b; Wolverton et al. 2007). Based on this understanding I chose only to use animals recovered from the state of Florida for my comparative sample. Out of the 93 specimens listed in the Museum's data base 22 individuals (16 females and six males) met at least three of the four selected criteria. All 22 samples were listed in the museum's records as over 12 months of age, there are no juveniles recorded in this section. All selected animals were listed as recovered carcasses, and as soft tissue was relatively intact at the time of collection, assessed sex is to be considered reliable. Records indicated museum

curators assessed age using tooth eruption and dental wear patterns citing Severinghaus (1949). Collection notes frequently included necropsy results as well as meat weight. By the 1930s Florida's native WTD population had been reduced to 20,000 individuals and almost extirpated from southern Florida. The species was reintroduced to areas depleted of native deer from stocks originating in Wisconsin (Schaefer and Main, 2012). Consequently, the identification of WTD sub-species in the FLMNH collections has not been attempted but could be an important point in evaluating my findings.

Three of the selected individuals (z: 4569, z: 4567, z: 3590) had no assigned age in the museum records, one individual z: 4576 was missing any phalanges (incomplete sets of phalanges were common), four male specimens' (z: 4571, z: 4711, z: 4578, and z: 4577) had antler burrs that could be measured for proximal circumference, but only two could be measured for distal circumference (Von Den Driesch, 1976: 36).

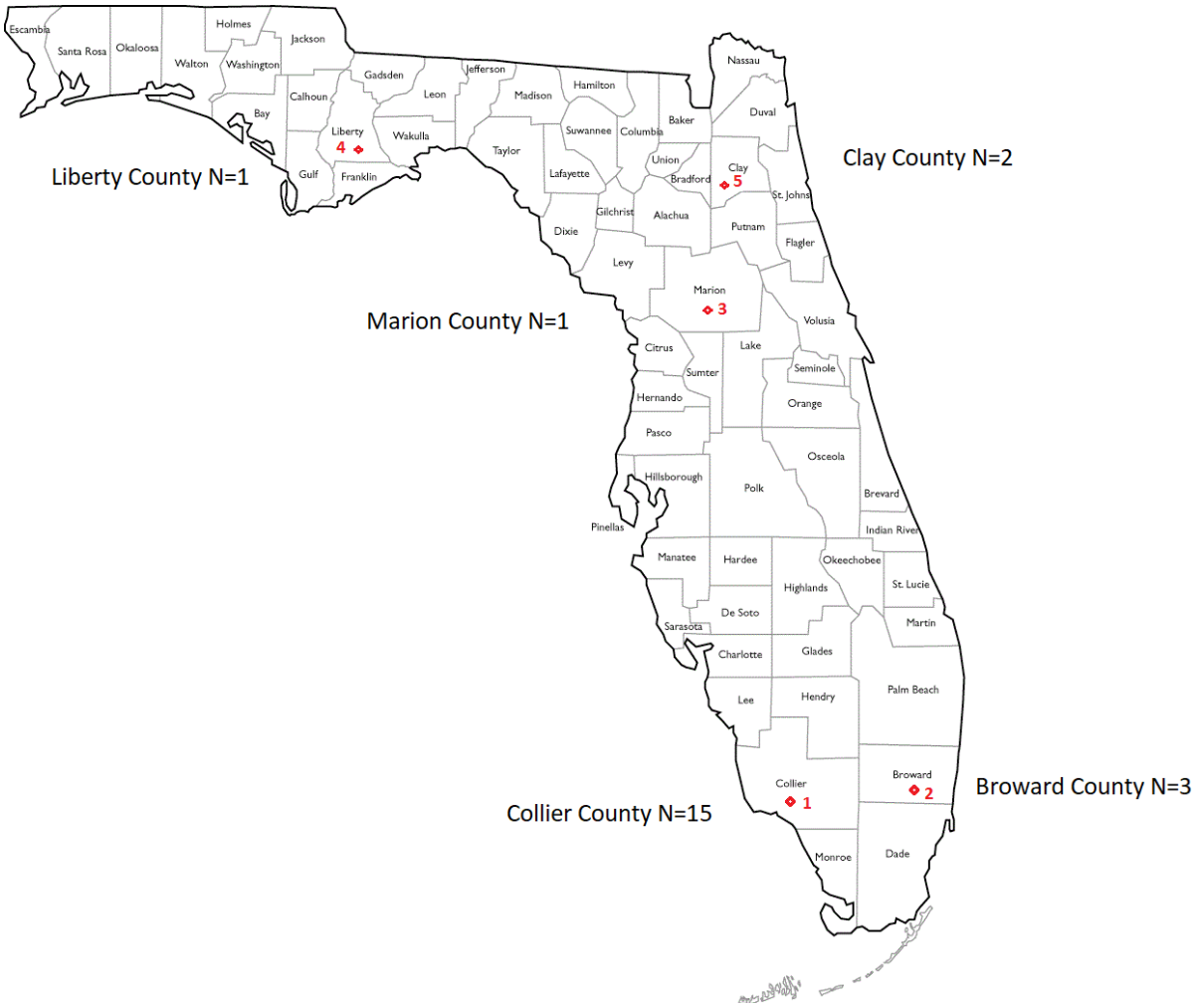


Figure 3-1 Florida counties modified to show specimen origin and number derived from each county. Source www.worldatlas.com.

Individuals in the collection originated in five Florida counties and each of those counties has been assigned a reference number to identify the origin in the following

tables (see Figure 3-1 previous page). Fifteen animals came from Big Cypress Preserve in Collier County, listed as area one, eleven females and four males. By coincidence, in addition to providing the largest selection of individuals, southern Florida is similar in rainfall patterns to portions of Maya culture area, with significant portions of terrain in both regions experiencing inundation during the summer months, hence WTD in south Florida drop their fawns in December rather than in spring as is typical for northern populations of this species (Shaefer and Main, 2012) Whether this might also be true of WTD in the Maya region is not available in the literature.

In the museum's records all the animals described in this section are listed as adults, use of that term stems from game management practices ascribing adult status to individuals capable of reproduction. Osteology takes a more nuanced approach with fusion of all limb bones defining adult status. Table 3-4 in the next section shows this does not occur until 38 months. For this study animals between 12 and 38 months should be classified as sub-adults. This is supported in the Chapter 4 'deer ecology' showing females do not typically bear offspring until their third year. Only eight animals in the selected reference collection meet this criterion, z: 4571 is the only male specimen to meet the criteria. In order to better manage age assessment of the archaeological materials, and because three reference specimens had no assigned age, independent age assessment was undertaken.

3.2 Mandibles and dental aging:

Game managers only rarely have access to de-fleshed bones for determining the age of individual animals, assessing tooth eruption and patterns of dental wear is widely accepted to be the most accurate method of assessing an animals age and is a frequently used; however, with archaeological materials it requires intact or mostly intact mandibles to be effective (Payne, 1973). The timing of tooth eruption varies between species and has been shown to differ between populations and individuals due to a wide variety of factors (e.g. health, disease, nutrition, geography).

For WTD, 'Tooth Development and Wear as a Criteria of Age in WTD' (Severinghaus, 1949) is a widely-used resource and can be summarised as follows. Deciduous incisors and premolars 2 and 3 emerge before birth. Deciduous pm1 emerges in week eight, at six months, permanent incisors and m1 emerge. The second molar (m2) begins eruption at nine months. Permanent pm1, pm2, pm3, and m3 begin eruption during months 13 to 17 (Severinghaus's, 1949: 202), his Table 2 (below) shows full eruption of the third molar would be at 36 months. The anomalous labelling of a 4th

molar in the table below is used to account for the late emergence of the posterior cusp of m3, appearing after the first and second cusps of that tooth are already in wear (Severinghause, 1949: 99).

Age Sub-class	Number of Specimens	Milk Premolars			Adult Premolars				Molars		
		1	2	3	1	2	3	1	2	3	4
Birth	7	0.0	0.0	0.0							
1 to 2 weeks	4	0.3	1.2	1.5							
2 to 4 weeks	8	0.4	1.6	3.0							
4 to 7 weeks	10	4.9	5.0	6.8							
7 to 10 weeks	7	4.9	5.0	5.9							
10 weeks to 4 months	1	5.0	5.0	6.5				2.8			
4 to 6 months	2	4.5	4.5	6.3				6.8			
6 to 7 months	1	4.5	5.0	6.0				8.5			
7 to 9 months	1	5.0	5.0	5.5				8	5.3		
9 to 11 months	3	5.0	5.0	5.3				9.3	6.8		
11 to 13 months	2	4.5	5.0	4.7				9.3	9.6		
13 to 17 months	1	4.5	4.5	4.7				9.5	10.5	10.5	3.5
17 to20 months	8	4.3	3.3	3.3	4.6	5.5	5.8	6.9	8.9	8.1	2.8
20 to 24 months	2				5.2	6.5	7.0	7.0	9.0	8.6	4.8
2.5 years	4				5.0	6.5	7.5	7.2	8.6	9.0	4.5
3.5 years	3				5.3	6.1	7.3	6.8	9.1	9.0	6.0
4.5 years	6				5.0	5.6	6.2	6.0	7.6	8.4	6.0
5.5 years	3				5.3	5.3	6.0	5.7	7.2	8.0	5.7
6.5 years	4				4.5	4.5	6.0	4.9	6.2	6.8	4.8
7.5 years	3				4.7	4.7	6.0	5.0	6.3	6.7	4.0
8.5 to 9.5 years	1				4.5	4.0	4.0	4.5	4.5	4.5	4.5
10.5 years and over	2				3.0	3.0	3.5	4.2	4.5	5.2	4.5

Table 3-2 Tooth eruption and dental wear: derived from Severinghaus (1949: 202) Table #3. M-4 references eruption and wear of the 3rd cusp of molar three.

The order in which teeth erupt and juvenile dentition is replaced within a population is generally consistent. Several studies have been published on WTD dentition (Severinghaus, 1949; Gilbert, 1966; Ransom, 1966; Brown and Chapman, 1991; Lister, 1996; Van Deelen et al. 2000). Since Severinghaus (1949) is frequently cited within archaeological literature on WTD, its use may be considered foundational, though it is not without criticism; 'In a blind test, 30% of experienced workers incorrectly identified the age of specimens' (Gee et al. 2002). The original study did not impose controls on the type of forage made available to test subjects (Severinghaus, 1949: 198) which would factor heavily in assessing the rate of dental wear (Chapman and Chapman, 1970).

Several regional projects have attempted to bridge this gap between a scientific paper and the needs of local hunters and game managers (Pierce, 2011; Cain, 2015). For this research, it was found the dental wear criteria of Pierce et al (2011) and the illustrations from the University of Missouri webpage below are considerably clearer than the photographs from Severinghaus's (1949) original article; while his description of the of the order and timing of tooth eruption remains unchallenged.

It is important to note that Severinghaus (1949) Gee et al. (2002) and Pierce (2011) writing for US game management publications use a simplified dental formula for mandibular teeth pm1, pm2, pm3, m1, m2, and m3, while anatomists recognize pm1 and m4 are rarely present in higher mammals (Hillson, 1986: 13), and the alternative if not 'proper' dental formula for members of the family *Capreolus* to which WTD belong is pm2, pm3, pm4, m1, m2, and m3 (Rumph, 1975: 7; Hillson, 1986: 96).

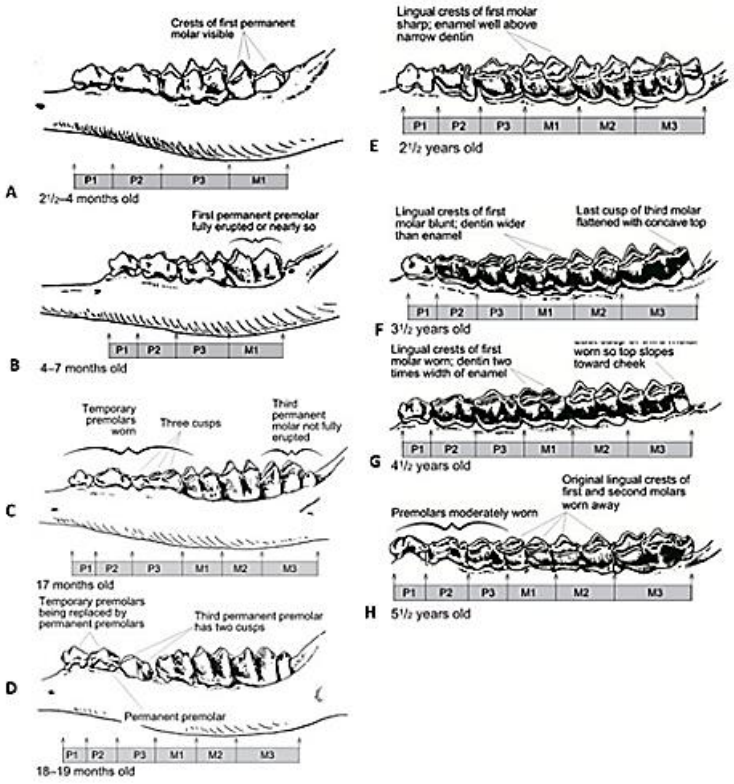
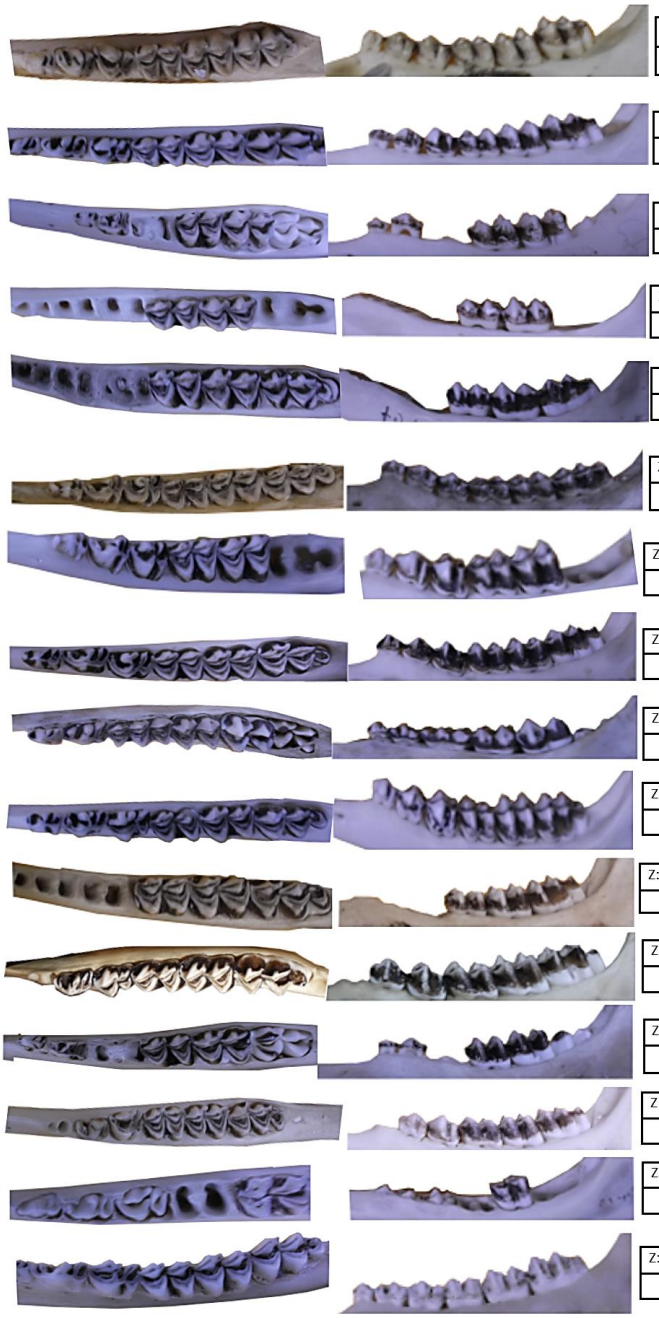


Figure 3-2 Determining dental wear: taken from University of Missouri Extension: source http://extention.missouri.edu/p/G9484

Recorded measurements for dental material were of limited scope, length of the molar row as per Von Den Driesch (1976: 52-53) and also the greatest length and greatest breadth of molars one, two, and three. The application of Severinghaus's Table #2 (1949: 202) 'measurements of crown height' is not possible, as my photos were intended for use as visual reference rather than age assessment. It is however possible to use these photos for assessing dental eruption per Severinghaus (1949) and dental wear per Pierce et al. (2011).

Table 3-3 presents mandibles for specimens z:4571, z:4574, z:4577, z:4578, z:4579, z:4580, z:4700, z:4702, z:4708, z:4581, z:4576, z:4711, z:3590, z:2773, and z:2850, The 15 photographed mandibles above are from the FLMNH-EAP reference collection and taken with my digital camera (see methods). The laboratory's reference

number and a description of the observed teeth are matched to the right of lingual and dorsal view photos. Deciduous teeth are scored [D], permanent teeth are scored [P] mandibular premolars [pm1, pm2, pm3] mandibular molars are scored [m1, m2, m3] following Gee (2005) and Pierce (2011). Dental eruption is tabulated per Severinghaus (1949) while wear is scored following Pierce (2011). The right side of Table 3-3 below scores tooth eruption per Table 3-2 and dental wear per Figure 3-2.



Z:4571	P1	P2	P3	M1	M2	M3	Age
	F	F	F	F	F	F	42m

Z;4574	P1	P2	P3	M1	M2	M3	Age
	E	E	E	E	E	E	28 m

Z:4577	P1	P2	P3	M1	M2	M3	Age
	C-D	C-D	Crypt	C-D	C-D	In crypt	17-20 m

Z:4578	P1	P2	P3	M1	M2	M3	Age
	missing	missing	missing	B	B	Missing	4-7 m

Z:4579	P1	P2	P3	M1	M2	M3	Age
	missing	missing	missing	D	D	D	20 m

Z:4580	P1	P2	P3	M1	M2	M3	Age
	H	H	H	H	H	H	66 m

Z:4700	P1	P2	P3	M1	M2	M3	Age
	E	E	E	E	E	Missing	28 m

Z:4702	P-pm1	P-pm2	P-pm3	P-m1	P-m2	P-m3	Age
	D	D	D	D	D	D	>20 m

Z:4708	D-pm1	D-pm2	D-pm3	P-m1	P-m2	P-m3	Age
	worn	C	C	C	C	in crypt	<17 m

Z:4581	D-pm1	D-pm2	P-pm3	P-m1	P-m2	P-m3	Age
	worn	worn	E	E	E	E	>30 m

Z:4576	P-pm1	P-pm2	P-pm3	P-m1	P-m2	P-m3	Age
	missing	missing	D	D	D	D	>20 m

Z:4709	P-pm1	P-pm2	P-pm3	P-m1	P-m2	P-m3	Age
	missing	D-E	D-E	D	D	D	,20 m

Z:4711	D-pm1	D-pm2	D-pm3	P-m1	P-m2	P-m3	age
	C	C	crypt	C	C	C	≤17 m

Z:3590	D-pm1	D-pm2	D-pm3	P-m1	P-m2	P-m3	Age
	missing	D	D	D	D	D	> 20 m

Z:2773	P-pm1	P-pm2	P-pm3	P-m1	P-m2	P-m3	Age
	crypt	crypt	crypt	missing	D	crypt	<17 m

Z:2850	D-pm1	D-pm2	P-pm3	P-m1	P-m2	P-m3	Age
	E	E	E	E	E	E	>30 m

Table 3-3 Reference collection mandibles: (photos taken by author). Used with permission of FLMNH-EAP.

The mandibles for specimens z: 4705 and z: 4703 were missing at the time of data collection. Specimens z: 4567, z: 4569, and z: 4573 have dental measurements

recorded in my data, but there are no photographs for these samples in my files. The current photographs are insufficient for applying Cooper's *Dentine Method* (Cooper et al. 2013).

3.3 Epiphyseal fusion:

Bone is among the most frequently encountered organic ancient material and while the interment of human remains usually signals a discrete event in the archaeological record, the deposition of animal bone typically is more diffuse (O'Connor, 2000: 98). As single skeletal elements in Maya faunal assemblages may each represent an individual animal, it is required to deduce the maximum possible information regarding species, age, and sex from each bone examined. Epiphyseal fusion of the long bones is frequently used to determine the animals age at death.

	initial fusion		partial fusion		full fusion	
element	females	males	females	males	females	males
prox. Radius	2 m	5 m	2 m	5 m	5m	8 m
dist. Radius	20 m	29/26 m	20 m	29/26 m	29/26 m	38 m
dist. Humerus	2 m	5 m	2 m	8 m	20 m	12 m
prox. Humerus	29/26 m	38 m	29/26 m	38 m	38 m	38 m
prox. Femur	20 m	20 m	20 m	23 m	29/26 m	29/26 m
dist. Femur	23 m	29/26 m	23 m	29/26 m	26 m	38 m
dist. Tibia	17/14 m	17/14 m	17/14 m	17 m	20 m	23 m
prox. Tibia	23 m	29/26 m	23 m	29/26 m	29/26 m	35/32 m
prox. Ulna	20 m	20 m	20 m	20 m	29/26 m	38 m
Metacarpal	20 m	23 m	20 m	23 m	29/26 m	29/26 m
Metatarsal	20 m	17 m	20 m	23 m	29/26 m	29/26 m
Calcaneus	17/14 m	20 m	20 m	20 m	29/26 m	29/26 m
1rst Phalanx	11/8 m	11 m	11/8 m	11 m	20 m	17 m
2nd Phalanx	5 m	8 m	5 m	8 m	11/8 m	17 m

Table 3-4 Derived from Purdue's Table #3 (1983b: 1210).

Different bones in the skeleton fuse at different ages, *Epiphyseal Closure in WTD* (Purdue, 1983b) is the basis for age assessments in this project. Recently a radiograph study has supported Purdue's (1983b) assessed schedule of epiphysis fusion (Flinn et al. 2013). The order of epiphysis fusion is consistent in all members of the Odocoileines group. The age at which fusion occurs however varies. Black-tail deer (*Odocoileus hemionus*) a larger related species fuses as much as a year later than WTD (Purdue, 1983b: 1211). Brocket deer are considerably smaller. There is no comparable study for this species so I have used Purdue's standards. Age assessments for brocket deer should accurately reflect the individual's status as juvenile, sub-adult, mature/reproductively active adult, but the actual age at which either brocket deer species transitions from one category to another is likely to be different than for WTD.

FLNHM-EAP collection number	Map location	reported sex	reported age in years	date collected	side	proximal humerus	distal humerus	proximal radius	distal radius	ulna superior crest	Fused to radius	proximal metacarpal	distal metacarpal	proximal femur	distal femur	proximal tibia	distal tibia	calcaneus fused	proximal metatarsal	distal metatarsal	Age assessed in months
z:4708	1	F	1	1985	L	U	F [v]	F [i]	U	U	N	F [i]	U	U	U	U	U	U	F [i]	U	12-14
z:2773	5	F	1.5	1979	R	U	F [i]	F [i]	U	U	N	F [i]	U	F [v]	U	U	F [i]	U	F [i]	U	17-20
z:4576	2	F	2	1985	R	F [v]	F [i]	F [i]	F [i]	F	N	F [i]	F [i]	F [v]	F [v]	F [v]	F [i]	F	F [i]	F [i]	20-29
z:4700	1	F	2	1985	R	U	F [i]	F [i]	U	U	N	F [i]	U	F [v]	F [v]	U	F [i]	F	F [i]	U	17-20
z:4709	2	F	2	1985	R	U	F [i]	F [i]	U	U	N	F [i]	F [v]	F [v]	U	U	F [i]	F	F [i]	F [i]	20-23
z:4581	1	F	2	1985	R	F [v]	F [v]	F [i]	U	F	N	F [i]	U	F [v]	F [v]	F [v]	F [i]	F	F [i]	F [i]	23-26
z:4569	1	F	NA	1985	R	F [v]	F [i]	F [i]	F [i]	F	N	F [i]	F [i]	F [v]	F [v]	F [v]	F [i]	F	F [i]	F [i]	23-26
z:4572	1	F	2.5	1985	R	F [v]	F [i]	F [i]	F [i]	F	N	F [i]	F [i]	F [v]	F [i]	F [i]	F [i]	F	F [i]	F [i]	23- 26
z:4702	1	F	2.5	1985	L	U	F [i]	F [i]	F [v]	F	N	F [i]	F [i]	F [v]	F [v]	F [v]	F [i]	F	F [i]	F [i]	23-26
z:4567	4	F	NA	1985	R	F [i]	F [i]	F [i]	F [i]	F	N	F [i]	F [i]	F [i]	F [i]	F [v]	F [i]	F	F [i]	F [i]	29-38
z:4574	1	F	3	1985	R	U	F [i]	F [i]	F [v]	F	N	F [i]	F [v]	F [v]	F [v]	F [v]	F [i]	F	F [i]	F [i]	23-26
z:2850	5	F	3.5	1979	R	F [v]	F [i]	F [i]	F [i]	F	N	F [i]	F [i]	F [v]	F [i]	F [i]	F [i]	F	F [i]	F [i]	26-29
z:4703	1	F	3.5	1985	L	F [i]	F [i]	F [i]	F [i]	F	Y	F [i]	F [i]	F [i]	F [i]	F [i]	F [i]	F	F [i]	F [i]	≥60
z:4705	1	F	3.5	1985	R	F [i]	F [i]	F [i]	F [i]	F	N	F [i]	F [i]	F [v]	F [v]	F [i]	F [i]	F	F [i]	F [i]	20-29
z:4580	1	F	4	1985	R	F [i]	F [i]	F [i]	F [i]	F	N	F [i]	F [i]	F [i]	F [i]	F [i]	F [i]	F	F [i]	F [i]	≥38
z:4573	1	F	5	1985	R	F [i]	F [i]	F [i]	F [i]	F	Y	F [i]	F [i]	F [i]	F [i]	F [i]	F [i]	F	F [i]	F [i]	≥60
z:4577	1	M	1	1985	L	U	F [v]	F [i]	U	U	N	F [i]	U	U	U	U	U	U	F [i]	U	17-20
z:3590	3	M	NA	1981	R	U	F [i]	F [i]	U	U	N	F [i]	U	U	U	U	F [v]	U	F [i]	U	17-20
z:4711	2	M	1.5	1985	L	U	F [i]	F [i]	U	U	N	F [i]	U	U	U	U	U	U	F [i]	U	17-20
z:4579	1	M	1.5	1985	R	U	F [v]	F [i]	U	U	N	F [i]	U	U	U	U	U	U	F [i]	U	8-20
z:4578	1	M	2	1985	L	U	F [i]	F [i]	U	U	N	F [i]	U	U	U	U	F [i]	U	F [i]	U	17-20
z:4571	1	M	3.5	1985	R	F [v]	F [i]	F [i]	F [i]	F	N	F [i]	F [i]	F [v]	F [v]	F [v]	F [i]	F	F [i]	F [i]	26-38

Table 3-5 Observed epiphysis fusion during data collection, U = unfused, F = fused, v = epiphysis line is visible, and i = epiphysis line is obscured.

Eeach skeletal element in the table above is scored for possible age, the degree to which epiphysis lines were obscured was inconsistent for several specimens. During initial scoring of element fusion for each individual, it became apparent the degree of fusion described by Purdue (1983b) was not as rigidly consistent as for dental eruption described by Serveringhaus (1949); this is not new information. As an example, z: 4571 (a large male) showed visible epiphyses at the proximal femur, fully fusing by 29 months, the distal femur fully fusing at 38 months, and the proximal phalanx fully fusing at 17 months, (Purdue, 1983b: 1210). The antlers, while broken, demonstrated a forked morphology indicating the animal was over two years old. All permanent dentition was present and extremely worn. It is possible the fusion lines had been re-exposed by nutritional deficit or by calcium recycling due to antler genesis (Miester, 1956; Goss, 1970). Big Cypress is a preserved wetland area. Many species of tropical grass and sedge contain substantial quantities of silica in their structures, and this could account for the considerable wear on the mandibular teeth. While it must be taken into account, Purdue (1983b) was not explicit in his description of full fusion for long bones; it is also true that as a result of nutritional stress, calcium may be scavenged from cortical bone in a way that mimics physical immaturity (O'Connor, 2000: 101). The

specimen is larger than the adult females from area one, but less than the 25% one would expect from reading the literature (see Chapter 5). Two females from area five however overlap or exceed the measurements of some elements for this adult male (see Figure 5-1).

Even with complete skeletons and mandibles it is easier to tell what age an animal is not, than what age it was. Another difficulty with assessing age by epiphysis fusion is identifying animals that are older than the age at which the specific element fuses. (Hambleton, 1998: 108; Needs-Howarth and Hawkins, 2016: 8). Purdue's Table #3 does not consider fusion of the ulna to the radius. As can be seen in Table 3-5, specimens z: 4703, originally assessed as 3.5 years, and z: 4573, assessed as 5 years old, have ulna fused to the distal radius. No other animals in the three or four-year-old class demonstrate this quality (see Chapter 6).



Figure 3-3 Fusion of ulna to radius: specimen z:4573 from the Florida Museum of Natural History photo taken by Nicole Cannarozzi and used with permission of FLMNH-EAP.

Is specimen z: 4703 a five-year-old female? She had no mandible present at the time measurements were being collected. Specimen z: 4573 has a mandible recorded but no photo is present in my files recording skeletal morphology. In Figure 3-3 the distal ulna shaft is fused to the distal radius. In Chapter 6 the nature of that fusion will be explored further.

A primary goal in exploring the modern materials was the creation of standard measurements for use in size index scaling. Specimen's z: 4571, z: 4573, z: 4580, and z: 4703, are judged to be the best candidates for these standard measurements as they are assessed to be fully mature and presumed to represent a coherent regional population of WTD.

FLMNH-EAP collection number	County of origin	reported sex	reported age	date collected	Age assessed epiphysis fusion	age by dentition	assessed specimen age
z:4708	1	F	1	1985	12-14	>17	12 months
z:2773	5	F	1.5	1979	17-20	>17	17 months
z:4576	2	F	2	1985	20-29	<20	26 months
z:4700	1	F	2	1985	17-20	<28	26 months
z:4709	2	F	2	1985	20-23	>20	20 months
z:4581	1	F	2	1985	23-26	>30	28 months
z:4569	1	F	NA	1985	23-26	NA	26 months
z:4572	1	F	2.5	1985	23-26	NA	26 months
z:4702	1	F	2.5	1985	23-26	>20	24 months
z:4567	4	F	NA	1985	29-38	NA	38 months
z:4574	1	F	3	1985	23-26	≥28	28 months
z:2850	5	F	3.5	1979	26-29	>30	30 months
z:4703	1	F	3.5	1985	≥60	NA	60 months
z:4705	1	F	3.5	1985	20-29	NA	29 months
z:4580	1	F	4	1985	≥38	>66	60 months
z:4573	1	F	5	1985	≥60	NA	60 months
z:4577	1	M	1	1985	17-20	17-20	17 months
z:3590	3	M	NA	1981	17-20	<20	20 months
z:4711	2	M	1.5	1985	17-20	>17	17 months
z:4579	1	M	1.5	1985	8-20	>20	17 months
z:4578	1	M	2	1985	17-20	4>7	17 months
z:4571	1	M	3.5	1985	26-38	<42	36 months

Table 3-6 Comparison of specimen ages by FLNHM record with independently assessed age by bone fusion, dental eruption and tooth wear. NA=not available for assessment.

3.3 i Brocket Deer:

The original project design did not include brocket deer. However, they present the largest percentage of measurable specimens for Tipu Negroman present in FLMNH-EAP shelves at the time of data collection, and are well represented in the data sheets for many of the sites investigated, so therefore must be considered in this investigation. Institutions with representative post cranial skeletons for brocket deer were difficult to identify, skins and skulls being the most regular representatives listed in museum archives, and while crania are particularly useful for distinguishing between populations (Molina and Molinari, 1999; Nickolay and Vaders, 2006; Martinez-Polanco, 2011) the work at hand requires post cranial skeletal elements. Nor are all brocket deer populations equally representative as is explained in chapters four and six.

The Environmental Archaeology laboratory had one modern partial skeleton identified as *Mazama* sp. and one individual identified as *Mazama americana* that was almost complete except for the skull. This individual was unsexed. A third carton in the EAP shelves UF no. 1440 also contained brocket deer elements that I judged represented several individuals (see appendix A). Additionally, FLNHM has a mammalogy department holding three partial skeletons from Guatemala and three

partial skeletons from the Island of Trinidad, all identified as *Mazama americana*. All specimens were measured and recorded, no assigned ages were available. The measurements from UF no. 1440 were excluded from analysis and thus are not represented below. Table 3-7 shows representation of skeletal elements for each brocket deer specimen and my assessed ages. All specimens are modern animals; when available the collection date is included.

Brocket deer skeletal elements present and assessed by epiphysis fusion

Provenance	FLMNH#	sex	date collected	species	side	scapula	humerus prox	humerus dist	radius prox	radius dist	ulna prox	ulna dist	carpal dist	pelvis	femur prox	femur dist	tibia prox	tibia dist	calcaneus posterior	astragalus	tarsal dist.	1st phalange	2nd phalange	assessed age by fusion
no data	z:7930	M		Mazama sp.		NA	NA	NA	NA	NA	NA	NA	P-F	NA	NA	NA	NA	NA	P-F	NA	P-F	NA	NA	26
Peten, Tikal	UF 6787	M		Mazama temama	R	NA	NA	NA	NA	NA	NA	NA	P-F	NA	NA	NA	NA	NA	NA	NA	P-F	NA	NA	26
Peten, Tikal	UF 6788	F	1960	Mazama temama	R	NA	NA	NA	NA	NA	NA	NA	P-F	NA	P-F	P-F	P-U	P-F	P-F	P	P-F	P	P	38
Peten, Altar de sacrifios	UF 6795	M	1961	Mazama temama	R	P	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	P	P	6
Dos Pilas, peten	z: 8851	US	1993	Mazama temama	R	P	P-F	P-F	P-F	P-F	P-F	P-U	P-F	P	P-F	P-F	P-F	P-F	P-F	P	P-F	P	P	38
Trinidad Nariva	UF 6609	F	1959	Mazama americana	R	NA	P-U	P-F	P-F	P-U	NA	NA	P-F	NA	NA	NA	P-U	P-F	P-F	P	P-F	P	P	20
Trinidad Mayaro	UF 6610	M	1959	Mazama americana	R	NA	NA	NA	P-U	P-F	NA	NA	P-F	NA	NA	NA	NA	NA	P-F	P	P-F	P	P	20-38
trinidad Siparia Forest	UF 6608	M	1959	Mazama americana	L	NA	NA	NA	NA	NA	NA	NA	NA	P	NA	NA	NA	NA	P-F	P	P-F	P	P	20

Table 3-7 M = male, F = female, US = unsexed, NA-not available, P = present, and P-F = present and fused.

In addition to being well represented in some assemblages, the brocket deer presented different morphology of the metatarsal and the first phalanx from Florida WTD. This in turn relates to the taxonomic identification of brocket deer species present in archaeological assemblages. All brocket deer specimens I examined at FLMNH were listed as *Mazama Americana.* The table above represents the specimens identified in the museum collections following the current taxonomy, though that taxonomy is currently being revised (see deer ecology in Chapter 4).

3.4 Archaeological Assemblages:

Historically, American archaeologists and institutions have been a significant influence in studying the ancient Maya. While previously it was both possible and reasonable that overseas institutions might assume stewardship of Mesoamerican antiquities, that is no longer the case. The transport of cultural artefacts across international borders is now regulated. While NAGPRA (the Native American Graves Protection and Repatriation Act) only manages archaeological materials from within the United States, repatriation of cultural materials to their country of origin is an international issue directly affecting how universities and museums manage and acquire collections. Consequently, American archaeology is increasingly dependent on representative sampling. This in turn impacts projects such as this one dependent on curated materials. Of the 43 assemblages made available to this project at FLMNH-

EAP, 16 had Cervidae bones with one or more of the measurement landmarks selected for recording. The geographic distribution of those sites and of an additional 36 assemblages represented in publications that were reviewed for comparison are shown in Figure 3-4 at the end of this chapter. The research designs of archaeologists assume time will provide improved methods and new technologies; thus management of undisturbed context as a cultural resource is overarching priority. Because geography and naturally occurring resources are key elements in sustaining urban cultures, Maya cities were often inhabited over long periods, but are only rarely investigated to their full potential. The lack of chronological depth from any single site, and an assumed curation bias of unknown scope, present a significant hindrance to this project's goal of clearly demonstrating diachronic stature change for WTD.

With the exception of Cueva de Los Quetzales which is exclusively a ritual deposit, the assemblages recorded for each site originate from a variety of ritual and domestic contexts, the priority in this study being to assess the stature and sex of WTD in relationship to developing social complexity among the Maya. Future studies may be able determine if context type can demonstrate a relationship with sex and age categories of WTD. Only a few sites offered materials from a single cultural period, more common was the presence of materials from two or more periods. In this section the following site descriptions are presented in a roughly chronological sequence from most recent to oldest. As the faunal materials available at the museum were representative samples, and in the interest of not trespassing on the intellectual property of stakeholders, the bone counts identified as deer in the original documentation are summarized per site in this section while the skeletal elements analysed are presented in Chapter 7 in considerably greater detail. The site information provided is a rough overview intended only to demonstrate the relevance within wider Maya studies but remains at this date far from comprehensive.

3.4 i Yucatan:

Ek Balam: Faunal Analysis: Dr Susan deFrance UF and Dr Craig A. Hanson. Samples examined originated in two deep pits [2-1-1:201795] and [2-1-2B:202695] cut into the limestone bedrock during the Historic Era. Two contexts are ascribed to these features, a colonial period stratum showing cultural deposits, and a post-abandonment phase. For the post abandonment phase these pits are described as a natural trap. 'Excavators recovered several complete and nearly complete animal skeletons, particularly those of immature cattle and deer' (deFrance and Hanson, 2008: 306). NISP

for the Spanish colonial phase was 1316 samples of which 25 were identified as WTD and 3 as brocket deer. For the post abandonment phase, total NISP was 215, with 131 samples identified as WTD (deFrance and Hanson, 2008: 308). A portion of this collection went to FLNHM-EAP for additional analysis, and those samples represent the post abandonment phases of the settlement (pers. com. Susan deFrance 2016). From those materials, 19 samples were selected for recording based on the viability of selected measurements. The assemblage presented here is the most recent in chronological time. Because the majority of samples are not a cultural deposit, this assemblage presents a unique opportunity to compare presumably wild WTD from colonial era Yucatán with modern specimens from Florida.

Located on the northern Yucatan peninsula (see map in Figure 3-1) the site represents continuous occupation from the Middle Formative period until the early 17th century when it was abandoned (Bey et al. 1997; Bey et al. 1998; Fedick and Morrison, 2004; deFrance and Hanson, 2008).

Permission for excavation and export granted by Mexican Instituto Nacional de Antropología e Historia (INAH); Principal Excavators: Dr George J. Bey III Millsaps College, Dr Craig A. Hanson, Dr William M. Ringle Davidson College.

3.4 ii Belize:

Four sites from Belize follow; Lamanai, Tipu Negroman (aka Tipu), San Pedro, and Marco Gonzales, were excavated by Elizabeth Graham and David Pendergast exploring Postclassic and Colonial/Historic Era Maya settlement organization (Graham and Pendergast, 1989; Graham et al. 1989; Graham and Bennet, 1989; Graham, 1991; Pendergast, 1993). During the later period, Spanish expansion in the region was politically and economically contested until the conquest of Nojpeten in 1697 (Simmons, 1991; Emery, 1999). A consistent phenomenon of the Postclassic period was expansion and reorganization of trade networks. These four sites were linked by canoe trade during the Postclassic with other polities including Mayapan in northern Yucatan via the river systems connected to Chetumal Bay and the Caribbean Sea (Sabloff, 2007). Salt production appears to have been an industry at both Marco Gonzales and at San Pedro (Graham and Pendergast, 1989; Stemp, 2004)

The records for these sites are incomplete, faunal analysis for San Pedro and Marco Gonzales is currently underway and the excavation records for these two sites were unavailable to this research. Twenty-two settlements have been identified on the Cay, and salt production appears to have been a local product in regional trade (Graham

and Pendergast, 1989); an isotope study for Marco Gonzales was published prior to my investigations (Williams et al. 2009) but the samples tested derive from different contexts than the samples I have recorded. Zooarchaeological identifications of the deer samples were available from the analysts from Lamanai and Tipu were available. However, the sites were excavated prior to digital media being commonplace, and while the samples are meticulously documented in their crates, some of the transcription entries translating field notes to digital format do not meet expectations. Of special concern is a lack of assessed dates for many of the operations from which the deer bones I recorded are derived (see digital appendix III.8 and III.16). A second data sheet was offered in 2015, cross referencing operation numbers filled in some of the missing dates, and direct communication with Dr Graham, and her generous effort to resolve dating problems with the files in her possession filled in a few more. Despite these efforts 32% of the recorded deer samples from Tipu are from contexts with dates unavailable to this research.

Lamanai: Faunal Analysis Dr Kitty Emery UF and Arianne Boileau UF. Published sources describe the total NISP as 5,737 but list the Cervidae material using MNI (minimum number of individuals). WTD with an MNI of 37 or12% of the total assemblage, the MNI of brocket deer is 25 or 8% of the total assemblage (Emery, 1999: 62). The original data sheet listed 256 deer bones from the Historic Era and Postclassic periods, 22 samples were identified as *Mazama* sp. seven samples were identified as *Cervidae*, and 227 samples were identified as WTD. Samples in the museum shelves offered 156 deer bones with one or more of the selected measurements, 105 identified as WTD, 11 samples identified as brocket deer, and seven samples identified as Cervidae were recorded for this study. Cross referencing of operation numbers with the assistance of Dr Emery UF and Ariana Boileau UF filled in most of the missing dates for this assemblage.

The site is located on the northwest shore of New River Lagoon (Emery, 1999). The earliest carbon 14 date for the settlement is 1500 B.C. remaining inhabited if not in florescence into the Spanish colonial period (Pendergast, 1981; Emery, 1999; Graham, 2000). Atypical for the region, monumental structures are oriented toward the lagoon shore (Pendergast, 1981: 32). Emery (1999) describes changing patterns of fauna during the Postclassic and historic periods, as well as shifting patterns of deer consumption over time.

Permission for excavation and export of materials granted by the Belize National Institute of Culture Heritage (NICH) Institute of Archaeology. Principal excavators: Dr Elizabeth Graham UCL and Dr David Pendergast UCL.

Tipu Negroman: Faunal analysis Dr Kitty Emery UF and Polydora Baker (English Heritage). Emery (1999) describes the total NISP as 24,590 but list the Cervidae materials using MNI (minimum number of individuals) WTD with an MNI of 52.28 or7% of the total assemblage. The MNI of brocket deer is 70.41 or 10% of the total assemblage (Emery, 1999: 63). Original data sheets provided to this research for Tipu listed nine samples as Cervidae, 11 as artiodactyl, 289 of the samples as WTD and 634 samples as brocket deer described as *Mazama americana* or *Mazama* sp. Inter-worker variation in anatomical terminology made some listed specimens difficult to identify. A total of 227 deer bone samples were suitable for measurement, 73 samples identified as WTD, 151 samples as brocket deer; two samples identified as Cervidae and one as artiodactyl were also recorded (see appendix II).

Tipu remained rural throughout its history (Emery, 1999). While Jones (1986) notes in historical sources, close political ties to the Itza Maya of Lake Petén made the settlement something of a lynch pin in Spanish efforts to bring the region under control of Colonial Authorities until 1654 when the region was ceded to England (Simmons, 1995: 137).

Permission for excavation and export of materials granted by the Belize National Institute of Culture Heritage (NICH) Institute of Archaeology. Principal Excavators: Dr Elizabeth Graham UCL. Faunal Analysis: Dr Kitty Emery UF.

San Pedro: Faunal Analysis: Petra Cunningham-Smith UF. A full faunal analysis is underway for San Pedro, only the isotope study was published at the time of data collection (Williams et al. 2009). The assemblage is the product of salvage archaeology and it is presumed the stratigraphy has been disturbed substantially by construction of the modern town (pers. com. Petra Cunningham-Smith, 2017). Ten samples from eight different contexts were suitable for measurement, the operation numbers for these samples do not match those published in the previously mentioned article. As of yet, no context specific dates are available for the samples recorded, the date range for the site spans both Postclassic and Historic periods.

Located on the windward side of the Ambergris Cay, San Pedro was excavated 1990-1993 and identified as a fishing community without monumental structures, it was

occupied from A.D. 1400 to 1650 (Williams et al. 2009: 41). As a modern town occupies the site, excavated materials should be understood as salvage archaeology, as such systematic investigation of the settlement is difficult. The Cay is 39 km long and no wider than 4km at any point. Separated from the mainland on the north side by a canal cut through natural limestone by the Maya around A.D. 600, and by Chetumal Bay on the east (Graham and Pendergast, 1989; Stemp, 2004; Williams et al. 2009). There is minimal evidence maize was consumed at San Pedro, and given the limited land area of Ambergris Cay, it is possible deer were imported from the mainland (Williams et al. 2009: 50).

Permission for excavation and export of materials granted by the Belize National Institute of Culture Heritage (NICH) Institute of Archaeology. Principal Excavators: Dr Elizabeth Graham and Dr David Pendergast UCL.

Marco Gonzales: Faunal Analysis: Petra Cunningham-Smith UF. Only four samples in the trays for Marco Gonzales were identified as WTD, a single radius and three tibiae. Data sheets were unavailable for these materials, the site is considered Postclassic but context specific dates must wait for full analysis.

Located on Ambergris Cay with formal architecture, elaborate burials and exotic materials, Marco Gonzales is considered a player in Postclassic trade networks. Excavated from 1986 thru 1990, the site was occupied from 100 B.C. to A.D. 1350 (Graham and Pendergast, 1989).

Permission for excavation and export of materials granted by the Belize National Institute of Culture Heritage (NICH) Institute of Archaeology. Principal Excavators: Dr Elizabeth Graham UCL and Dr David Pendergast UCL.

3.4 iii Guatemala:

Ten sites represent four regional clusters, Lake Peten Itza, the Rio Ususmacinta and its tributaries, the Petexbatun Basin, and the El Mirador Basin see map Figure 3-4. These comprise political associations that were variously allied or in conflict with each other (Demarest, 2006; Golden et al. 2012; Foias and Emery, 2015).

Motul de San Jose: Faunal Analysis Dr Kitty Emery UF. Published data for the site a total NISP of 1020, WTD 159, brocket deer 16, and four samples identified as Cervidae (Emery, 2003a:38). Original catalogue numbers were written on the samples, and operation numbers inscribed on the plastic bags containing faunal materials. These are recorded along with my test numbers and the measurements recorded for each

sample. The samples dated from the Middle, Late, and Postclassic periods. That document also provided descriptions of the materials recovered, for WTD the NISP was 245, brocket deer 32 samples, 14 samples were identified as Cervidae, and five samples were identified no higher than artiodactyl. A total of 39 deer bones in the trays presented one or more measurements, three samples identified as brocket deer, one as artiodactyl and 35 WTD were recorded. The number of Cervidae samples listed in documentation provided to this research is greater than those in the published account.

Located three kilometres north of Lake Petén Itza and the affiliated port city La Trinidad de Nosotros, this polity also had seasonal access to Rio Aket, part of the watershed for Rio Usumacinta offering access to the Gulf of Mexico and the polities such as Dos Pilas and Piedras Negras (Thornton and Emery, 2006).

Permission for excavation and export provided by the Guatemalan Instituto de Antropología e Historia (IDAEH) Principal Excavators: Dr Antonia E. Foias Williams College and Dr Kitty Emery UF. Motul de San Jose Archaeology/Ecology Project.

La Trinidad de Nosotros: Faunal Analysis: Dr Erin Thornton WSU. Published NISP data shows 81 skeletal elements identified as WTD (Thornton, 2012: 334), the original data sheets tendered to this study recorded 91 WTD samples and six samples identified as Cervidae. Six samples in the museum trays were suitable for recording. Original documentation was tendered by Dr Tornton UW and provided Postclassic dates for two samples.

Located on the shore of Lake Peten Itza, the site functioned as a trading port in the Motul Polity (Thornton, 2012).

Permission for excavation and export provided by the Guatemalan Instituto de Antropología e Historia (IDAEH) Dr Antonia E. Foias Williams College and Dr Kitty Emery UF. Motul de San Jose Archaeology/Ecology Project.

Piedras Negras: Faunal Analysis: Dr Kitty Emery UF. The published NISP data offers a total NISP of 5715, WTD 566 and 17 brocket deer from Phase 2 excavations (Sharpe and Emery, 2015: 293-298). Data sheets provided to this research by Dr Emery count 561 WTD samples, 40 samples identified as brocket deer, 27 listed as Cervidae, and 27 samples not identified above artiodactyls. There were no issues with the assessed dates for this assemblage. From the museum shelves 108 samples identified as WTD and seven brocket deer samples were measured and recorded. The faunal samples tested represented Late Classic and Terminal Classic Periods.

Located on the north bank of Rio Usumacinta, dynastic rule of in the Piedras Negras Polity held political sway in opposition to the neighbouring Yaxchilan dynasty from the Early Classic A.D. 350 until A.D. 810 (Emery, 2007b; Golden et al. 2012).

Permission for excavation and export provided by the Guatemalan Instituto de Antropología e Historia (IDAEH) Principal Excavators: Dr Stephen Houston Brown U. Piedras Negras Archaeology Project.

El Kinel: Faunal Analysis: Dr Ashely Sharpe STRI and Dr Kitty Emery UF. Total published NISP 2475 of which 176 were identified as WTD and 28 identified as brocket deer (Sharp and Emery, 2015: 293-298). In the data sheets offered to this study 110 samples were identified as WTD, 11 samples were identified as brocket deer, 26 were listed as Cervidae, and four were listed as artiodactyl. Eight WTD samples in the museum trays were suitable for measurement. One sample representing the Late Classic, two samples representing the Terminal Classic, and the remaining five listed as Terminal/Late Classic.

The city is considered a client of the Yaxchilan polity and connected to Rio Usumacinta by a canal facilitating canoe trade (Golden et al. 2012; Balzotti et al. 2013).

Permission for excavation and export provided by the Guatemalan Instituto de Antropología e Historia (IDAEH) Principal Excavators: Dr Charles Golden Brandeis U and Dr Andrew Scherer Brown U. Sierra Del Lacandón Regional Archaeology Project.

La Joyanca: Faunal Analysis: Dr Kitty Emery UF and Arianne Boileau UF. No published sources were identified for this assemblage. The original data sheets provided by Dr Emery list a WTD NISP of 319, nine samples are identified as brocket deer, 24 are listed as Cervidae, and seven samples were not identified above artiodactyl. A total of 87 samples were suitable for recording: 75 WTD, three brocket deer, three Cervidae and six samples that were not originally identified above artiodactyl were recorded; 51 samples were identified as Terminal Classic, eight samples were from the Late Classic, and one phalanx from the Early Classic. Sixteen samples were from mixed deposits and could not be assigned to a specific cultural period.

Located in the uplands south of Rio San Pedro Mártir. and first identified in 1994, the site was assessed as an important Late Classic centre. Excavations began in 1999. The last reported field season was 2012 (Arnauld et al. 2013).

Permission for excavation and export provided by the Guatemalan Instituto de Antropología e Historia (IDAEH) Principal Excavators: M. Charlotte Arnauld Université de Paris.

Cancuen: Faunal Analysis: Dr Erin Thornton WSU. Faunal analysis for this assemblage is in progress (pers. com. Erin Thornton). The original document provided to this research by Dr Thornton UW listed 231 WTD samples, 11 brocket deer, five samples identified as Cervidae, and two samples not identified above the level of artiodactyl. Of the material in the museum shelves 35 samples identified as WTD and one sample listed as brocket deer were suitable for measurements and recorded. The deposit is believed to be of Late Classic origin, while exact dates are not currently available. Samples available at FLMNH-EAP showed excellent preservation.

Strategically located on the Rio Pasión with access to the Rio Usumacinta system and navigation from southern Petén to the Gulf of Mexico, this polity is thought to be a significant regional player with direct management of trade and resources by the local dynasty (Demarest et al. 2014: 187).

Permission for excavation and export provided by the Guatemalan Instituto de Antropología e Historia (IDAEH) Principal Excavators: Dr Arthur Demarest, Vanderbilt U Vanderbilt Petexbatun Regional Archaeology Project.

Aguateca: Faunal Analysis: Dr Kitty Emery UF. From published sources, the total NISP for the assemblage is 12,656, of which 552 samples were identified as WTD and 47 samples identified as brocket deer (Sharpe and Emery, 2015: 293-298). In the original identification data provided by Dr. Emery, the NISP for WTD was 286, identified brocket deer samples were 22. Nine samples could not be identified above artiodactyl, and 18 samples were identified as Cervidae. Eleven WTD samples in the museum's shelves were suitable for measurement.

The site offers a unique opportunity in assessing elite activity as it was abruptly abandoned after a catastrophic fire approximately A.D. 850 (Inomata and Stiver, 1998; Inomata et al. 2002).

Permission for excavation and export provided by the Guatemalan Instituto de Antropología e Historia (IDAEH) Principal excavators: Dr Takeshi Inomata Arizona U. and Dr Daniela Tridan U. of Arizona, Phase 2 materials from the Aguateca Archaeology Project.

Punta de Chimino: Faunal Analysis: Dr Kitty Emery UF. The faunal assemblage presented a total NISP of 947, 115 samples were identified as WTD and one sample as brocket deer (Sharpe and Emery, 2015: 293-298). The original data sheet provided by Dr Emery listed 70 samples as WTD, 2 samples were identified as brocket deer, 3 were designated as Cervidae, and 1 sample as not identified above artiodactyl. Thirteen WTD samples in the museum trays were suitable for measurement.

The site represents a strongly fortified settlement built on a peninsula in Lake Petexbatun, excavations focused on the Late Classic Period (Foias and Bishop, 1997).

Permission for excavation and export provided by the Guatemalan Instituto de Antropología e Historia (IDAEH) Principal excavators: Dr Arthur Demarest Vanderbilt U, Dr Takeshi Inomata Arizona U. Petexbatun Regional Archaeology Project.

Cueva de Los Quetzales: Faunal Analysis: Dr Kitty Emery UF. Published sources list the total NISP for the assemblage as 1283, 107 samples were identified as WTD and 47 samples as brocket deer (Emery, 2002: 106). Original identification data was provided by Dr. Emery; twenty-five WTD samples and two artiodactyl samples present in the museum shelves were relevant for testing. Materials represent a ritual deposit from a cave beneath the main plaza at Las Pacayas (Brady and Rodas, 1995) dated as Early Classic (pers. com. Kitty Emery 2015).

Permission for excavation and export provided by the Guatemalan Instituto de Antropología e Historia (IDAEH) Principal Excavators: Dr Arthur Demarest, Vanderbilt U, Dr James E. Brady CSU, Petexbatun Regional Archaeology Project.

El Mirador: Faunal Analysis: Dr Kitty Emery UF, Dr Erin Thornton WSU. Published sources describe the total NISP as 3351; 89 samples were identified as WTD, and 43 samples were identified as brocket deer (Thornton and Emery, 2016: 236-237). Original identification data was provided by Dr. Emery to this research listed 47samples identified as WTD. Of the samples in museum shelves, 11 WTD samples and 13 brocket deer samples were sufficiently intact for osteological analysis. All WTD samples were listed in the original data sheets provided as late Preclassic.

The oldest of the assemblages tested in this project. This large and important Preclassic site is located in the southern Maya lowlands; the El Mirador basin straddles the border between Guatemala and Mexico, containing four major settlements, Nakabe, Tintal, Xulnal, and El Mirador, (Wahl et al. 2007; Šprajc et al. 2009). The faunal samples tested in this project were collected under the direction of Bruce Dahlin and

Ray Matheny during seasons 1978-1983 (Thornton and Emery, 2016: 234). Date range for this assemblage is 350 B.C. to A.D. 150.

Permission for excavation and export provided by the Guatemalan Instituto de Antropología e Historia (IDAEH) Principal excavators: Dr Ray Matheny BYU.

3.4 iv Honduras:

Copan: Faunal Analysis: Dr Kitty Emery UF. This assemblage is not yet published, no data sheets were available at the time of data collection, operation numbers I recorded with the measurements were cross referenced for assessed dates by Dr Emery and provided to this research. The tray for Copan in the FLMNH-EAP stores contained eight measurable samples, each from a different operation, three samples from the Early Classic Period, one sample from the Middle Classic, two samples from Late Classic Period, and two samples from operations that are currently not available to this research.

Situated in the Copan valley 2000 meters above sea level, the ancient city was at the extreme southern margins of the Maya culture sphere. Several different faunal assemblages have been published over time (Pohl, 1995: 463; Collins, 2003: 301). WTD are unusually prominent in the faunal remains possibly indicative of a community wide emphasis on Maya cultural identity (Pohl, 1995: 465). This Maya city is one of the most studied in archaeological literature (Fash, 1991; Sharer and Traxler, 2006). The local geology is rather distinct for a Maya settlement as a large portion of the catchment area is steep uplands comprised of igneous rock and soils derived from the same (Fash, 1991: 27-37; Wingard, 1996).

Permission for excavation and export provided by the Instituto de Historia e Antropología de Honduras: Principal excavator: Dr Robert J. Sharer, Copan Acropolis Project.

3.5 Locations:

The map below illustrates the location and spatial relationships of the archaeological assemblages discussed above along with 20 additional assemblages from published sources that are reviewed in the following chapter.

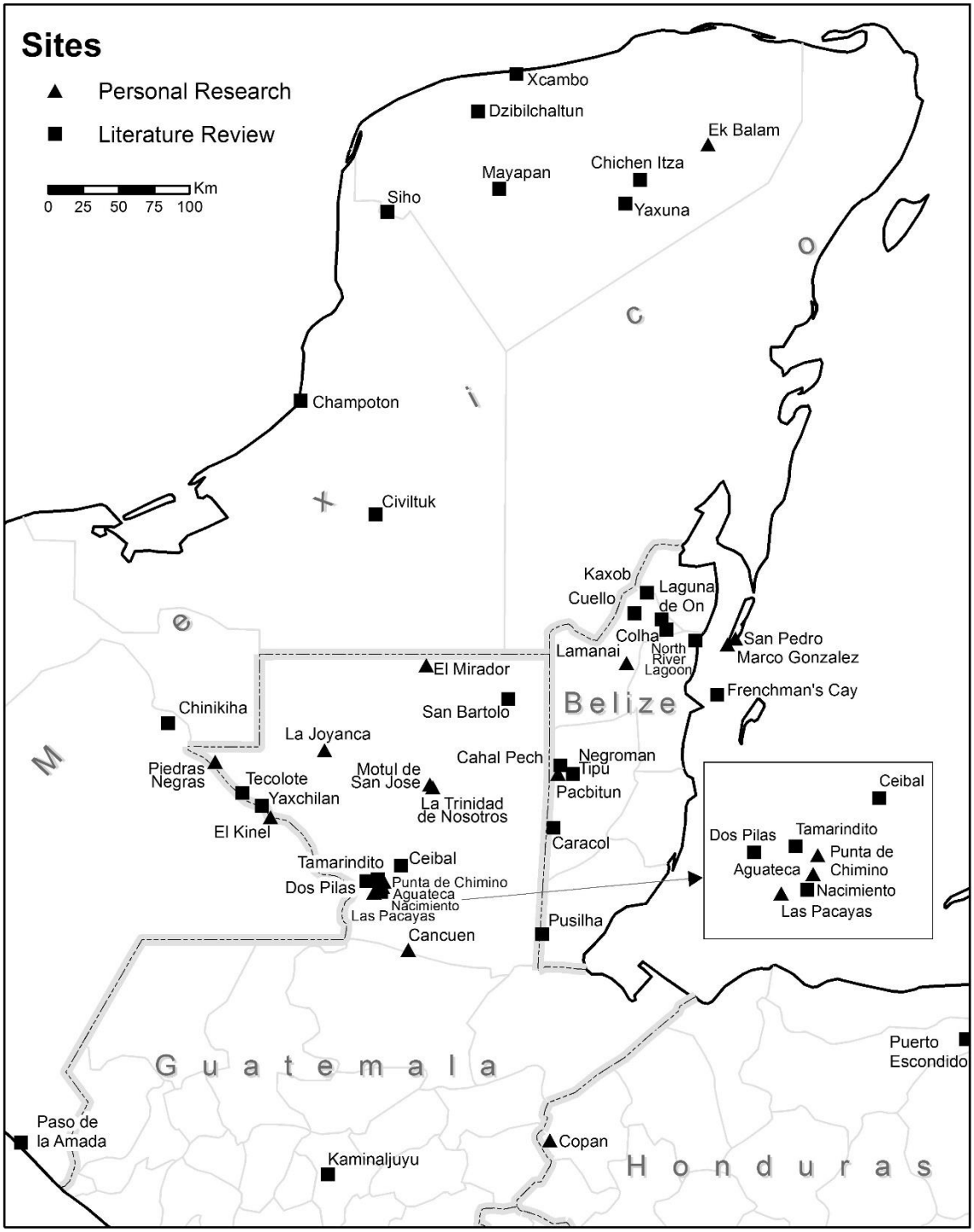


Figure 3-4 Custom map by Witschey; data from the Electronic Atlas of Ancient Maya Sites [accessed January 4, 2017] used with permission of Walter R. T. Witschey Longwood University.

3.6 Synopsis:

Use of comparative WTD specimens is a requirement for application of size index scaling and recommended for comparative assessment of stature and sexual dimorphism. Twenty-two modern WTD of known sex with complete or nearly complete skeletons originating from Florida were present in FLMNH-EAP reference collection, and independently assessed for age at death using tooth eruption, dental wear, and

epiphysis fusion. Fifteen of those specimens represent a discrete WTD population from Big Cypress Preserve in Collier County Florida (see Figure 3-1). Seven partial and one almost complete red brocket deer (*Mazama* sp.) skeletons were also assessed to develop an understanding of variations in skeletal morphology that were observed among the archaeological assemblages. The materials described above were present in the shelves of FLMNH's Environmental Archaeology Project and the FLMNH Mammal Centre at the time of data collection. Four additional WTD specimens at the Museum of Vertebrate Zoology were photographed for the purpose of illustrating bone measurements and age-related morphology described in Chapters 2 and 6.

The nomenclature for describing WTD dentition was found to be variable between disciplines. Publication for game managers list the teeth present as they were counted in the field (Severinghaus, 1949: Gee et al. 2002; Gee, 2005; Pierce et al. 2011), while the nomenclature used by anatomists references the dental formula for early mammals; the first premolar and fourth molar being absent in many higher mammals including WTD (Rumph, 1975; Hillson, 1986). My Table 3-2 is copied from Sevearinghause (1949) Table 2, and references the posterior cusp of m3 as a fourth molar incorrectly, even if his intent was to clarify a problem in recording the measurements to quantify specimen age.

Over 1100 Cervidae bones were recorded from 16 Maya sites derived from four modern nation states. The content of the archaeological assemblages tested is described with references to published faunal data and a brief overview of the sites relevance. In most cases the archaeological samples tested were fragmented to some degree, detailed descriptions of each recorded sample are presented in Chapter 7, where they are tested for stature, age at death, and sex.

Chapter 4 Querying the Question:

As described in my introduction, several attempts to establish whether WTD remains demonstrate patterns that are similar to those ascribed as evidence of animal domestication in Eurasia have been pursued. A comparison of faunal assemblages from distinct polities and differing social contexts within those polities has been pursued; as well as across multiple cultural periods that demonstrate varying levels of large game procurement across social and chronological strata (Teeter and Chase, 2004; Emery, 2004b, 2007a, 2008; Götz, 2008; Montero-Lopez, 2009; Sharpe and Emery, 2015). The taxonomic diversity of Maya faunal assemblages is very broad but also varies based on the local environment and dietary preferences (Masson, 1999, 2004; Masson and Peraza-Lope, 2008; Nickels, 2008; Sharpe et al. 2014; Sharpe and Emery, 2015). Quantification methods in archaeology usually fall under four categories: number of individual specimens present (NISP), minimum number of individuals (MNI), minimum number of skeletal elements (MNE), and bone weight, their representation in publication can vary further, being presented as whole numbers or calculated percentages of the total assemblage or of a subset of same i.e. a percentage of total mammals or total of large mammals compared to totals of medium and small mammals, rather than the total number of fauna samples. Each metric has its strength balanced by a weakness depending on the question under review.

4.1 Zooarchaeology Synthesis of Published Data:

While the raw NISP data in these sources cannot be used to determine the age and sex, or the exact number of individuals of one species compared to another in these assemblages, it has been used to infer the relative importance of the different species identified in Maya archaeology (Hammond, 1999; Emery, 2003a, 2003b, 2007a, 2008; Masson, 1999a; 1999b; 2004; Foreman, 2001).

Science is measurement (Serjeantson, 2005). Because primary access to resources is presumed to reflect various degrees of social stratification, an independent assessment of the published data for WTD representing the Maya is undertaken in this section. In that effort, I tabulated published data from 57 quantified assemblages representing 32 different Maya sites. Table 4-1 identifies each assemblage quantified by NISP, presenting NISP for large bodied vertebrates in each of the reviewed assemblages.

site ID	country	dates	period	author	page #	WTD NISP	Brocket deer NISP	Cervidae NISP	Peccary NISP	Artiodactyl NISP	Dog/canid NISP	Turtle NISP	L. Mam UIS NISP	Total assemblage NISP
Paso de la Amada	MX, Chiapas	1350-1200 B.C.	Preclassic	Wake, 2004	215-218	26	1	1	7	8	22	140	775	1390
San Bartolo	Guatemala	750 B.C. - A.D. 700	Middle Preclassic to Late Classic	Sharpe et al. 2014	92	34	5	10	19		21	50		511
La Trinidad de Nosotros	Guatemala	B.C. 700-1300 A.D.	Middle Preclassic - Early Post Classic	Thornton, 2012	334	104	21	11	17	2	21	48		10,687
Kaminaljuyu	Guatemala	700 B.C.-A.D. 800	Middle Preclassic to Late Classic	Emery et al. 2013	392-393	5		3			121	1		2518
Cahal Pech	Belize	450-300 B.C.	Late Middle Formative	Powis et al. 1999	369	15	1				3	3		2877
Puerto Escondido	Honduras	400 B.C. - A.D. 300	Middle Preclassic-Early Classic	Henderson & Joyce, 2004	230	80	4		3		0	8	104	675
Las Pacayas	Guatemala	300 B.C. A.D. 500	Late Preclassic to Early Classic	Emery, 2002	106	107	24		10	8	67	173		1283
Chinikiha	MX, Chiapas	200 B.C. - A.D. 900	Preclassic-Terminal Classic	Montero Lopez, 2013	330	178	1			68	3	2	13	269
Xcambo	MX, Yucatan	A.D. 200-900	Early-Late Classic	Gotz, 2008	157-161	105	5		9		18	417		1383
Motul de San Jose	Guatemala	A.D. 550-850	Late Classic	Emery, 2008	38	159	16	4	11		23	136	150	1020
Aguateca	Guatemala	A.D. 550-850	Late Classic	Sharpe & Emery, 2015	293-298	552	47	41	28	6	251	3283	730	12,656
Punta de Chimino	Guatemala	A.D. 550-850	Late Classic	Sharpe & Emery, 2015	293-298	115	1	3	3	1	40	116	36	947
Nacimento	Guatemala	A.D. 550-850	Late Classic	Sharpe & Emery, 2015	293-298	3		1	5		5		18	271
Piedras Negras	Guatemala	A.D. 550-850	Late Classic	Sharpe & Emery, 2015	293-298	566	17	18	31	15	85	473	848	5715
Yaxchilan	Guatemala	A.D. 550-850	Late Classic	Sharpe & Emery, 2015	293-298	742	63	3	56		37	76		1439
Tecolote	Guatemala	A.D. 550-850	Late Classic	Sharpe & Emery, 2015	293-298	5		38	13		2	15		321
El Kinel	Guatemala	A.D. 550-850	Late Classic	Sharpe & Emery, 2015	293-298	176	28		27	16	49	200	6	2475
Pusilha	Belize	A.D. 650-800	Late Classic	Nickels, 2008	34	8	2	12	7	24			46	5266
Dzibil-chaltun	MX, Yucatan	A.D. 650-1000	Late Classic to Terminal Classic	Gotz, 2008	157-161	517	11	82	71	52	6	1		1067
Siho	MX, Yucatan	A.D. 650-1000	Late Classic to Terminal Classic	Gotz, 2008	157-161	24	2	23						93
Siho	MX, Yucatan	A.D. 600-1000	Late Classic to Terminal Classic	Gotz, 2008	157-161	34		26	10		29			56
Copan	Honduras	A.D. 700-850	Late Classic	Pohl, 1995	463	35			0		124			473
Copan	Honduras	A.D. 850-950	Terminal Classic	Pohl, 1995	463	86			1		131			316
Chichen Itza	MX, Yucatan	A.D. 800-1500	Terminal Classic to Early Postclassic	Gotz, 2008	157-161	2250	91	324	31	9	49			4001
Laguna de On	Belize	A.D. 1000-1550	Postclassic	Masson, 2004	118	18	23		21		5	126		786
Isla Civivituk	MX, Campeche	A.D. 1000-1550	Postclassic	Alexander et al. 2013	297, 298	89	25	410	24		70	4366	240	6328
Mayapan	MX, Yucatan	A.D. 1000-1550	Postclassic	Masson & Lope, 2008	173, 174	10,783	1254	104	511	180	2094	107	12,177	46,771
Mayapan	MX, Yucatan	A.D. 1000-1550	Postclassic	Masson & Lope, 2008	173, 174	1482	177	24	62		248	88	5868	17,602
Champoton	MX, Yucatan	A.D. 1000-1550	Postclassic	Gotz, 2008	157-161	65	1	5	2		124	234		1717
Yaxuna	MX, Yucatan	A.D. 1250	Postclassic	Gotz, 2013	214-215	70	7	22	1		53		142	522
Ek Balam	MX, Yucatan	A.D. 1545	Historic	deFrance & Hanson, 2008	308	25	3		4		705			1316
Ek Balam	MX, Yucatan	A.D. 1600	Historic	deFrance & Hanson, 2008	308	131					2			215

Table 4-1 Archaeological sites represented in published sources using NISP data.

In many cases portions of a total assemblage had been quantified separately for chronology, or context type. These separate quantifications were retained, allowing me to sort for species, cultural period, settlement ranking, context type and rank, i.e. commoner or elite status, as well as by political affinities of each site (when reported). Figure 3-1 in the previous chapter is a custom designed map distinguishing between assemblages assessed solely from published literature and the representative assemblages from 16 Maya sites subjected to first-hand analysis and tested for evidence of sexual dimorphism, mortality, and changes in stature by this research.

Some sources identified canine remains to species while others did not, two different types of dogs (*Canis lupus familiaris*) maintained by the Maya were describe in the literature reviewed for this project and distinguishing these dogs from native fox (*Urocyon cinereoargentus*) and coyotes (*Canis latrans*) is difficult (Clutton-Brock and Hammond, 1994). Therefore, in Table 4-1 and Figure 4-1 all canids were plotted together, the same is true for turtles. Most reports did identify turtle specimens to the level of species, but harvested species varied widely between sites, marine and freshwater turtles are counted together. It is also the case that use of NISP data for turtles can be misinterpreted (Lyman, 1987). Two species of peccary are reported in the archaeology (*Tayassu tajacu*) and (*Tayassu pecari*). While these species vary by size and habitat, distinguishing between species by bone morphology is reported as precarious (Olsen,1982) and few of the reviewed sources made the attempt, thus both species were tabulated in a single column. Reviewed literature did not distinguish between the two brocket deer species, therefore the *Mazama* family is tabulated in a single column. WTD are regularly reported to species, and tabulated in their own column. While Table 4-1 also reports NISP for Cervidae, artiodactyls and large mammals unidentified to genus, these categories were not subjected to analysis, they are however included within the table for verisimilitude.

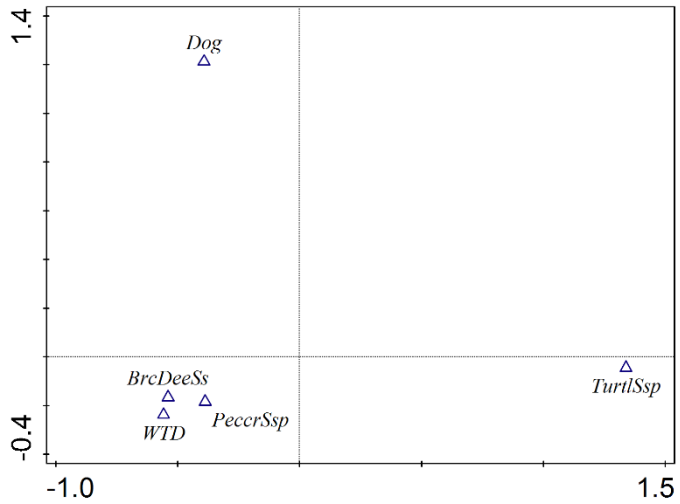


Figure 4-1 correspondence analysis for large vertebrate prey species at Maya sites reviewed.

This section makes no effort to represent the full picture of animal protein consumed by the Maya. A variety of aquatic and terrestrial sources including numerous invertebrates made important contributions to the diet (Clutton-Brock and Hammond, 1994; Masson, 2004: Foreman, 2011). The five vertebrate classes most frequently described in the literature were subjected to correspondence analysis (CA) using the Canoco software package. CA identifies variance between categories of 'things' on two axes, the more distant a category is from the intersection of these axes, the less it resembles other groups shown (Lep and Smilauer, 2003: 19; Baxter and Cool, 2010: 211). In Figure 4-1 the horizontal axis shows the assemblages reporting one or more of the five taxa selected for analysis. The vertical axis shows the NISP (number of individual specimens) for each class reported from those assemblages. Where a class of artefacts falls on the axis illustrates its relationship or its variation from other classes of artefacts represented in the graph. The intersection of axes shows where these relationships cluster. Within the chart WTD (*Odocoileus virginianus*) brocket deer (*Mazama* sp.) and peccary (*Tayassiudae* sp.) appear in close proximity to each other showing a correspondence in NISP totals and the number of assemblages in which these taxa appear, while dogs (*Canis* sp.) and turtles (*Testudines* sp.) appear as outliers, showing recovery of each of these taxa lacks a clear relationship to the other four taxa represented in the graph. The analysis in this graph is exceedingly coarse grained as it excludes chronological change, regional variation, and reduces the taxonomic richness typical of Maya fauna assemblages, however it does serve to illustrate the abundance of WTD within Maya fauna assemblages.

While correspondence analysis is often applied to biological communities (Lep and Smilauer, 2003), sufficient variables related to WTD for a more detailed approach

using this method are currently either lacking or undiscovered during this research. In the following charts WTD NISP for each assemblage was calculated as a percentage of the total NISP; assemblages were then sorted for chronology, settlement rank, and context type. As the original publications tackled a diversity of issues the data included was not always applicable to each of my questions. As can be seen in Table 4-1 above, many of the fauna assemblages reviewed lack detailed and clear chronological sequences. The number of sources that referenced context types was also incomplete. Fauna assemblages in Central America tend to be small. Abundant rainfall, high temperatures, and thriving microbial life are not conducive to bone preservation, additionally the primary destruction of animal bone for manufacture of artefacts and extraction of nutrients is implicated by the volume of faunal material too degraded for taxonomic evaluation. As is the case at any archaeological site, the recovered skeletal remains of animals allow us to hypothesize the relationship ancient peoples had with their environment. Which species are abundant, which - if any - are treated with reverence, and which seem to be intrusive or exceptional, are lines of evidence that can be followed to better understand how humans interacted with the landscape (O'Connor, 2000: 1; Reitz and Wing, 2008: 1; Valenzuela et al. 2016).

Abundance across time: it is believed large urban settlements are incompatible with diets based on naturally occurring resources. Upon this orthodoxy is premised the motivation for plant and animal domestication (Zeder, 1998). WTD are primarily edge browsers rather than grazers, and tropical grasses are particularly poor in the nutrition this species favours (Carr, 1996). Prior to the advent of forest clearance for agriculture, WTD are not abundant in archaeological deposits (Hammond et al. 1979). Dietary studies of the Ancient Maya have been published by several authors (Foreman, 2004; Emery, 2004; 2008; Williams et al. 2009). What has emerged is a variable pattern of food status and preference over space and time (Emery, 2003b; Allen et al. 2003: 625; Freiwald, 2010: 399; Sharpe et al. 2014: 93).

Assemblages attributed to specific chronological sequences are shown below, with the number of assemblages contributing to a period listed on the left. The historic samples derive from Ek Balam, the samples from that site's post abandonment phases represent a non-human deposition and are excluded in this section. Assemblages from Lamanai and Tipu are also represented during the historic period. However, as the published data is represented as MNI in those publications it cannot be directly compared to the other sites in this review or tabulated with the samples from Ek Balam.

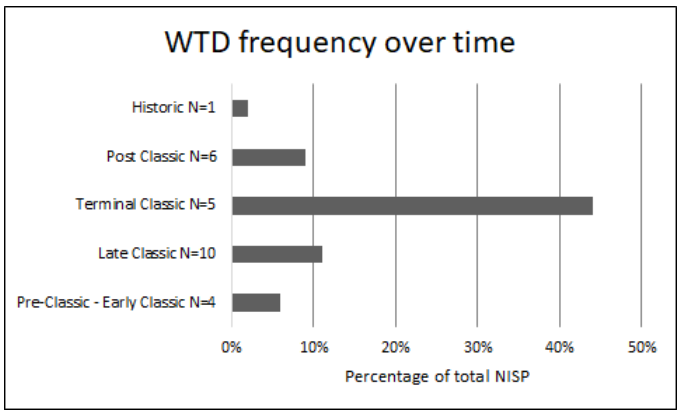


Figure 4-2 WTD consumption represented through time in archaeological deposits.

Several assemblages conflated adjacent cultural periods. The notable increase in WTD represented for the Terminal Classic assemblages as case in point, even though the literature appears to support this finding (Sharer and Traxler, 2006: 638; Aimers, 2007; Emery, 2007a). Without published data specific to the Preclassic, Early Classic, and Middle Classic periods, it is not possible to demonstrate the results shown by Emery's Table 3 and Table 4 (Emery, 2007: 189-190). In fact, because Emery (2007a) conflated the Terminal Classic and Postclassic data no such outcome is reasonable. The Terminal Classic often described in earlier literature as the Maya Collapse 800 – 1000 A.D. is frequently ascribed to environmental degradation or out of control resource consumption by the elite class. While paleolimnological and paleoclimate models indicate significant environmental change, study of human remains from the period shows no decline in health or nutrition that would normally indicate famine or dietary stress (Wright and White, 1996; Danforth, 1999; Emery, 2008). Given the level of anthropogenic activity during this period the abundance of WTD in these contexts is striking.

The Postclassic period is reported to demonstrate significant shifts in political, economic, and social organization for Maya communities (Aimers, 2007). Mythic narratives likely remained intact, while social and economic references to that narrative may have changed. Friar Landa's 1561 immolation of Maya libraries was an intentional replacement of the indigenous narrative with Roman Catholic mythology (Timmer, 1997), and its success is shown by the postcolonial adaption of the *Cuch* ritual substituting the bull and pig for deer and peccary (Pohl and Feldman, 1982), demonstrating a retention of formula but not of content.

Settlement ranking: Sites were recorded by social ranking and political affiliations when this information was available. In the figure below, rural settlements appear to consume fewer WTD than the monumental centres, but this may be more

reflective of excavation bias than primary access to resources (Fash, 1991: 27; Henderson, 1997; Sharer and Traxler, 2006) this pattern varies by region and by time (Sharpe and Emery, 2015: 289).

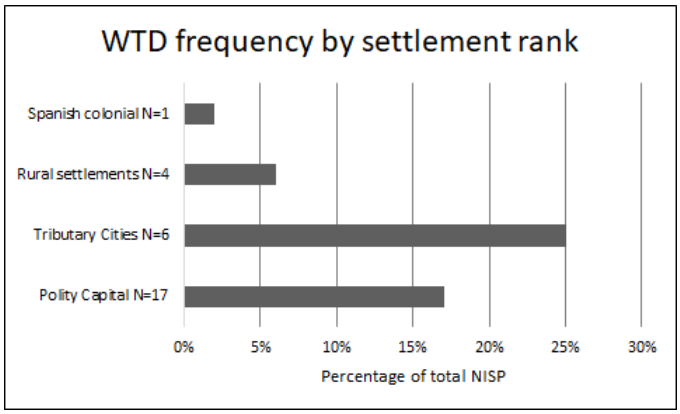


Figure 4-3 WTD consumption represented in settlements of differing political rank.

In Figure 4-3 the percentage of WTD occurring at monumental centres under the political dominance of other dynasties does not indicate deer were a source of tribute to ruling capitals.

Differential consumption by social rank: WTD are represented in the literature as high-status food for the Maya, deer bone is frequently recovered near structures associated with the elite, leading some writers to conclude venison may have been among the materials offered as tribute to the ruling classes (Carr, 1985; Nickels, 2008; Montero-Lopez, 2009) the pattern is not universal across time or space (Pohl, 1985; Sharpe and Emery, 2015: 292). Mammal bone was extensively used as a raw material for tools and ritual objects, and its concentration in proximity to site cores maybe due to the presence of artisans in the ritual precincts they served (Emery, 2009).

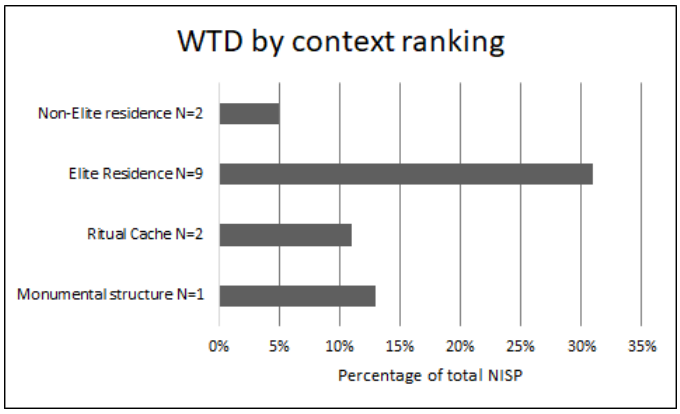


Figure 4-4 WTD consumption from contexts attributed to social rank.

Assumptions about differential access to high valued resources Emery (2003b) appear to be supported in Figure 4-3 WTD samples attributed to non-elite residences are

fewer than those attributed to elite residential compounds. This is contradicted by the literature which indicates deer bones were common in both lower ranking and the high level elite households (Collins, 2003:152; Sharpe and Emery, 2015: 289).

The function of deer bone samples recovered from ritual caches and monumental structures is elusive, as distinguishing categories of remains attributed to feasting/food offerings and those that might imply manipulation of the supernatural-orders are not clearly addressed in the sources from which the NISP data was extracted.

4.2 Deer and deer ecology:

This section offers an overview of deer species naturally occurring in the Maya culture region, their habits and ecological requirements, and how these attributes might influence the interactions between these animals and the human communities sharing the landscape. First this section discuses species identification and why that is important to the topic of this research.



Figure 4-5 Deer species: source http://consejo.bz/belize/herbivores/herbivores.html. Left WTD (Odocoileus virginianus), right red brocket deer (Mazama temama).

Species: there are three native deer species present in the Maya region, WTD (*Odocoileus virginianus* ssp.), red brocket deer (*Mazama temama*) and brown brocket deer (*Mazama pandora*). The taxonomy of brocket deer species is currently being revised; Geist (1998) describes Central American red brocket deer as a separate subspecies *(Mazama americana temama)* without any description of the differences or the logic motivating a change in taxonomy. Escobedo-Morales et al. (2016) tracing mitochondrial DNA identifies the Central American red brocket as *(Mazama temama)* and the Yucatan brown brocket *(Mazama pandora)* and proposes these species are distinct from either red or brown brocket deer clades found in South America (Medellin et al. 1998; Weber and Gonzalez, 2003: Varela et al. 2010; Groves and Grub, 2011; Conteras-Moreno et al. 2015). It is worth noting most of the post-cranial skeletal

elements for brocket deer I examined at FLMNH were listed on their cartons as *Mazama americana*.

Despite his admonition that Landa (1566) frequently borrowed sections of text from other writers, Tozzer (1941: vii) citing Genet (1934), Tozzer (1941: 127) identifies the word *Corzo* as referring to white-tailed deer *(Odocoileus virginianus)*, due at least in part to Landa's (1566) reference to a small shy forest goat '*casta de cabrillas monteses pequenos y muy lingeras'* (Landa, 1566: 107). Which Tozzer (1941) assumed satisfactorily identified brocket deer in the original Spanish text, pursuing the possible identification of deer species within the that text no further. *Corzo* is the Spanish designation for roe *deer* (*Capreolus capreolus*). The Landa text (1566:57) uses the word *corzo* only in this single paragraph. All other descriptions of deer use the word *venado*, usually understood within Spain as red deer (*Cervus elphas*)*;* the translocation of the Spanish language to the New World and its species may account for this discrepancy. However, Tozzer's (1941) translation accounts for two deer species on the landscape when in fact three deer species are present, leaving open the question of which species/type of deer is being described in the original Spanish text.

Distinguishing between related species is difficult and sub-species are largely invisible to archaeology (Bossneck, 1996). Within Maya archaeology species identification for deer has mostly been determined by size, brocket deer typically being smaller than WTD. However, modern WTD within the size range of brocket deer have been observed (pers. com. Kitty Emery, 2015). Several of the Maya faunal reports reviewed for this project classify all Cervidae together and none distinguish between red and brown brock deer. Academic articles describing brocket deer habits and social organization were few, and brocket deer appear to have been understudied. Discovered literature of distinctions between species are limited to genetic analysis, and cranial morphology, no sources were identified describing post cranial skeletal elements. Whitehead (1972) describes red brocket deer as preferring virgin rainforests and the brown brocket native to the Yucatan peninsula as preferring the dry tropical and scrub forests. Brown brocket deer are more cursorial than red brocket (Geist, 1998: 119; Whitehead, 1972: 57). Citing Leopold, (1959) 'females are virtually as large as the males' and they occupy forage patches either singly or as mated pairs (Whitehead, 1972: 58-59). Maturity is early, with females reproducing as early as eleven months (Geist, 1998: 118). The early literature asserts brown brocket deer are smaller than red brocket deer, but Medellin et al. (1998) describes the brown brocket deer of Yucatan as

larger than the sympatric red brocket (Medellin et al. 1998: 6). The information discovered from early sources is suspect, as I cannot be certain whether descriptions of *Mazama americana* are describing the brocket deer from Mexico and Guatemala or those of South America; this is equally true for species of brown brocket deer (*Mazama pandora*) described in earlier literature as *Mazama gouazoubira* and *Mazama nemorivaga*.

While not the intention, this research has identified some distinctions in skeletal morphology between WTD and red brocket deer that have not been previously reported in archaeology (see Chapter 6). This finding was unexpected but not surprising, as forage patterns and predator avoidance strategies between these species are distinct enough for archaeologist to have used the relative abundance of one species compared to another as a proxy for local environmental conditions and land management regimes (Emery et al. 2000). Additionally, morphological differences between WTD and the closely related black-tailed deer (*Odocoileus hemionus*) have previously been identified (Jacobson, 2003).

WTD, however, are well studied, particularly populations in the United States, where they are a primary game species and generate considerable revenue from recreational hunting. This species probably first evolved in Central America, spreading to the North and South American continents thereafter (Miller et al. 2003: 906). WTD are regularly described as a woodland species or as edge browsers, but they inhabit a wide variety of habitats from dense woodlands to open range grasslands. Ready adaptation to seasonal and geographic opportunities is a species trait (Hirth, 1977; Miller et al. 2003). WTD populations associated with the Maya are the focus of this research, while most of the published papers concern animals in the United States and Canada some work has been done on modern deer populations in Mexico (Jorgenson, 1995; Mudujano and Gallina, 1996; Bello et al. 2001; Santos-Fita et al. 2012).

Feast or famine: plant species regularly defend themselves with an array of spines, thorns, toxins, and organic structures to avoid predation by herbivores (Palo and Robbins,1991; Hanley et al. 2007). In northern latitudes, seasonal shifts in solar radiation limit these defensive strategies (Huston and Wolverton, 2011). A considerable body of literature has been devoted to how WTD take advantage of these seasonal fluctuations (Hirth, 1977; Purdue, 1987; Beier, 1987; Beier and McCullough, 1990; Grenier et al. 1990; Wolverton, 2005; Main, 2008; Therrien et al. 2008). In tropical regions, the growing season is a function of rainfall rather than solar radiation. WTD in

all habitats typically forage on young leaves, shoots, fungi, fruit, and nuts (Miller et al. 2003; Mandujano and Rico-Gray, 1991) and have been observed preying on eggs and fledglings (Stribling, 1996). They are opportunistic and experimental in their foraging habits (Miller et al. 2003; 912-913). The feeding behavior of WTD has both positive and negative impacts on natural ecosystems from seed dispersal to reduction of species diversity. Ecological damage can be catastrophic when deer populations are allowed to grow unchecked (Roony and Waller, 2003: Wolverton et al. 2007).

Available nutrition is a primary factor affecting growth, sexual maturity, reproductive success, health, and longevity for all species. Archaeology has detected significant shifts in the stature of WTD over time. Using astragali, Purdue (1987b) describes changes in deer stature during the middle and late Holocene, coinciding with denser human settlement and the establishment of horticulture. He argues it was increased summer precipitation and resulting improved plant growth that caused late Holocene populations of WTD to increase in stature (Purdue, 1987b: 314). Compton (2000) records Late Colonial period deer astragali are sufficiently smaller than astragali from the Early Colonial period to indicate either a change in the demographic profile of animals being harvested or a shift in deer foraging success, and discuses several reasonable explanations for this change in deer populations without drawing any conclusions, but does not consider the impact of European disease on indigenous human populations or how such changes would affect agricultural and land management strategies. While several variables related to WTD stature are considered by these authors, their assumption that human impact on deer stature is limited to hunting pressure is less than wholistic.

However, ‘Isotopic Analysis of Ancient Deer Bone’ corrects this oversight using the proportions of $^{13}C/^{12}C$, to estimate changes in land use regimes by the ancient Maya (Emery et al. 2000: 545). Ethnographic sources on deer hunting by modern Maya show forest clearance favors WTD while primary forests favour brocket deer in the same regions (Mandujano et al. 1991; Jorgenson, 1995; Escamilla et al. 2000 Naranjo et al. 2004). Wolverton (2008) also tests environmental carrying capacity for WTD in central Texas. Comparing modern samples from populations managed by recreational hunting at Fort Hood TX, with samples from a population not subject to hunting or management in suburban areas of Austin TX, he found the unmanaged population was significantly smaller in stature than the managed population. These findings suggest that managed predation of WTD produces a population at optimum fertility and sustained growth;

while WTD populations not subject to predation experience a decrease in fertility, stature, and sexual dimorphism (Wolverton et al. 2007; Wolverton, 2008).

Fight or flight: in all published articles, the role of dense cover as shelter for sleeping animals and as the concealment of newborns is emphasized (Bello et al. 2001; Escamilla et al. 2000; Hirth, 1977; Lingle, 2001; Mandujano and Rico-Gray, 1991; Mandujano and Gallina, 1996; Naranjo et al. 2004; Purdue et al. 2000; Schafer and Main, 1997). Defensive concealment is perhaps a dominant strategy; rapid flight is another. WTD employ a rotary gallop when fleeing predators attaining speeds from 24 to 35 MPH for short distances, though speeds up to 40 MPH have been recorded (Miller et al. 2003: 909). The front toes of WTD are larger than the rear toes (Miller et al. 2003: 909). Discovered literature did not describe the skeletal morphology of either species of brocket deer.

Social behavior is another defensive strategy described by biologists; shared vigilance and diluted risk are theories used to describe this behavior. Within the United States the distribution of WTD has expanded and population density has increased, especially in suburban areas (Creacy, 2006; Miller et al. 2003: 906). Adult deer easily jump fences up to seven feet tall (Miller et al. 2003: 909) making suburban yards and plantings prime habitat. Most deer predators avoid towns and cities, so this too is a form of predator evasion. The basic WTD social unit is the dam, her current offspring and yearling daughters from the previous season. Males socialize in pairs or groups as large as five individuals except during rutting season. In more open terrain these groups may congregate while feeding (Hirth, 1977; Lingle, 2001; Miller et al. 2003). Unlike the closely related black-tailed deer *(Odocoileus hemionus)* WTD do not employ a defensive group posture when confronted by a predator, scattering in multiple directions and relying on speed to evade predation (Lingle, 2001: 297).

Birth and Death: Cervidae are distinguished from other ungulates by the annual generation and discarding of antlers. This process is synchronized in northern populations with seasonal changes in day length. In regions without an annual shift in solar radiation, antler-genesis is asynchronous. In all regions, the shedding of velvet signals a male's entry in to rut (Goss, 1970: 231; Miller et al. 2003: 908). Tropical deer populations do not have the synchronized breeding and birthing seasons typical of northern populations; there is however evidence that hormones secreted by males may trigger ovulation in females (Miller et al. 2003: 911). Fawns with exceptional nutrition may engage in breeding during their first year, though males typically are unsuccessful

until they reach full mass near their fourth anniversary. Females in environments with limited nutrition might not produce offspring until their third year. WTD do not achieve full skeletal fusion of all long bones until 38 months of age (Purdue, 1983b; Flinn et al. 2013). Pregnancy, lactation, and antler-genesis are physically challenging and may delay or limit skeletal growth. For male and female WTD, adult size is one aspect of social ranking and reproductive success.

Forest environments are considered less productive than grasslands, and woodland species typically are more dispersed in their habits (Hirth, 1977). In this species, adult females occupy and defend a forage patch to maintain themselves and their offspring, producing between one and three fawns each year depending on available fodder. Immediately prior to birth the hind will eject the previous year's young from her territory. Daughters may return to the maternal patch after the new fawns are weaned but yearling stags will form bachelor groups and disperse (Beier and McCullough, 1990; Bello et al. 2001; Hirth, 1977; Mandujano and Gallina, 1996; Schafer and Main, 1997). Daughters establish a forage territory prior to delivery of their first fawn, usually near the maternal patch (Purdue et al. 2000). The successful rearing of offspring is dependent on competition between hinds for areas of productive forage.

A chief characteristic of WTD described in the literature is their ability to colonize new landscapes and discern forage with the highest nutrient value (Geist, 1971, 1998; Miller et al. 2003). Members of this species may live in captivity until 15 or 18 years of age (Miller et al. 2003). Within populations not subject to trophy hunting, stags age eight to ten reportedly enjoy the greatest reproductive success. Males court females nearing oestrus for several days before and after copulation (Hirth, 1977: 41). Unlike grazing ungulates WTD do not migrate between pastures, social organization is limited, defensive strategies are orientated toward individual rather than the collective, and reproductive strategy is organized by overlapping individual territories. Based on these parameters a direct comparison of Eurasian animal domestication and the domestication of WTD seems problematic, but not impossible. Not all domesticates fit the herd and pasture model, geese and pigeons form mated pairs, chickens and pigs are omnivorous, rabbits have no communal defence strategies. These animals are part of the farm yard pattern and their maintenance often falls to women (Reitz and Wing, 2008: 296).

4.3 Synopsis:

The literature reports WTD were a favoured prey most often found in elite contexts, and that consumption increased from the Preclassic until Late Classic and

Terminal Classic periods. Published accounts of 45 Maya sites presented data on 60 quantified assemblages, 36 of these sites offered NISP data that could be compared and calculated to demonstrate changes in the role of WTD in Maya society. The graphs presented show changes through time and differentiation by social ranking of settlement type and social rank, but show little variation between polity capitals and tributary cities in WTD frequency. Ritual caches, cave shrines, and monumental structures, include remains associated with tombs and dedicatory caches showing WTD were significant in religious ritual. Emery (2007a) and Sharpe and Emery (2015) report similar findings and tests for consumption by time-period and social status are loosely comparable, the data tested in this section is drawn solely from published papers and book chapters while Emery employed published material in combination with unpublished data to increase the total number of samples and number of assemblages represented in that paper.

Optimum foraging theory predicts nutritional demand. However, animals are harvested for a variety of products beyond food, raw materials for tool, craft, ornament production, medicine, markers of social class and political power, among them (Emery, 2007b: 191). The cosmological significance of deer to the Maya is frequently raised in published articles but not discussed in any depth, and though the subject falls more in the realm of anthropology than archaeology, it is almost certainly a point of entry to Maya concepts of both social organization and cultural identity. The reproductive strategy and social organization of WTD indicate a poor match for the herd and pasture model typical of domesticated hooved mammals, but more intensive forms of animal husbandry remain possible. Maya cultural narratives identify important intersections between deer, maize, the natural forces personifying supernatural beings, and culture heroes, indicating a relationship between deer and Maya cultural identity. Control of that narrative would be a vital attribute of political and social influence.

Having discussed how deer are represented in the archaeology and the natural attributes of these species, this thesis returns to the reference collection of modern deer in Chapter 5 for a detailed examination of how sex and age class may be represented in the bones recovered by archaeology.

Chapter 5 A baseline study:

In order to understand how the deer bones recovered by archaeologists can best be identified to species, sex, age cohort, and regional variations in stature, it is essential to test these qualities using reference materials where those variables are known qualities. This chapter addresses variations in stature between WTD from the five Florida counties which contributed modern specimens selected as reference materials for this investigation, and compares those specimens for regional variations in stature. The chapter proceeds by examining a subset of specimens from Big Cypress Preserve presuming they represent a coherent regional deer population, testing these individual specimens by sex and age cohort using metric comparision for evidence that may best identify these qualities among archaeological samples.

5.1 Variations in WTD stature:

Understanding how human landscape management impacts stature in this species is addressed first. Florida is a large U.S. state with diverse ecotones including savanna, freshwater wetlands, large estuarial systems, and several types of forest. While much of the state is devoted to agriculture, some counties are among the most densely inhabited in the United States. Figure 5-1 shows the adult specimens from three of the five Florida counties (see Figure 3-1). Specimens from another two counties, Broward N=1 and Marion N=3 were exclusively sub-adults and are not shown here, they are however represented in Figure 5-7 showing all Florida specimens.

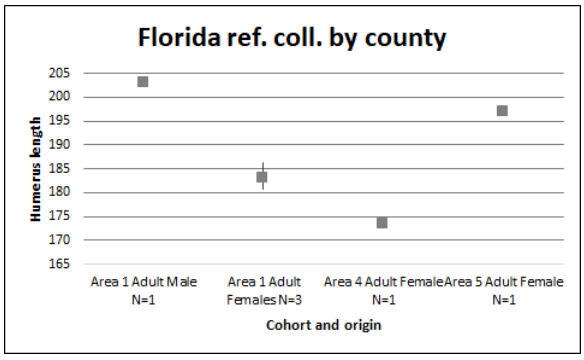


Figure 5-1 Comparison of humerus length measurements for Florida counties.

The greatest length of the humerus was chosen for this test as the proximal epiphysis fuses after skeletal growth is relatively complete. The length of a long bone can be used with regression equations to determine an individual's height (White, 2000: 371). This was not attempted as the method requires a substantial and well documented baseline population for comparison, and while such studies are common for domesticated animals they remain rare for wild animal species.

Humerus length is examined by county and sex. Seven adult specimens are represented, one adult male and four are adult females are from Big Cypress National Preserve in Collier County FL (area 1). A single adult female from Apalachicola National Forest in Liberty County FL (area 4), and an adult female from Camp Blanding Military Reservation in Clay County FL (area 5) are compared with each other in the chart above for GL (greatest length) of the humerus, length measurements of this element were not available for sub-adults. Specimen z: 4571 (adult male) has the longest humerus and is presumably the greatest withers height. The adult female from Clay County z: 2850 (area 5) is also quite tall. Specimen z: 4567 from Area-four is the smallest adult individual, see Figure 3-1 in the previous chapter, Figure 5-4 and Figure 5-5 below. The adult female humeri from Area-one range between 181mm and 186mm in length.

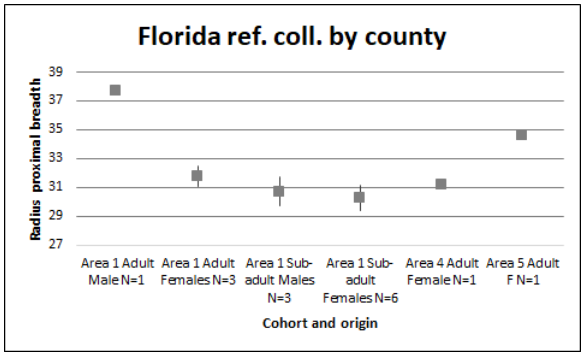


Figure 5-2 Comparison of proximal radius breadth measurements for three Florida counties.

In addition to population height, it is necessary to test skeletal morphology by sex and age cohort. Proximal measurements of the radius were selected for this purpose (see Table 3-11). In Figure 5-2 specimen z: 2850 from Area-five plots between the large male and females from Area-one, specimen z: 2773 sub-adult female from Area-five plots as comparable in breadth measurement to the specimen z 2850 but lacked even partial fusion of the proximal humerus and distal radius and was therefore excluded from these graphs, while Specimen z: 4567 from Area-four is within the same range of breadth measurements as the females from Big Cypress. Sub-adult males and females from Area-one average slightly below adult females; there is however some overlap.

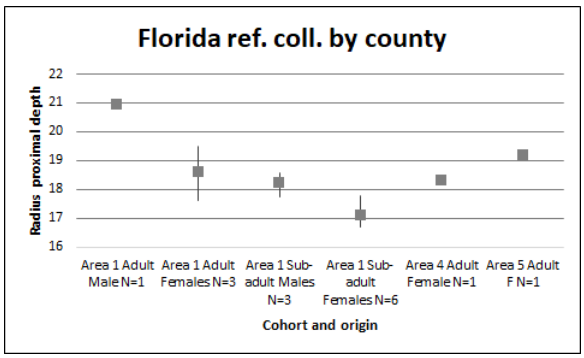


Figure 5-3 Comparison of proximal radius depth measurements for Florida counties.

Figure 5-3 compares specimens by proximal depth of the radius; the adult females all seem to fall inside the same range for depth measurements, the adult male plots above, and the sub-adult females plot almost consistently below all other individuals.

The sample size is small and additional investigation into the modern collections is required to determine if these individuals are representative of the populations in these counties (Damuth and Macfaden, 1990; Messner, 2011).



Figure 5-4 Comparison of vegetation management regimes for Liberty County left, Clay County right: sourced http://www.floridacountiesmap.com.

WTD flourish in disturbed habitats, on the right side of Figure 5-4 Camp Blanding (area 4) is shaded in grey. It is not possible at this time to say how much disturbance of the soil and vegetation would result from human activity on a military reservation but it is almost certainly greater than is the case at either Apalachicola National Forest, on the left and shaded in green, or at Big Cypress National Preserve in Figure 5-5 below.



Figure 5-5 Collier County and Big Cypress National Preserve.

Variation in deer stature between these counties is a factor that must be considered when comparing the deer remains recovered by archaeologists. The stature of WTD varies by region and time (Purdue, 1987b; Purdue and Rietz, 1993; Wolverton, 2005). The proposition that WTD stature is so variable among contemporaneous populations when rainfall patterns, climate, and terrain are relatively consistent across these landscapes is surprising. The most obvious variable is human activity. Big Cypress Preserve (area 1) is in Collier County in south east Florida. Land area is 5246.02 km^2 of which 2916 km^2 is occupied by the preserve (National Park Service). The human population was 410,297 in 2015. Collier City (area 2) in Broward County is a community now incorporated into the city of Pompano Beach, population 150,000. Marion County (area 3) in Central Florida has 4110 km^2, with a population of 331,298. It is a fair supposition that plant communities co-evolving with WTD could be more resistant to these browsing herbivores than introduced plant species propagated for economic production, but other factors almost certainly play a role in deer stature.

Adult females	Hum. GL	Hum. Bp	Hum. Dp	Rad. GL	Rad. Bp	Rad. Dp	Fem. GL	Fem. Bp	Fem. DC	Tibia GL	Tibia Bp	Tibia Dp	
z:4580	180.78	38.58	43.31	203	31.24	18.13	217	48.8	22.15	264	47.38	47.54	
z:4573	182.39	39.69	50.16	204.71	32.51	19.09	216	50.87	21.97	267	48.28	54.77	
z:4703	186.17	41.72	46.9	194.53	31.08	19.51	227	50.19	22.11	274	49.43	56.03	
Averaged	183.11	40.00	46.79	200.75	31.61	18.91	220	49.95	22.08	268.33	48.36	52.78	
Adult male													
z:4571	203.03	48.43	57.79	218	37.63	20.96	247	58.71	25.55	288	52.24	56.23	Difference
percentage	111%	121%	124%	109%	119%	111%	112%	118%	116%	107%	108%	107%	113%

Table 5-1 Expression of sexual dimorphism at Big Cypress.

In the literature reviewed for WTD, sexual dimorphism for the species was described as 25 to 35 percent (Miller et al. 2003). Table 5-1 shows the bone measurements of four adult WTD specimens from Big Cypress (area 1). Comparison of the male specimen's long bone measurements to the averaged metrics for the adult females from the same area shows the male specimen is approximately 13% larger than the adult females, but only 10% larger in terms of long bone length. This suggests that bone length alone is not necessarily diagnostic of sexual dimorphism. Wolverton (2008) indicates insufficient hunting pressure may negatively impact available forage, reducing both population stature and sexual dimorphism. As these specimens derive from Federal lands that are annually open to managed deer hunting (National Park Service), overpopulation seems an unlikely cause for smaller stature or reduced sexual dimorphism in these populations.

5.2 Applying Log Ratios to Questions of Sex and Age:

In this section, the specimens are tested for evidence as to how sex and age might manifest in the archaeological materials evaluated in this project. As has already been shown, stature can vary between populations and this may be dependent on the nutrient value of available forage. The demographics of any selected population are often represented as averages rather than absolute numbers. The use of averages makes comparisons between populations possible when one or more variables such as habitat size or precipitation rates are not directly comparable. Log ratios were selected as a relevant statistical method to evaluate the differences between paleo-populations of WTD studied for this project. Before this method can be applied to archaeological materials it is necessary to interpret what log ratios reveal about the reference specimens.

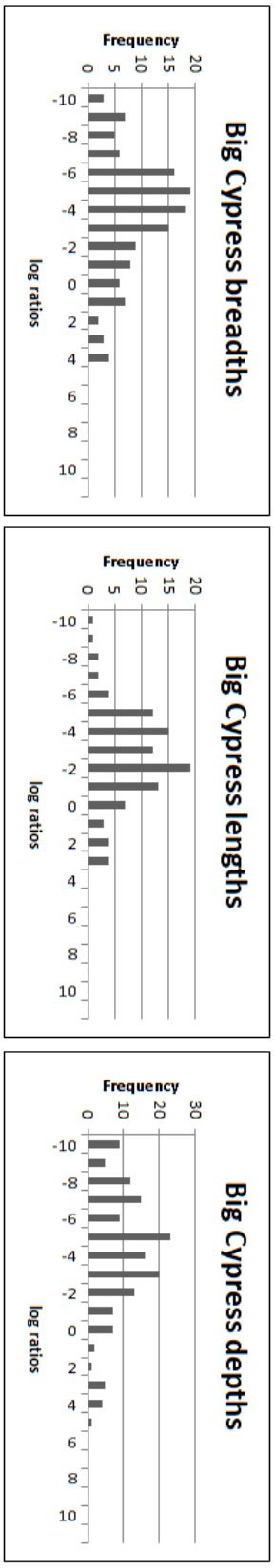


Figure 5-6 Log-ratios for specimens from Big Cypress Preserve – Area-one.

The largest sample comes from Big Cypress Preserve in Collier County, representing three sub-adult males, five sub-adult females, four adult females, and one adult male. Four adult specimens from Big Cypress were selected as the Standard (see Table 2-1), the Mean for their measurements in each anatomical plane is represented as

zero in the histograms. The resulting log ratios show how far and in what direction (greater or smaller) a sample diverges in size from the Standard. A fourth adult female (z:4705) displayed a mix of adult and sub-adult traits and was excluded from the Standard but is included as an adult in the scatterplots in the next section.

Keeping in mind the ratios are multiplied by 100, a comparison of the ratios generated for the Standard with those for the other specimens appears to be useful, and will be used to frame my interpretation of the archaeological samples presented in chapters seven and eight. The male specimen z: 4571) generated log ratios for breadth from 3.98 to 0.39, the log ratios for length range from 2.63 to 0.87, and log ratios for depth of 4.25 through 1.33, showing he is larger in all planes than the Mean used to generate the standard. The three adult females show breadth ratios ranging between 0.95 and -5.73, length ratios of 0.08 thru -5.05 and depth ratios from -0.78 to -8.91, showing that some skeletal-elements from these specimens exceed the standard ratio while other elements appear below -5 on that scale. Sexual dimorphism does appear to be relevant in evaluating these specimens, the visibility of that trait is less than expected and that has implications for distinguishing males from females in the archaeological assemblages. The ratios for any specimen vary by element; this diversity is a product of using the Mean to generate the ratios applied to each skeletal-element.

Measurements for sub-adult WTD are variable as shown in the XY graphs Figures 5-8 thru 5-26 that follow in the next section. Sub-adult males show log ratios for breadth between -4.22 and -8.0, absent any completely fused long bones -- the length of the astragalus is the only viable ratio in the plane for length for these three specimens and ranges between -7.51 and -9.83. The sub-adult females offer log ratios for the same element from -2.80 to -7.42; the lowest ratio for length is from specimen z: 4708, the youngest of the sub-adult females (See Table 3-5). The other five sub-adult females are 12 months older than any of the sub-adult males from Area-one; this appears to be significant (see Figure 5-8). Log ratios of breadth for sub-adult females range from 1.33 through -11.21, with length ratios between -2.8 to -13.17. The log ratios in the depth plane for sub-adult males fall between -0.80 and -11.03 with sub-adult female depth ratios between 0.52 through -13.99. As the astragalus is the smallest of the skeletal elements subjected to statistical analysis, the above ratios derived for that element demonstrate it is the scale rather than the measurements that produce the variation seen in the histograms.

While not without value, the unrestrained range of ratios generated are difficult to interpret. However, confinement within a log-scale as seen in Figures 5-6 and 5-7 produces easily visible patterns. The chart for depth shifts away from the Standard with a spike in frequency at -10. Since the scale limits the dispersal of ratios, this pattern is significant. As was the case in Figure 5-3 (above), it suggests bone growth is not symmetrical on all planes and indicates measurements taken on the depth plane may be more diagnostic of ontological age. Additional evidence for this hypothesis is shown in the scatterplots that follow.

Figure 5-7 shows the log ratios in each plane for 179 skeletal-elements representing 22 specimens from the reference collection. These charts compare all the recorded specimens from Florida, including sub-adults from Broward, Marion and Clay counties. The addition of two female adults and five sub-adults from four counties increases the frequency of ratios near the zero but does not alter the pattern for breadth, length, and depth seen in Figure 5-6.

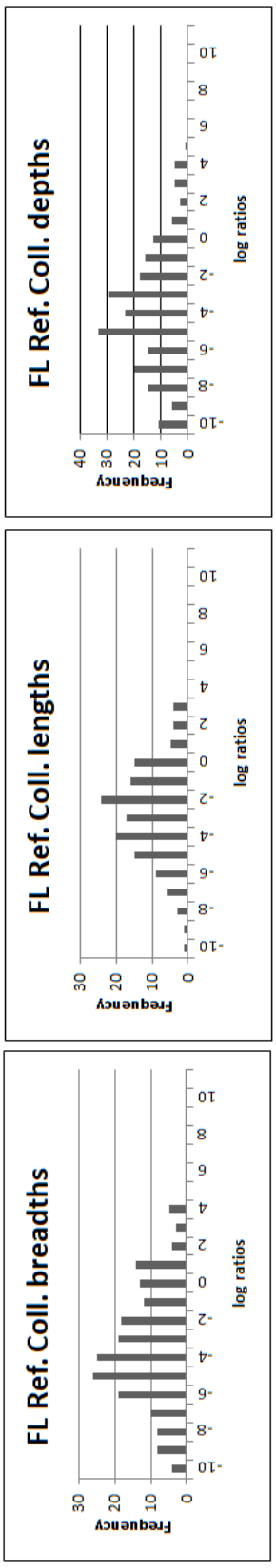


Figure 5-7 Log ratios for FLMNH-EA WTD reference collection.

Figures 5-1, 5-2, and 5-3 showed variations in stature between the adult specimens from three Florida counties. Figure 5-7 offers an understanding of how that type of variation may appear within the charts for log ratios. One adult female, Specimen z: 2850, and one sub-adult female, Specimen z: 2773 from Clay County (area

5), were both larger than the females from Area-one. Despite the lack of any completely fused long bones (see Table 3-4) z: 2773 plots very near the adult male, data not shown (see Digital Appendix II). However, the use of ratios here may suffice to prove the point. Breadth ratios for this specimen range between 0.51 and -4.38, while the adult female shows a breadth range between 0.99 and -5.98; in the length z: 2773 presents a single length ratio of -0.82 for the astragalus, while Specimen z: 2850 shows a log ratio of -0.29 for the same skeletal-element. Other length ratios for the adult female range between 0.87 and -1.06. For depth, Specimen z: 2773 shows a range between 0.97 to -4.64 and Specimen z: 2850 displays a range between 3.68 to -6.83, demonstrating that both individuals are larger in the breadth and depth planes than the Area-one females despite z: 2773's status as a sub-adult.

The smallest of the adult females, Specimen z: 4567 from Liberty County from Area-four offers a contrasting set of - numbers. In Figures 5-2 and 5-3, breadth and depth *measurements* for this specimen's radius appeared within the same range as those for Big Cypress's adult females. However, log ratios for breadth range between -4.16 to -10.73 and are more comparable with the sub-adults. Direct comparisons showed this was true for some but not all skeletal-elements. This specimen generated log ratios for length ranging from -2.95 to -8.73 and depth between -3.68 and -9.48; a comparison of these ratios with those generated for the females from Clay County supports the posit that land management regimes are relevant when assessing stature in modern WTD and presumably archaeological samples. These comparisons for variations in stature of the modern specimens can now be applied to interpretation of fauna samples.

5.3 Comparing the Metrics

The osteometrics studies on WTD by Purdue (1983b), Wolverton (2008), as well as the measurements more general to artiodactyls, Von Den Driesch (1976), Davis (1996), and Popkin et al. (2012) are used to comparatively evaluate the modern reference specimens for sex and age. A chief criterion for the modern WTD specimens included in this reference collection was skeletal completeness. Each of the skeletal-elements in the collection yielded a set of measurements that could be applied to the archaeological samples; the selection of which measurements could yield the greatest amount of detail regarding sex and mortality profiles for the archaeological assemblages was a prime concern. Based on previously published literature and the quality of sample preservation, a variety of measurement combinations were attempted. XY scattergrams were selected as the clearest means for representing the dimensions of the bones and

their relationship to the sex and age of the specimen being tested. In this section the most relevant of these combinations are presented in the following scattergrams along with clarifications regarding the selection of measurements and what qualities they demonstrate.

5.3 i Astragali:

Because astragali are so well represented in archaeological assemblages and consequently the literature of zooarchaeology, this section begins with that skeletal-element. Von Den Driesch (1976: 88) lists five measurements for artiodactyl astragali, and Purdue (1987b) lists six measurements for WTD. In bi-variate charts, various combinations produced several patterns. Figure 5-8 shows two combinations using Purdue's devised ASLEN (astragalus length), designated in this paper as Lcc (length of the central constriction). His argument that this feature is the least likely to degrade after deposition in sediments is sound. Purdue's (1987b) statement, 'ontological age can be ignored because the astragalus is near adult size in six-month-old fawns. In contrast, the bones differ between sexes' (1987b: 308) is not supported in Figures 5-8 through 5-10. All individuals in this reference collection are at least 12 months old. The sub-adult males plot among the adult females and in two graphs the sub-adult females plot distinctly from either sub-adult males or mature females. This includes sub-adults with partially fused proximal humerus and distal femora. Specimen z: 4571 is assessed as an adult male even though the individual demonstrates a mix of adult and sub-adult traits; that specimen appears consistently in the upper right-hand corner of the scatter plots proving it is the largest individual from Big Cypress Preserve.

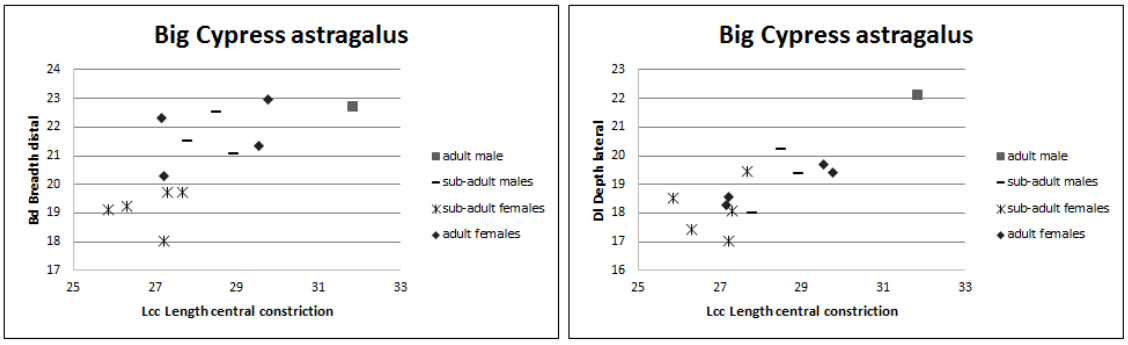


Figure 5-8 Astragali, left Purdue (1987b) right Wolverton (2008).

While Purdue's (1983b) original measurement above does show separation between the single adult male and the other individuals from Big Cypress, there is little variation between other specimens on this axis to demonstrate differences by either sex or age category. On the left side of Figure 5-8 the vertical axis shows measurements for the Bd (breadth distal). While sub-adult females plot below all other specimens, there is

little distinction on this axis between the male specimens and the adult females. On the right side of the same figure, Lcc is paired with the Dl (depth lateral) of the astragalus per Wolverton (2008). Lateral depth shows a very strong distinction between the large male and all other specimens from Big Cypress. However, it does not show any marked distinctions between adult female specimens and sub-adult males.

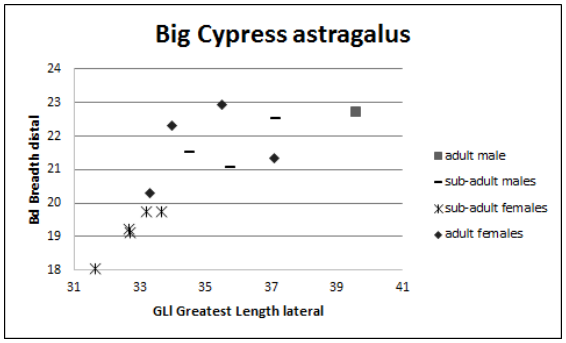


Figure 5-9 Astragali GLl and Bd per Sykes et al. (2011).

In Figure 5-9 the Bd (breadth distal) is paired with the GLl (greatest length lateral). Using this comparison, the sub-adult females appear in the lower left corner of the graph, while the horizontal axis (length) separates the adult male from all other specimens. This combination was used in the study of Fallow Deer (*Dama dama*) to show variation in the species by region (Sykes et al. 2011).

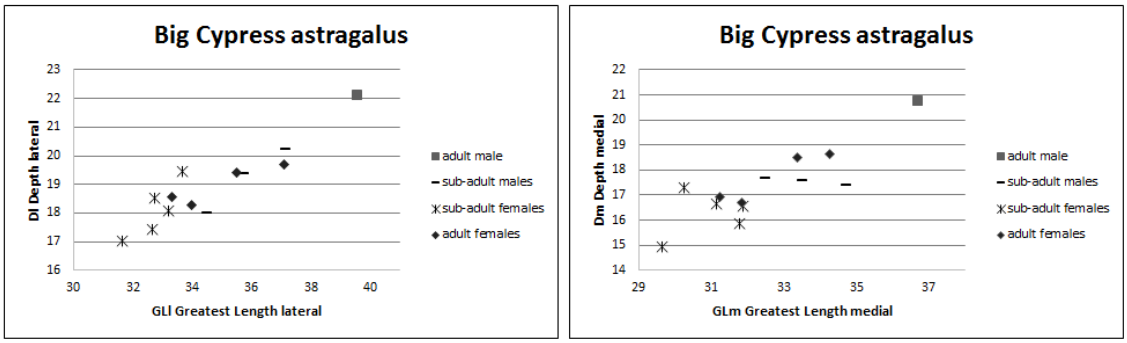


Figure 5-10 Astragali, left GLl and Dl, right GLm and Dm.

A principal goal of this study is to distinguish the ratio of males and females harvested by the ancient Maya. The GLl (greatest length lateral) and Dl (depth lateral) on the left side of Figure 5-9 appear to show the clearest separation between the adult male and sub-adult females. On the right, the GLm (greatest length medial) and Dm (depth medial) show the oldest females, z: 4703 and z: 4580, are very slightly larger on the depth plane than the sub-adult males, while the youngest of the sub-adult females, z: 4708, assessed as 12 months, old appears in the lower left corner of the graph for medial measurements of the astragalus. Use of the medial measurements with the reference

specimens appears to offer slightly more clarity in terms of age class than is visible for the lateral measurements.

Proximal breadth of the astragalus was observed to vary considerably between individuals and, while not a standard measurement, it was recorded. However, in this sample it failed to consistently plot within any sex, age, or regional cohort and therefore is not presented here; the fault may be the small size of the collection, or the degree of individual eccentricity may be too great for this measurement to be quantifiable. Technically neither the astragalus nor calcaneus are long bones. This limited sample suggests that, despite early fusion, the astragali of sub-adults would continue to grow as these animals matured. While the premise is not proven, additional data supporting post-fusion bone growth is demonstrated below and in the following Chapter 6.

5.3 ii Scapulae:

Seven measurements are recorded for the scapula, only HS (height of scapular spine), LD (dorsal length) left, and LG (length of glenoid) and BG (breadth of glenoid) right, are shown in Figure 5-11. The HS and LD show distinctions in size by age and sex. The two female specimens closest to the large male, z: 4703 and z: 4573, are the oldest individuals in the collection; the smallest sub-adult female and three sub-adult males are assessed as 18< months of age (see Figure 3-5) indicating the HS and Ld measurments are age related, though clarification of this variation requires a larger sample to quantify.

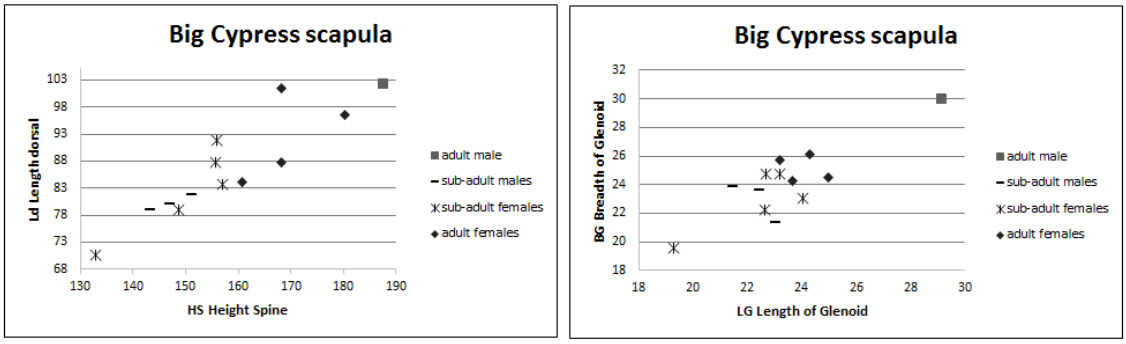


Figure 5-11 Scapulae, left HS and LD, right LG and BG.

On the right side of the figure measurements of the glenoid, LG and BG are shown. In the archaeological collections only the glenoid and culumar neck were observed to survive intact. These measurments are therefore more relevent to the project's goals. However, as can be seen while the large male and youngest sub-adult female are distinct, the other specimens are too tightly clustered for size to be a reliable indicator of age and sex cohort. Soto-Toral (1998) used the LG and BG measurements

as proxy for the humeral head, attempting to distinguish between male and female WTD represented in the archaeology. In the figure above distinguishing sub-adults from adult females via bone measurements appears uncertain.

5.3 iii Humerii:

The proximal humerus is one of the last growth plates to fully fuse in WTD, with males fusing later than females (see Table 3-4). In all graphs individuals lacking at least partial fusion of a designated measurement point are not considered, meaning the sub-adults specimens and particularly male sub-adults in the reference collection are not always visible in these comparisons. Complete fusion of both the proximal and distal epiphysis is generally considered to mark the end of lateral growth for long bones. This is not strictly true, the repair and remodelling of microfractures can incrementally increase bone dimensions; defining the difference between incremental bone growth from substantial growth and how this effects understanding of an assemblage is a significant problem and addressed in this study, but not conclusively. Sub-adults are catagorized by open epiphysis and therefore incomplete growth. The humerus has separate growth plates for the proximal tubercle and for the humerus head. Purdue (1983 b) does not distinguish whether the timing of fusion for these growth plates is simultaneous or sequential; in this document it is considered to be simultaneous as observed materials demonstrated the humeral head and tumbercle were attached to each other while separated from the shaft among sub-adults lacking proximal fusion of the humerus. As Purdue's (1983b) collection was derived from hunted animals, seasonality could be implicated. The specimens from Big Cypress were largely roadside casualties; however, seasonality can not be discounted as the age profile for sub-adults of both sexes suggest a relationship between the dispersal of sub-adults of this species and ejection of offspring from maternal territories prior to birth of new fawns.

In Figure 5-12 the GL is compared to the SD measurement. How the SD (smallest diameter) should be used or interpreted is not clear in the literature. However, the SD was consistently found to be larger in adult cohorts of the reference collection, hence it is paired with long bone length in most of the following graphs.

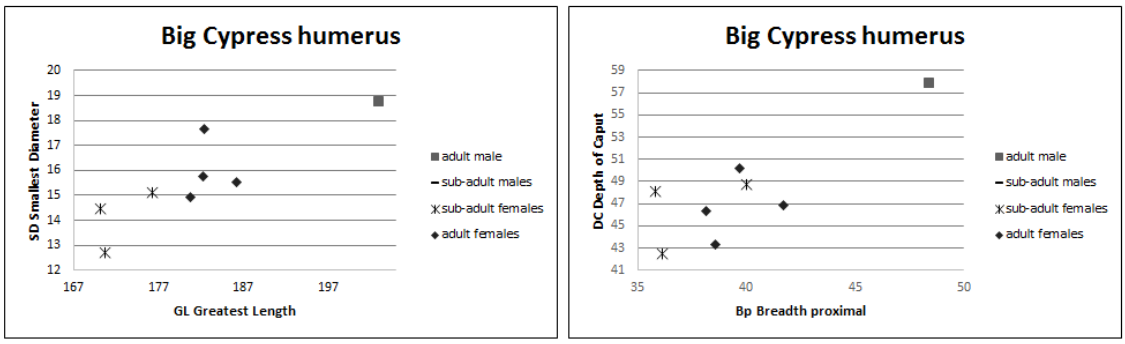


Figure 5-12 Proximal humeri, left GL and SD, right Bp and DC.

Unlike most long bones for WTD, the smallest diameter of the humerus was consistently found diagonal to the sagital plane, meaning it can not be classified as either a breadth or depth measurement. All the sub-adult males presented unfused proximal humerii.

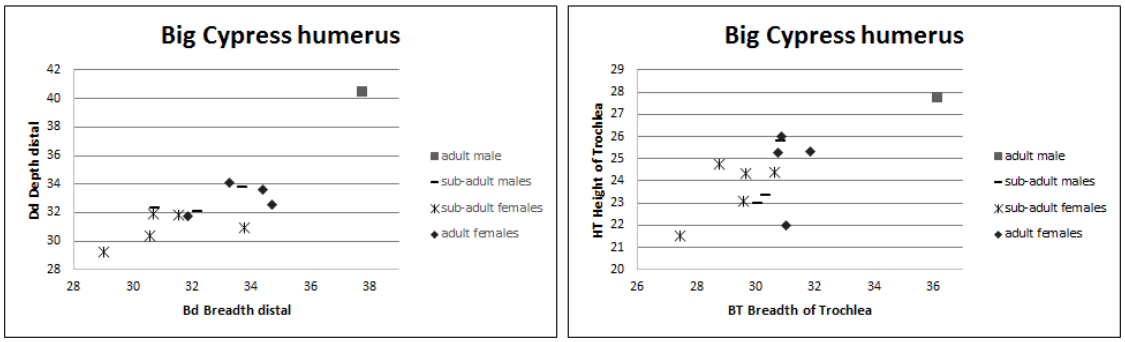


Figure 5-13 Distal humeri 1, left Bd and Dd, right BT and HT.

Distal fusion of this element begins early, thus all sub-adults are represented. Figure 5-13 shows the distal measurements, on the left side breadth and depth are considered. The large male plots separately from all specimens, while there is less distinction between the adult females and sub-adult specimens of both sexes. On the right, height and breadth of the trochlea also conflate sub-adult males with adult females. The trochlea is quite robust and seems to survive well in sediment. There are four measurements used for the distal humerus used in this paper, see Chapter 2. Below in Figure 5-14 the height of the trochlea is compared to the height of the trochlea constriction. Unlike most of my scatter plots, these two measurements both occur in the depth plane. While the distal humerus fuses quite early, cortical bone surface of young individuals may not survive in tropical sediments. These two measurements were consistently available when other osteo-landmarks for this element were not preserved in the assemblages and have proven useful.

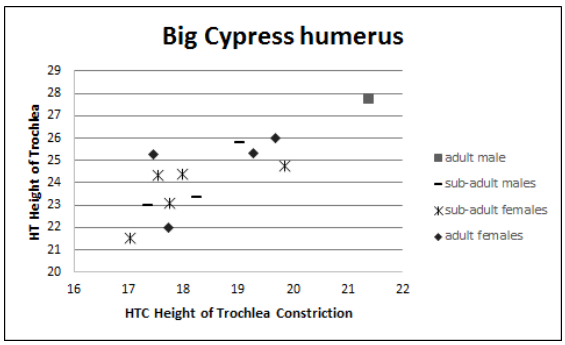


Figure 5-14 Figure Distal humerii trochlea.

There is less separation between the large male and oldest two adult females using these two measurements, though one sub adult male and one sub-adult female also appear in that cluster. These sub-adult individuals z: 4579 and z: 4581 are assessed at 17 and 28 months respectively.

5.3 iv Radii:

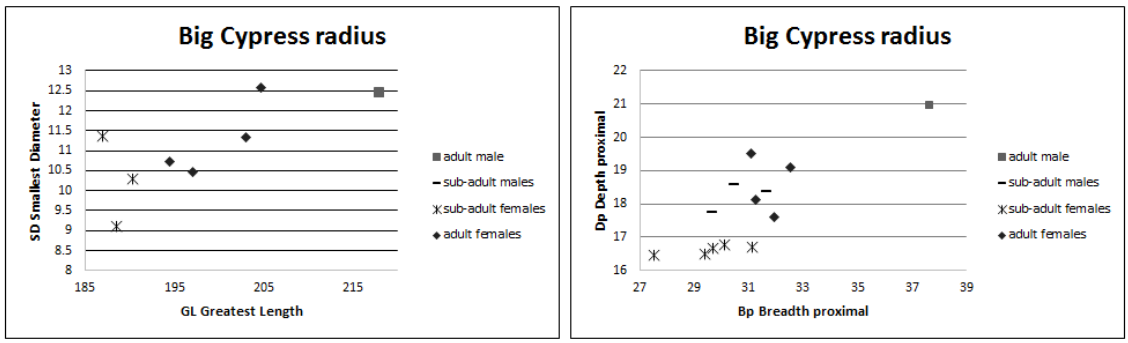


Figure 5-15 Proximal radii, left GL and SD, right Bp and Dp.

Initial fusion of the proximal radius is early (at two months) with complete fusion at eight months. In Figure 5-15 GL is plotted with SD on the left and absent representation of the sub-adult males, the differences between the remaining three cohorts represented are clearly seen. On the right side of the figure, sub-adult females appear to be more distinct than previously.

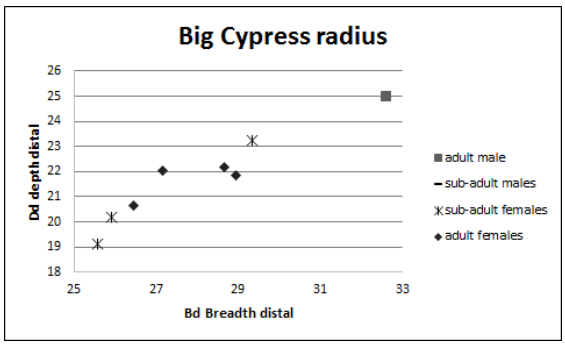


Figure 5-16 Distal radii.

The later fusing distal articualation in Figure 5-16 is not as clear; specimen z: 4569 regularly plots as largest of the sub-adult females but in this graph she appears to be larger than the oldest adult females in measurements of the distal radius.

5.3 v Ulnae:

The ulna is not a weight bearing structure, its proximal surface is an attachment point for the olecranon ligament originating on the humerus, mediating flexion and extention of the humerus with the radius.

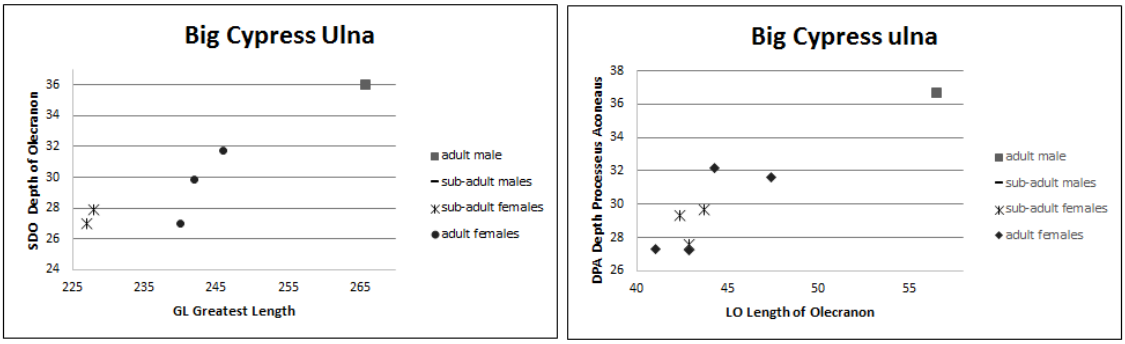


Figure 5-17 Ulnae.

Figure 5-17 shows dimensions of the ulna, on the left; sub-adult females demonstrating fusion of the olecranon articulation plot as smaller than adult females for greatest length. Specimen z: 4573 demonstrating fusion of the ulna to the radius could not be measured for the GL as the osteometric board available could not accommodate this measurement without damage to the bone. On the right side of Figure 5-16 the length of the olecranon and the depth of the processus aconeaus are plotted together: specimens z: 4703 and z: 4573, the oldest females, are larger than all other females.

5.3 vi Calcanei:

The calcaneus is also a primary facilitator of locomotion. Figure 5-17 compares Von Den Driesch's (1976) GB (greatest breadth) on the left, with Purdue's (1987a) GD (greatest depth) on the right, and the horizontal axis represents the GL (greatest length). Lack of caudal fusion for the male sub-adults eliminated them from comparison. pairing of the GB and GD failed to show a pattern for age or sex; limited sample size may be implicated.

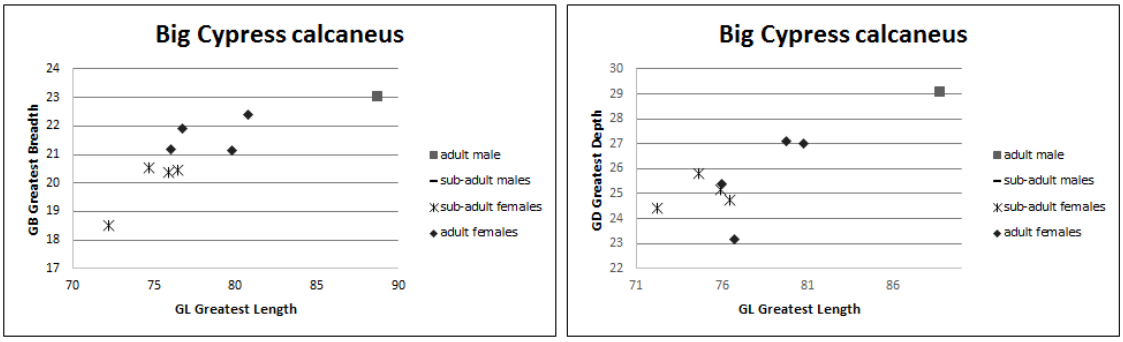


Figure 5-18 Calcanei, left GL and GB, right GL and GD

Mechanical stress is implicated in the greater depth measurements for older specimens seen in Figure 5-19 below.

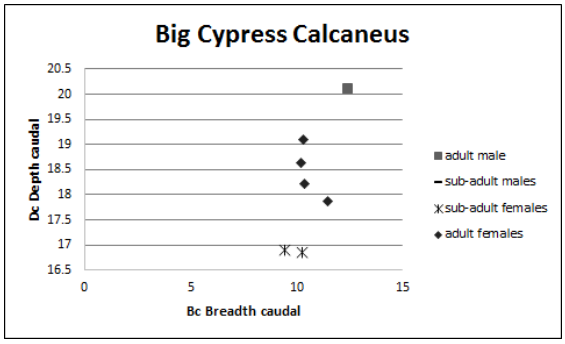


Figure 5-19 Caudal calcanei.

Skedros et al. (2004) describes the histological results of mechanical stress specifically on the calcaneus, and generally on load bearing skeletal-elements. Bc (breadth caudal) and Dc (depth caudal) are original measurements devised for this project. Because this measurement was not found in previous literature, I have choosen not to alter the axes (see Figure 7-40). As the attachement point for the achilles tendon, it is expected this skeletal-element would be subject to considerable biomechanical stress.

5.3 vii Femora:

Unlike the bones of the front limbs, the femur and tibia begin fusion fairly late (see Table 3-4). No sub-adult males and only three sub-adult females displayed at least partial fusion of the distal femur. Specimen z: 4573 is missing greatest length measurements for the femur and tibia; the osteoboard was unavailable at the beginning of data collection and the opportunity to apply it retroactively to these two elements for this specimen was missed. She is not represented on the left side of Figure 5-20 but does appear on the right side for Bp (proximal breadth) and DC (depth of the femoral head), where again she is larger than two younger adult females, if not to the same degree as in other graphs. Measurements for the distal femur below show the same pattern.

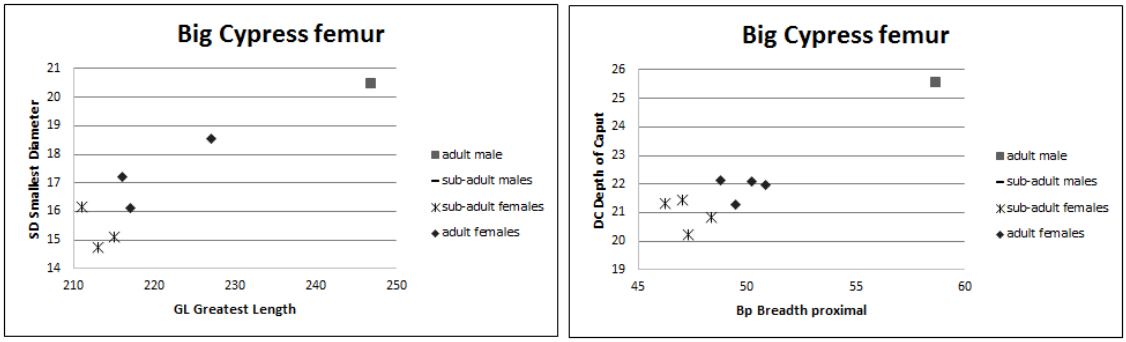


Figure 5-20 Proximal femora, left GL and SD, right Bp and DC.

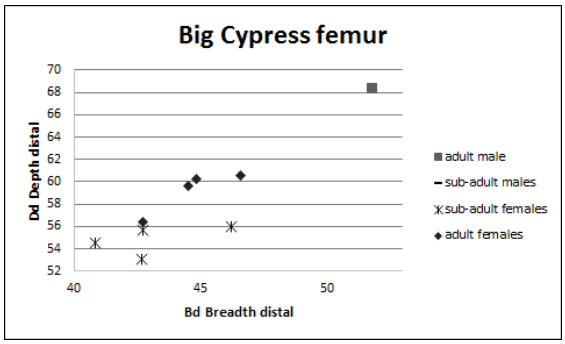


Figure 5-21 Distal femora.

5.3 vii Tibiae and fibulae:

Initial fusion of the proximal tibia begins at 23 months for females and not before 26 months for males. Two of the sub-adult females demonstrated at least partial fusion of both proximal and distal epiphyseas. There is however a noticable difference in the greatest length between the sub-adult and adult females on the left side of Figure 5-22, below, for the proximal measurements on the right side the two older females plot much more closely with the large male for depth.

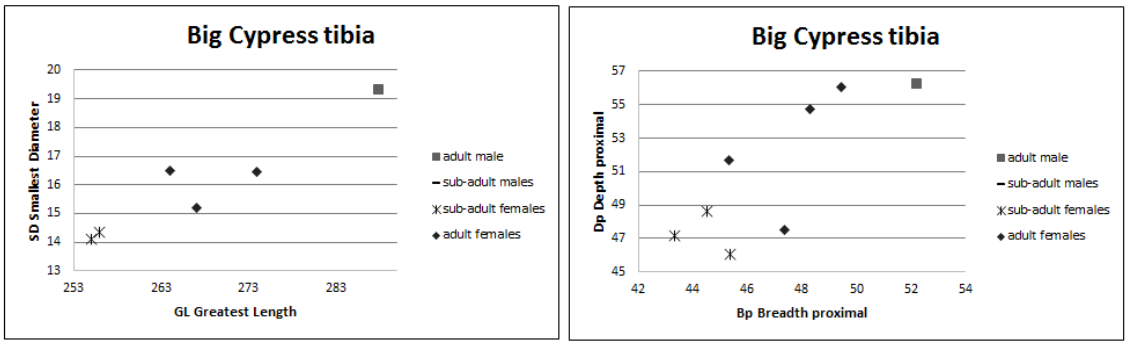


Figure 5-22 Proximal tibiae, left GL and SD, right Bp and Dp.

Distal fusion of the tibia initiates between 14 and 17 months for both male and female WTD. One sub-adult male, z: 4578, displayed partial fusion of the distal tibia and is represented in Figure 5-23 below; significantly, again, the depth measurements of this specimen plot below those of the adult females but within the same range of measurements for breadth.

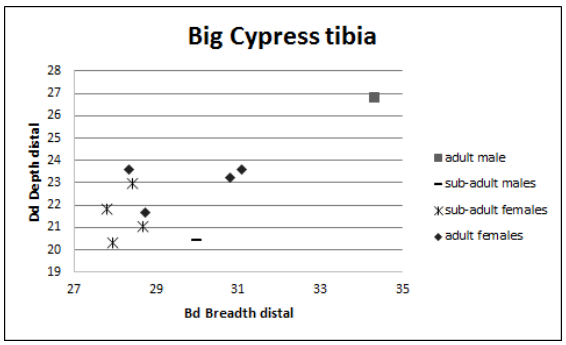


Figure 5.23 Distal tibiae.

The fibula is vestigial in WTD, the proximal and distal ends do ossify and are recoverable when fine gauge (1/8 to 1/16 inch) sieves are used (pers. com. Kitty Emery, 2015). This is consistent with observations recorded by Rumph (1975: 89). Specimen z: 4567 (area 4) has her proximal fibula fused to the tibia at the epiphysis forming a spur like structure that was originally recorded in my field notes as possible pathology (see appendix A).

5.3 vii Metapodia:

Metacarpals and metatarsals are treated together. Fusion of the proximal epiphysis ocures before or shortly after birth, while the distal epiphysis fuses after 20 months with some slight variation between males and females (Purdue, 1983b: 1211).

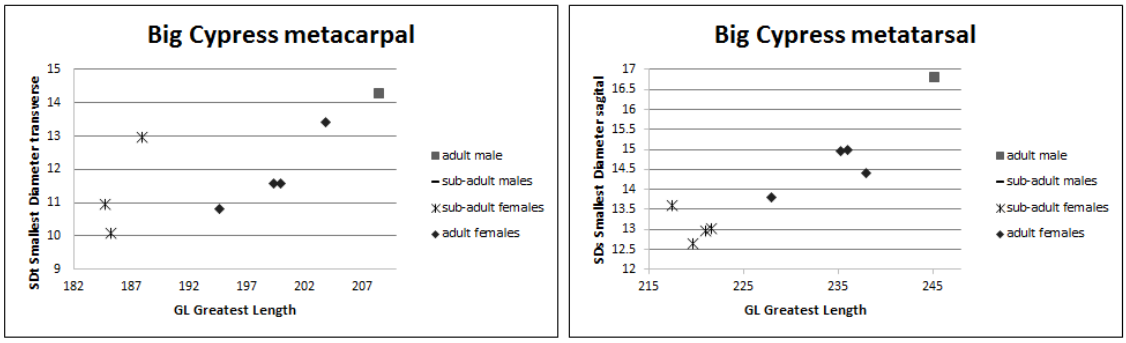


Figure 5-24 GL metacarpal and metatarsal.

In Figure 5-24, with the exception of Specimen z: 4569 (who demonstrated the very large measurments of the distal radius), proximal measurements of the metacarpals show breadth of adult females and sub-adults is fairly consistent, while depth measurments appear to vary based on age. For the metatarsals on the right, breadths are more variable than depth measurements. As the SDt of the metacarpal appears to be relocated after distal fusion, only metacarpals demonstrating distal fusion are presented above.

The greatest length of the metapodia confirms an interesting point about bone remodlleing: of the sub-adult females three demonstrated partial fusion of the distal

metacarpal and four showed fusion of the metatarsal, yet there is a clear separation in total lengths between these individuals and the adult female specimens in this collection. As previously described in the measurements section, the smallest diameter of the metatarsal occures on a different position and plane depending on the age or possibly the sex of the individual, see Figures 6-12 and 6-13 in the next chapter.

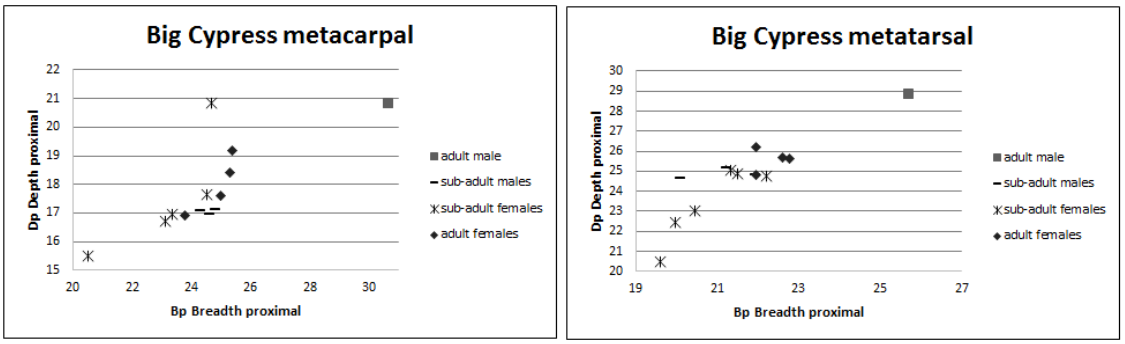


Figure 5-23 Proximal metacarpal and metatarsal.

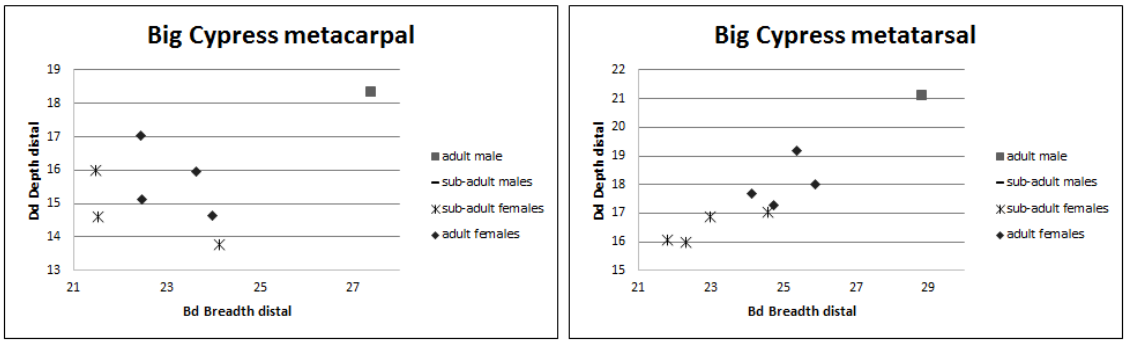


Figure 5-24 Distal metacarpal and metatarsal.

None of the sub-adult males demonstrated even partial distal fusion for either metacarpals or metatarsals. It is possible that the cleaning of bones during initial curation processing disarticulated some partially fused epiphyseas; however, natural prcesses in the soil would produce the same effect on archaeological samples.

5.4 Synopsis:

Despite not matching the degree of sexual dimorphism predicted in the literature, the largest male, Specimen z: 4571 in the reference collection, is distinct from other specimens in most of the scatterplots. Two females, z: 4580 and z: 4573, demonstrating fusion of the ulna to the radius, also stand out as generally larger than other female specimens in the Big Cypress collection. Predictions in the literature for assessing population stature and sexual dimorphism via the astragalus (Purdue, 1983b) appear unsupported in these findings. While individual variation can not be excluded as a factor, in most of the proceeding scatter-plots the large male is readily distinguished from adult females and sub-adults. Differentiating adult females from sub-adult males is

more difficult, breadth meassurements in particular seem to overlap between these two cohorts. This is a fairly common problem in the study of species considered to be sexually dimorphic, and one reason intact mandibles are prefered materials for assessing the presence of sex and age catagories in faunal assemblages. My original research design did not anticipate an extensive investigation of the modern materials, resulting in a failure to record the measurements from unfused articulating structures. However, measurements of unfused diaphysis were more robust than the same measurement post-fusion, implying osteoclasts may be actively remodeling bone at an early point in skeletal development. A more through investigation of the museum's reference specimens, including both unfused skeletal elements, and the all available specimens regardless of skeletal completeness should produce a more robust data set and may clarify if these variations are individually ecentric or developemental in nature and to what degree stature and sexual dimorphism are a product of landscape management.

Human manipulation of the landscape appears to be one factor influencing WTD stature. Reduced predation can produce increased intra-individual competition for nutrition (Wolverton et al. 2007). Over time this may reduce population stature and sexual dimorphism (Purdue, 1987b; Gueist, 1998). The primary native predator for Florida's WTD is the endangered Florida panther *(Puma concolor).* In modern times human predation of WTD is regulated by state-issued hunting licenses. While questions about WTD stature and its relationship to anthropogenic landscapes have been raised, significant expansion of the sample needs to be undertaken before any solid results can be proposed.

Osteological markers of specimen age: The application of log ratios to the reference collection proved informative. The ratios generated for each specimen were diverse, and this is a product of using the mean for comparison with actual measurements. While these ratios are dervived from measurements, they show patterns among the materials rather than actual size of a particular sample. One such pattern is shown for depth; in the scatter plots depth measurements were consistently smaller for younger specimens than they were for mature individuals. The log ratio charts illustrate this is a trend within the reference collection for measurements of the depth plane, but not in the planes of breadth or length. The scatterplots above confirm this observation is valid for the reference collection while also showing a similar trend for length that was not nearly as distinctive in the histograms.

Almost without exception the two oldest adult females, z: 4703 and z: 4573, demonstrating fusion of the ulna to the radius, were larger in all dimensions than the other females or the sub-adult males from Big Cypress. Davis questions whether post-fusion bone growth occurs (Davis, 1996: 598). The answer to this question must depend on the definition of bone growth: if growth is defined by ossification of the cartilage matrix of the diaphysis or whether histological reaction to micro fractures occurring underneath the periosteum may also be considered bone growth (Skedros et al. 2004). The evidence presented above indicates bone dimensions increase after epiphysis fusion. Homeostatic maintenance of active tissue is a presumed limitation but not necessarily demonstrated in this chapter.

The preceeding chapter presented the deer species relevant to this research along with an overview of their social organization, environmental requirements, and more briefly, the impact they may have on the biotic communities in which they participate. In this chapter, I have tested the modern WTD reference materials for sex and age cohort and how these qualities might be represented in the osteological materials available to archaeologists. Three deer species were available to the ancient Maya, the next chapter discusses the variations in bone morphology identified in this research as ontological and species specific.

Chapter 6 Species and Age-Related Morpholgy:

As seen in the previous chapter, there is regional variation in WTD stature that is independent of Bergman's rule by any definition; whether that difference is due to landscape management regimes or to intra-individual competition for nutrition is currently unclear. Also demonstrated is variation in domensions of the bones examined, in many cases attributable to the age and sex of the specimen under study. Variations in bone morphology between related species are commonly reported but difficult to quantify, for example sheep (*Ovis aries*) and goats (*Capra hircus*), or WTD (*Odocoileus virginianus*) and black-tailed deer (*Odocoileus hemionus*); anatomical variations between related species may result from adaptation to forage opportunities or genetic divergence between populations (Bossneck, 1969; Davis, 1993; Jacobson, 2003; Zeder and Lapaham, 2010). The first section of this chapter tests observed differences in stature and bone morphology between the WTD specimens from Big Cpyress Preserve in Florida and the limited skeletal-elements present in FLMNH collections that represent red brocket deer (*Mazama* temama) specimens from Guatamala and the island of Trinidad (*Mazama americana*) see Table 3-6. The second section describes nonmetric traits for WTD that may be further developed to identify older animals in archaeological assemblages, providing more detailed mortality profiles and deeper investigation into prey selection and the cultural values that informed resource management for prehistoric societies.

Individual variations in the dimensions and shape of bones may result from various types of trauma -- injury, infection, nutritional deficite, or confinement being the most common (O'Connor, 2000; O'Regan and Kitchener, 2005). Changes in morphology can be ontological, environmental (Skedros et al. 2003; Skedros et al. 2004) or genetic (White, 2000: 28). Identification of which deer species are present in the Maya faunal assemblages cannot be ignored, and the taxonomy of the *Mazama* family has been under scrutiny for several decades (see deer ecology). Three native deer species occure in the region inhabited by the ancient Maya, each occupying distinct ecological niches and readily discernable from the others by size according to Giest (1998). However, Emery has observed overlaps in the size of WTD and brocket deer skeletal-elements (pers. com. Kitty Emery 2015), thus stature is not a reliable metric by which species can be defined for archaeological samples. Therefore osteological characteristics by which WTD may be segregated from *Mazama temama* and *Mazama pandora* would be a valuable addition to the zooarchaeology of the Maya. No post-

cranial skeletal-elements for brown brocket deer were identified during my time at FLMNH, post-cranial bones for brocket deer at MVZ were from South America and in my judgement were likely to confuse rather than clarify the issue of species identification. No reports or journal articles were discovered distinguishing brown brocket deer from red brocket deer in the archaeology, the two species are mentioned within zooarchaeological literature only as 'brocket deer' and *Mazama sp.* (Masson and Peraza-Lope, 2008). Nor were any sources identified describing post cranial skeletal-elements for these species. The Florida Museum of Natural History (FLMNH), list these animals as *Mazama americana*. While retaining the original taxonomic nomeclature in my field notes, this document applies the most current taxonomy for the brocket deer specimens from Guatemala and Belize. In the following scatterplots brocket deer are designated as BD. The place of origin for each population is listed in the graph's legend, more detailed information for each of the red brocket deer specimens is in Table 3-6 and in Appendix A.

The Mammalogy collection had three partial red brocket deer skeletons from Guatemala and three from the Island of Trinidad all of which were sexed. FLMNH-EAP's specimen z: 8851, of unknown sex, was almost complete, and Specimen UF no 1440 has already been dismissed from consideration. Specimen z: 7930, labelled as *Mazama* sp. and listed as male, had no data for specimen origin or date of collection, additionally it produced measurements that fell between WTD and the other brocket deer specimens from Guatemala, possibly representing a *Mazama pandora*, though this is uncertain. Its measurments are however anomalous and therefore excluded in the graphs below (see field notes in Appendix A and measurements in Digital appendix III). All other brocket deer specimens examined at FLMNH were labled as *Mazama americana*. With a limited collection of skeletal-elements, a thorough interogation of species variation is unreasonable but there are sufficient phalanges and metapodia present in the collections for some differences to be observed. Phalanges are represented in six and metatarsals in seven of the eight specimens available. Davis instructs the smallest diameter should be taken in whatever plane it ocurs (Davis, 1996: 597). I was already recording the archaeological samples before noticing the smallest diameter of the metatarsal consistently appeared in a different location on the metatarsals of white tailed deer than samples identified as brocket deer. The same appeared to be true of the 1st phalanx. In testing this observation two original measurements were created, SDt smallest diameter transverse and SDs smallest diameter sagital (see Chapter 2).

Revisisting the reference collections, I applied the new measurements to all metapodia and phalanges for specimens demonstrating distal fusion of the metapodia and full fusion of the phalanx. These new measurements replaced those previously collected for the reference collections.

6.1 Astragalus morphology by species and population:

The four modern WTD specimens selected from the Big Cypress for size index scaling are compared in Figure 6-1 with modern brocket deer from Trinidad Island and Guatemala. FLMNH catalog numbers, designated sex, and assessed age are present for brocket deer in Table 3-7 and for WTD in Table 3-6. Among WTD from the reference collection the GLl (greatest length lateral) and Dl (lateral depth) were found to be the most sexually dimorphic measurements for the astragalus. According to Geist (1998) brocket deer do not display strong sexual dimorphism, and that appears to be the case here. The Trindad specimens are assessed as sub-adults , two males and one female. The Guatemalan specimens are assessed as adult, specimen UF 6788 is known to be female and z:8851 is of unknown sex (see Table 3-6). For clarity's sake the following graphs use one symbol for each population without distinctions between sex and age cohort. In the following graphs specimens from Big Cypress are WTD, specimens from Guatemala are red brocket deer assumed to represent *Mazama temama*, and specimens from the island of Trinidad are red brocket deer listed in museum stores as *Mazama americana* but presumed in this research to represent a third species I have not yet identified satisfactorily.

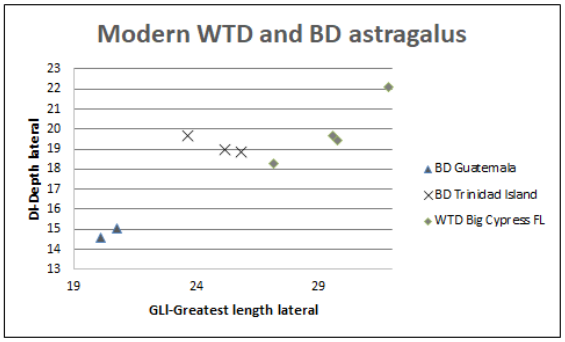


Figure 6-1 Astragalus WTD and red brocket deer.

During the last glacial period a land bridge connected the Island of Trinidad to the South American mainland allowing the migration of terestrial animals including deer (Comeau, 1991: 35). The variation in size between these three populations is readily apparent in Figure 6-1; whether the red brocket deer *(Mazama americana)* from Trindad are smaller than the mainland population in South America is unknown, but they are larger than red brocket deer from mainland Guatemala, large enough to plot

with the adult females from Big Cypress along the measurment plane for depths, which may be significant. The specimens from Trinidad are assessed as sub-adults, and depth measurements for WTD in the previous chapter appear to reflect ontological age.

6.2 Phalanx morphology by species and population:

The smallest diameter is a standard measurement of a long bone's girth (Von Den Driesch, 1976; Davis, 1996). Its location indicates where the least amount of mechanical stress is exerted on the bone, hence the gracile dimensions. Among the specimens from FLMNH-EAP, for WTD the smallest diameter occurs at the distal end of the diaphysis and on the transverse plane for the metacarpal, femur, tibia, and 1st phalanx. The metric comparisons in Chapter five began with the astragalus, ended with discussion of metapodia, but did not attempt any description of the phalanx as that element presents different dimensions for front and rear feet in WTD and because the paired bones for each foot present very slight variations in shape undoubtedly related to the mechanics of gait. However, consistent variations in the morphology of 1st phalanx and metatarsal were observed between species and this is addressed below.

Artiodactyls are distinguished from other quadrupeds by the presence of three vestigial toes, AKA dew claws, and it is believed each taxonomic family evolved this trait independently, hence the organization and morphology of the phalanges varies from one genus to another. In WTD the digits 1, 2, and 5 are vestigial while the 3rd and 4th phalanges present as paired weight bearing elements. As the skeletal-element most directly involved with negotiating the individual's environment, phalanges are especially variable in morphology, and in artiodactyls they are particularly difficult to identify to side and limb. For red brocket deer from Guatemala variant morphology was identified for the 1st phalanx (the dew claws were not examined). All specimens showed the SD (smallest diameter) was on the sagittal plane and mid-shaft. There was no detected variation in morphology between front and rear feet; the length measurements (GL) of front and rear feet varied less than 4 mm.



Figure 6-2 1st phalanx and 2nd phalanx, front and hind feet: specimen z: 8851 (Mazama temama) from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Nicole Cannarozzi and used with permission of the FLMNH-EAP.

The Guatemalan red brocket (*Mazama temama*), the photo above represents the hind and fore feet, showing minimal difference in the length of the toes or other distinctions by which these bones might be distinguished per foot. In the dorsal view the shaft of the 1st phalanx appears to be constricted between the proximal and distal articular facets. The ventral surface on the right side of Figure 6-2 shows an almost straight line from the proximal facet to the distal epiphysis and a completely straight line along the dorsal surface.



Figure 6-3 1st phalanx and 2nd phalanx, front and hind feet: specimen z: 2850 (Odocoileus virginianus ssp.) from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Nicole Cannarozzi and used with permission of the FLMNH-EAP.

For WTD the literature reports the front toes are longer than those of the hind feet and this is apparent in Figure 6-3. In the dorsal view of the 1st phalanx the shaft appears to taper steadily from the proximal to distal articulations. The medial view shows a very slight arc along the ventral surface of the 1st phalanx representing the front foot, and a slight indentation of the dorsal surface below the proximal epiphysis line.



Figure 6-4 1st phalanx and 2nd phalanx: specimen 6610 (Mazama americana) from the Florida Museum of Natural History, Mammal Centre (FLMNH). Photos taken by Nicole Cannarozzi and used with permission of the FLMNH.

Above in Figure 6-4 the length of the 1st and 2nd phalanx of the front and rear feet is distinguishable by length, though which is the fore foot and which the hind foot is not certain. It may be similar to the case for WTD, though absent illuminating literature, or the study of an intact specimen, that cannot be determined. In the dorsal-view the longer phalanx also demonstrates constriction of the shaft relative to the articular terminals similar to the brocket deer from Guatemala. In the medial-view this specimen shows an indentation below the proximal epiphysis on both dorsal and ventral surfaces of the 1st phalanx. The 2nd phalanx appears to be quite similar in all three species.

Even though the number of samples for each species/population is small, mapping the lumps and bumps of the element under question is a neccesary prerequisite to demonstrating the variations in measurement. In Table 6-1 below I compare the SDt and SDs (smallest diameter) measurments and a derived quotient for the three populations observed. In this table phalanges for front and rear feet of each specimen are segregated, measurements for each class are then averaged, indicated by * in the column for side. Some specimens presented an incomplete set of phalanges that could not be segregated by front and rear foot and were excluded from Table 6-1.

FLMNH#	State	Location	Date	Species	Age	Sex	Element	Side	SDt	SDs	Quotient
z:8851	Guatemala	Dos Pilas, peten	1993	Mazama temama	38 m	US	phalanx1	R		7.18	
UF:6787	Guatemala	Tikal	1960	Mazama temama	20 m	F	phalanx1	L	6.93	6.02	115%
UF:6787	Guatemala	Tikal	1960	Mazama temama	20 m	F	phalanx1	*	6.58	5.64	117%
UF:6788	Guatemala	Tikal	1960	Mazama temama	38 m	F	phalanx1	*	6.93	5.99	116%
UF:6788	Guatemala	Tikal	1960	Mazama temama	38 m	F	phalanx1	*	6.36	5.58	114%
UF:6795	Guatemala	Altar de Sacrificios	1961	Mazama temama	20 m	M	phalanx1	*	7.11	6.59	108%
UF:6795	Guatemala	Altar de Sacrificios	1961	Mazama temama	20 m	M	phalanx1	*	6.59	6.1	108%
UF:6608	Trinidad	Siparia Forest	1959	Mazama a.	20 m	M	phalanx1	L		8.37	
UF:6609	Trinidad	Nariva,tabaquit	1959	Mazama a.	20 m	F	phalanx1	*	8.12	8.36	97%
UF:6609	Trinidad	Nariva,tabaquit	1959	Mazama a.	20 m	F	phalanx1	*	7.25	8.11	89%
UF:6610	Trinidad	Mayaro	1959	Mazama a.	20 m	M	phalanx1	*	8.03	8.19	98%
UF:6610	Trinidad	Mayaro	1959	Mazama a.	20 m	M	phalanx1	*	7.2	8.07	89%
z:4571	Florida	Collier County	1985	Odocoileus v.	36 m	M	phalanx1	*	11.37	12.07	94%
z:4571	Florida	Collier County	1985	Odocoileus v.	36 m	M	phalanx1	*	11.24	11.55	97%
z:4576	Florida	Collier City	1985	Odocoileus v.	26 m	F	phalanx1	*	8.62	9.31	93%
z:4576	Florida	Collier City	1985	Odocoileus v.	26 m	F	phalanx1	*	8.46	8.76	97%
z:4703	Florida	Collier County	1985	Odocoileus v.	60 m	F	phalanx1	*	9.31	10.4	90%
z:4703	Florida	Collier County	1985	Odocoileus v.	60 m	F	phalanx1	*	8.93	9.17	97%
z:4580	Florida	Collier County	1985	Odocoileus v.	60 m	F	phalanx1	*	9.69	10.5	92%
z:4580	Florida	Collier County	1985	Odocoileus v.	60 m	F	phalanx1	*	8.96	9.41	95%
z:4573	Florida	Collier County	1985	Odocoileus v.	60 m	F	phalanx1	*	10.3	11.05	93%
z:4573	Florida	Collier County	1985	Odocoileus v.	60 m	F	phalanx1	*	9.8	9.94	99%
z:4572	Florida	Collier County	1985	Odocoileus v.	26 m	F	phalanx1	*	9.12	9.37	97%
z:4572	Florida	Collier County	1985	Odocoileus v.	26 m	F	phalanx1	*	8.88	8.99	99%
z:4581	Florida	Collier County	1985	Odocoileus v.	28 m	F	phalanx1	*	7.58	8.75	87%
z:4581	Florida	Collier County	1985	Odocoileus v.	28 m	F	phalanx1	*	7.24	8.06	90%
z:4705	Florida	Collier County	1985	Odocoileus v.	29 m	F	phalanx1	*	9.02	10.08	89%
z:4705	Florida	Collier County	1985	Odocoileus v.	29 m	F	phalanx1	*	8.66	9.02	96%
z:4569	Florida	Collier County	1985	Odocoileus v.	26 m	F	phalanx1	*	8.42	9.73	87%
z:4569	Florida	Collier County	1985	Odocoileus v.	26 m	F	phalanx1	*	8.27	9.05	91%
z:2850	Florida	Clay county	1985	Odocoileus v.	30 m	F	phalanx1	*	9.68	10.3	94%
z:2850	Florida	Clay county	1985	Odocoileus v.	30 m	F	phalanx1	*	9.39	9.6	98%

Table 6-1 SDt and SDs 1rst phalanx.

The table above shows that the smallest diameter transverse (SDt) is proportionally larger for the modern brocket deer from Guatemala than for the brocket deer from Trinidad or the WTD from Florida, despite what appears to be a similar constriction of shaft width of the 1st phalanx in both brocket populations. The SD (smallest diameter) for the Guatemalan specimens 1rst phalanx (proximal phalanx) occurs midshaft on the sagital plane, while it appears at the distal end of the shaft and on the transverse plane for WTD and brocket deer from Trinidad.

Another way to test the claim of morphological difference between these species is direct comparison of the actual measurements using SDt and SDs. In Figure 6-5 below the front and rear feet are presented using the GL (greatest length) against both measurments for the smallest diameter. On the left sub-adult WTD from Big Cypress seen in Table 6-1 are presented with the adult specimens showing phalanx length compared to SDs (smallest diameter sagital). The deer from Trinidad show the sagital measurement is in the same range as the sub-adult WTD while the phalanx length overlaps the brocket deer from Guatemala. As the SD for the Florida and Trinidad deer was habitually found on the transverse plane (anterior to posterior) the sagital measurment for these speciemens is better described as *least breadth* and its similarity to the WTD sub-adults is interesting as the specimens from Trinidad were also assessed to be sub-adults.

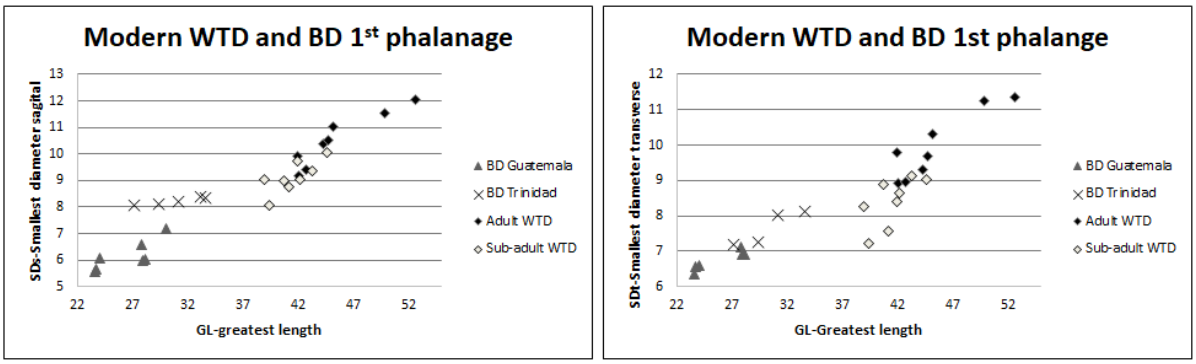


Figure 6-5 WTD and brocket deer comparison 1st phalanx by GL and SD.

On the right transverse measurements of the Guatemalan brockets are less distinctive from the Trinidad deer.

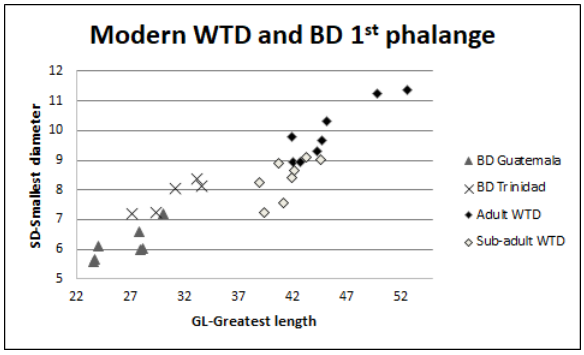


Figure 6-6 BD Guatemala SDs compared to SDt for BD Trinidad and WTD big Cypress.

A more concise way to see this information is Figure 6-6, showing the SDs (smallest diameter sagital) for the Guatemalan brocket deer, and the SDt (smallest diameter transverse) for the brocket deer of Trinidad and the Big Cypress WTD. In this graph sub-adult WTD displaying distal fusion of the metapodia are included and highlighted demonstrating how the smallest diameter overlaps the brocket deer specimens. Unlike Table 6-1, only specimens from Big Cypress are represented in Figures 6-5 and 6-6, for more detail see Digital Appendix VI: proximal phalanges.

In Figure 6-7 below a single WTD specimen from El Salvador demonstrates a cause for caution in distinquishing fore from hind feet for WTD in this southern margin of the North American continent. The 1st phalanges show minimal variation in length between front and rear feet (harvested in El Salvador's Department of San Pedro in 1956). Close observation of the phalanges from MVZ specimen 98889 detect irregularities in the shape of individual phalanges, though except for length the morphology is similar to the WTD from Florida. The crate did not contain 2nd phalanges for this specimen.



Figure 6-7 1st phalanges: specimen MVZ98889, (Odocoileus virginianus truei) age assessed 29-38 months: from the Museum of Vertebrate Zoology (photo taken by author) and used with permission of MVZ.



Figure 6-8 Radius pathology: specimen MVZ98889 (Odocoileus virginianus truei) from the Museum of Vertebrate Zoology (photo taken by author) and used with permission of MVZ.

In life this animal suffered severe osteomyelitis of the right radius, a condition that almost certainly impacted the animal's gait, causing a histological reaction in the cortical bone of the 1st phalanges. Was the resulting pathology of one foot severe enough to change the morphology in all four feet, or does this WTD subspecies differ sufficiently in gait or habitat from Florida's deer to account for the different proportions?

For the 2nd phalanx (intermediate phalanx), no variations in bone morphology were observed between species or populations. The smallest diameter occurs at the distal end of the diaphysis on the sagital plane for all three populations.

FLMNH#	State	Location	Date	Species	Age	Sex	Element	Side	SDt	SDs	Quotient
UF:6787	Guatemala	Tikal	1960	Mazama temama	38 m	F	phalanx2	*	7.37	6.32	117%
UF:6787	Guatemala	Tikal	1960	Mazama temama	20 m	F	Phalanx2	L	7.29	5.38	136%
UF:6788	Guatemala	Tikal	1960	Mazama temama	20 m	F	phalanx2	*	7.27	6.56	111%
UF:6788	Guatemala	Tikal	1960	Mazama temama	38 m	F	phalanx2	*	9.88	5.97	165%
UF:6795	Guatemala	Altar de Sacrificios	1961	Mazama temama		M	Phalanx2	*	7.36	6.52	113%
UF:6795	Guatemala	Altar de Sacrificios	1961	Mazama temama	20 m	M	phalanx2	*	7.03	6.32	111%
UF:6609	Trinidad	Nariva,tabaquit	1959	Mazama a.	20 m	F	phalanx2	*	9.2	8.26	111%
UF:6609	Trinidad	Nariva,tabaquit	1959	Mazama a.	20 m	F	Phalanx2	*	8.74	7.49	117%
UF:6610	Trinidad	Mayaro	1959	Mazama a.	20 m	M	phalanx2	*	9	8.48	106%
UF:6610	Trinidad	Mayaro	1959	Mazama a.	20 m	M	phalanx2	*	9.01	7.42	112%
z:4571	Florida	Collier County	1985	Odocoileus v.	20 m	M	phalanx2	*	13.36	10.59	126%
z:4571	Florida	Collier County	1985	Odocoileus v.	20 m	M	phalanx2	*	13.48	11.07	122%
z:4576	Florida	Collier City	1985	Odocoileus v.	36 m	F	phalanx2	*	10.42	8.17	128%
z:4576	Florida	Collier City	1985	Odocoileus v.	36 m	F	phalanx2	*	10.19	7.85	130%
z:4703	Florida	Collier County	1985	Odocoileus v.	26 m	F	phalanx2	*	10.75	9.96	108%
z:4703	Florida	Collier County	1985	Odocoileus v.	26 m	F	phalanx2	*	10.51	8.73	120%
z:4580	Florida	Collier County	1985	Odocoileus v.	60 m	F	phalanx2	*	11.05	9.59	115%
z:4580	Florida	Collier County	1985	Odocoileus v.	60 m	F	phalanx2	*	10.86	9.24	118%
z:4573	Florida	Collier County	1985	Odocoileus v.	60 m	F	phalanx2	*	11.41	9.49	120%
z:4573	Florida	Collier County	1985	Odocoileus v.	60 m	F	phalanx2	*	10.81	9.24	117%
z:4572	Florida	Collier County	1985	Odocoileus v.	60 m	F	phalanx2	*	10.47	8.54	123%
z:4572	Florida	Collier County	1985	Odocoileus v.	60 m	F	phalanx2	*	10.46	7.98	131%
z:4581	Florida	Collier County	1985	Odocoileus v.	26 m	F	phalanx2	*	9.27	8.26	112%
z:4581	Florida	Collier County	1985	Odocoileus v.	26 m	F	phalanx2	*	9.12	7.44	123%
z:4705	Florida	Collier County	1985	Odocoileus v.	28 m	F	phalanx2	*	10.27	8.5	121%
z:4705	Florida	Collier County	1985	Odocoileus v.	28 m	F	phalanx2	*	10.12	7.82	129%
z:4569	Florida	Collier County	1985	Odocoileus v.	29 m	F	phalanx2	*	10.44	7.78	134%
z:4569	Florida	Collier County	1985	Odocoileus v.	29 m	F	phalanx2	*	10.31	7.11	145%
z:2850	Florida	Clay county	1985	Odocoileus v.	30 m	F	phalanx2	*	11.25	8.48	133%
z:2850	Florida	Clay county	1985	Odocoileus v.	30 m	F	phalanx2	*	10.98	8.24	133%

Table 6-2 SDt SDs 2nd phalanx

As the length of the proximal phalanx was shown in Figure 6-5, the following scatter plots compare the 1rst and 2nd phalanges by their distal and proximal measurements; phalanges for each animal were segregated as front and rear feet and measurements for these two classes were averaged as per Table 6-1 and Table 6-2.

Proximal breadth and depth are tested below. The Big Cypress sub-adults have been excluded from these graphs for clarity. In the graphs for the 1st phalanx on the left and the 2nd phalanx on the right, the Trinidad deer appear to bridge any gap between the WTD from Florida and the red brocket deer from Guatemala. The same is true for the phalanges distal breadth and depth in Figure 6-10 below.

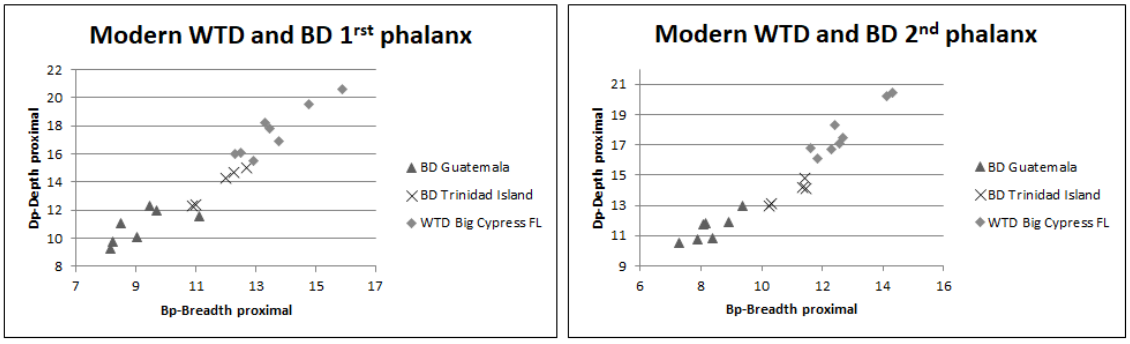


Figure 6-9 WTD and brocket deer comparison phalanx by Bp and Dp.

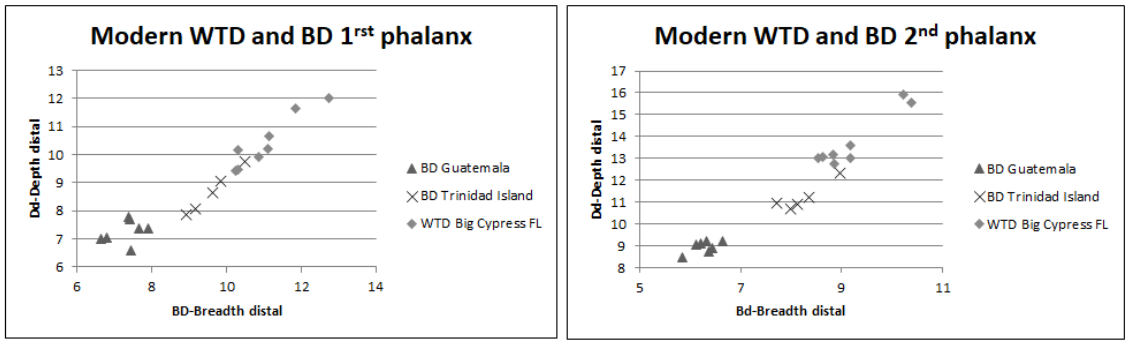


Figure 6-10 WTD and brocket deer 1st phalanx and 2nd phalanx.

The red brocket deer from Guatemala demonstrate the smallest diameter of the 1st phalanx, which occurs on a different anatomical plane than the WTD from Florida or the red brocket deer from Trinidad (see Table 6-1) and this has been demonstrated as adequately as the small number of specimens can allow.

However, as all three populations demonstrated the smallest diameter of the 2nd phalanx on the sagital plane, Figure 6-11 shows the separation between populations using the GL (greatest length) and the SDs (smallest diameter sagital). Brocket deer from Trinidad are again larger than the modern specimens from Guatemala but there is a clearer separation between specimens from Trinidad and the adult WTD derived from Big Cypress.

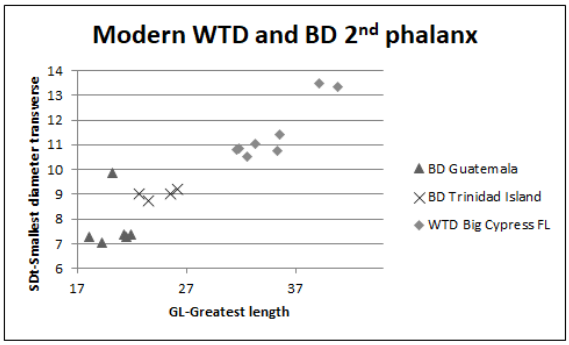


Figure 6-11 WTD and brocket deer 2nd phalanges.

6.3 Nonmetric traits:

The term refers to readily observed (and not so easily observed) structures that cannot be easily quantified by measurement; previous descriptions of the location of the smallest diameter on the metatarsal in Chapter 2 serve as an example. If not for the presence of a second deer species in the assemblages and the question posed by Dr Emery about species identification, these nonmetric qualities might have been misreported as individual variation or possible pathology like Thomas and Grimm's (2012) earlier estimation of the bone buttresses on sheep metatarsals. The attempt is

made here to qualify if not quantify the variations in morphology for the specimens under examination.

6.3 i Fusion of the ulna and radius:

As was the case for the original illustrations showing the measurements, my photographs of the WTD metatarsals resident in FLMNH's reference collection were inadequate for this comparison. In the process of replacing the original illustrations with photographs of MVZ specimens, I observed that the MVZ specimens also demonstrated the nonmetric traits observed among the WTD specimens from FLMNH's collections.

'Epiphyseal Closure in WTD' (Purdue, 1983b), while an excellent work, fails to address skeletal markers indicating age greater than 38 months. In human osteology, identifying age greater adult maturity is often addressed by non-metric traits i.e. analysis of pubis symphysis, fusion of cranial sutures, degree of fusion between the sacrum and ilium, (White, 2000: 338). However, if most human skeletons are deposited intact, the case for faunal material is quite different. Absent opportunity to compare osteological markers of maturity from different bones of the same individual, an attempt is made to derive the most possible information from each skeletal-element; however, those methods may be imprecise, as epiphysis fusion is sequential but it is not as rigidly scheduled as dental eruption (see Figures 3-3 and 3-4).

Purdue (1983b) does not include fusion of the ulna to the radius in his study of WTD. The FLMNH-EAP specimens z: 4703, originally assessed as 3.5 years, and z: 4573, assessed as 5 years old in the museum's records, demonstrate partial fusion of the ulna to the distal radius. Zeder (2006) notes the ulna fuses to the radius in the oldest class of modern goats [D] under study but not in sheep (Zeder, 2006: 93). *Bone Characteristics Associated with Aging in Elk* notes that the ulna fuses to the radius in some female elk over five years of age but not in others. A description of the stages of this fusion coincides with my observations of woven bone along the margins of the posterior groove for some radii samples (Knight, 1966). In Figure 6-12 below the woven bone binding the ulna to the radius is clearly visible and possibly produced by osteocytes migrating through micro tears in the periosteum resulting in deposits of woven-bone where the ulna and radius interact. If this is the case, my original estimation of the phenomenon as pathology would be correct, the trait was observed for some of the archaeological samples and taken as evidence of maturity. Similar phenomenon have been documented for horse metapodia (Bendry, 2007).



Figure 6-12 Demonstration of fusion of ulna to radius: specimen z: 4573 from the Florida Museum of Natural History photo taken by Nicole Cannarozzi and used with permission of FLMNH-EAP.

American elk/Wapiti *(Cervus canadensis)* are extremely large animals, as such the timing for fusion of the ulna to the radius may be earlier in WTD than it is in Wapiti and an absence of fusion may not prove an animal is under five years. Specimen MVZ3111 in Figure 6-12 from the museum of vertebrate zoology displayed nearly total fusion of the ulna to the radius.



Figure 6-13 Fusion of ulna to radius: specimen MVZ31118 (Odocoileus virginianus covesi). from the Museum of Vertebrate Zoology (photo taken by author) and used with permission of MVZ.

Without a skull or any dentition, it was not possible to assess MVZ31118 for age or sex with any certainty, but the specimen is believed to represent an older individual as the ulna was fused to the radius for nearly its full length, and two 1st phalanges had fused together at the proximal articulation. Other 1st phalanges from this specimen displayed bands of ossified connective tissue despite being chemically de-fleshed in the 1950s.

6.3 ii Nonmetric traits for the metatarsal:

Skeletal bone is dynamic tissue, remodelling in response to mechanical and biological stress throughout the individual's life (White, 2000: 32). 'Osteocytes (living bone cell) do not divide and because bone matrix calcifies soon after being produced, the tissue cannot undergo expansion from within. Bone growth results from new deposition on pre-existing surface' (White, 2000: 28). Unlike fish and reptiles, mammals are endothermic. Hence metabolism limits the maximum possible adult size in any species. This is significant when considering bone remodelling. As mechanical stress may trigger growth of cortical bone (biologically active tissue) to repair micro-fractures, and the limits of the metabolism restrain the total mass of active tissue that can be supported, the creation of new bone tissue will trigger homeostatic processes directing osteoclasts to reduce cortical bone where mechanical stress is less pronounced (White, 2000: 32; Skedros et al. 2003: 837; Skedros et al. 2004: 281).



Figure 6-14 Metatarsal ontogeny: Specimen z: 8851 (*Mazama americana*) From the Florida Museum of Natural History, *photo taken by Nicole Cannarozzi and used with permission of FLMNH-EAP.*

Specimen z: 8851 (see Table 3-6) was assessed as mature; the lateral view of this brocket deer metatarsal shows clear tapering from the proximal articulation to the distal epiphysis. This morphology of the metatarsal was consistent among all brocket deer in the reference collections and among all archaeological samples identified as brocket deer in the assemblages studied, qualifying this as a metric trait.

In direct contrast, WTD metatarsals from the reference collection were more variable. As shown in Figure 2-27, the smallest diameter of the metatarsal was variable by measurement plane and location on the shaft among the Florida specimens. As the transverse measurement of the distal metatarsal among adult WTD in the reference collection was frequently greater than the sagittal breadth of the upper shaft, bone remodelling is implicated, possibly a result of bone buttress formation described by Klein (1964) Thomas and Grimm (2011).

Figure 6-15 shows anterior, posterior, and lateral views of MVZ121107 estimated as age 29-36 months per incomplete fusion of the proximal humerus and distal femur.



Figure 6-15 Metatarsal ontogeny: specimen MVZ121107 (Odocoileus virginianus covesi). From the Museum of Vertebrate Zoology, photo taken by author and used with permission of MVZ.

This specimen shows a clearly defined anterior groove while the posterior groove below that image is wide and shallow. The distal breadth of the shaft is more gracile than the proximal portion of the diaphysis. The lateral view shows the pronounced taper from the proximal to the distal end of the shaft.



Figure 6-16 Metatarsal ontogeny: specimen MVZ 31118 (Odocoileus virginianus covesi). From the Museum of Vertebrate Zoology (photo taken by author) and used with permission of MVZ.

Specimen MVZ31118 (see description of specimen age above) demonstrates an obscured anterior groove, and vertical ridges of smooth cortical bone on the proximal portion of the anterior shaft. The posterior groove is partially obliterated at the distal end of the shaft, while being deeper and narrower along the upper two thirds of the bone; this is consistent with a description by Rumph (1975: 96). What appears to be a remodelled fracture thickens the shaft mid-length. The lateral view demonstrates less taper between the proximal and distal ends of the shaft. These two specimens derive from the same area of Arizona and were donated to the Museum of Vertebrate Zoology by the same collector, presumably representing a coherent WTD population.

The morphology is believed to represent age related bone remodelling, a nonmetric trait, and is consistent with morphology observed among the Florida specimens and the described buttressing of sheep metatarsals (Thomas and Grimm, 2011). Skedros et al. (2003) finds the mineral (ash) content of distal limb bones for Mule Deer (*Odocoileus hemionus* ssp) increases proportionally to that of proximal limb bones relative to age and biomechanical stress; this may explain the observed variation in metatarsal morphology described above.

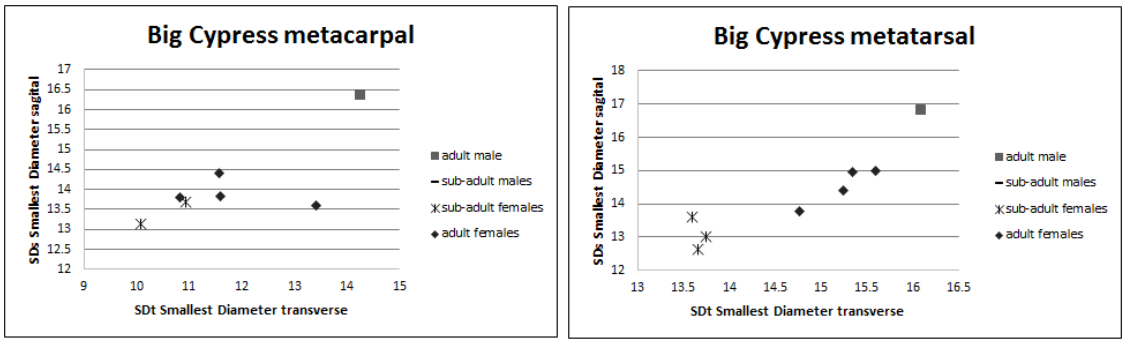


Figure 6-17 Big Cypress metapodia smallest diameter comparison.

Figure 6-17 shows the SDt and SDs for the metacarpal and metatarsal from the Big Cypress deer per age and sex cohort. In all metacarpals the smallest diameter transverse (SDt) was found on the distal portion of the shaft, 5 to 10mm superior to the distal epiphysis, while the metacarpal's smallest diameter sagital (SDs) was found in the same location on the sagital plane.

The smallest diameter of the metatarsal, however, varied by location and plane (see Figure 2-27). The SDs was taken wherever the diameter was smallest whether that was on the upper shaft or at the distal portion (see Figure 2-27). For unfused metacarpals and metatarsals the smallest diameter was always on the transverse plane 15 to 20mm superior to the distal epiphysis. On the right side of Figure 6-17 sub-adult females are noticably smaller on the transverse plane than the adult females, while the large male specimen shows a closer affinity to the oldest of the adult females, z:4573, than is seen on the left side of the figure or in the majority of graphs in the Baseline Study. The SDs for specimen z:4571 was at the distal end of the diaphysis and in fact smaller on the transverse plane (16.1mm) than on the sagital plane (16.79mm), while all females were smaller on the sagital plane than on the transverse plane. The degree of difference between planes was greater for adult females than for sub-adults; this quality may be either sex or age related (see Table 6-4); a larger sample size may clarify this point..

FLMNH#	State	Location	Date	Species	Age	Sex	Element	Side	SDt	SDs	Quotient
UF:6787	Guatemala	Tikal	NA	Mazama temama	20 m	US	metacarpal	R	8.07	9.98	81%
UF:6788	Guatemala	Tikal	NA	Mazama temama	38 m	F	metacarpal	R	7.36	9.85	75%
UF:6609	Trinidad	Nariva,tabaquit	1959	Mazama a.	20 m	F	metacarpals	*	8.79	12.8	69%
UF:6610	Trinidad	Mayaro	1959	Mazama a.	20 m	M	metacarpal	*	8.39	13.62	62%
z:4571	Florida	Collier County	1985	Odocoileus v.	36 m	M	metacarpals	*	14.35	16.35	88%
z:4576	Florida	Collier City	1985	Odocoileus v.	26 m	F	metacarpal	*	9.65	12.71	76%
z:4703	Florida	Collier County	1985	Odocoileus v.	60 m	F	metacarpal	*	11.57	13.83	84%
z:4580	Florida	Collier County	1985	Odocoileus v.	60 m	F	metacarpal	*	13.39	13.61	98%
z:4573	Florida	Collier County	1985	Odocoileus v.	60 m	F	metacarpal	*	11.6	14.42	80%
z:4572	Florida	Collier County	1985	Odocoileus v.	26 m	F	metacarpal	*	11.05	13.69	81%
z:4581	Florida	Collier County	1985	Odocoileus v.	28 m	F	metacarpal	*	10.75	12.78	84%
z:4705	Florida	Collier County	1985	Odocoileus v.	29 m	F	metacarpal	*	10.92	13.8	79%
z:4569	Florida	Collier County	1985	Odocoileus v.	30 m	F	metacarpal	*	10.32	13.15	78%
z:2850	Florida	Clay county	1985	Odocoileus v.	36 m	F	metacarpal	*	12.48	14.27	87%

Table 6-3 Metacarpals WTD Florida, brocket deer Guatemala, brocket deer Trinidad Island.

Table 6-3 above compares populations showing the SDt compared to SDs for metacarpals. Two brocket deer specimens from Guatemala had only right side metacarpals in their boxes. All other specimens had left and right metacarpals. When right and left side elements were present, their measurements were averaged, indicated by * in the table. WTD assessed under 24 months were excluded from this test as the metacarpal was unfused. In metacarpals the smallest diameter was found just above the distal epiphysis in both transverse and sagital planes. It is worth noting that side by side comparisions of bones from each population were not attempted largely because the materials were stored in separate labs, even though no variation was observed during data collection. The resulting quotient for the Trinidad Island specimens is smaller than for the deer from Florida and Guatemal. Metacarpals for all three populations taper steadily from the proximal articulation to the distal portion of the shaft as was shown in Figure 6-13 above.

FLMNH#	State	Location	Date	Species	Age	Sex	Element	Side	SDt	SDs	Quotient
UF:6787	Guatemala	Tikal	NA	Mazama temama	20 m	US	metatarsal	R	9.04	10.16	89%
UF:6788	Guatemala	Tikal	NA	Mazama temama	38 m	F	metatarsal	R	9.14	10.26	89%
UF:6609	Trinidad	Nariva,tabaquit	1959	Mazama a.	20 m	F	metatarsal	*	11.03	13.24	83%
UF:6610	Trinidad	Mayaro	1959	Mazama a.	20 m	M	metatarsal	*	11.57	13.51	86%
z:4571	Florida	Collier County	1985	Odocoileus v.	36 m	M	metatarsal	*	16.1	16.3	99%
z:4576	Florida	Collier City	1985	Odocoileus v.	26 m	F	metatarsal	*	12.39	13.1	95%
z:4703	Florida	Collier County	1985	Odocoileus v.	60 m	F	metatarsal	*	15.35	14.76	103%
z:4580	Florida	Collier County	1985	Odocoileus v.	60 m	F	metatarsal	*	15.24	14.2	107%
z:4573	Florida	Collier County	1985	Odocoileus v.	60 m	F	metatarsal	*	15.59	14.56	107%
z:4572	Florida	Collier County	1985	Odocoileus v.	26 m	F	metatarsal	*	13.6	13.39	102%
z:4581	Florida	Collier County	1985	Odocoileus v.	28 m	F	metatarsal	*	13.75	13.07	105%
z:4705	Florida	Collier County	1985	Odocoileus v.	29 m	F	metatarsal	*	14.77	13.82	107%
z:4569	Florida	Collier County	1985	Odocoileus v.	30 m	F	metatarsal	*	13.66	12.46	110%
z:2850	Florida	Clay county	1985	Odocoileus v.	36 m	F	metatarsal	*	14.73	13.5	109%

Table 6-4 Metatarsals WTD Florida, BD Guatemala, BD Trinidad Island.

Table 6-4 above demonstrates the same information for the metatarsal. For the brocket deer in both populations and for specimens z: 4571 and z: 4576 from Florida the SDs was at the distal end of the metatsal. The table shows transverse measurements were smaller than those taken on the sagital plane. For all other Florida specimens SDs

was approximately 30-40mm inferior to the proximal articualtion. For these individuals measurements on the sagital plane were smaller than those taken on the transverse plane. On these samples the shaft showed a greater depth between the anterior and posterior margins with the posterior surface presenting a slightly curved profile. Specimens z: 4571 and z: 4576 also displayed this anterior to posterior deepening but not to the same extent.

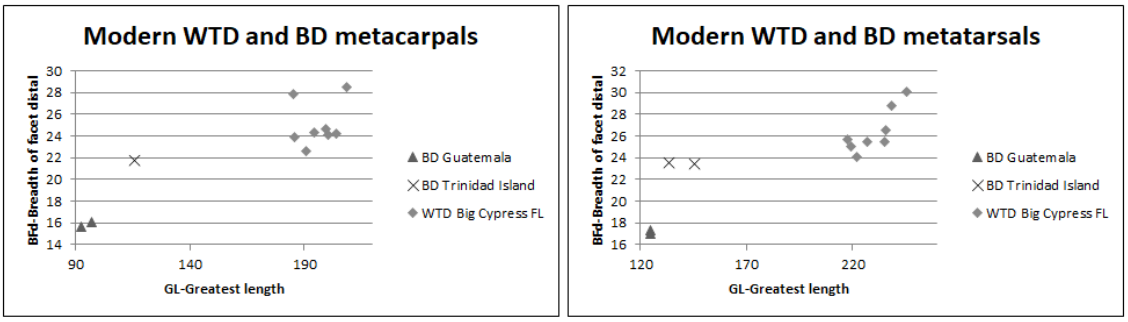


Figure 6-18 WTD and brocket deer comparison of metapodia by GL and BFd.

Figure 6-18 above compares metapodia GL (greatest length) with BFd (breadth of the distal facet) for metacarpals and metatarsals (see Figure 2-26); in the previous chapter GL was platted against SDt and SDs. In Figure 5-21 the pattern for WTD in these two figures is almost identical despite the use of a different breadth measurement in each figure.

The two animals fromTikal Guatemala are each represented by a single metacarpal and metatarsal. Two specimens from Trinidad had paired metacarpals and metatarsals, as did nine WTD specimens from Florida. Measurements from each pair were averaged and are shown in Figures 6-17, 6-18, and 6-19; these charts show brocket deer from these two populations cluster separately from the Big Cypress WTD by length. However, the breadth of the distal facet of the vertical axis of Figure 6-17 plots the Trinidad island deer in the same range as the WTD from Big Cypress, FL, including those sub-adults demonstrating distal fusion (see Chapter 5). The Guatemalan deer plot separately from both the WTD and Trinidad Island brocket deer for proximal breadth in Figure 6-18 below.

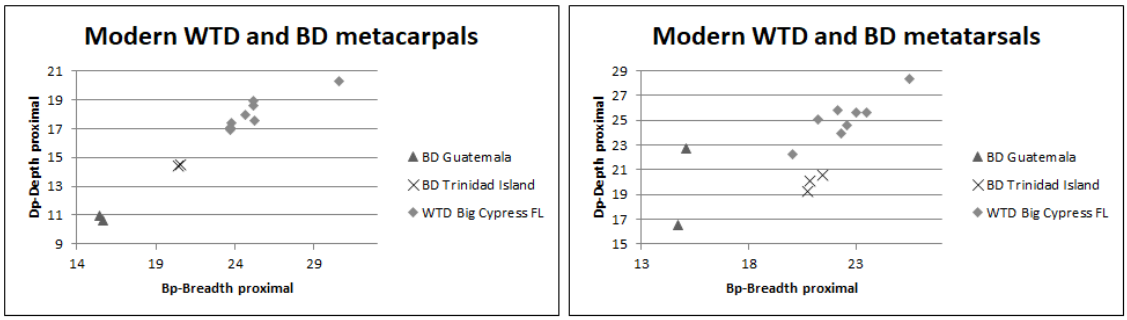


Figure 6-19 WTD and brocket deer comparison of distal metapodia by Bd and Dd.

Applying proximal depth and breadth measurments shows Trindad specimens fall between animals from Guatemala and Florida using breadth measurements of the metacarpals. For the metatarsal, those measurements plot the Trinidad population more closely with the Florida sub-adults.

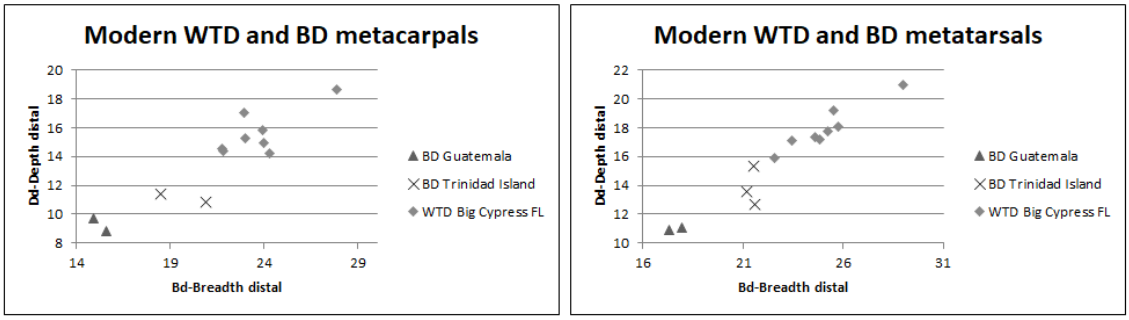


Figure 6-20 WTD and brocket deer comparison of distal metapodia using Bd (distal breadth) and Dd (distal depth).

Later fusing distal measurements above (see Figure 3-11) show distinctions between these populations. That the Trinidad deer are assessed in this research as sub-adults should be considered.

The difference in metatarsal morphology between WTD and brocket deer from the populations in Guatemala and the Island of Trinidad may be related either to gait or to the size (mass) of these animals. The quality of available forage, local terrain, and need for predator avoidance are also factors to be considered.

6.4 Synopsis:

The one goal of this project is to determine the relative contribution of male and female WTD to Maya diets/economy. Since brocket deer also contributed to Maya economies and are recorded in many of the archaeological assemblages and the question of species identification remains open, it was agreed I would record any brocket deer present in the assemblages. The available modern reference materials for brocket deer at FLMNH (only Specimen z: 8851, unsexed, was relatively complete) were too few to develop better than tentative understanding of the species. Available specimens do not

appear to be sexualy dimorphic and this agrees with discovered literature (Giest, 1998; Miller et al. 2003), therefore it is not possible to test the archaeological samples of brocket deer for sex at this time.

Test results show the smallest diameter of the 1st phalanx among red brocket deer from Guatemala appears in a different plane and position than specimens from the Island of Trinidad or for the WTD from Florida. This was consistent for both modern reference specimens and Central American archaeological samples identified to species. The location and plane on which the smallest diameter is identified for WTD metatarsals seems to be related to the individual's age and total body mass. The large male specimen z4571 did not display this attribute. However, in addition to demonstrating a stature less than predicted by the literature, the larger dimensions of that individual's limb bones may have been sufficient to buffer the extensive bone remodeling that was observed among adult female specimens.

The taxnomy of the red brocket deer from the Maya area is in dispute and inclusion of the specimens from the Island of Trinidad failed to illuminate the question. Typically island mammals are smaller than their mainland relatives, but that is not the case here. The morphology of the 1st phalanx (proximal phalanx) is different between the two brocket deer populations, and this could support the hypothesis the red brocket deer from Guatemala are a different species than the red brocket deer from South America (Grove and Grubb, 2011; Escobedo-Morales et al. 2016). The observations of MVZ speciemen 98889 (*Odocoileus virginianus truie*) from El Salvador in Figure 6-6 might indicate a parrallel adaptation of gait for WTD and red brocket deer in the region or may be pathology resulting from inividual misadventure. Which ever way the official taxonomy falls out, the modern brocket deer specimens from Guatemala are not comparable to the specimens from Trinidad, and therefore the later must be excluded from comparisons to the archaeological samples. Only brocket deer Specimen z:8851 presented a relatively complete skeleton. The measurements of this specimen could be used as a standard for log ratio analysis. However, the physiology and anatomy of this species needs to be expanded significantly before I can formulate useful questions that such analysis might serve.

An annoyingly casual reference within a text cataloguing artefacts from the Sidey-Mackay site describes 'a harpoon point made from WTD metatarsal buttress' (Hamalainen, 1999), absent any citation or reference for this anatomy; I must question if this anatomical quality was sufficently well known in the recent past to have fallen out

of the literature. If these anatomical traits are known, refreshing academic discussion on the topic would be valuable to future studies.

Understanding the age profiles of hunted game animals is a significant step toward understanding how ancient peoples managed their resources, providing a valuable lens through which archaeology might understand the economic and social paradigms informing resource management. Indeed, documenting of nonmetric anatomical traits that could enable a more detailed view of the mortality profile and sex ratio for WTD is an important step in in this research for discerning prey selection.

Having conducted an in-depth analysis of the modern collections of WTD and expanded on the original a series of methods to facilitate the analysis of archaeological collections, it is now time to return to the overarching focus of this thesis; that is, the Maya's relationship with WTD.

Chapter 7 The Artefacts - Looking for Sex:

From the known to the unknown, the baseline study tested modern reference specimens of WTD of known sex and age for evidence of sexual dimorphism using osteometrics and size index scaling (Meadow, 1999; Albarella, 2002; Sykes, 2011). In the chapter for morphology the reference materials were examined for diagnostics that might assist in distinguishing between deer species present in the assemblages and for ontological markers that could discern age-class among older deer. These characteristics are applied to the archaeological samples in this chapter with the intention of illuminating the demographics of deer harvested by the Maya as well as demonstrating the potential of these diagnostics to advance faunal analysis.

This section compares deer bone samples recovered by archaeologists to the modern reference collections for the purpose of determining the ratio of males to females present in the archaeological assemblages. As shown in the baseline study of modern specimens from Florida, while adult males and sub-adult females cluster reasonably distinctly, sub-adult males intersect in size with adult females. In order to determine the number of male animals compared to females it is necessary to examine the mortality profile present in each assemblage as well as how the archaeological samples compare to references specimens for measurements of length, breadth and depth. This chapter attempts to account for each of the artefacts recorded and make the fullest possible use of trends in size and morphology observed for sex and age cohorts in the baseline study. The detailed descriptions that follow are intended as demonstration of support for the following chapters.

Since intact mandibles were uncommon among the observed archaeological material, epiphyseal fusion of the long bones must suffice for assessing the age category of deer bones excavated by archaeologists (see Table 2-3). The age assessment tables below categorize each skeletal element by the age at which a specific epiphysis is predicted to fuse sufficiently for preservation, following Purdue (1983b). Six age categories are listed, less than five months old, greater than six months old, greater than 14 months, equal to or greater than 20 months, equal to or greater than 30 months, and equal to or greater than 38 months; the predicted ages are specific to the samples analysed rather than the whole assemblage. Additionally, these tables serve to quantify the samples recorded for this study by species and cultural periods represented in the basal documentation.

The second method uses log ratios as shown in Figures 5-6 and 5-7 in the baseline study. The Mean measurements of four adult specimens from the reference collection are represented as zero in each measurement plane for breadth, length, and depth in the charts for log ratios (see Table 2-1). Measurements from each sample in the archaeological assemblages were segregated per plane of measurement for comparison to that standard (see Digital Appendix IV: multiples averaged). The histograms generated for this chapter show how the archaeological materials compare to the modern population studied. As breadth measurements for adult females and sub-adult males are similar but depth measurements seem to increase as these animals age, a comparison of breadth and depth charts can potentially distinguish between stature and which age classes are present. The length of the long bones seems to vary between different populations in Florida but except for specimen z: 2850, the breadth of these same skeletal elements is consistent between adult females from different parts of the state. The variations above zero may indicate changes in either population stature or the presence of adult males in an assemblage.

Finally, XY scatter plots facilitate a side by side comparison of the measurements from the four adult specimens from Big Cypress. These were used to create the Standard and are applied in the log ratios to facilitate direct comparison between methods and to avoid overcrowding the scatter-grams. The testing of reference specimens in the baseline study confirmed that bone size reflects sexual dimorphism, while revealing fusion sufficient to survive intact in sediments does not necessarily demonstrate adult stature (see Figures 5-12, 5-16, 5-20, 5-21) and thus the discernment of sex and age profiles in any assemblage must be a nuanced process.

The assemblages tested for this project come from several sources and some variations in consistency of terminology and sample identification were detected. Adjustments to the terminology were therefore required; these changes are described in my field notes (see Appendix B). The archaeological sites described in the materials section often contain samples from multiple periods in the chronology of Maya civilization. As one goal of this project is detection of changes in WTD stature in relationship to changes in human population demographics and landscape management, the chronology of these assemblages and the samples derived from them is described in each chart and graph presented below. A second issue in understanding variations in stature among WTD is the quality of available nutrition. Both landscape regime and variations in the environment would naturally influence the nutrient quality of deer

forage, thus the sites are organized in this chapter first by geographic regions and secondly by chronology.

7.1 Yucatán:

Northern Maya Lowlands

Ek Balam: this Historic Era assemblage is presented first as most of the samples recorded from that assemblage are the result of a naturally occurring deposit rather than a cultural context, and primarily represent animals presumed to be wild and most directly comparable to the modern reference specimens. This is the only assemblage from the Yucatan region as well as being the only assemblage in this study formed under direct Spanish political and economic control.

Assessed age by element fusion

Ek Balam		
Period	Species	WTD
Historic Era	< 5 months	
	humerus shaft only	0
	≥6 months	
	prox. Metacarpal	2
	prox. Metatarsal	2
	complete 2nd phalanx	1
	astragalus	2
	scapula	1
	distal humerus	1
	prox. Radius	0
	< 14 months	
	tibia shaft only	0
	femur shaft only	0
	unfused ulna	1
	unfused calcaneus	0
	≥ 20 months	
	distal radius	0
	distal metacarpal	0
	distal metatarsal	0
	distal tibia	0
	complete 1rst phalanx	2
	prox. Femur	1
	fused ulna	1
	fused calcaneus	2
	≥ 30 months	
	complete metacarpal	0
	complete metatarsal	0
	prox. Humerus	1
	distal femur	1
	prox tibia	0
	≥ 38 months	
	complete humerus	0
	complete femur	0
	complete tibia	0
	complete radius	1
	Total	19

Table 7-1 Samples recorded for Ek Balam, number of samples for each category.

In Table 7-1, nine of the recorded elements are early fusing; three samples in the 30 to 38-month categories would represent adult animals. Only the unfused ulna proves the presence of a sub-adult. As was expected, few intact long bones (except phalanges) were observed in the archaeological assemblages. Most samples presenting breadth measurements also offered depth measurements but this was not always the case, and the number of samples seen varies from one chart to another in the same assemblage. In the Baseline Study, sexual dimorphism between the adult male and adult females from Big Cypress, while less distinctive than was reported in the literature for this species, remains clearly visible in all planes of measurement. However, differences between adult females and sub-adults were only visible when comparing measurements of bone breadth with depth measurements. For ease of comparison the log ratio charts are organized in one figure throughout this document.

The log ratios in Figure 7-1 show the largest number of breadth ratios coincide with zero; four samples, however, plot above zero including one ratio at the top of the-scale at + 10. Five samples presented intact lengths, one that plots at zero and four that plot below, only one ratio plots below minus seven. For depth ratios 13 samples contributed data; six were below zero, two at zero, and three ratios plot above zero. There were no depth ratios smaller than minus five.

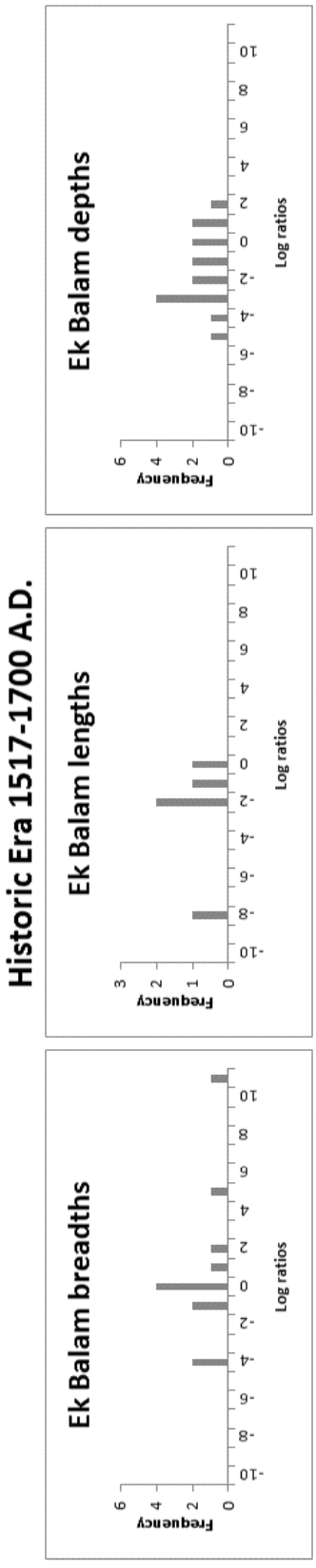


Figure 7-1 Log ratios of Historic Era Ek Balam samples compared to the standard for evidence of sex and age cohort.

As was the case for the Baseline Study these descriptions begin with the astragalus as the density of this skeletal element means it is well preserved in most of the assemblages studied.

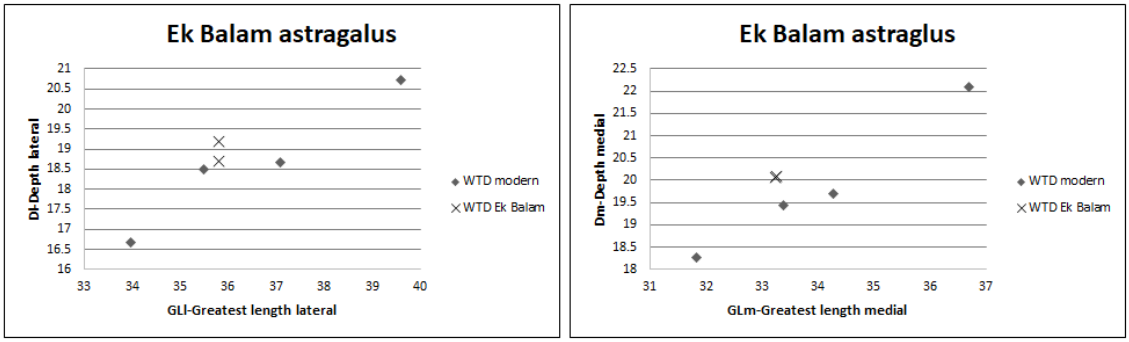


Figure 7-2 Comparison of Ek Balam samples with modern specimens using lateral and medial measurements of the astragalus.

In Figure 7-2 the modern male specimen plots separately from the female specimens in the upper right corner of both graphs. For the astragalus, length and depth measurements appeared in the Baseline Study to be the clearest for discerning sexual dimorphism. This robust skeletal element preserves well, but variations in sample preservation coincide with my objective of deducing the greatest possible information that each sample can deliver, thus length and depth measurements for both the lateral and medial sides of the astragali are presented when these are available in the recorded data. Samples 702EB and 718EB plot with the modern females from the reference collection for length but slightly greater for depth on both the lateral and medial sides of the bone. If my hypothesis that depth measurements are more sensitive to ontological age is correct this could indicate these samples derive from individuals older than specimens z:4580 and z:4703; however, that hypothesis requires additional support beyond what was seen in the previous chapters.

Preservation of scapula among the archaeological assemblages was extremely poor, only the LG and BG were consistently available for measurement. Figure 7-3 shows Sample 711EB the sample plots between the modern adult females and the male specimens. Figure 5-9 showed little variation between adult female specimens and sub-adults using these measurements for the glenoid. The sample may represent a sub-adult male but an older adult female is equally likely.

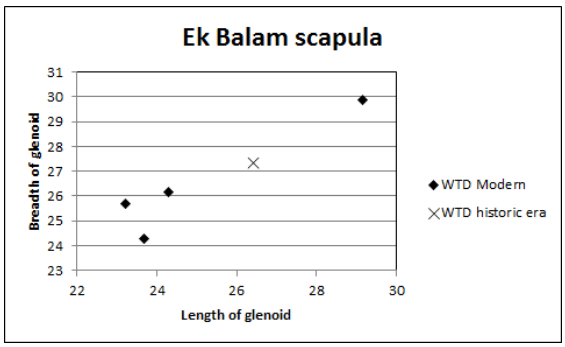


Figure 7-3 Comparison of Ek Balam samples using glenoid breadth and depth.

There are two humeri recorded in the Ek Balam collection. In the left side of Figure 7-4, Sample 704EB, a fused proximal humerus indicating an adult animal, appears close to the modern male and is recorded as unusually large in my field notes. While sample 705EB (modified), indicating it is from the cultural phase of the excavation, appears in the right-side graph and is noted in my field notes as having thin cortical bone suggesting a juvenile individual. The height of the trochlea is below the range demonstrated by sub-adults in the reference collection (Figure 5-11), though the larger breadth measurement is unexpected in a juvenile sample.

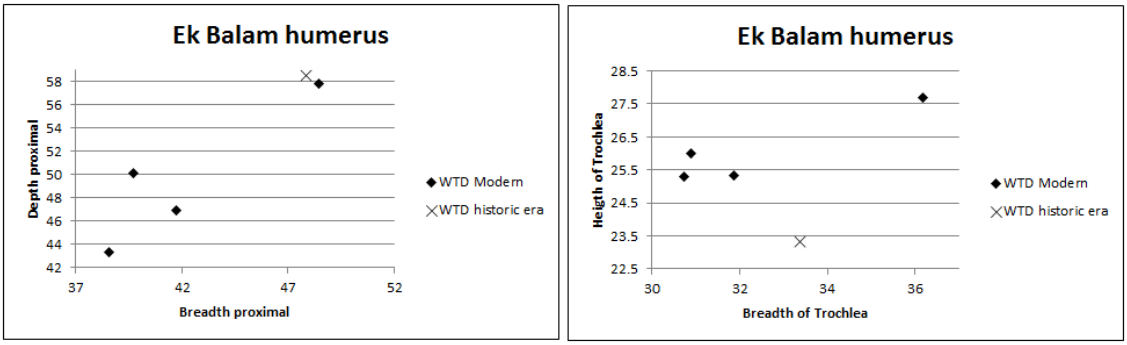


Figure 7-4 Comparison of Ek Balam samples using proximal and distal measurements of the humerus.

Sample 712EB is a single intact radius, it plots with the female specimens for proximal breadth and depth, slightly larger for the late fusing distal breadth and smaller for distal depth. The distal radius fuses earlier for females than it does for males (see Table 3-4). The greatest length for this sample is 10mm shorter than the modern female sub-adults and 20mm less than the adult females. There was no evidence of woven bone along the ulnar grove that would suggest fusion of the ulna to the radius. This does not prove the animal was young, but paired with the shorter GL it may suggest a young adult.

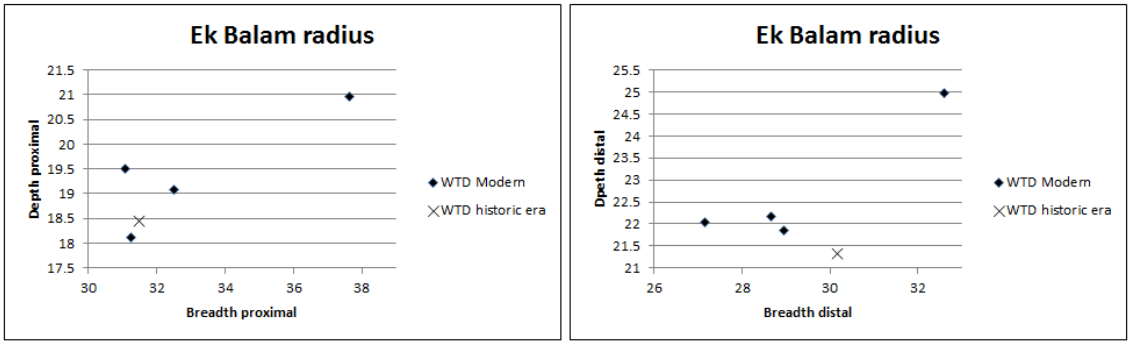


Figure 7-5 Comparison of Ek Balam samples using proximal and distal measurements of the radius.

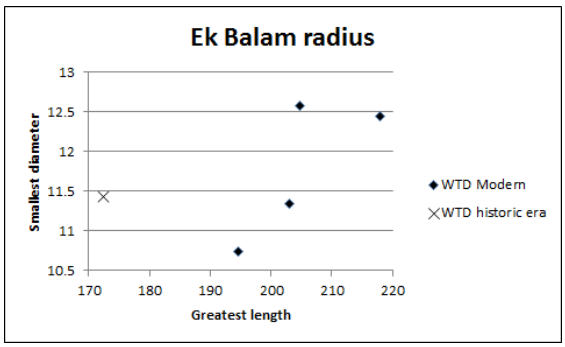


Figure 7-6 Comparison of Ek Balam samples using length and smallest diameter measurements of the radius.

Two femurs are present in the Ek Balam assemblage, Sample 703EB is recorded as distal condyles and 50% of the shaft noted as a large individual with prominent muscle scaring. This sample displays gnawing marks sufficient to obliterate all distal measurements except Dd. With only one standard measurement it is absent from Figure 7-7 but is represented in the log ratios in Figure 7-1 Sample 703EB is a proximal femur with visible fusion lines indicating either a sub-adult or young adult. The sample's position on the graph midway between adult females and the male in the reference collection indicates a young male.

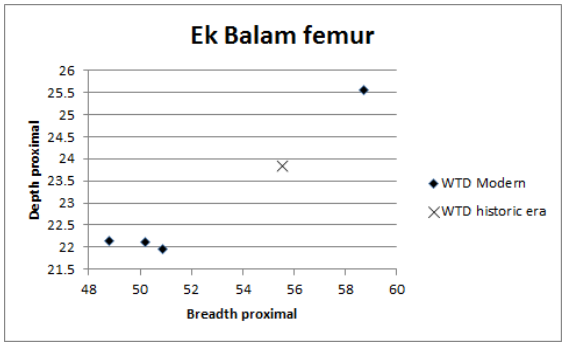


Figure 7-7 Comparison of Ek Balam samples using proximal measurements of the femur.

There were two ulnae recorded in the collection. Sample 713 not shown in Figure 7-8 was unfused indicating a sub-adult or juvenile. Sample 714 was fused and in

the graph above the DPA plots with the female specimens. The LO measurement plots 20% smaller than the modern female specimens. However, the DPA and LO measurements were inconclusive for distinguishing between adult and sub-adult females in the reference collection.

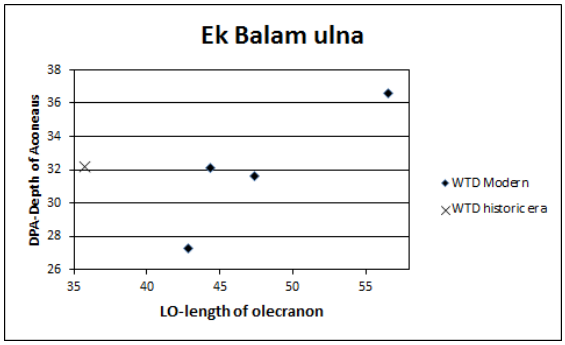


Figure 7-8 Comparison of Ek Balam samples using measurements of the olecranon.

Two calcanei were recorded; Sample 701EB fits within the range for modern females. Sample 719EB circled in green is recorded in my field notes as gracile, despite the large breadth and depth measurements of the articular facet. The GL of this sample plots within the female range. On the right side of the graph the greatest depth GD is larger than any modern females, on the left side of Figure 7-9 the GB measurement exceeds all modern male and female specimens. Based on Skedros et al. (2004) this could indicate an older animal or one subject to significantly more biomechanical stress than the modern animals from Florida.

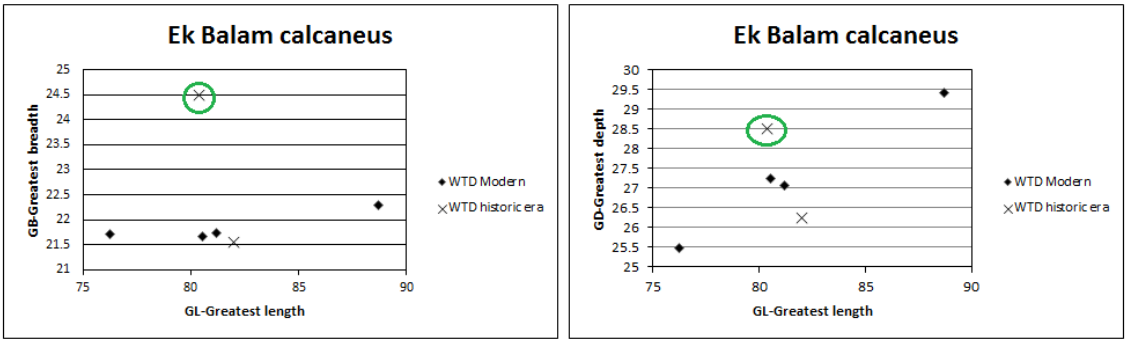


Figure 7-9 Comparison of Ek Balam samples using length, breadth, and depth measurements of the calcaneus.

Metapodia: in Chapter 3 it was shown that distal fusion of metacarpals and metatarsals occurs late in the second year of life. In Chapter 6 it was also hypothesised that biomechanical stress can cause significant bone remodelling of the metatarsal among WTD. These two qualities of ontology are used in this chapter to discern sub-adult from adult samples.

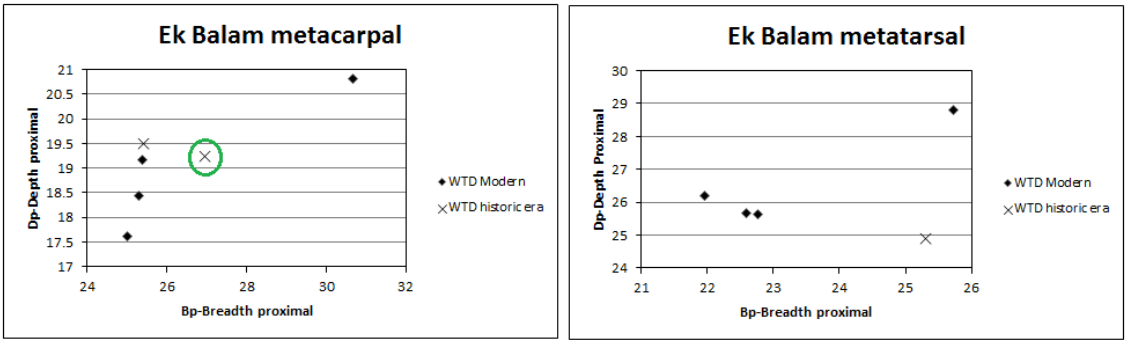


Figure 7-10 Comparison of Ek Balam samples using proximal measurements of the metacarpal and metatarsal.

Proximal breadth and depth: on the left side of Figure 7-10 are proximal metacarpals. Sample 706EB circled in green is slightly larger in breadth than the female specimens. Sample 700EB has 90% of its shaft intact. Both exceed the modern females for depth. On the right-side the graph for metatarsals show Sample 707EB is similar in breadth to the male specimen but plots more closely to the female specimens in depth. None of the male specimens demonstrated the smallest diameter of the metatarsal on the sagittal plane, possibly because of the limited age range for males in the collection.

7.1 i Summary of data:

Table 7-1 categorizing age class shows three samples that demonstrate adult morphology and one sample attributed to a sub-adult class. Figure 7-1 shows five samples at zero or greater in the chart for breadth and two samples in depths that are - 4, all within the range of adult specimens. The scatterplots appear to represent one adult male, two adult females of which one may have been quite old, one juvenile, and at least one but possibly two sub-adults, one of which may have been male. If a second sub-adult is represented by the radius, it likely represents a female.

Overall the animals from Ek Balam seem a close match in size for the modern adult specimens from Florida. As the single preserved long bone in the assemblage is assessed here as a sub-adult female it is not possible to determine if withers height is comparable between the deer from Ek Balam and those from Big Cypress.

7.2 Belize:

Southern Maya lowlands

The next four sites are from the modern state of Belize and roughly contemporary with each other, these assemblages reflect human cultural activity. During the historic period, the Spanish were an intrusive influence in the region but had not yet established political dominance of the region (Pendergast, 1981; Graham et al. 1989).

7.2 i Tipu Negroman:

The settlement's close cultural and political ties with Lamanai have already been noted as well as its participation in regional trade networks (Graham and Bennet, 1989; Emery, 1999; Williams et al. 2009). The Tipu collection was contained in 14 numbered boxes. Brocket deer dominate this assemblage. Table 7-2 below lists the recorded samples by species and cultural period in addition to categorizing the age cohorts as represented by bone fusion.

This is one of several assemblages that contributed a large number of samples suitable for recording and, while most Cervidae bones in this assemblage are identified in original documents as brocket deer, WTD are also present. For the historic era 12 WTD samples are early fusing elements. One sample may represent a juvenile, 13 samples indicate sub-adults and none definitively represent adult animals for this period. Postclassic samples present eight early fusing elements. Five samples that may represent sub-adults and one sample that can be identified as an adult. Roughly 46% of the WTD in this collection are from undated contexts or contexts containing material from several periods. This is not unusual as the ancient Maya regularly recycled construction materials. Only samples identified as WTD from firmly dated contexts are shown in the charts for this assemblage.

Age cohort using epiphysis fusion

Tipu Negroman													
Period		Historic Era		post-classic		mixed post classic & histc		undated contexts		Historic Era		post-classic		mixed post classic & histc		undated contexts	
Species		WTD		WTD		WTD		WTD		BD		BD		BD		BD	
< 5 months																	
humerus shaft only		0		0		0		0		1		0		0		0	
≥6 months																	
prox. Metacarpal		0		1		1		0		4		4		6		2	
prox. Metatarsal		1		2		0		2		0		3		3		1	
complete 2nd phalanx		6		1		0		1		1		1		2		2	
astraglus		3		1		1		4		9		5		2		2	
scapula		1		3		0		0		4		2		2		1	
distal humerus		1		0		0		0		3		3		0		1	
prox. Radius		0		0		0		1		2		1		3		2	
< 14 months																	
tibia shaft only		0		0		0		0		0		0		0		0	
femur shaft only		1		0		0		0		0		0		0		0	
unfused ulna		0		0		0		0		1		1		0		0	
unfused calcaneus		0		1		1		2		0		3		0		0	
≥ 20 months																	
distal radius		1		0		0		0		0		0		1		1	
distal metacarpal		0		0		0		0		0		0		1		1	
distal metatarsal		0		0		0		0		3		0		0		1	
distal tibia		1		0		1		2		3		1		2		6	
complete 1rst phalanx		6		1		3		6		8		3		4		0	
prox. Femur		1		0		0		1		1		5		1		2	
fused ulna		1		0		0		1		1		1		0		0	
fused calcaneus		3		0		1		2		3		0		2		5	
≥ 30 months																	
complete metacarpal		0		0		0		0		2		2		0		2	
complete metatarsal		0		0		0		0		2		2		0		2	
prox. Humerus		0		0		0		0		0		0		0		0	
distal femur		1		0		0		0		0		0		0		0	
prox tibia		0		0		0		0		0		0		0		0	
≥ 38 months																	
complete humerus		0		0		0		0		1		0		0		2	
complete femur		0		0		0		0		0		0		0		1	
complete tibia		0		0		0		0		0		1		0		0	
complete radius		1		0		1		0		0		1		0		2	
Total		24		11		14		26		52		41		29		36	

Table 7-2 Samples recorded for Tipu Negroman.

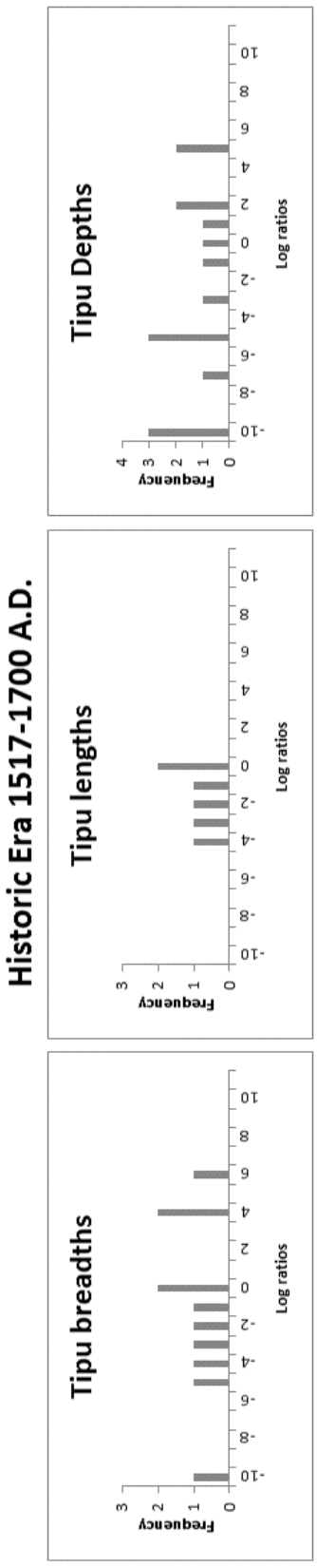


Figure 7-11 Log ratios of Historic Era Tipu Negroman samples compared to the standard for evidence of sex and age cohort.

Figure 7-11 shows WTD from historic period contexts. The presence of adult males is possibly indicated in the chart for breadths on the left; one sample plots at -10 for breadth, which is consistent for modern sub-adults. The ratios for length in the

centre chart are at or slightly below zero, while on the right a mix of depth ratios may show the presence of adult and sub-adult animals.

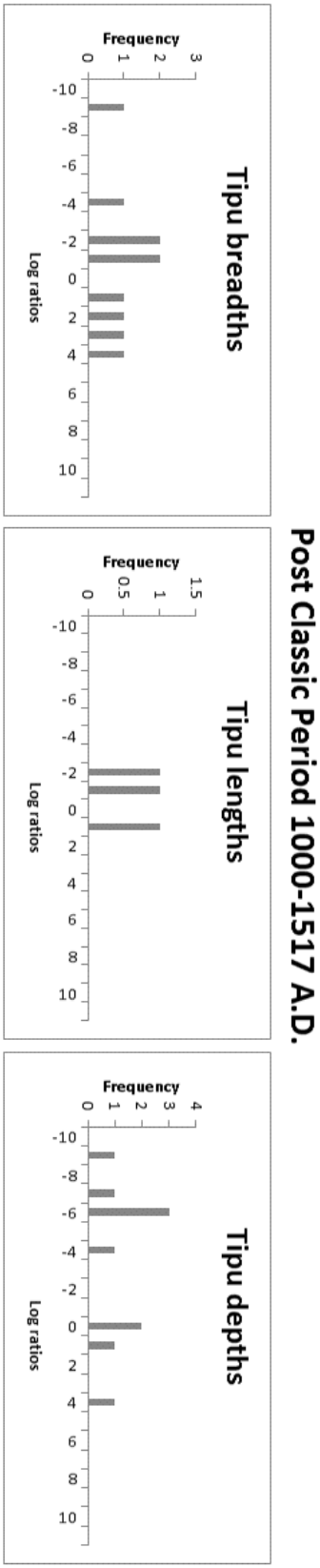


Figure 7-12 Log ratios of Postclassic Tipu samples compared to the standard for evidence of sex and age cohort.

Figure 7.12 shows WTD from contexts dated to the Postclassic Period. The chart for breadth ratios on the left side of Figure 7.12 shows four samples plotting above zero. In the centre, the chart for lengths show three ratios plotting close to zero, and on the right the chart for depths reveals five ratios plotting at or below -6, possibly indicating sub-adults are present in the assemblage.

After excluding all samples that might represent brocket deer and WTD derived from undated or contexts representing more than one distinct cultural period, four astragali were plotted using the length and depth measurements for both lateral and medial sides of the astragalus. On the left, all four samples plot within the range of the modern female specimens. On the right side, one historic sample had no medial measurements to contribute, and one historic sample overlaps a modern specimen almost exactly.

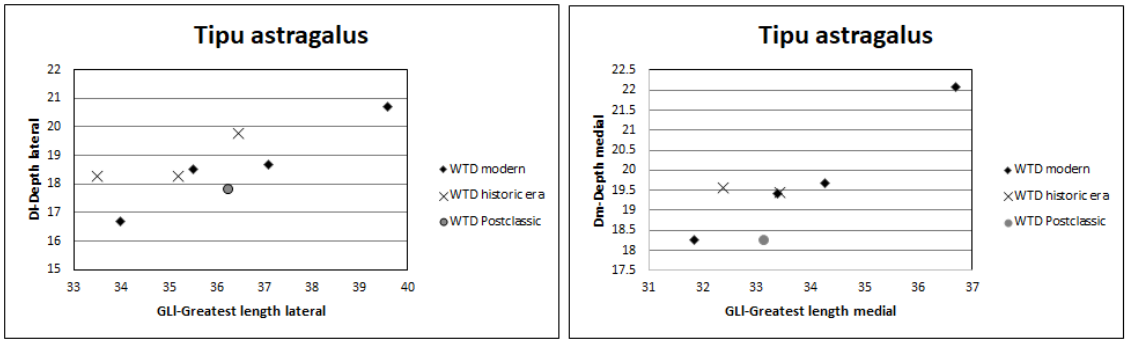


Figure 7-13 Comparison of Tipu samples using lateral and medial measurements of the astragalus.

For the scapula in Figure 7-14 below Sample 456T7 (Postclassic) plots more closely with the male specimen, and the historic Sample 339T1 falls between the modern male and female specimens for breadth but has a greater depth measurement. Samples 413T6 and 414T6 (Postclassic) plot with the female specimens.

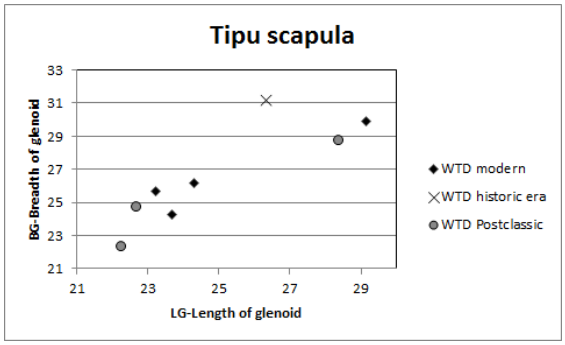


Figure 7-14 Comparison of Tipu samples using breadth and depth of the glenoid.

Of the 12 humeri present in the boxes only one could be identified as WTD. This historic period sample plots slightly larger than the female specimens for breadth

measurements, but in the same range as females for depth measurements. In Figure 5-11 the sub-adult males were smaller or within the same range for breadth and depth measurements as the adult females. Assuming the ontology for these two populations is similar this may indicate a more robust stature for some of the animals represented in the assemblage.

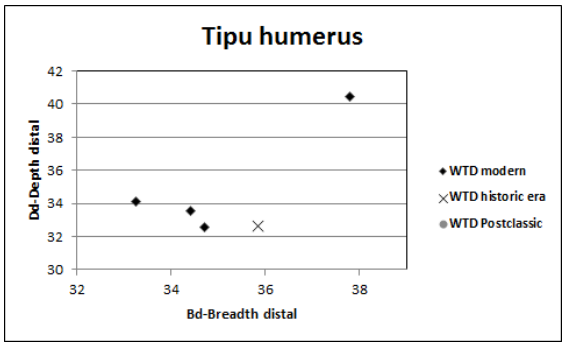


Figure 7-15 Comparison of Tipu samples using distal measurements of the humerus.

Four WTD radii were available for measurements: two from undated contexts, one from the historic era and one from the Postclassic. The greatest length for Sample 488T9 (Postclassic) is a refit shown in both graphs, and plots among the adult females for length and smallest diameter on the left in Figure 7-16. While plotting with the male specimen on the right side of the figure for distal breadth but not for depth. Sample 530T14is a distal radius from the historic period. In the right-side graph it plots more closely with the male specimen for breadth and depth.

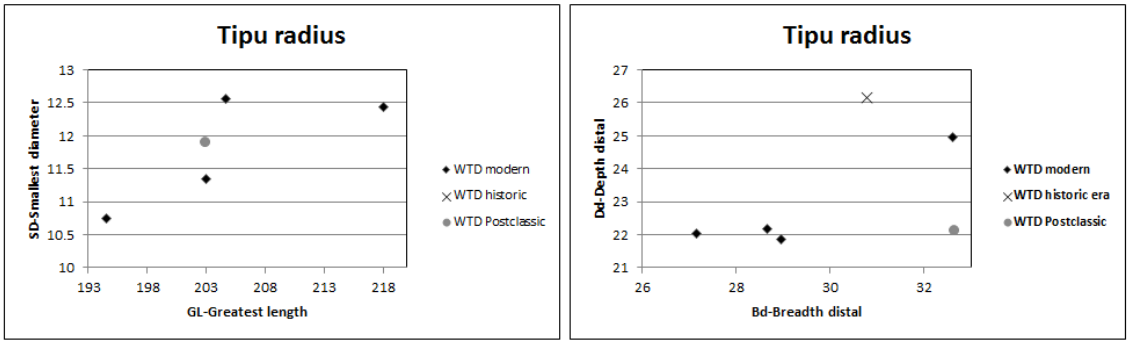


Figure 7-16 Comparison of Tipu samples using GL, SD, Bd, and Dd measurements of the radius.

Out of 18 tibiae recorded, four distal samples were identified as WTD, two of those from undated contexts. The depth measurement for Sample 318T4 (historic) is markedly greater in depth than all modern specimens but plots within the female range for distal breadth. Sample 432T8 also plots with the modern females for breadth but slightly smaller for depth and may be either an adult female or a sub-adult male.

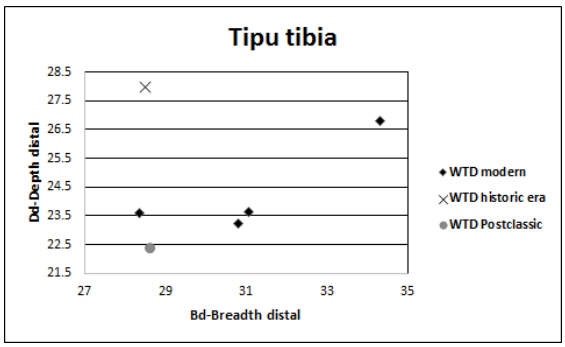


Figure 7-17 Comparison of Tipu samples using distal measurements of the tibia.

Three ulnae were recorded, one from an undated context, and two from the historic period, one of which was unfused. Sample 528T14 in Figure 7-18 plots with the adult females.

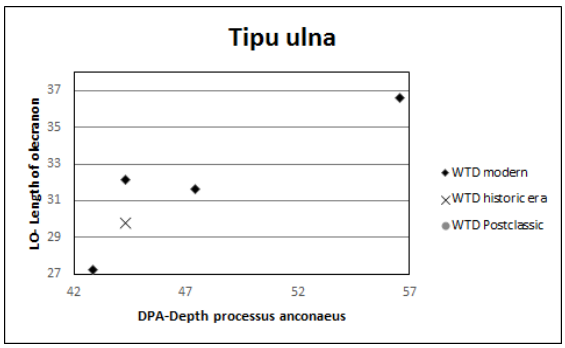


Figure 7-18 Comparison of Tipu samples using measurements of the olecranon.

Eight fused WTD calcaneus were recorded, one sample from deposits with mixed Postclassic and historic materials and two from undated contexts were excluded. In Figure 7-19 we see Samples 506T12 from the Postclassic circled in green and 474T7 from the historic era circled in red plot between male and female specimens for length. Sample 455T7 circled in blue may be an older female. Among the reference specimens GD and GB measurements for the calcaneus appeared consistent, it is however a very small number of individuals from which to assume knowledge for a whole population or species.

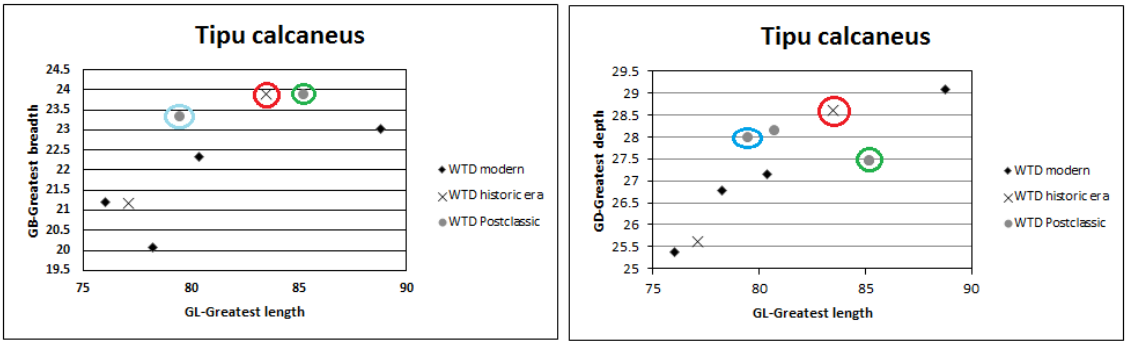


Figure 7-19 Comparison of Tipu samples using length, breadth, and depth measurements of the calcaneus.

Two WTD proximal metacarpals were recorded. Sample 337T1 is slightly larger than the modern females in breadth but smaller than all specimens for depth, indicating a sub-adult male. The comparable Sample 429T8 was from a mixed deposit and is not shown here.

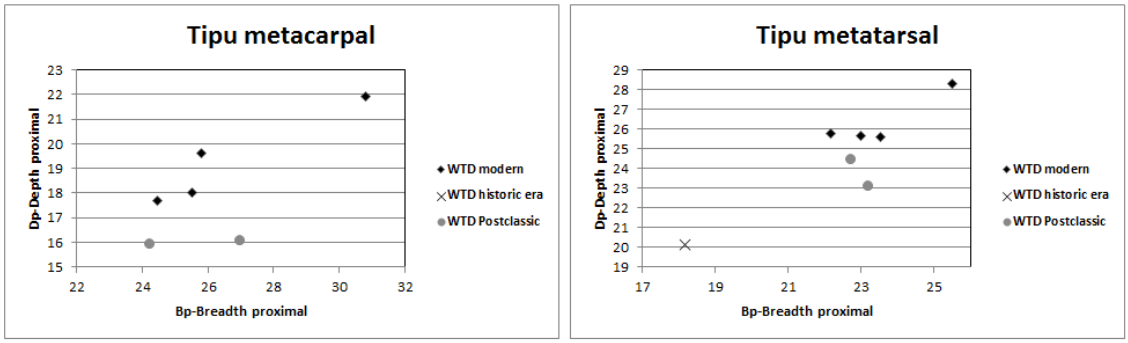


Figure 7-20 Comparison of Tipu samples using proximal measurements of the metacarpal and metatarsal.

Three WTD proximal metatarsals are shown, Sample 307T4 (historic) falls between red brocket and WTD in size (see Figure 8-10). Samples 336T1 and 415T6 test within the breadth range for adult females.

7.2 ii Summary of data:

Table 7-2 shows 12 early fusing skeletal elements and no samples presented with definite adult morphology and one sample that demonstrates sub-adult characteristics in the historic era. Postclassic samples show eight early fusing bones that may be adults or sub-adults, one sample with adult morphology and one sample with sub-adult qualities. In Figure 7-11 tracking Historic Era materials the chart for breadth shows five ratios at or greater than zero, five ratios below the Standard and one breadth ratio below -10. In the chart for depths four ratios are below -6 with a spike at -10. As Chapter 5 showed, sub-adults demonstrate smaller depth measurements in comparison to the breadth measurements for the same specimens. Figure 7-11 implies the presence of sub-adults in the assemblage. Figure 7-12 (Postclassic) displays four ratios at or greater than zero in the chart for breadth and seven ratios at or smaller than minus 6. In the baseline study (see Figure 5-6) the depth readings at the bottom of the scale appeared to discern the presence of sub-adults in the reference collection. In the scatterplots above, two samples from the historic era appear to represent adult males, seven samples represent adult females or sub-adult males and one sample may represent a sub-adult female. Samples from the Postclassic Period present one adult male, ten samples that could be either adult females or sub-adult males and two samples that are likely to represent sub-adult males. Assuming the hypothesis proposed in the baseline

study regarding depth measurements is accurate two females and one male individual could represent older animals. There may be some variation in stature represented in this assemblage independent of sexual dimorphism or age cohort (see Chapter 9).

7.2 iii Lamanai:

Historic Era WTD remains include 20 early fusing elements, 42 samples that indicate sub adults, and four samples that can be defined as having adult morphology. Early Postclassic materials include 9 early fusing elements, 12 samples that are at least 20 months old and one sample that is definitively adult.

The largest number of samples come from historic layers. The early Postclassic is also well represented in the material recorded with a few samples attributed to the Buk Phases of early Postclassic which is also reported for Marco Gonzales (Williams et al. 2009) and Tipu (Emery, 1999). Other samples are attributed to middle and late Postclassic and one to the Preclassic Period. Table 7-3 shows elements recorded for this assemblage and their chronology.

Age cohort using epiphysis fusion

| Lamanai, Belize | | |

Figure 7-21 shows seven breadth ratios at zero and nine exceeding the averaged measurements for the reference, indicating mature males may be present in the assemblage. Three length ratios are greater than the Standard, all other length ratios plot below zero. In the chart for depth, a single sample plots as greater than the Standard and eight ratios fall below -6 possibly indicating the presence of female sub-adults or juveniles in the assemblage while 28 ratios fall within the range for adult females and sub-adult males.

Figure 7-21 Log ratios of Historic Era Lamanai samples compared to the standard for evidence of sex and age cohort.

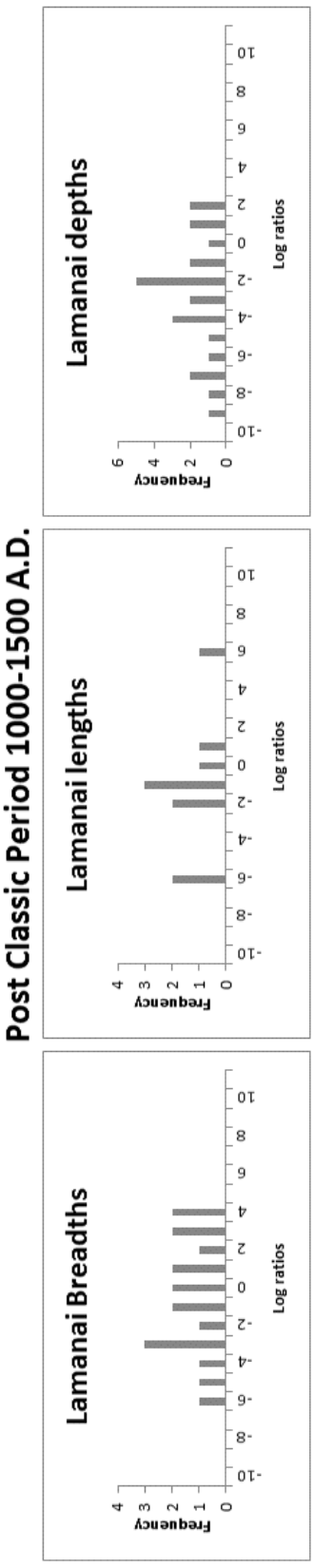


Figure 7-22 Log ratios of Postclassic Lamanai samples compared to the standard for evidence of sex and age cohort.

Figure 7-22 for the Postclassic shows two ratios at zero in the chart for breadth with seven ratios exceeding the Standard. Seven ratios are smaller in breadth than the reference. In the chart for length, three ratios plot at or above zero, five samples plot

below the reference. For depth, five ratios plot at or above zero and four samples plot below - 6. Overall there are fewer Postclassic samples than historic, however the number of breadth ratios below minus four among the historic samples is interesting.

There were too few samples from the Preclassic to produce histograms for that period. Th Preclassic samples are, however, addressed in the next chapter (see Figure 8-2). The samples from undated contexts are shown in Table 7-3 but otherwise excluded in this chapter (see Figure 8-22).

A total of 14 WTD astragali were recorded, ten from the historic period, four from the early Postclassic. When compared to the reference specimens' length measurements on the medial and lateral side of the astragalus are relatively consistent. On both sides of Figure 7-23, Sample 525LA (historic) appears in the upper right of both graphs likely representing an adult male, while Sample 526LA appearing in the lower left may represent a sub-adult female. All other samples cluster with the modern female specimens. There is some slight separation between the Historic Era samples and those from the Postclassic on the left side of Figure 7-23 that might indicate the presence of sub-adult males in the historic assemblage but this is by no means certain.

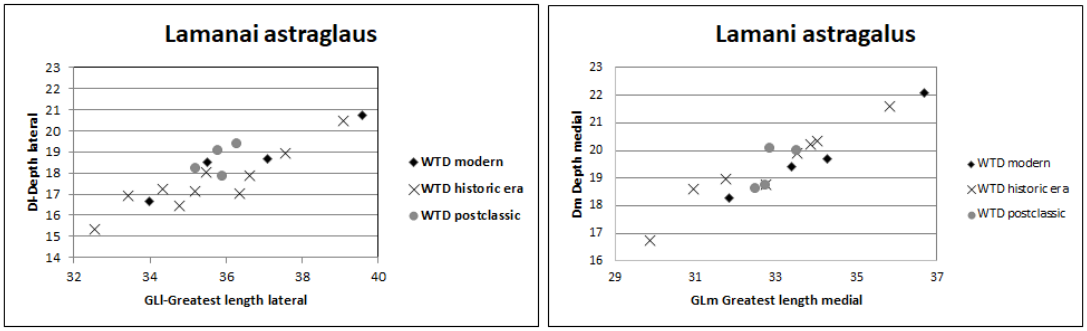


Figure 7-23 Comparison of Lamanai samples using lateral and medial measurements of the astragalus.

Two scapulae were recorded but only Sample 517LA had sufficient measurements to generate a scatter plot, shown in Figure 7-24, possibly an older adult female.

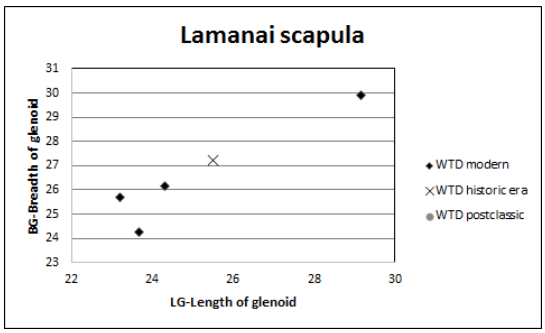


Figure 7-24 Comparison of Lamanai samples using breadth and depth measurements of the glenoid.

Seven WTD humeri were recorded; on the left side of Figure 7-25 Sample 578LA (historic) has a visible proximal epiphysis indicating the sample derived from a young adult. The smaller breadth measurement would be consistent with a sub-adult female but the proximal depth measurements are a better match for the oldest of the female specimens. No comparable measurements for sub-adult male specimens were recorded.

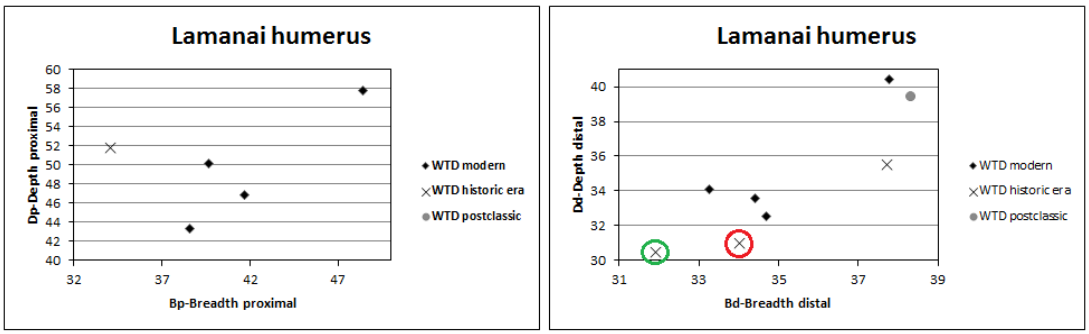


Figure 7-25 Comparison of Lamanai samples using proximal and distal measurements of the humerus.

On the right side four samples could be measured for distal breadth and depth but all six had HT and HTC measurements to contribute. In Figure 7-25, Sample 609LA appears in the upper right corner for distal breadth and depth plotting with the male specimen, Sample 579LA (historic) occupies the same range for breadth but not for depth, Sample 510LA (circled in green) and Sample 554LA (circled in red) also appear in Figure 7-25 above and Figure 7-26 below. A comparison to measurements of the trochlea in Figure 5.12 could indicate these two samples represent sub-adults.

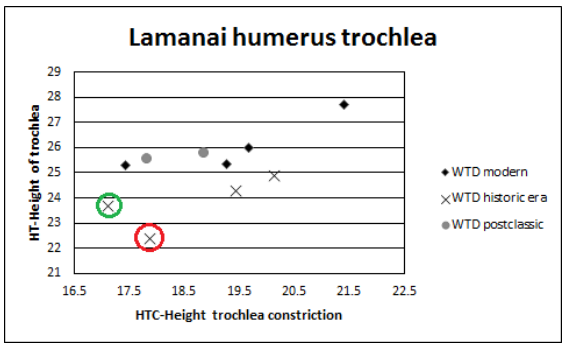


Figure 7-26 Comparison of Lamanai samples using measurements of the trochlea.

Seven radii were recorded, not shown in the graphs two brocket deer, and a third Sample 564LA identified as Cervidae whose measurements fall between those of my red brocket and WTD specimens.

In Figure 7-27, Samples 502LA (modified) and 585LA could be either adult females or sub-adult males. The distal measurements on the right show Sample 602LA; no epiphysis line was visible indicating this represents a mature animal. Distal breadth plots with the modern females, while depth measurements are slightly smaller.

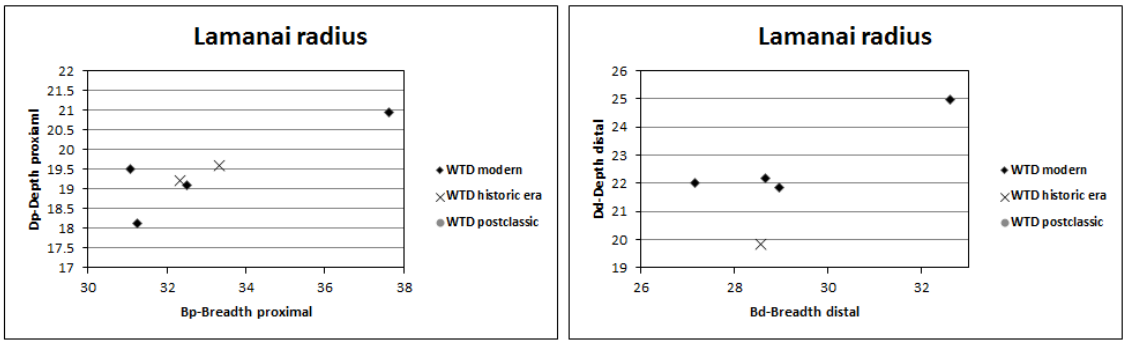


Figure 7-27 Comparison of Lamanai samples using proximal and distal measurements of the radius.

On the left-side of Figure 7-28 below, Sample 575LA from the early Postclassic had suffered erosion of the lateral proximal articulation. GLC as well as distal breadth and depth were recorded. The length measurement exceeds the male specimen by 8%, while on the right side of the figure this sample's distal breadth and depth plots closely with the female specimens. Sample 559LA (historic), shown on the right side of Figure 7-28, was recorded in field notes as condyles with no shaft, the surface was eroded and Bd and Dd measurements are suspect, possibly representing a juvenile.

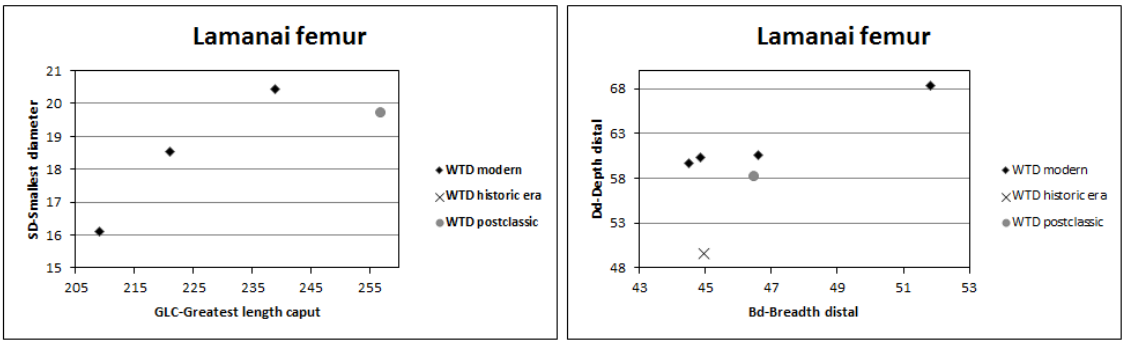


Figure 7-28 Comparison of Lamanai samples using GL, SD, Bd, and Dd, measurements of the femur.

In the Lamanai assemblage eight tibia were identified as WTD. Sample 576LA (Postclassic) appears in all three graphs and is circled in green, the length is shown in Figure 7-29 while the breadth and depth measurements appear in Figure 7.30. For the GL, this sample plots between the male and female specimens. The SD (smallest diameter) is very close to the male specimen in Figure 7-29.

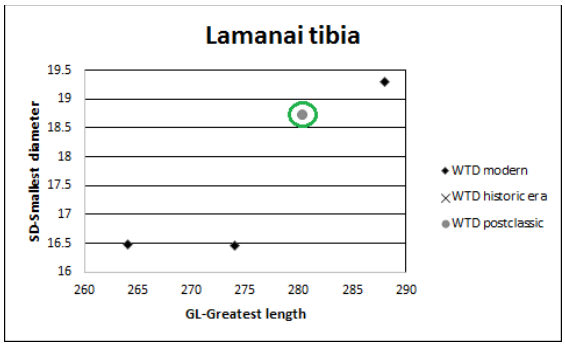


Figure 7-29 Comparison of Lamanai samples using GL and SD measurements of the tibia.

Below the proximal measurements are closer to the male specimen than to the adult females from Big Cypress but the distal measurements of this sample are not consistent with the single male specimen, perhaps because the distal end of the tibia is not completely fused before 20 months (see Figure 3-11); an older animal might show more thickening of cortical bone than is seen here. The close association of Samples 514LA historic and Sample 589LA Preclassic (listed as Cervidae) might suggest an age class if these animals were adult males. The remaining four historic samples plot more closely with the oldest of the female specimens. On the left side of Figure 7-30 Sample 604LA (historic) in the graph for proximal measurements appears in the female cluster but may represent a sub-adult male.

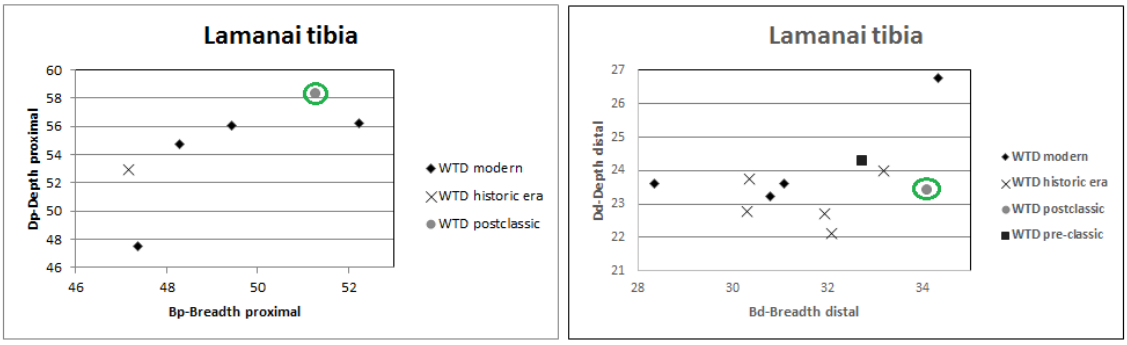


Figure 7-30 Comparison of Lamanai samples using proximal and distal measurements of the tibia.

Nine WTD ulnae were recorded, six were listed as historic and four of those were unfused indicating sub-adults. The remaining two historic samples plot with the modern females. All three samples from early Postclassic were fused. Among the specimens from the reference collection measurements of the ulna showed a separation between the adult male and adult females but little difference was found between the latter and sub-adult females. The pattern observed in Figure 7-31 may suggest two of the Postclassic samples and one of the historic samples represent older females.

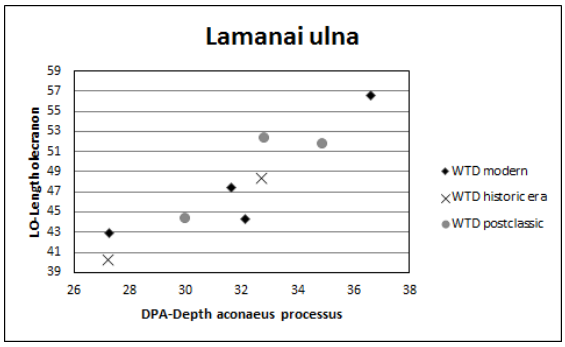


Figure 7-31 Comparison of Lamanai samples using measurements of the olecranon.

Twenty-two calcaneum were recorded, seven historic samples and three Postclassic samples were unfused and cannot be compared for length, Sample 518LA historic (not shown) had broken shaft showing thin cortical bone indicating a juvenile individual. Twelve samples are shown below; circled in green Sample 503LA is almost certainly an adult male and Sample 586LA, circled in red, an adult female; variation in breadth versus depth measurements are not understood for the modern specimens, thus that variation in the archaeological samples is currently unexplained.

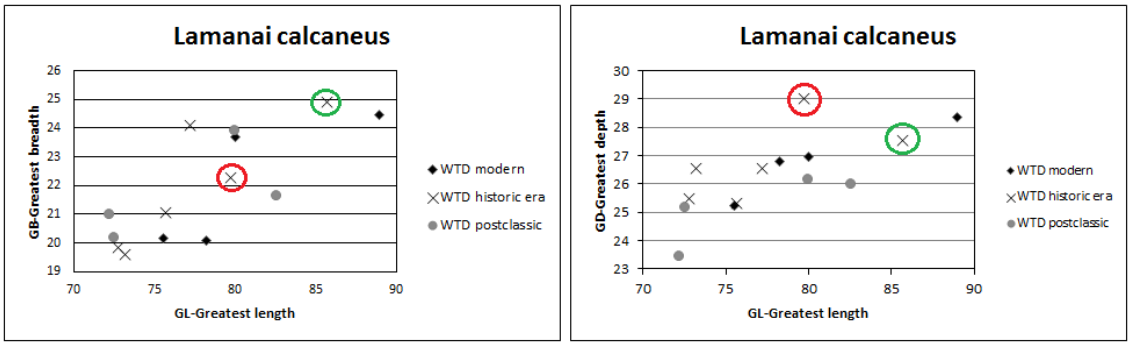


Figure 7-32 Comparison of Lamanai samples using length, breadth, and depth measurements of the calcaneus.

One proximal metacarpal 501LA (historic) plots with the female specimens. Two proximal metatarsals 500LA (historic) possibly sub-adult male and 619LA (early Postclassic) almost certainly represents an adult male.

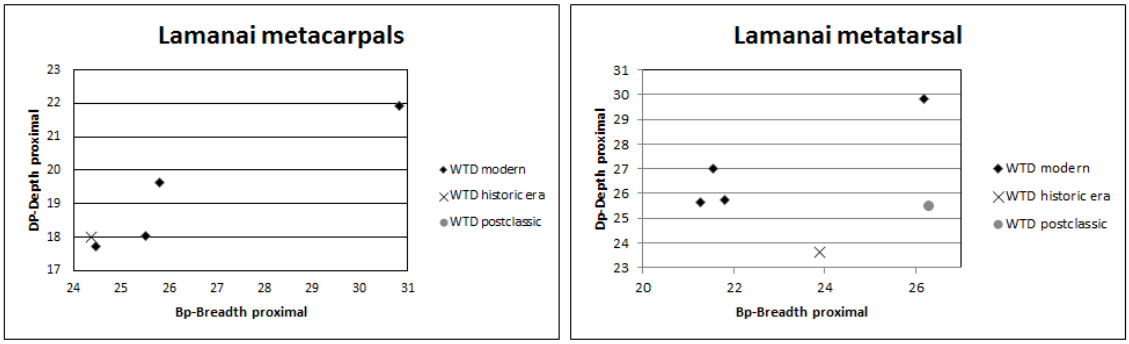


Figure 7-33 Comparison of Lamanai samples using proximal measurements of the metacarpal and metatarsal.

7.2 iv Summary of data:

Ten unfused historic calcaneus and ulna and three Postclassic samples can only represent sub-adults. For the historic period, Table 7-3 predicted four adults and 42 sub-adults, and an additional 20 elements were early fusing and could belong in either age cohort. The Postclassic offered two samples with adult morphology and 21 samples that may represent the presence of adults or sub-adults in the assemblage. Figure 7-21 for log ratios predicts 9 adult samples in the graph for breadths and 12 sub-adult samples using the graph for depths. Figure 7-22 predicts nine adults and five sub-adults. This combination of evidence suggests a shift toward the harvest of younger animals during the historic period. Within the previous scatterplots for Lamanai a single Preclassic sample may represent an adult male. Historic samples demonstrate four samples that may be adult males, 23 samples are either sub-adult males or adult females, smaller depth measurements for some samples could indicate young males, and four samples are almost certainly sub-adults, possibly female. Four Postclassic samples are presumed to represent adult males; 13 samples would represent adult females or sub-adult males

though most show depth measurements that rival or exceed the oldest females in the reference collection.

7.3 Ambergris Cay, Belize:

While naturally a peninsula forming the eastern boundary of Chetumal Bay, the Maya excavated a canal around 600 A.D. facilitating the canoe trade with the Caribbean (Graham and Pendergast, 1989).

7.3 i San Pedro:

Located on Ambergris Cay, a faunal analysis is currently underway. Ten samples from eight different contexts were suitable for measurement. At the time of recording no context specific dates were available, and as the stratigraphy has been disturbed by modern occupation, contexts dates will be delayed (pers. comm. Petra Cunningham-Smith, 2017). The site was active during the Postclassic Period and Historic Era (Williams et al. 2009). San Pedro was one of the few archaeological assemblages recorded after including the new measurements for the caudal end of the calcaneus shaft (see Figure 2-20).

Age cohort using epiphysis fusion

San Pedro, Belize		
Period	Species	WTD
Postclassic/Historic Era		
< 5 months	humerus shaft only	0
≥ 6 months	prox. Metacarpal	0
	prox. Metatarsal	0
	complete 2nd phalanx	1
	astragalus	1
	scapula	1
	distal humerus	0
	prox. Radius	0
< 14 months	tibia shaft only	0
	femur shaft only	0
	unfused ulna	0
	unfused calcaneus	0
≥ 20 months	distal radius	0
	distal metacarpal	0
	distal metatarsal	0
	distal tibia	1
	complete 1rst phalanx	1
	prox. Femur	1
	fused ulna	0
	fused calcaneus	1
≥ 30 months	complete metacarpal	2
	complete metatarsal	1
	prox. Humerus	0
	distal femur	0
	prox tibia	0
≥ 38 months	complete humerus	0
	complete femur	0
	complete tibia	0
	complete radius	0
Total		10

Table 7-4 Samples recorded for San Pedro.

Among the ten recorded samples shown above, three were early fusing, four are in the greater than 20-month category and three are present in the 30-month or greater column. No samples were definitively adult or juvenile.

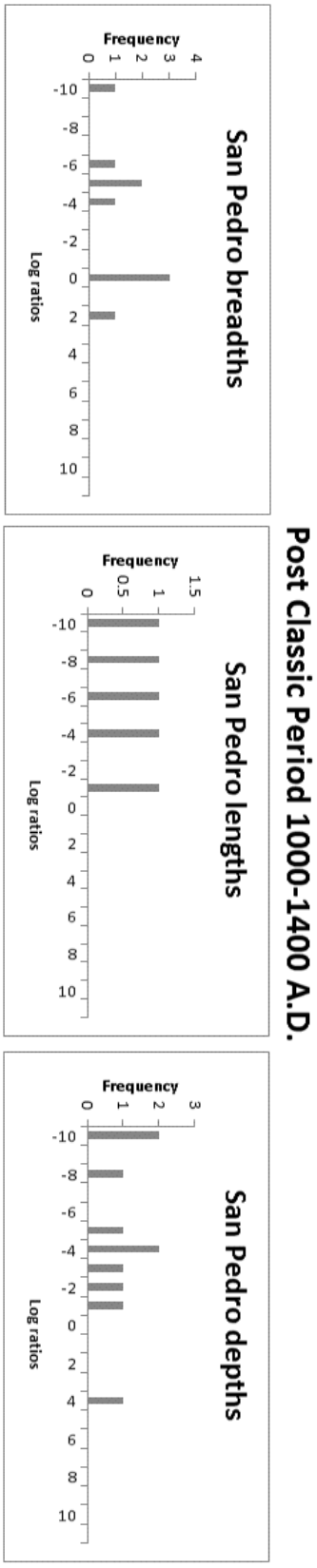


Figure 7-34 Log ratios of Postclassic/Historic Era San Pedro samples compared to the standard for evidence of sex and age cohort.

In the chart for breadth four ratios are at or greater than zero, all length ratios are below the Standard, while the chart for depth shows one ratio greater than zero and two at -10.

Sample 607SP astragalus plots with the modern females.

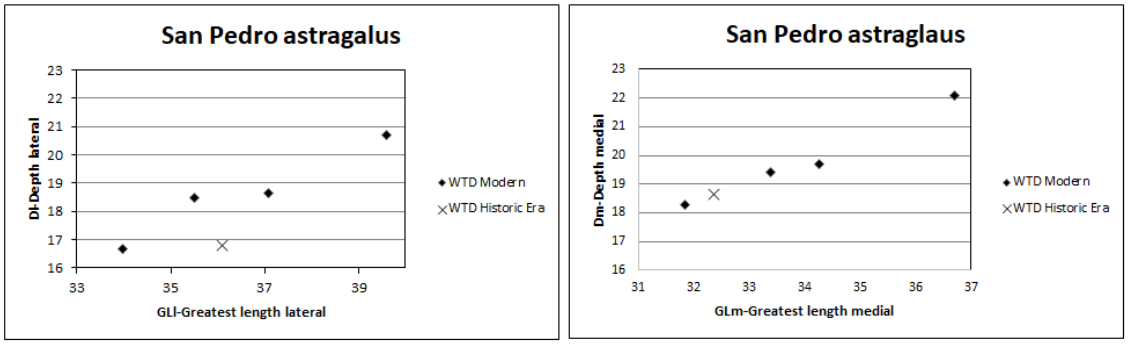


Figure 7-35 Comparison of San Pedro samples using measurements of the lateral and medial astragalus.

Sample 602SP, a scapula, may be a sub-adult male or a large female.

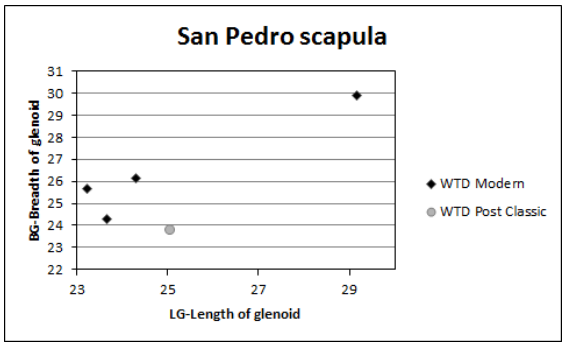


Figure 7-36 Comparison of San Pedro samples using breadth and depth of the glenoid.

Two distal humeri were recorded. Sample 603SP, circled in green in Figure 7-37, was very weathered, and plots with the female specimens for depth but between the male and females for breadth. Sample 604SP presented only the trochlea, possibly a young sub-adult or juvenile.

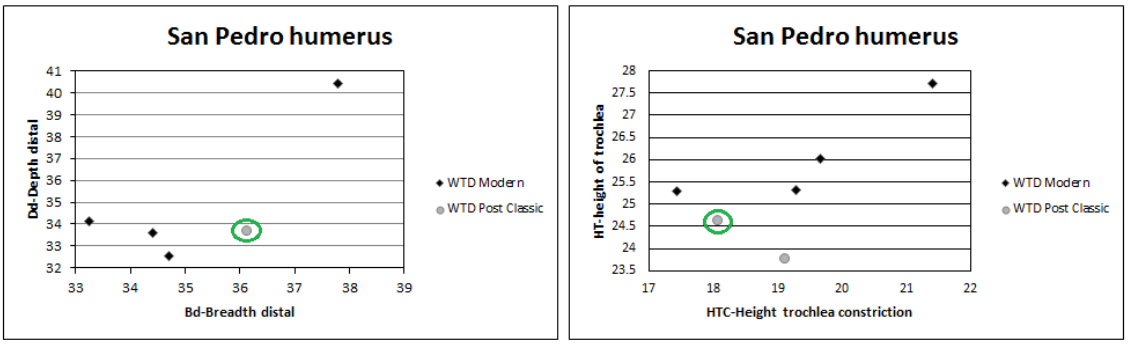


Figure 7-37 Comparison of San Pedro samples using proximal and distal measurements of the humerus.

Sample 611SP, a proximal femur, was a modified artefact; it plots with the male specimen for depth but not breadth. Sample 605SP, an unfused distal tibia, plots below the expected range of a sub-adult. However, it exceeds the measurements of the brocket deer in the reference collection (see section 8.9).

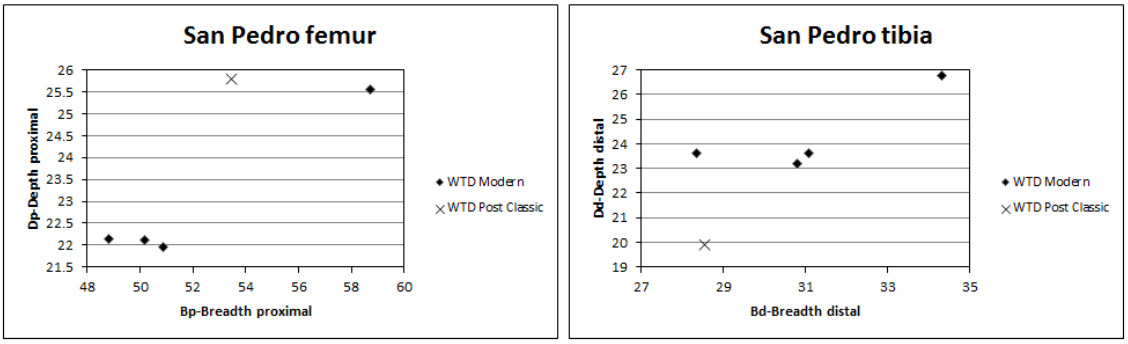


Figure 7-38 Comparison of San Pedro samples using proximal measurements of the femur and distal measurements of the tibia.

A single calcaneus was recorded, Sample 608SP; my field notes describe it as gracile. In Figure 7-39 the greatest length is to comparable female specimens while the both breadth and depth are smaller than WTD but significantly larger than any brocket deer in the reference collections.

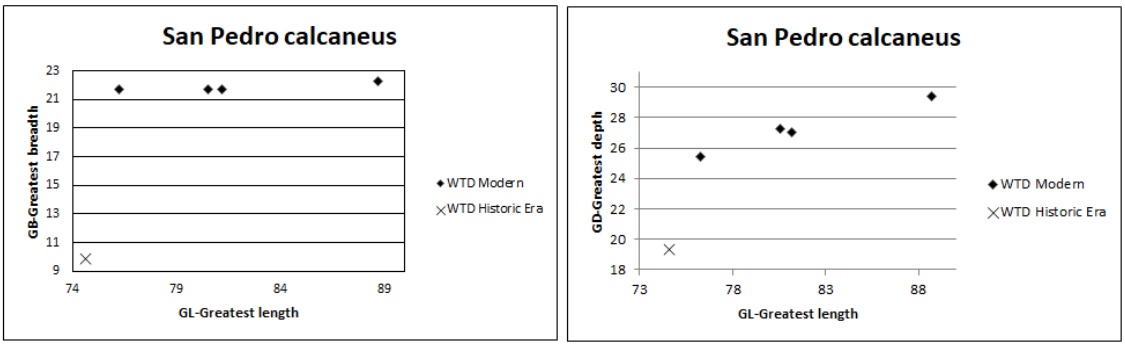


Figure 7-39 Comparison of San Pedro samples using length, breadth, and depth measurements of the calcaneus.

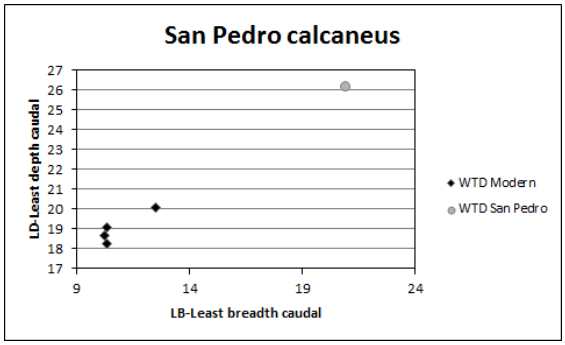


Figure 7-40 Comparison of San Pedro samples using caudal measurements of the calcaneus.

The Baseline Study indicates the thickness of the caudal shaft is correlated with greater age, see Figure 5-18; both biological and mechanical stress may impact the

deposit and recycling of the hydroxyapatite forming the mineral portion of bone matrix. Figure 7-39 shows the archaeological sample is within the same range as the adult specimens for calcaneus length, the depth measurements is noticeably smaller, and the breadth measurements are significantly smaller than the reference specimens. However, the caudal breadth and caudal depth measurements are startlingly larger (see Figure 5-18). This could suggest a histological reaction to mechanical stress that would exceed the process of normal locomotion, and leading me to speculate that the living animal was either injured or restrained in a way that caused prolonged atypical stress on the Achilles tendon resulting in a histological reaction. The long-term survival of an animal with limited mobility might suggest captivity.

Two almost complete metacarpals were recorded; Sample 606SP, circled in green in Figures 7-41 and 7-42, was tagged as artiodactyl in the museum tray but almost certainly represents a Cervidae. The morphology is not a match for peccary or tapir, and it is considerably longer than any of the brocket deer specimens in the reference collection (see Figure 8-10), averaging 100mm. Damage to the distal end of this sample prohibited taking a distal breadth measurement, therefore the sample is not represented in Figure 7-43. As the sample seemed to be longer and more gracile than many of the metacarpals in previously examined assemblages, my first impression was that it might represent a castrate. However, in Figure 7-42 the proximal measurements of the sample plot in the modern female cluster. No historical or ethnographic sources were identified documenting the ancient Maya practiced this form of husbandry with tame deer, though the castration of dogs is recorded in historical sources (Tozzer, 1941).

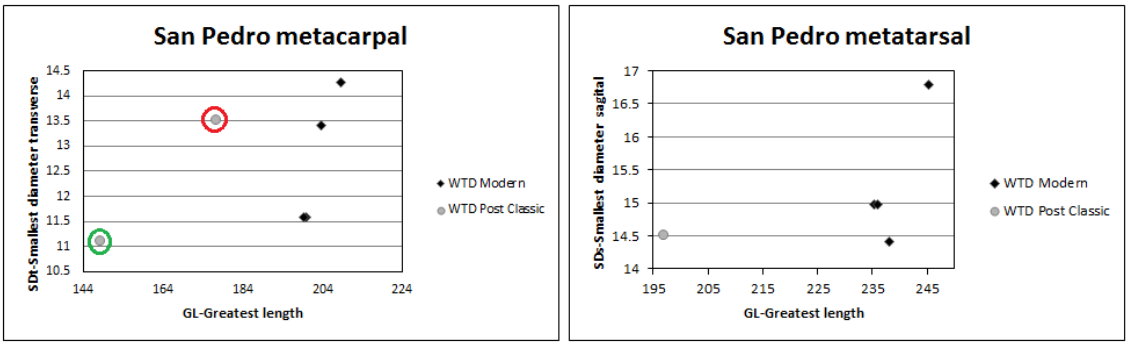


Figure 7-41 Comparison of San Pedro samples using GL, SDt measurements of the metacarpal and GL, SDs measurements of the metatarsal.

A complete metatarsal was recorded, Sample 600SP is also shorter than the reference specimens. In Figure 7-41 the smallest diameter recorded was on the transvers plane indicating this is an older sub-adult. Proximal breadth measurements place it between the modern male and females, while proximal depth plots below all specimens

in Figure 7-42 Distal measurements in Figure 7-43 plots as smaller than the modern animals in both breadth and depth.

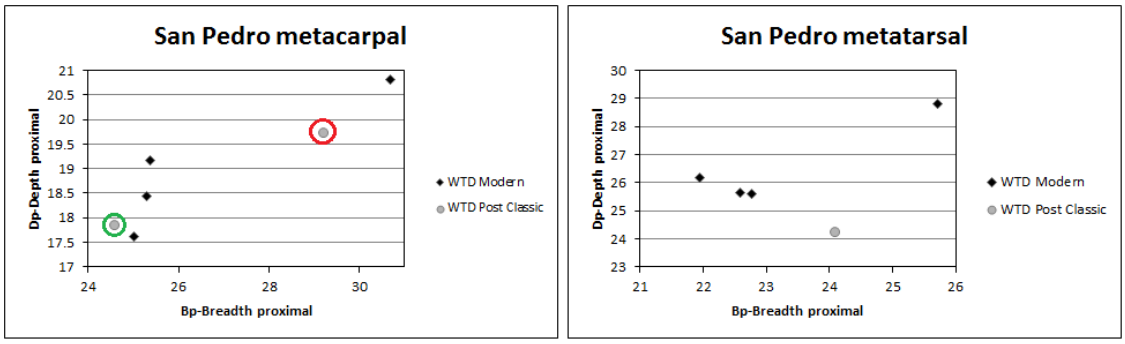


Figure 7-42 Comparison of San Pedro samples using proximal measurements of the metacarpal and metatarsal.

Sample 610SP, circled in red, appears as shorter than the modern male in Figure 7-41, though it plots among the modern specimens for smallest diameter. In Figures 7-42 and 7-43 it plots more closely with the male specimen for proximal and distal measurements.

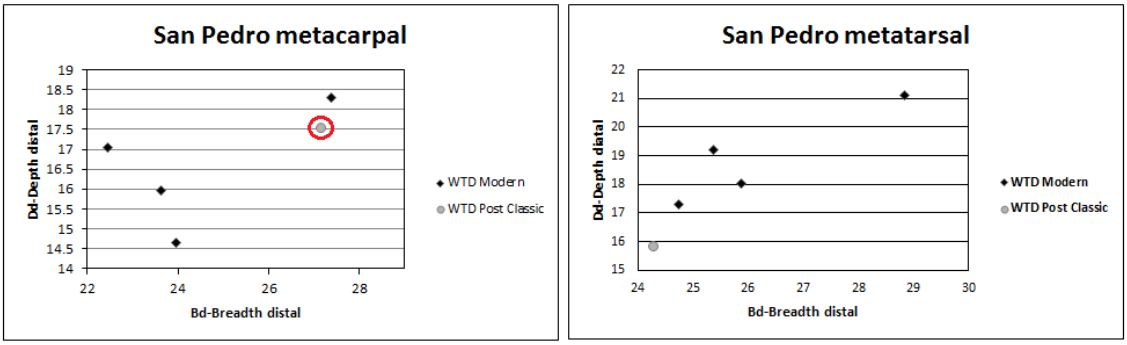


Figure 7-43 Comparison of San Pedro samples using distal measurements of the metacarpal and metatarsal.

While the length of the three metapodia from San Pedro are shorter than the Florida specimens, metacarpals at least are roughly equivalent in all depth and breadth measurements.

7.3 ii Summary of data:

In Table 7-4 no samples were identified with adult or juvenile traits. Figure 7-34 showed the samples were generally smaller than the measurements for the baseline. Scatterplots indicate the presence of one adult male, seven samples that may be adult females or sub-adult males, two samples believed to be sub-adults, possibly female, and one sample that could represent a juvenile. Though no sub-adult or juvenile morphology was observed among any of the samples, sub-adults might be present. Samples tagged as brocket deer, were excluded from this assessment but may not have been correctly identified, as no post cranial bones for brown brocket deer were recorded in my

reference materials. The prehistoric range for that species is uncertain, but it has been established that deer bones, if not live deer, were exchanged over some distance (Thornton, 2011).

7.3 iii Marco Gonzales:

Also located on Ambergris Cay, the settlement had several monumental structures that indicate the resident lineages were important players in the regions political and trade networks. The site's connection to Lamanai via the canoe trade has been discussed in Chapter 3. Faunal analysis for this site is underway; no context specific dates were available at the time of recording but the site is considered Postclassic (Williams et al. 2009). Land subsidence has facilitated the intrusion of Mangrove forest onto the site (Graham and Pendergast, 1989).

The four samples within the museum's trays were suitable for recording from this site. The complete tibia represents an adult, while two distal tibiae and one proximal radius might indicate sub-adults, though this is not certain.

Age cohort using epiphysis fusion

Marco Gonzales, Belize		
Period		
Postclassic		
WTD	Species	
0	humerus shaft only	< 5 months
0	prox. Metacarpal	≥6 months
0	prox. Metatarsal	
0	complete 2nd phalanx	
0	astraglus	
0	scapula	
0	distal humerus	
1	prox. Radius	
0	tibia shaft only	< 14 months
0	femur shaft only	
0	unfused ulna	
0	unfused calcaneus	
0	distal radius	≥ 20 months
0	distal metacarpal	
0	distal metatarsal	
2	distal tibia	
0	complete 1rst phalanx	
0	prox. Femur	
0	fused ulna	
0	fused calcaneus	
0	complete metacarpal	≥ 30 months
0	complete metatarsal	
0	prox. Humerus	
0	distal femur	
0	prox tibia	
0	complete humerus	≥ 38 months
0	complete femur	
1	complete tibia	
0	complete radius	
4	Total	

Table 7-5 Samples recorded for Marco Gonzales.

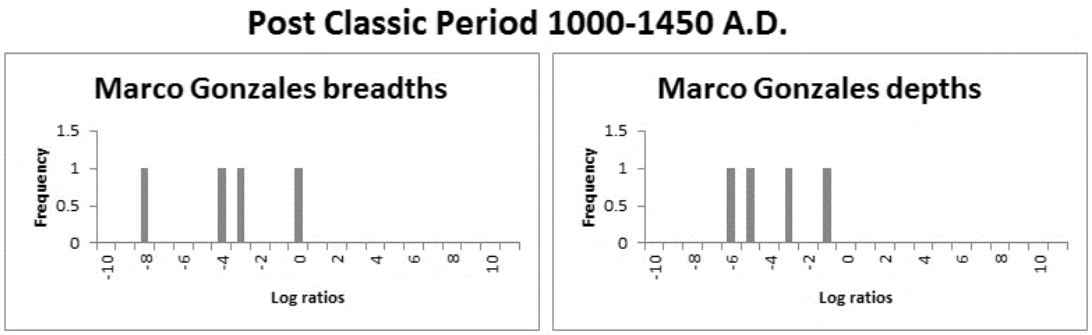


Figure 7-44 Log ratios of Postclassic Marco Gonzales samples compared to the standard for evidence of sex and age cohort.

Because only one element from this collection had a greatest length, a histogram of that plane could not be generated for this assemblage. In this assemblage one ratio in the chart for breadth plots at zero indicating an adult animal, all others plot below with one ratio at -8. In the chart for depth all four ratios plot between -1 and -6 within the range of the adult female specimens.

The proximal radius in Figure 7-45 plots with the adult females for depth but somewhat smaller than the reference specimens for breadth.

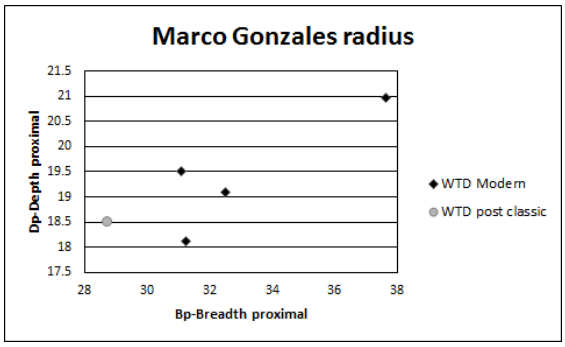


Figure 7-45 Comparison of Marco Gonzales samples using proximal measurements of the radius.

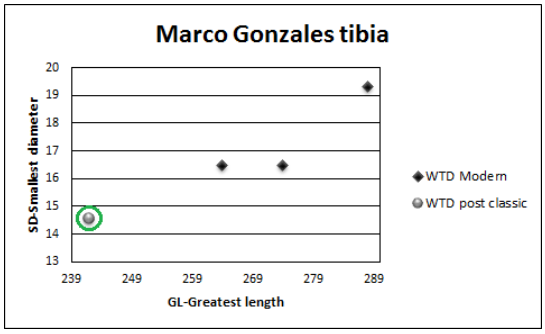


Figure 7-46 Comparison of Marco Gonzales samples using GL and SD measurements of the tibia.

Sample 152MG circled in green is a complete tibia (modified) shown in Figures 7-46 and 7-47 with a fused but visible epiphysis line, indicating a sub-adult. The GL in Figure 7-46 shows the individual was shorter than the modern specimens. Figure 7-47

reveals it was also slightly smaller in proximal breadth, but within the depth range for modern females. On the right side of Figure 7-47 the distal measurements are the smallest of any samples from Marco Gonzales. Sample 151MG is also small. Sample 153MG has the largest distal measurements; the degree of difference in the depth from the reference samples indicates this is an adult female rather than a sub-adult male.

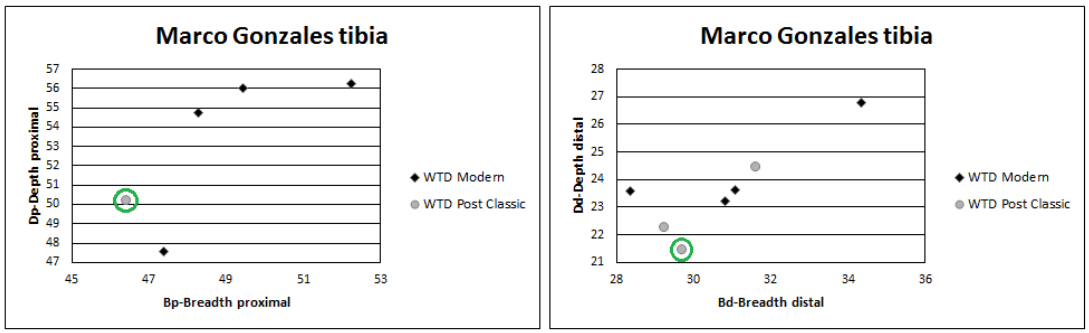


Figure 7-47 Comparison of Marco Gonzales samples using proximal and distal measurements of the tibia.

The GL measurement in Figure 7-46 is approximately 20mm shorter than the smallest of the reference specimens. On examination, it demonstrated a visible epiphysis indicating the individual was a sub-adult. The proximal and distal measurements are also small. The distal tibia fuses between 17 and 20 months for female WTD, while males experience complete fusion of this epiphysis at 23 months.

7.3 iv Summary of data:

Table 7-5 predicts the presence of at least one adult and two sub-adults. Figure 7-44 shows one sample in the breadth and depth charts that is a close match for the baseline measurements. In the scatterplots, there is no evidence of the presence of adult male deer. One tibia likely represents an adult female and three samples may be sub-adults of undetermined sex.

Assuming no local deer were available on Ambergris Cay, deer bones recovered at San Pedro and Marco Gonzales would be the product of exchange with other settlements. It is reasonable these animals might have derived from multiple sources representing environments that varied in nutritional resources. Nutritional deficit could also indicate dependence on human provisioning.

7.4 Lake Petén Itza, Guatemala:

Southern Maya Lowlands

Motul de San Jose, Late Classic through early Postclassic. Two recorded samples are from the Postclassic and one sample from Terminal Classic Periods, while 31 samples represent the Late Classic. Fourteen samples are early fusing elements, two

samples represent juveniles or young sub-adults, and 16 early fusing elements, ten of which are 1st phalanges also early fusing. No samples demonstrate adult characteristics.

Age cohort using epiphysis fusion

Motul de San Jose					
Period					Late Classic
Post Classic	Terminal Classic	Late Classic	Species		BD
WTD	WTD	WTD			
< 5 months					
0	0	0	humerus shaft only		0
≥6 months					
0	0	1	prox. Metacarpal		0
0	0	1	prox. Metatarsal		0
0	0	6	complete 2nd phalanx		0
0	1	4	astraglus		0
1	0	1	scapula		0
0	0	1	distal humerus		0
0	0		prox. Radius		2
< 14 months					
0	0	0	tibia shaft only		0
0	0	0	femur shaft only		0
0	0	1	unfused ulna		0
0	0	1	unfused calcaneus		0
≥ 20 months					
0	0	1	distal radius		0
0	0	0	distal metacarpal		0
0	0	0	distal metatarsal		0
0	0	0	distal tibia		0
0	0	10	complete 1rst phalanx		0
1	0	1	prox. Femur		0
0	0	0	fused ulna		0
0	0	3	fused calcaneus		1
≥ 30 months					
0	0	0	complete metacarpal		0
0	0	0	complete metatarsal		0
0	0	0	prox. Humerus		0
0	0	0	distal femur		0
0	0	0	prox tibia		0
≥ 38 months					
0	0	0	complete humerus		0
0	0	0	complete femur		0
0	0	0	complete tibia		0
0	0	0	complete radius		0
1	2	31	Total		3

Table 7-6 Samples recorded for Motul de San Jose.

In Figure 7-48 the chart for breadth shows 15 of ratios cluster on either side of zero, but four ratios plot at + 4 or greater. For lengths, ratios are clustered on either side of zero. In the chart for depths, eight ratios are greater than zero. Only five ratios are -4 or smaller. The log ratios in Figure 7-48 indicate all samples represent adult animals, some of which may be identified as adult males.

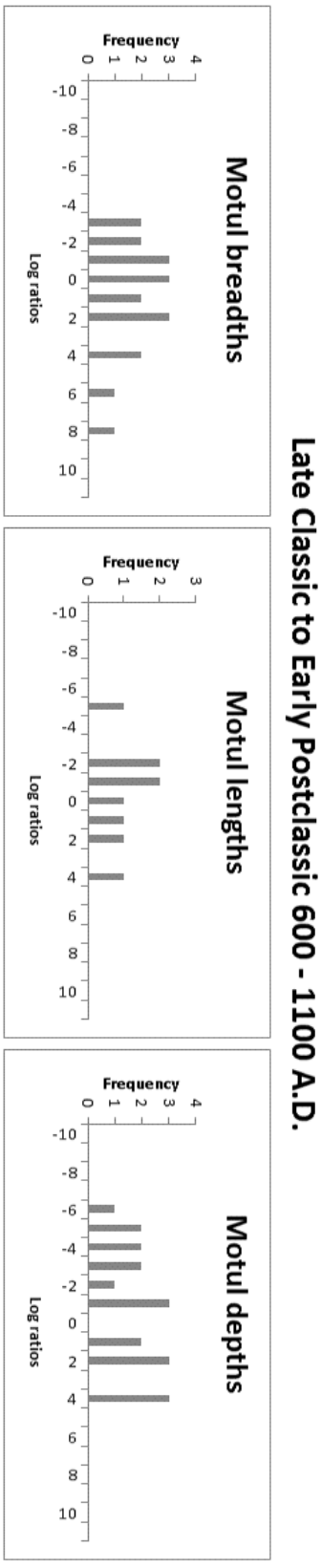


Figure 7-48 Log ratios of Late Classic through Early Postclassic Motul de San Jose samples compared to the standard for evidence of sex and age cohort.

Five Late Classic and one Terminal Classic astragali were present in the assemblage. Sample 218MSJ plots very closely with the adult male specimen. Sample 217MSJ (circled in red) had no lateral measurements to contribute; its position in the

graph for medial measurements suggests an adult female. The Terminal Classic sample plots between the male and female specimens for length and depth that may suggest an older female. Two other Late Classic samples plot very closely with the female cohort.

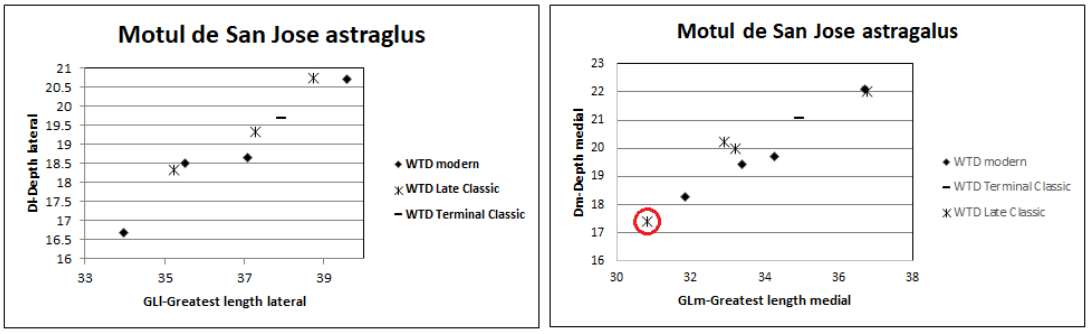


Figure 7-49 Comparison of Motul samples using lateral and medial measurements of the astragalus.

Three scapula contributed measurements, Samples 220MSJ (Late Classic) and 233MSJ (Terminal Classic) are notably larger than the modern female in LG which I consider a depth measurement but not for the BG breadth. Sample 224MSJ plots within the female cluster.

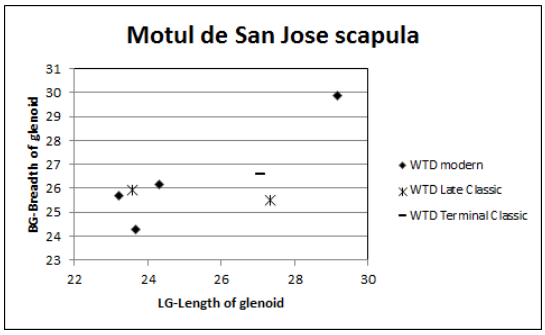


Figure 7-50 Comparison of Motul samples using breadth and depth of the glenoid.

On the left side of Figure 7-51, Sample 232MSJ shows the breadth and height of the trochlea, on the left is the HT of the same sample compared to the HTC. Even though the HT and HTC are on the same plane of measurement, both graphs show this sample in the adult female cluster. Eighty percent of the shaft was intact, while the proximal end of the shaft had suffered trowel trauma. The humerus head was not in evidence. The sample could represent either an adult female or sub-adult male.

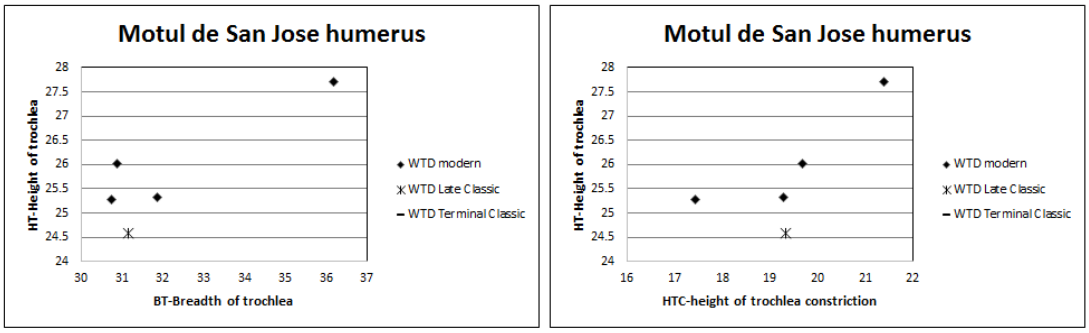


Figure 7-51 Comparison of Motul samples using measurements of the distal humerus.

Sample 221MSJ, a modified radius, presented only distal measurements. This sample is greater in breadth but less in depth than the modern females. Distal fusion makes male sub-adult an unlikely determination. If it represents a young female the stature might have been comparable to specimen z: 2850 in the reference collection (see Figure 5-2).

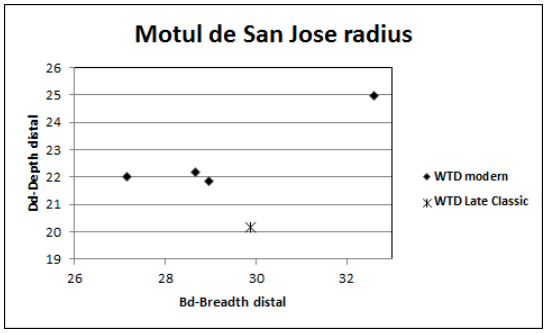


Figure 7-52 Comparison of Motul samples using measurements of the distal radius.

A single ulna was recorded. Sample 209MSJ demonstrated significant erosion to the olecranon attachment; it appears in the female cluster. Figure 5.16 shows a clear separation between the adult male and adult female specimens, but not between adult females and sub-adults.

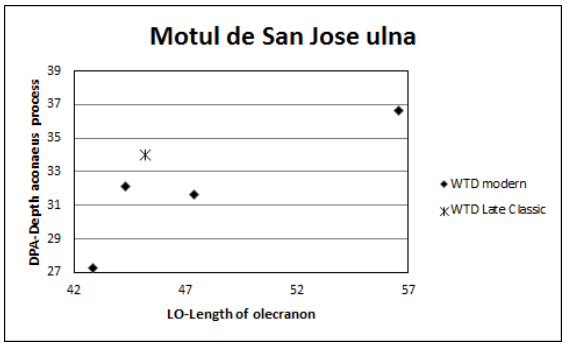


Figure 7-53 Comparison of Motul samples using measurements of the olecranon.

The Late Classic Sample 229MSJ is a modified proximal femur and plots as larger than the modern male. Sample 234MSJ (Postclassic) demonstration of full

epiphysis fusion, even though the cortical surface shows considerable erosion it still plots in the male range.

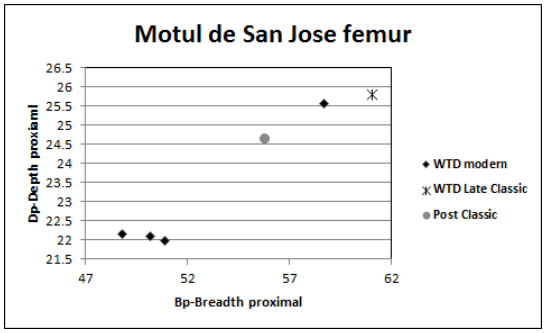


Figure 7-54 Comparison of Motul samples using proximal measurements of the femur.

Five calcanei were recorded; four of which demonstrated caudal fusion. In Figure 7-55, Sample 210MSJ (circled in green) overlaps Specimen z: 4703 almost exactly. Sample 237MSJ is a bit larger than the modern male specimen. Sample 211MSJ (not shown), Late Classic and unfused, was recorded with a breadth measurement of 26.04mm, exceeding all modern specimens and archaeological samples from Motul de San Jose despite its sub-adult status.

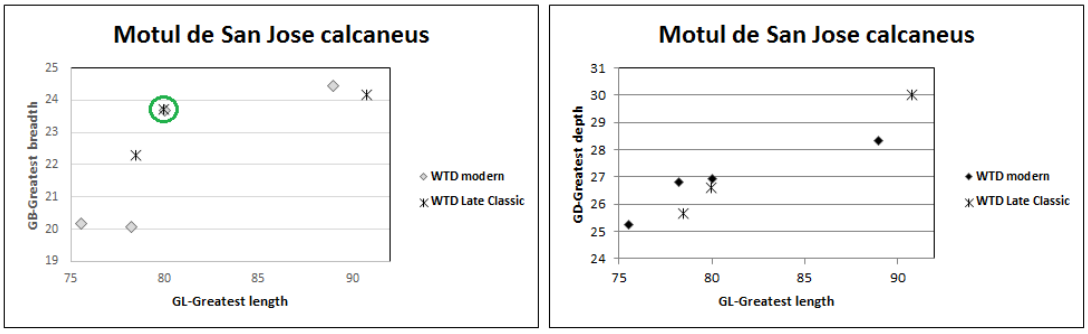


Figure 7-55 Comparison of Motul samples using length, breadth, and depth measurements of the calcaneus.

One unfused metatarsal was recorded; even though this almost certainly represents a sub-adult, the proximal breadth exceeds the modern female specimens from Big Cypress, but z: 2850 from Clay County rivalled the male specimen in some dimensions.

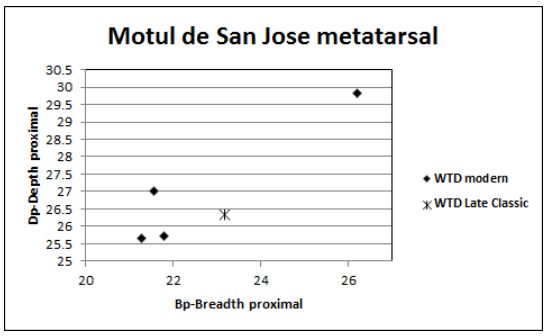


Figure 7-56 Comparison of Motul samples using proximal measurements of the metatarsal.

7.4 i Summary of data:

Two unfused samples must represent sub-adults but both showed unusually large breadth measurements. Table 7-6 showed 34 WTD samples, including 16 phalanges, and two of the samples indicate sub-adult animals. All other samples represented skeletal elements that could belong to either adult or sub-adult animals. No samples could be defined as adult. Figure 7-48 lacked ratios indicating young animals. Those three charts, breadths, lengths, and depths, showed a number of samples that exceeded the baseline measurements indicating the WTD population resident at Motul de San Jose that several large males are represented in the assemblage or that breadth of the long bones may have been more robust for this population than was the case for the deer at Big Cypress. In the scatterplots seven samples are estimated as adult males and nine samples may represent adult females or sub-adult males.

7.4 ii La Trinidad de Nosotros:

Late Classic and Postclassic Periods, the site is considered a secondary centre to be Motul de San Jose. The city functioned as a port for the canoe trade on Lake Petén Itza. Out of six measurable samples a single distal tibia and two fused phalanges came from dated contexts, distal fusion of the tibia indicating an individual greater than 20-months.

Age cohort using epiphysis fusion

La Trinidad de Nosotros		< 5 months	≥6 months									< 14 months				≥ 20 months								≥ 30 months						≥ 38 months			Total	
Period	Species	humerus shaft only	prox. Metacarpal	prox. Metatarsal	complete 2nd phalanx	astragalus	scapula	distal humerus	prox. Radius	tibia shaft only	femur shaft only	unfused ulna	unfused calcaneus	distal radius	distal metacarpal	distal metatarsal	distal tibia	complete 1rst phalanx	prox. Femur	fused ulna	fused calcaneus	complete metacarpal	complete metatarsal	prox. Humerus	distal femur	prox tibia	complete humerus	complete femur	complete tibia		2	3
Post Classic	WTD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	1	0	0	0	0	0	0			
undated contexts	WTD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Post Classic	BD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0			
																																	1

Table 7-7 Samples recorded for La Trinidad de Nosotros.

With only one dated sample no log ratios could be generated specific to La Trinidad de Nosotros, but its samples are considered in log ratios for period in Chapter Eight.

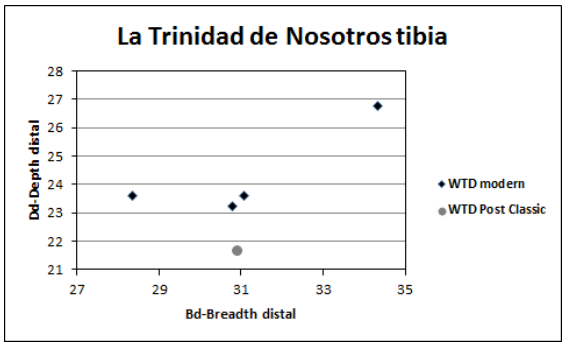


Figure 7-57 Comparison of La Trinidad de Nosotros samples using distal measurements of the tibia.

This Postclassic Period sample plots in the same breadth range as the oldest of the modern female specimens but slightly below all modern females for depth.

7.4 iii Summary of data:

A single tibia may represent either an adult female or a sub-adult male.

7.5 Sierra de Lacondon, Guatemala:

Southern Maya Lowlands

7.5 i Piedras Negras:

No definitively juvenile samples appear to be present in the assemblage. For the Terminal Classic, 24 early fusing elements are shown in Table 7-8; a single unfused calcaneus indicates a young sub-adult or juvenile. One adult sample is present, and 22 samples that may represent either adult or older sub-adults are shown. Late Classic materials show seven early fusing elements, and 14 elements attributable to either adults or sub adults. No samples demonstrate clear adult morphology. Of the six samples attributed to the Middle Classic Period four are early fusing and two appear in the 20 months or older category.

Age cohort using epiphysis fusion

Piedras Negras		< 5 months	≥6 months											< 14 months				≥ 20 months										≥ 30 months						≥ 38 months				Total
Period	Species	humerus shaft only	prox. Metacarpal	prox. Metatarsal	complete 2nd phalanx	astragalus	scapula	distal humerus	prox. Radius	tibia shaft only	femur shaft only	unfused ulna	unfused calcaneus	distal radius	distal metacarpal	distal metatarsal	distal tibia	complete 1rst phalanx	prox. Femur	fused ulna	fused calcaneus	complete metacarpal	complete metatarsal	prox. Humerus	distal femur	prox tibia	complete humerus	complete femur	complete tibia	complete radius	
Terminal Classic	WTD	0	0	0	9	9	1	3	2	0	0	0	1	0	0	0	0	20	0	0	2	0	0	0	0	0	0	0	0	0	1	48
Late Classic	WTD	0	0	0	4	3	0	0	0	0	0	0	0	0	1	0	0	12	0	0	2	0	0	0	0	0	0	0	0	0	0	22
Middle Classic	WTD	0	0	0	0	1	0	2	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	6
undated contexts	WTD	0	0	0	5	8	0	0	3	0	0	0	2	0	0	0	1	6	2	0	0	0	0	0	0	0	0	0	0	0	2	29

Table 7-8 Samples recorded for Piedras Negras.

For the Terminal Classic, there is an almost even distribution of breadth ratios on either side of zero with single ratios at either extreme, possibly indicating males and females are more evenly represented. For lengths, three ratios plot at zero, one above, and seven below. For depths, zero is vacant with two ratios plotting above and seventeen below, but only one at minus ten. The presence of sub-adults in this assemblage may be indicated.

More than 25% of the samples recorded are from contexts with dates unavailable to this research. Only WTD samples from contexts dated to period are represented in the following log ratio charts and scatterplots.

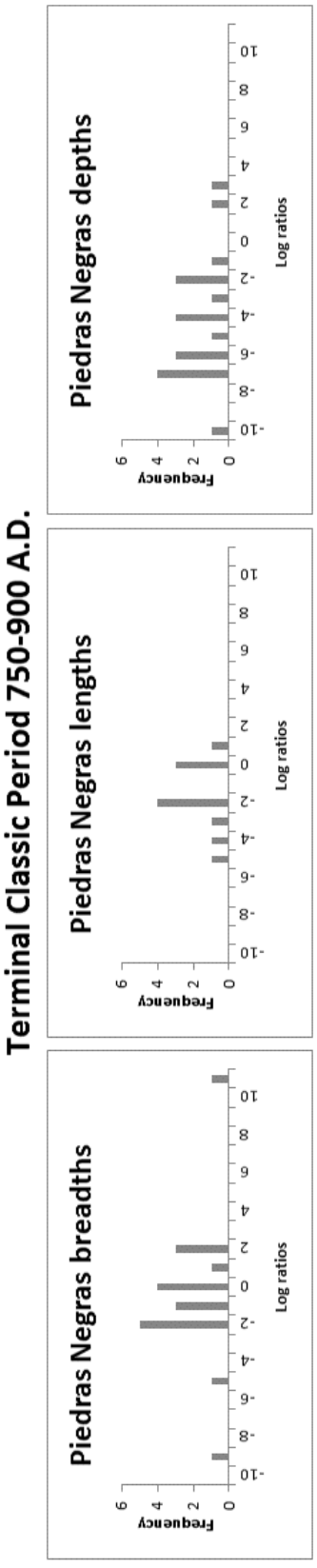


Figure 7-58 Log ratios of Terminal Classic Piedras Negras samples compared to the standard for evidence of sex and age cohort.

The Late Classic Period presented fewer samples suitable for recording. Very little suggests that males are present among these samples; there appear to be no sub-adults represented.

Figure 7-59 Log ratios of Late Classic Piedras Negras samples compared to the standard for evidence of sex and age cohort.

With few exceptions, most skeletal elements in this assemblage were broken or fragmented. Phalanges and astragali were the most abundant intact samples in the collection. Currently comparison of phalanges recovered in excavation with the modern

collection is problematic. Ratios for breadth cluster close to the Standard at zero. In the chart for length, three of the ratios appear at -4, and are within the predicted range for sub-adult male and adult female specimens. The chart for depth shows all ratios plot below the standard, again within the range of sub-adult males and adult female specimens.

Figure 7-60 considers the astragali assigned to the Terminal Classic, Late Classic, and Middle Classic Periods. All samples from all periods present dimensions that are consistent with adult females, though the pattern seems unusually dispersed.

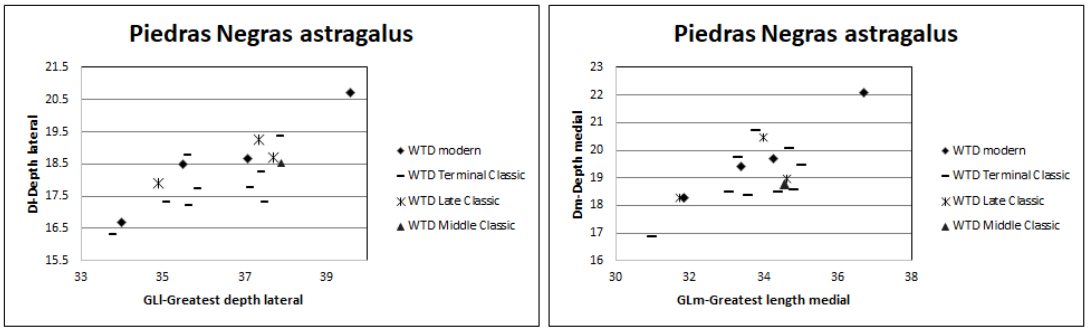


Figure 7-60 Comparison of Piedras Negras samples using lateral and medial measurements of the astragalus.

Figure 7-61 the single glenoid sample plots with the modern females.

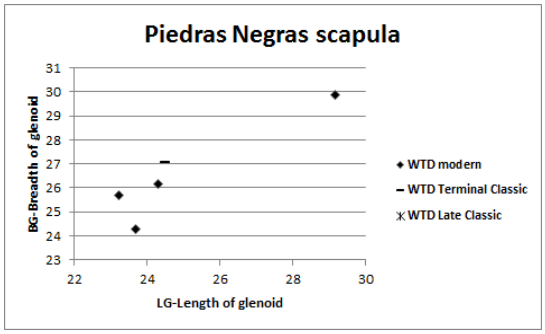


Figure 7-61 Comparison of Piedras Negras samples using breadth and depth of the glenoid.

Four WTD distal humeri were recorded. Sample 777PN (Terminal Classic) (circled in green in Figure 7-62) was an unfused distal condyle and almost certainly represents a juvenile. Sample 767PN (Terminal Classic) demonstrated partial fusion of the distal epiphysis, a juvenile trait. Sample 737PN (Middle Classic Period and circled in red) shows the cortical bone of the lateral surface is too eroded for a BT measurement, though Bd (distal breadth) Dd (distal depth) Dd and measurements of the trochlea were available. Sample 754PN (Terminal Classic) presented 80% of the shaft but was too fragile for SD measurements distal measurements are suspect. Two samples

almost certainly represent juveniles, given their close association in the graph; Samples 754PN and 736PN may also represent juveniles or young sub-adults.

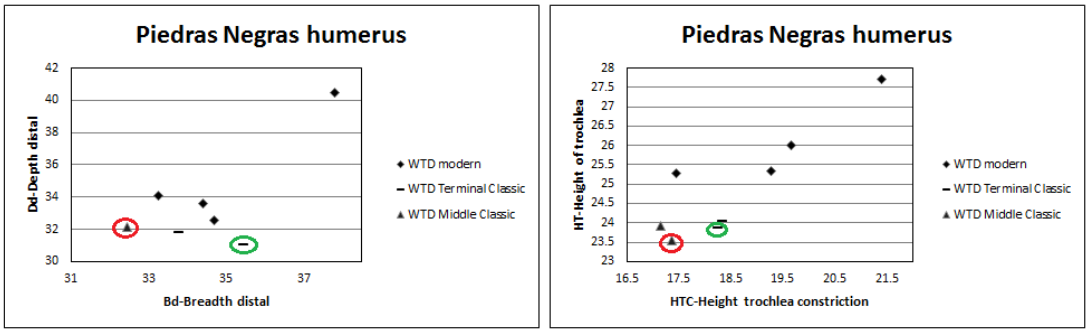


Figure 7-62 Comparison of Piedras Negras samples using distal measurements of the humerus.

Nine radii were present. Five had no assigned dates and are excluded here, and one sample was designated as Naba period (Middle Classic). In Figure 7-63, Sample 751PN was broken but the refit was sufficient for a confident GL; this sample appears in all three graphs for the radius and is circled in green. The recorded length is shorter than the modern specimens, 185mm or 90% of the averaged length for all modern specimens, but the smallest diameter plots with the adult females. In Figure 7-64 this sample plots consistently with the oldest modern specimens for proximal and distal measurements.

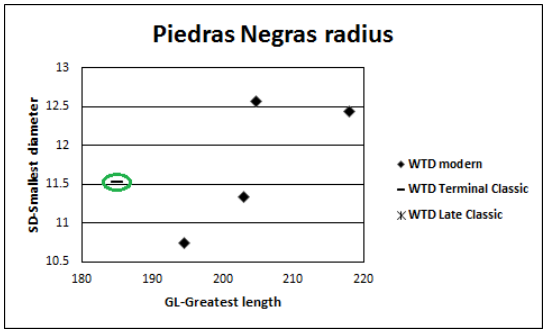


Figure 7-63 Comparison of Piedras Negras samples using GL, and SD measurements of the radius.

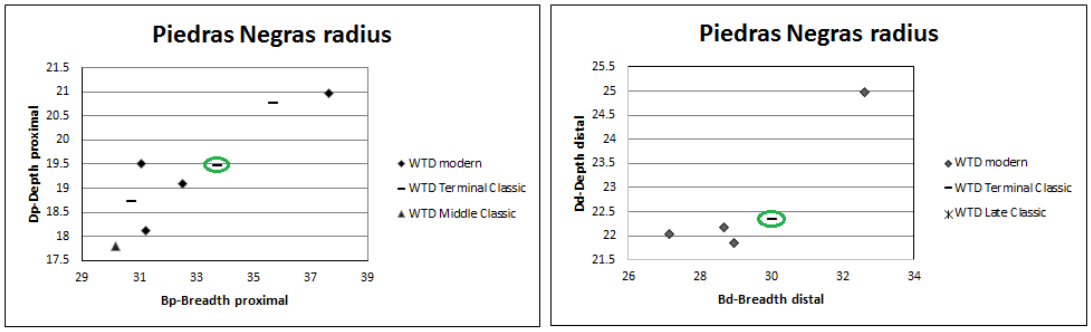


Figure 7-64 Comparison of Piedras Negras samples using proximal and distal measurements of the radius.

On the left of Figure 7-64 Sample 766PN plots most closely with the modern male, Sample 759PN appears in the female cluster, and Sample 721PN (Middle Classic) appears in the lower left corner, almost certainly female, possibly sub-adult.

Two distal tibia were present one from undated contexts and excluded, and one from the Naba period. Sample 733PN (modified) plots with the female specimens.

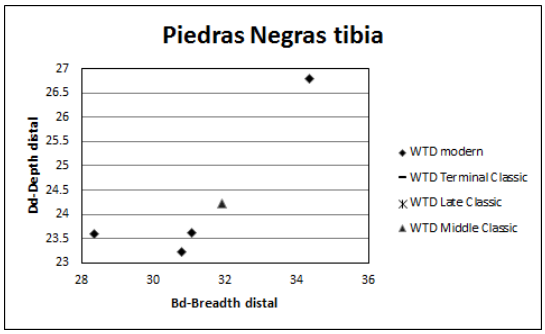


Figure 7-65 Comparison of Piedras Negras samples using distal measurements of the tibia.

Seven calcanei were recorded; two undated, two unfused samples and one broken sample from the Terminal Classic are not shown. Sample #719PN (Terminal Classic) had a partially open suture at the caudal crest, and is noted as gracile in the field notes. This sample had also been broken along the dorsal side of the articular surface, so a GD was not possible. Two intact samples, 778PN and 789PN (shown in Figure 7-66), were designated as Late Classic in the original data sheets. Three intact calcanei plot with the modern females.

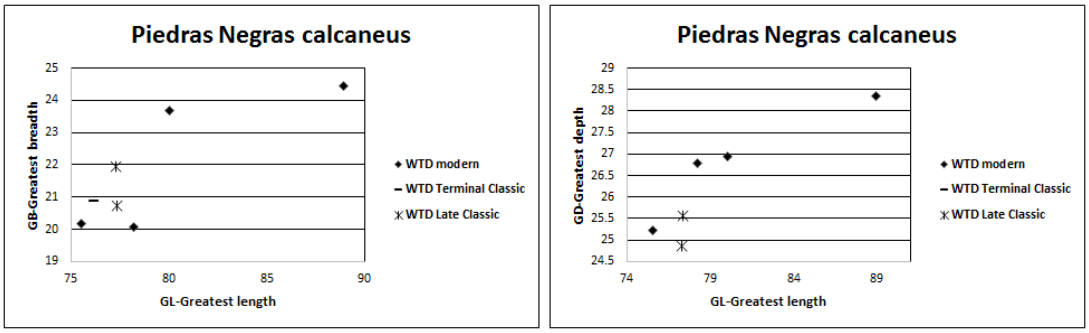


Figure 7-66 Comparison of Piedras Negras samples using length, breadth, and depth measurements of the calcaneus.

In Figure 7-67 Sample 707PN, a distal metacarpal, plots among the modern adult females.

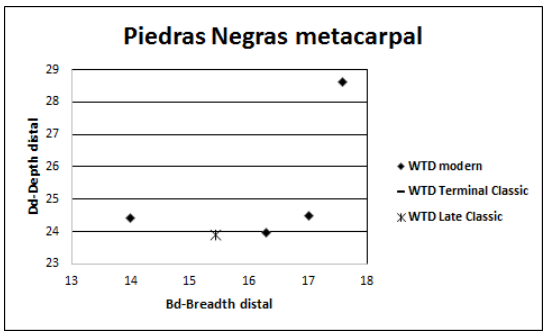


Figure 7-67 Comparison of Piedras Negras samples using distal measurements of the metacarpal.

7.5 ii Summary of data:

Table 7-8 shows six samples that indicate the presence of sub-adults and six showing adult morphology, 112 phalanges were present but excluded from this analysis. Figure 7-57 for the Terminal Classic indicates most samples are adult with two samples in the breadth chart and five in the chart for depth that indicate the presence of sub-adults. Log ratios shown in Figure 7-58 indicate no adult males, sub-adults, or juveniles. There were too few samples from the Middle Classic Period to generate histograms for log ratios and these samples were excluded from log ratio charts for the terminal and Late Classic Periods at Piedras Negras. The scatter plots for Piedras Negras for the Terminal Classic show one adult male, five samples believed to represent older females, nine samples that may represent either adult females or sub-adult males, one sample representing a sub-adult male, and two juvenile specimens. Two unfused Calcanei demonstrate sub-adults. Forty-six samples are phalanges and not determinable to sex. Late Classic samples are estimated to represent five females greater than five years of age and four that may be adult females or sub-adult males. Middle Classic shows five samples that may be adult females or sub-adult males.

7.5 iii La Joyanca:

Located in the uplands south of Rio San Pedro Mártir, and the first of the archaeological assemblages I recorded for this study, the deer bones in this assemblage were noted by the original analysts (Boileau and Emery) as unusually large.

Age cohort using epiphysis fusion

La Joyanca, Guatemala		< 5 months	≥6 months										< 14 months				≥ 20 months										≥ 30 months						≥ 38 months				Total
Period	Species	humerus shaft only	prox. Metacarpal	prox. Metatarsal	complete 2nd phalanx	astragalus	scapula	distal humerus	prox. Radius	tibia shaft only	femur shaft only	unfused ulna	unfused calcaneus	distal radius	distal metacarpal	distal metatarsal	distal tibia	complete 1rst phalanx	prox. Femur	fused ulna	fused calcaneus	complete metacarpal	complete metatarsal	prox. Humerus	distal femur	prox tibia	complete humerus	complete femur	complete tibia	complete radius	
Terminal Classic	WTD	3	4	4	7	6	4	2	3	0	0	1	3	1	0	0	4	7	0	0	1	0	1	0	0	0	0	0	0	0	51
Late Classic	WTD	0	0	0	3	2	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	0	0	0	0	0	0	0	0	0	9
Early Classic	WTD	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2

Table 7-9 Samples recorded for La Joyanca.

For the Terminal Classic 30 samples are early fusing elements. Three samples likely represent juveniles, while four are definitively juveniles or young sub-adults. Thirteen samples could represent sub-adults or young adults; one sample may be interpreted as adult. Late Classic presents nine samples, five early fusing elements, and four that may be either sub-adults or adults, with no definitively adult samples. One Early Classic samples is almost certainly a juvenile, represented by humerus shaft unfused at both proximal and distal ends, the second element for the Early Classic Period is a phalanx; these two samples elements are excluded from consideration. Out of 63 samples recorded, 51 are from the Terminal Classic Period, 700 to 900 A.D. and nine samples represent Late Classic, 600 to 700 A.D.

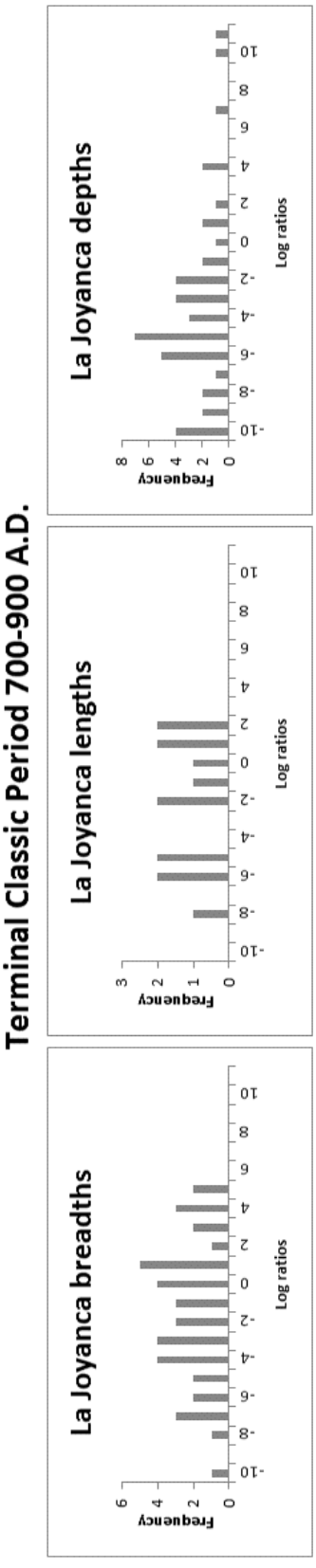


Figure 7-68 Log ratios of Terminal Classic La Joyanca samples compared to the standard for evidence of sex and age cohort.

Figure 7-68 shows only samples attributed to the Terminal Classic Period in the original data sheet. For breadths, 13 ratios are above zero possibly indicating the presence of adult males in the collection. The histogram for lengths also indicates

samples larger than the averaged measurements of specimens contributing to the Standard. This is interesting as there was a single intact metatarsal to contribute long bone lengths (phalanges were excluded from computing log ratios), therefore all other length ratios for the Terminal Classic are derived from astragali or calcanei. In the chart for depth ratios, the tail at -10 indicates sub-adults or possibly juveniles. What is surprising about the depth ratios is the number of samples plotting at + 4 and greater. This could represent large adult males. Equally possible is the presence of older adult specimens of either sex.

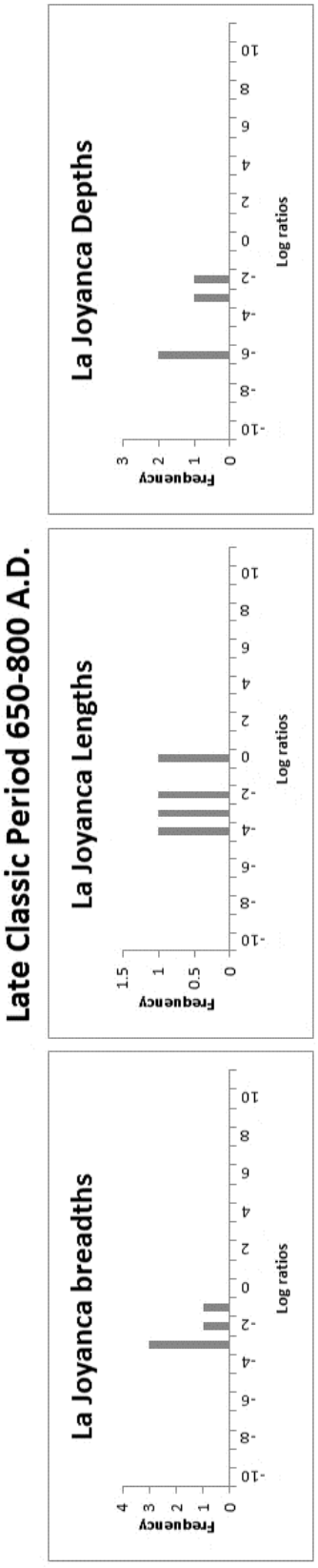


Figure 7-69 Log ratios of Late Classic and Early Classic La Joyanca samples compared to the standard for evidence of sex and age cohort.

Late Classic and Early Classic samples are combined in Figure 7-69 and breadth ratios show no samples at zero or greater. In the chart for length, one ratio plots at zero and none are smaller than minus four. Depth ratios show two samples at -6. The

samples in Figure 7-69 most likely represent adult animals even though none of the samples seen in Table 7-9 can definitively be attributed to the adult cohort.

Nine astragali were recorded and three samples were eroded and offered incomplete measurements. Sample 757LJ appears close to the modern male in the graphs for lateral and medial measurements. In the graph for medial measurements Samples 738LJ, 737LJ (Terminal Classic) and Sample 736 (Late Classic) are greater in medial depth than the modern male specimen, while being comparable for both lateral and medial length with the modern females. Age class is suspected as causal for this variation.

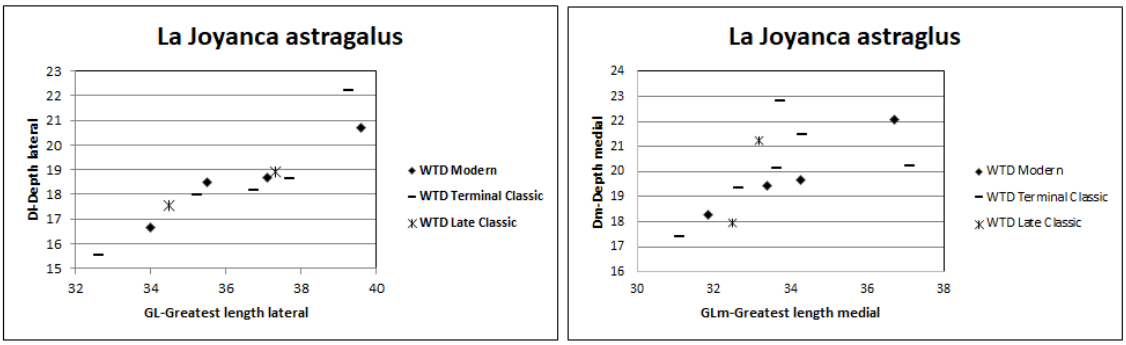


Figure 7-70 Comparison of La Joyanca samples using lateral and medial measurements of the astragalus.

Of the four scapulae recorded only two presented comparative measurements. Sample 721LJ (upper right corner) plots comparatively with the modern male, while Sample 745LJ (lower left) is comparable to the modern female specimens.

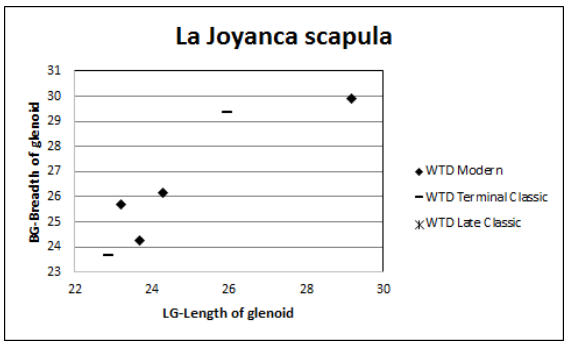


Figure 7-71 Comparison of La Joyanca samples using breadth and depth of the glenoid.

Of the six humeri present, four were unfused bone shafts offering only smallest diameter measurements, and two samples 705LJ and 759LJ, were unfused distal condyles. Therefore all six samples are likely to represent juveniles.

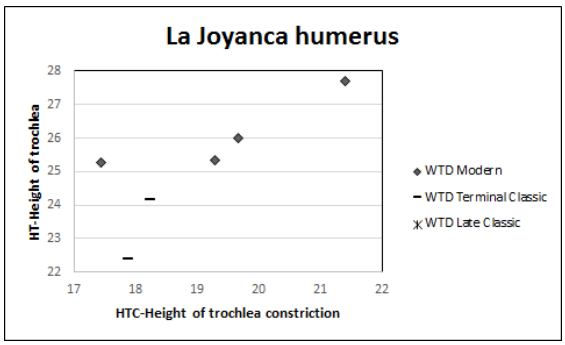


Figure 7-72 Comparison of La Joyanca samples using distal measurements of the humerus.

Three proximal and one distal radii were recorded. The proximal samples overlap with the modern females. The left side of Figure 7-73 shows the distal Sample 749LJ plots separately from all modern specimens. While being too large for a red brocket deer, enough of the distal shaft was present to prove fusion indicating an adult or older sub-adult.

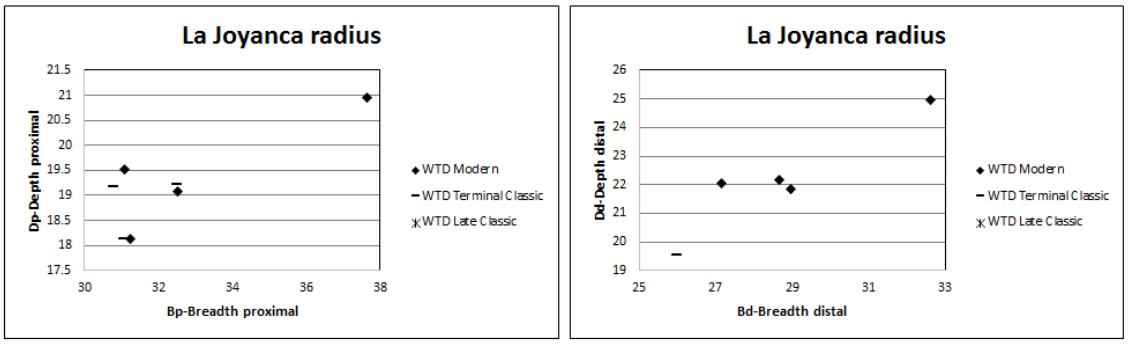


Figure 7-73 Comparison of La Joyanca samples using proximal and distal measurements of the radius.

Four distal tibiae were recorded and destruction of the bone shaft on all four samples was considerable. Only Sample 742LJ was sufficiently intact for a SD measurement. Sample 732LJ is larger than the modern male. Samples 711LJ and 758LJ are larger than the females from Florida in terms of distal breadth but marginally smaller along the plane of depth. Sample 742LJ (lower left corner) is within the same breadth range as the female specimens.

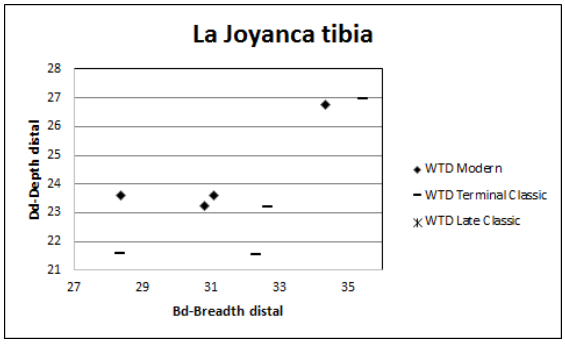


Figure 7-74 Comparison of La Joyanca samples using distal measurements of the tibia.

Five calcanei were recorded and three were unfused, proving the presence of sub-adults in the assemblage. From the Terminal Classic Sample 741LJ presents another greatest breadth measurement that exceeds the modern specimens. Though in terms of calcaneus length and depth this sample plots within the female cluster. Sample 750LJ (Late Classic) also falls within the modern female cluster for length. Within modern reference collection standard measurements of the calcaneus were relatively consistent between sex and age cohorts; why some archaeological samples present unusually large GD (greatest depth) measurements is not currently understood.

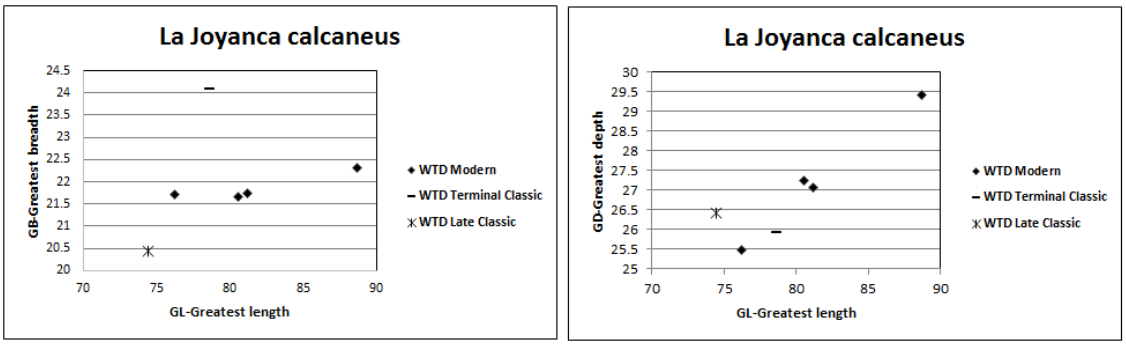


Figure 7-75 Comparison of La Joyanca samples using length, breadth, and depth measurements of the calcaneus.

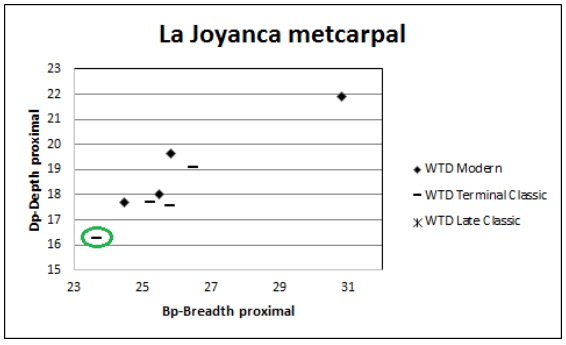


Figure 7-76 Comparison of La Joyanca samples using measurements of the proximal metacarpal.

Of three unfused metacarpals and one fused sample 700LJ (circled in green) the sample was damaged at the distal end no GL or Bd measurements were viable. All four samples plot within or close to the modern female specimens.

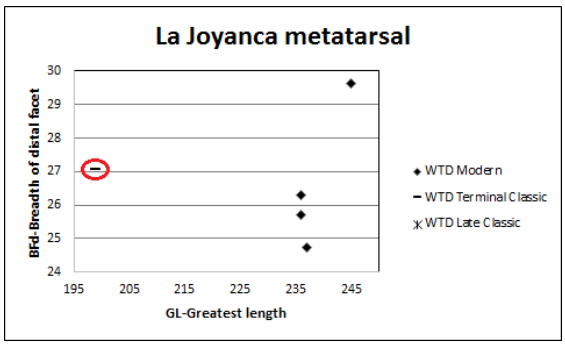


Figure 7-77 Comparison of La Joyanca samples using GL and SD measurements of the metatarsal.

Five metatarsals were sufficiently intact for recording. Sample 739LJ (circled in red in Figures 7-77 and 7-78) showed distal fusion, the shaft was broken in four places, and while smallest diameter and proximal measurements were not possible, the refit of shaft was sufficient for a confident GL measurement. Because of damage to the sample, greatest length (GL) measurement is paired with BFd (breadth of distal facet) measurement. The length of this metatarsal 199mm is similar to Sample 600SP 197mm from San Pedro. Breadth of the distal facet for Sample 739LJ plots slightly above the modern female specimens, while in figure 7-78 this sample plots closely with the female cluster in terms of distal breadth and depth. On the left side four proximal metatarsals appear to be sub-adults. Sample 763LJ (circled in green) is likely a female sub-adult.

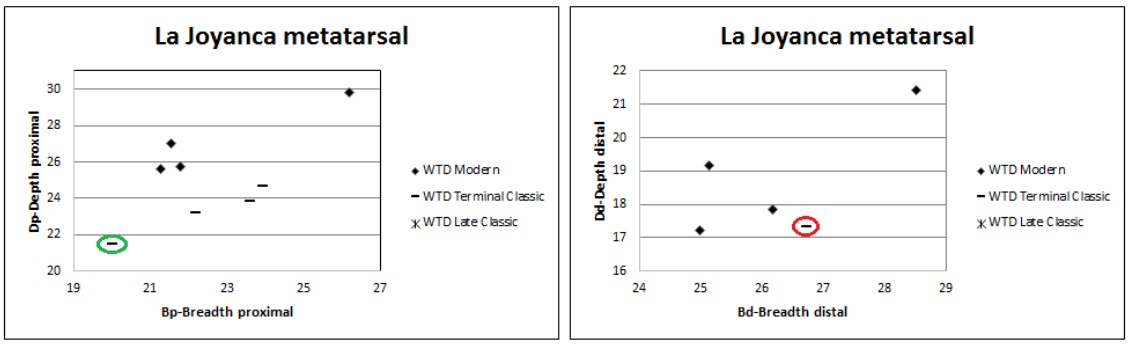


Figure 7-78 Comparison of La Joyanca samples using proximal and distal measurements of the metatarsal.

7.5 iv Summary of data:

Table 7-9 shows four samples defined as juvenile and four that may represent juveniles or sub-adults. One sample shows adult morphology and seven samples may represent adults or sub-adults. No femora were sufficiently intact for recording. For the Terminal Classic four unfused samples, including a fragment of ulna, are not illustrated. Humeri, radius, and tibia present in this collection show only the earliest fusing epiphysis. While not part of this analysis, the measurements of 18 phalanges are part of the recorded data. Figure 7-68 for the Terminal Classic reveals a distribution in all three

charts that indicates the presence of both smaller and larger deer thus the presence of a juvenile/sub-adult cohort is supported. Figure 7-69 samples from the Late Classic Period appear to represent adult females. In the scatterplots two adult males are represented, four samples that may demonstrate the presence of an older female cohort, 18 samples that could represent either adult females or sub-adult males and nine samples are assessed as sub-adults of unknown sex. Three Late Classic samples are assessed as adult females.

7.5 v El Kinel:

A total of eight samples were recorded for El Kinel; with one astragalus assessed as Late Classic and one metatarsal attributed to the Terminal Classic. The other six samples were listed in the original data sheet as late/Terminal Classic; when present in the scatter plots these samples are shown in red.

Age cohort using epiphysis fusion

El Kinel, Guatemala		
Period	Species	WTD
Late/Terminal Classic		
< 5 months	humerus shaft only	0
≥6 months	prox. Metacarpal	0
	prox. Metatarsal	1
	complete 2nd phalanx	0
	astragalus	1
	scapula	0
	distal humerus	1
	prox. Radius	0
< 14 months	tibia shaft only	0
	femur shaft only	0
	unfused ulna	0
	unfused calcaneus	0
≥ 20 months	distal radius	0
	distal metacarpal	0
	distal metatarsal	0
	distal tibia	1
	complete 1rst phalanx	3
	prox. Femur	0
	fused ulna	0
	fused calcaneus	0
≥ 30 months	complete metacarpal	0
	complete metatarsal	1
	prox. Humerus	0
	distal femur	0
	prox tibia	0
≥ 38 months	complete humerus	0
	complete femur	0
	complete tibia	0
Total		8

Table 7-10 Samples recorded for El Kinel.

For the breadth plane, one ratio plots at zero and is bracketed by two ratios below and two above. For lengths one ratio is minus two and the other at minus six. For depth, only one ratio is above zero with three below. The presence of adult males in the assemblage is indicated. All ratios are within the range of modern adult specimens, no sub-adults are indicated.

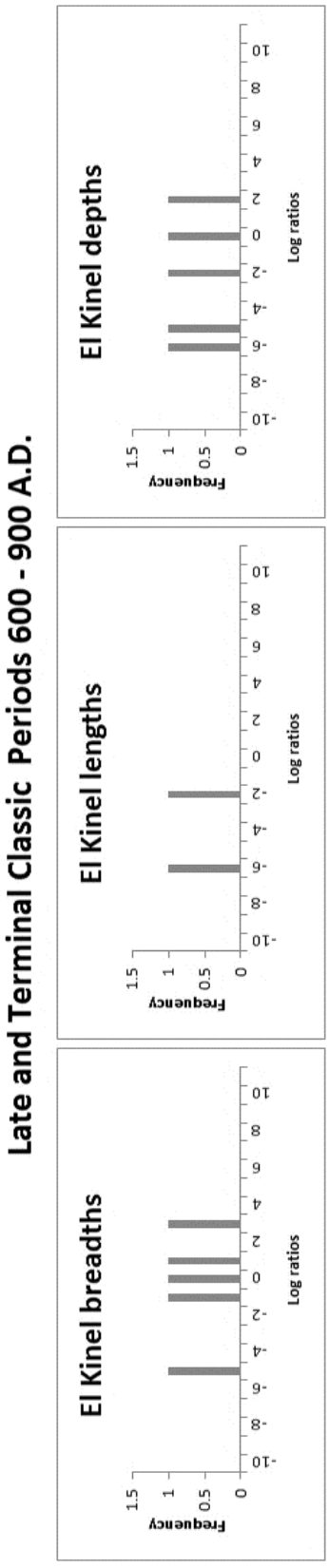


Figure 7-79 Log ratios of Late Classic thru Terminal Classic El Kinel samples compared to the standard for evidence of sex and age cohort.

The single astragalus Sample 302SL (Terminal Classic) plots with the modern females for lateral and medial length, but slightly greater for medial depth.

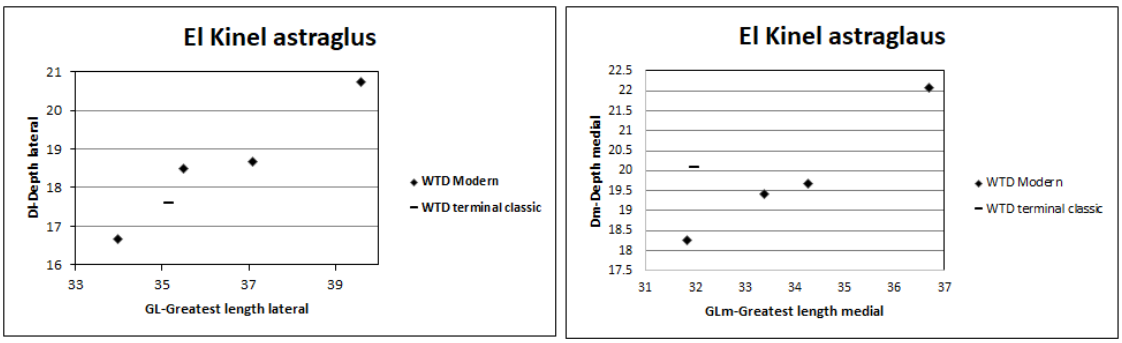


Figure 7-80 Comparison of El Kinel samples using lateral and medial measurements of the astragalus.

Sample 303SL (terminal/Late Classic) is a distal humerus that plots below the modern females suggesting a young sub-adult or possibly juvenile animal.

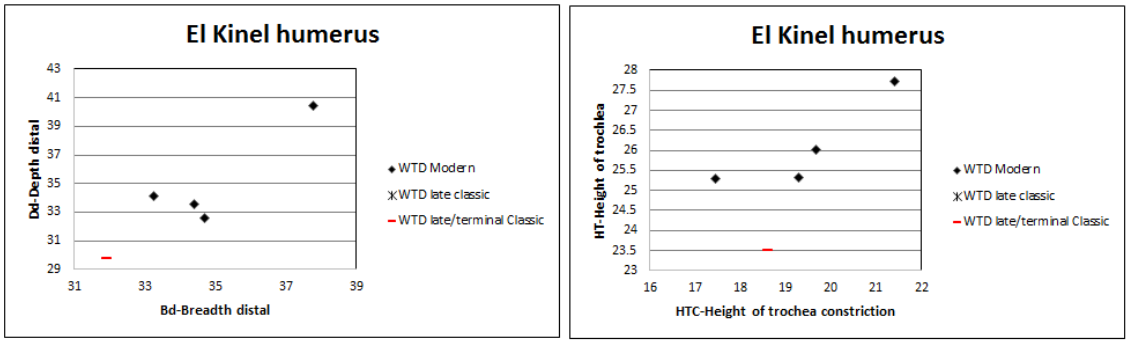


Figure 7-81 Comparison of El Kinel samples using distal measurements of the humerus.

The distal tibia for Sample 301SL (Terminal Classic) plots closely with the modern male.

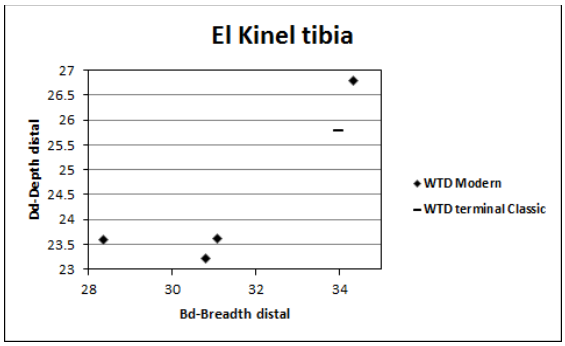


Figure 7-82 Comparison of El Kinel samples using distal measurements of the tibia.

Two metatarsals were recorded; Sample 300SL (Late Classic), shown in Figures 7-83 and 7-84, was broken in three pieces, GL is a refit. Proximal anterior surface was missing, only the distal measurements are secure. The greatest length at 209mm is longer than the samples from San Pedro or La Joyanca but still below length for the modern specimens. The smallest diameter measurements in Figure 7-83 are more closely associated with the male specimen.

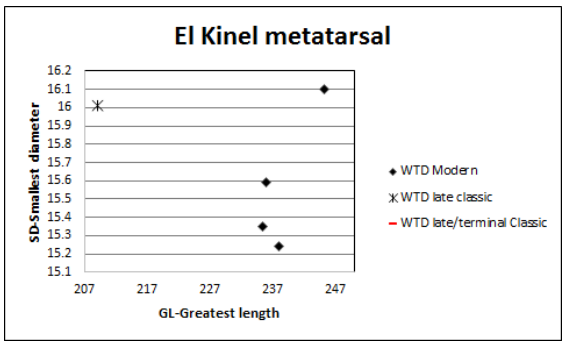


Figure 7-83 Comparison of El Kinel samples using GL and SDs measurements of the metatarsal.

The distal measurements fall between modern male and females for both breadth and depth suggesting this individual was a large female. Sample 305SL in Figure 7-84 (Late/Terminal Classic) had been modified. Breadth measurements suggest a male while depth measurements are consistent with an adult female.

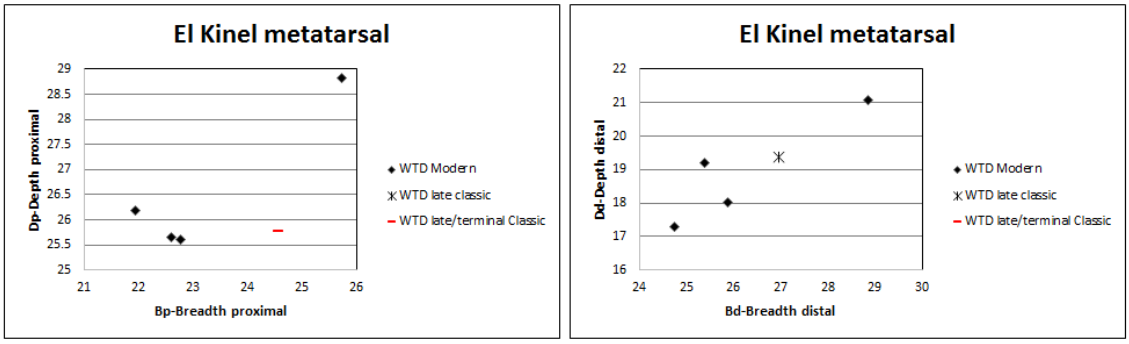


Figure 7-84 Comparison of El Kinel samples using proximal and distal measurements of the metatarsal.

7.5 vi Summary of data:

Table 7-10 shows three early fusing elements, four samples that would indicate animals over 20 months, and one sample with adult morphology. Figure 7-79 shows one sample in the chart for breadth and two samples in the chart for depth that indicates small individuals as well as a single sample in both charts, indicating an individual that exceeds the baseline. Samples shown in the scatterplots are assessed as one adult male, three adult females, one juvenile or young sub-adult of undetermined sex. The remaining three samples are phalanges and not presented.

7.6 Petexbatun region: Guatemala:

Southern Maya Lowlands

7.6 i Cancuen:

Located on the Rio Pasión with canoe access to the Rio Usumacinta. The Cervidae samples are unusually large, a fact also noted in the original faunal analysis (pers. com. Erin Thornton).

Age cohort using epiphysis fusion

Cancuen, Guatemala			
Period			
Late Classic	Late Classic		
BD	WTD	Species	
0	0	humerus shaft only	< 5 months
0	2	prox. Metacarpal	≥6 months
0	2	prox. Metatarsal	
0	2	complete 2nd phalanx	
0	1	astraglus	
0	1	scapula	
0	2	distal humerus	
0	3	prox. Radius	
0	0	tibia shaft only	< 14 months
0	0	femur shaft only	
0	1	unfused ulna	
0	0	unfused calcaneus	
0	1	distal radius	≥ 20 months
0	2	distal metacarpal	
0	0	distal metatarsal	
0	4	distal tibia	
0	1	complete 1rst phalanx	
1	3	prox. Femur	
0	0	fused ulna	
0	2	fused calcaneus	
0	0	complete metacarpal	≥ 30 months
0	2	complete metatarsal	
0	0	prox. Humerus	
0	4	distal femur	
0	4	prox tibia	
0	0	complete humerus	≥ 38 months
0	0	complete femur	
0	0	complete tibia	
1	37	Total	

Table 7-11 Samples recorded for Cancuen.

Table 7-11 shows 13 early fusing elements, one unfused ulna indicating a sub-adult or juvenile, 13 elements in the over 20-month category, and ten samples in the over 30-month category.

In Figure 7-85, the chart for breadths shows seven ratios at less than the Standard and 20 ratios greater than the standard, indicating adult males are represented in this assemblage. For lengths, one ratio is -4, one at + 2, and two ratios at + 3. In the chart for depth, eight ratios match the Standard. Three ratios are -6 or less, and 13 are greater than zero, indicating this assemblage represents animals of greater stature than the Standard.

Figure 7-85 Log ratios of Lat Classic Cancuen samples compared to the standard for evidence of sex and age cohort.

One astragalus is recorded, and plots with the male specimen.

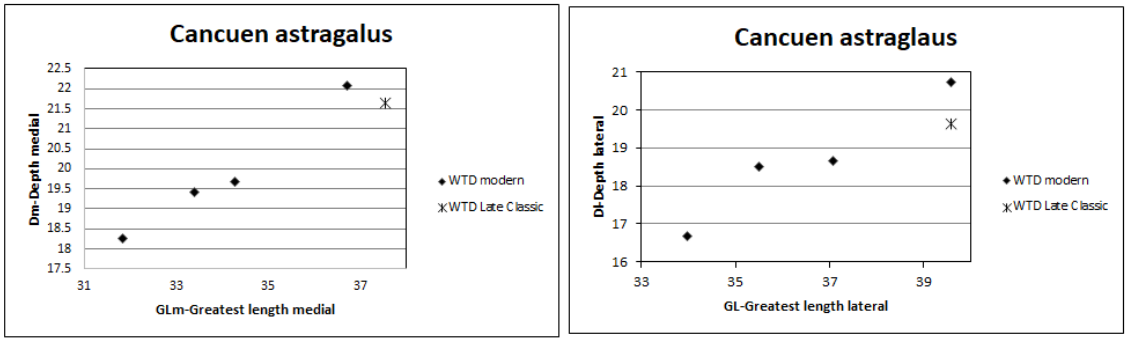


Figure 7-86 Comparison of Cancuen samples using lateral and medial measurements of the astragalus.

The single scapula recorded appears to represent an adult male.

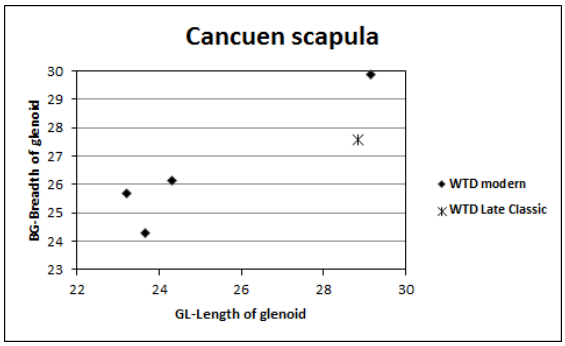


Figure 7-87 Comparison of Cancuen samples using breadth and depth of the glenoid.

Two humeri were recorded. Sample 929C (circled in green) shows a greater affinity for the male specimen. Sample 907C plots with the adult females on the left side of Figure 7-88; the height of the trochlea is smaller but not in the range of sub-adults (see Figure 5-12).

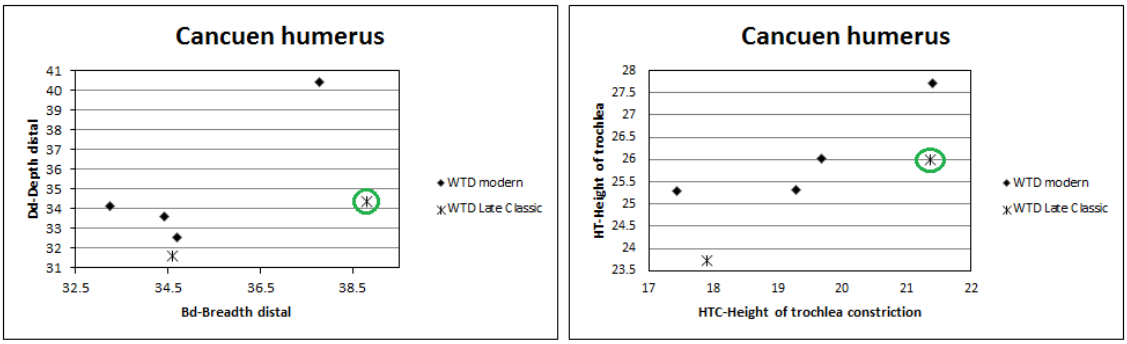


Figure 7-88 Comparison of Cancuen samples using distal measurements of the humerus.

Four radii, three proximal and one distal are recorded. Samples #921C and sample 920C (circled in green in Figure 7-89) may represent the same individual but the shaft was too fragmented for a refit. Both samples possess a closely matching ridge of woven bone along the ulnar groove that may indicate an older individual, and therefore not a sub-adult. Samples 902C and 903C on the left plot nearest the female cohort.

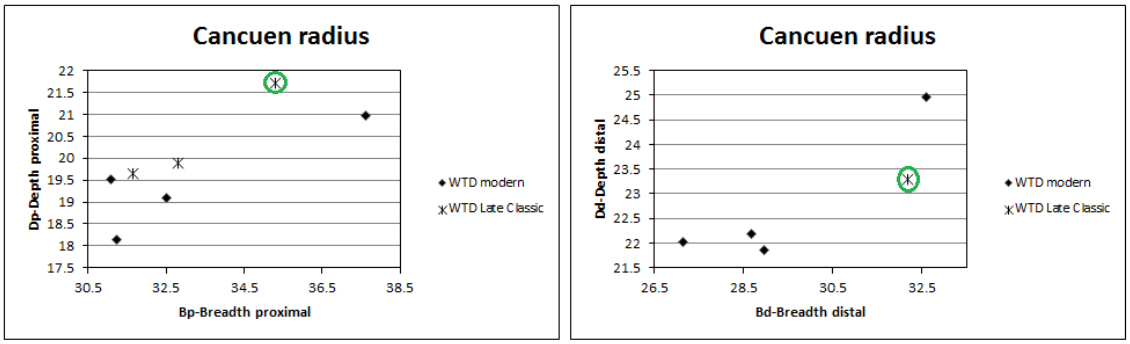


Figure 7-89 Comparison of Cancuen samples using proximal and distal measurements of the radius.

Seven WTD femora were recorded. Sample 912C offered only a single measurement (proximal breadth) and my data sheet records the epiphysis was still visible, indicating an age of less than 29 months. Sample 937C, severely eroded and modified, yielded a single distal depth measurement; these samples are accounted for in Table 7-11 and contributed measurements to the log ratios graphs but are not represented in the scatter plots as measurements as two axes are required for representation.

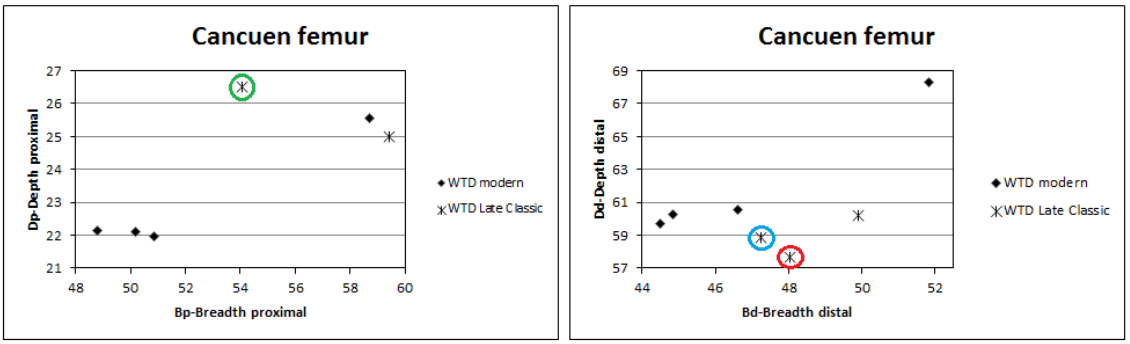


Figure 7-90 Comparison of Cancuen samples using proximal and distal measurements of the femur.

On the left Sample 919C (circled in green) showed a visible epiphysis, possibly indicating an age of less than 29 months, though this is not certain. Nutritional deficit caused by antler genesis, pregnancy, and lactation can produce temporary reabsorption of calcium from the skeleton, and therefore my recorded observation for this specimen is not proof of immaturity. This sample falls between the male and female specimens for breadth but is greater than all modern specimens for depth. Sample 925C presented a broken shaft, the attempt to refit the shaft and obtain a GL measurement failed. Proximal measurements plot closely with the male specimen, only a single distal measurement (Bd) was viable for that sample.

On the right of Figure 7-90 in the graph for distal measurements, Sample 904C (circled in blue) had prominent muscle scars. Sample 916C (circled in red) displayed a

distal epiphysis, indicating an age of less than 38 months. Sample 917C is the largest individual presenting distal measurements, the large breadth measurements fall between male and female specimens but plots with the adult females for depth.

Four proximal and four distal tibiae were recorded. On the left, proximal measurements of the tibia, Figure 7-91 shows samples 923C and 926C exceed the modern male specimen for breadth while also exceeding that specimen for depth. Sample 913C (circled in green) displays a visible proximal epiphysis, indicating an age not over 32 months while matching specimen 4571 (male) for breadth. This individual's depth measurements plot with the modern females, possibly indicating a sub-adult male or a very large female. Sample 918C plots among the adult females.

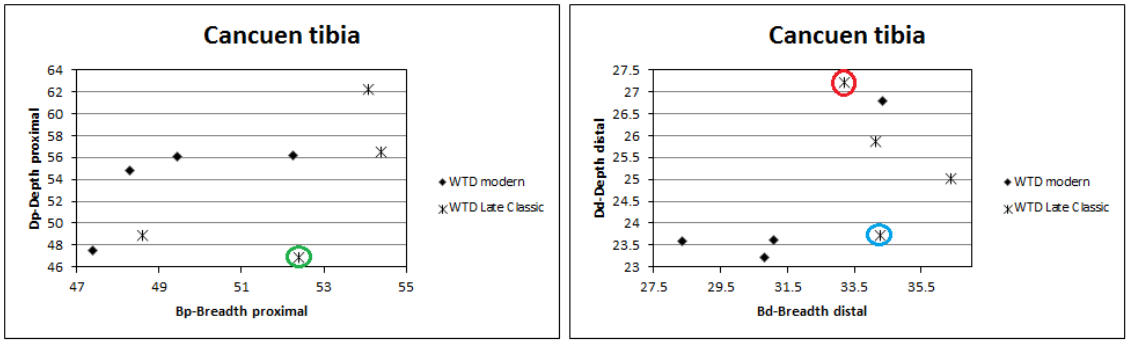


Figure 7-91 Comparison of Cancuen samples using proximal and distal measurements of the tibia.

The distal measurements on the right shows Sample 924C (circled in red) has the largest depth measurement indicating an adult male, while 914C (circled in blue) has a breadth equal to the male specimen but depth measurements in the female range.

The two calcanei shown in Figure 7-92 are a close match for the male specimen in terms of length but differ for breadth and depth.

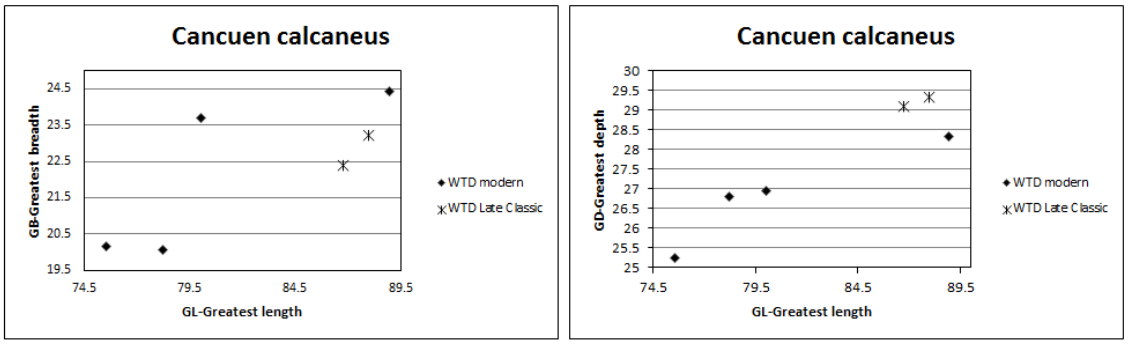


Figure 7-92 Comparison of Cancuen samples using length, breadth, and depth measurements of the calcaneus.

Two proximal and two distal WTD metacarpals are recorded. On the left Sample 932C has the greatest depth measurements and Sample 905C the smallest (old and

young female?). On the right Sample 911C (circled in green) has a visible distal epiphysis showing an age greater than 20 months but less than 29. Sample 915C plots in the same range for depth. Both are more closely associated with the male specimen than the females.

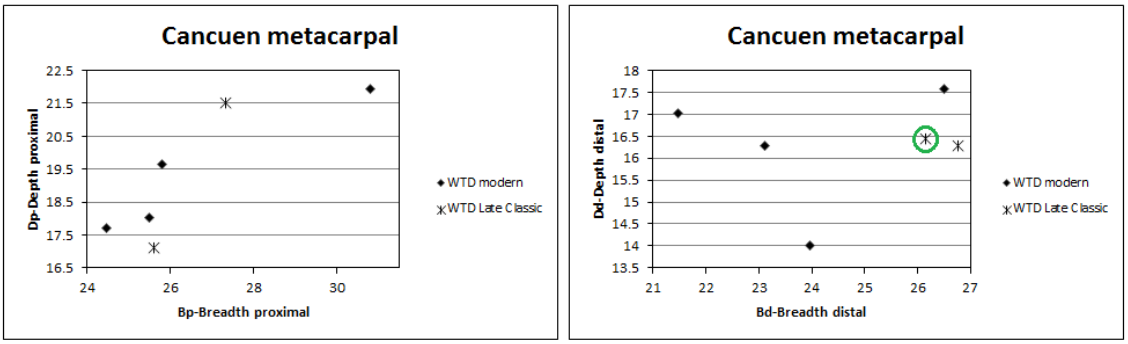


Figure 7-93 Comparison of Cancuen samples using proximal and distal measurements of the metacarpal.

Four metatarsals were recorded.

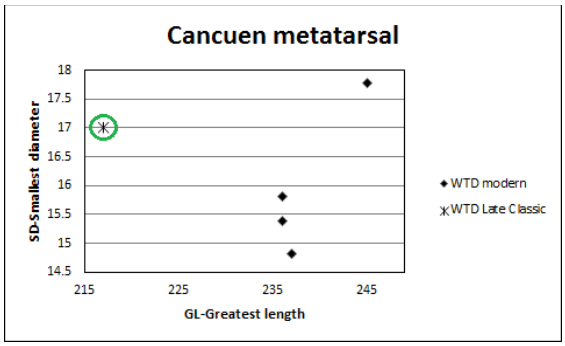


Figure 7-94 Comparison of Cancuen samples using the GL and SDs measurements of the metatarsal.

Sample 933C circled in green was almost complete, offering a greatest length in Figure 7-94 in addition to the proximal and distal measurements in Figure 7-95. This sample is more closely associated with the male specimen for proximal and distal breadth measurements, but both depth measurements and the smallest diameter for 933C falls between the modern male and female specimens, possibly indicating an adult animal, but the greatest length is 20mm smaller than the modern female cohort.

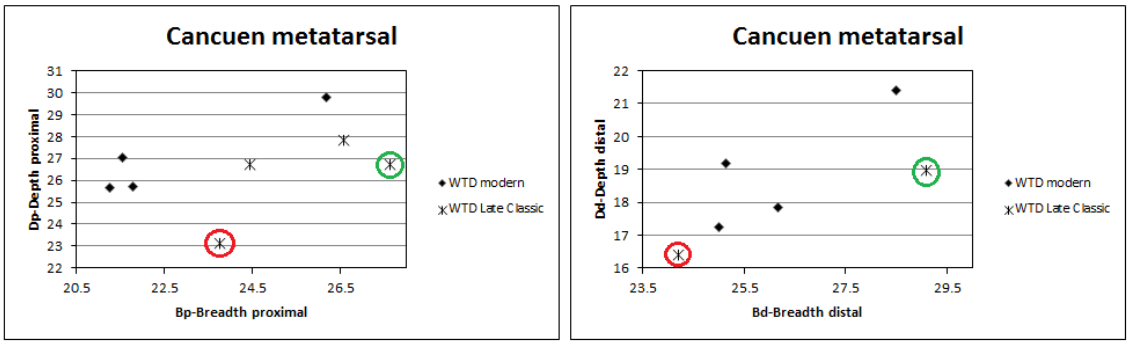


Figure 7-95 Comparison of Cancuen samples using proximal and distal measurements of the metatarsal.

On the left in Figure 7-95 Samples 906C and 909C offered only proximal breadth and depth measurements. Both exceed the modern female specimens for breadth but not for depth. Sample 910C circled in red was broken (no GL measurement was possible) but yielded proximal and distal measurements. The proximal breadth is considerably larger than the female cluster but the distal breadth is slightly smaller, interestingly the proximal depth is less comparable to the female specimens than the distal depth.

7.6 ii Summary of data:

Table 7-11 shows one unfused ulna (not seen in scatterplots) that proves the presence of a sub-adult and ten samples in the over 30-month category, as well as 13 early fusing elements and 13 in the 20 month or greater category. Figure 7-85 shows more ratios exceed the standard than fall below it. This assemblage appears to be dominantly composed of male WTD. The scatterplots appear to show 18 samples representing adult males, and 12 samples that may represent either adult females or sub-adult males. One sample is assessed as a sub-adult male; there is no evidence suggesting juveniles. These animals appear to be generally more robust if not necessarily taller than the modern specimens from Big Cypress. Several samples plot as larger than the male specimen in both breadth and depth but this is not always the case. As the proportions of any specific sample do not seem to be consistent with the proportions of the reference material discriminating between samples that fall between the male and female specimens is especially difficult.

7.6 iii Aguateca:

Located on a limestone bluff overlooking Petexbatun Lagoon and surrounded by defensive walls. In comparison to the reported assemblage (page 57) the number of samples available for recording was quite small. Table 7-12 shows four early fusing elements, one element in the young sub-adult category, three elements in the older sub-adult category and one that is definitively adult.

Age cohort using epiphysis fusion

Aguateca, Guatemala		< 5 months	≥6 months										< 14 months				≥ 20 months										≥ 30 months						≥ 38 months			
Period	Species	humerus shaft only	prox. Metacarpal	prox. Metatarsal	complete 2nd phalanx	astragalus	scapula	distal humerus	prox. Radius	tibia shaft only	femur shaft only	unfused ulna	unfused calcaneus	distal radius	distal metacarpal	distal metatarsal	distal tibia	complete 1rst phalanx	prox. Femur	fused ulna	fused calcaneus	complete metacarpal	complete metatarsal	prox. Humerus	distal femur	prox tibia	complete humerus	complete femur	complete tibia	Total
Late Classic	WTD	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	6
mixed Classic	WTD	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
undated contexts	WTD	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Table 7-12 Samples recorded for Aguateca.

Figure 7-96 shows one ratio in breadths at + 9, indicating an adult male is present, while the four ratios below zero are not sufficiently distant to indicate a difference in size from the standard. None of the lengths are larger than the standard, and the depths show one ratio at -9, indicating a sub-adult or possibly a specimen from a different catchment area.

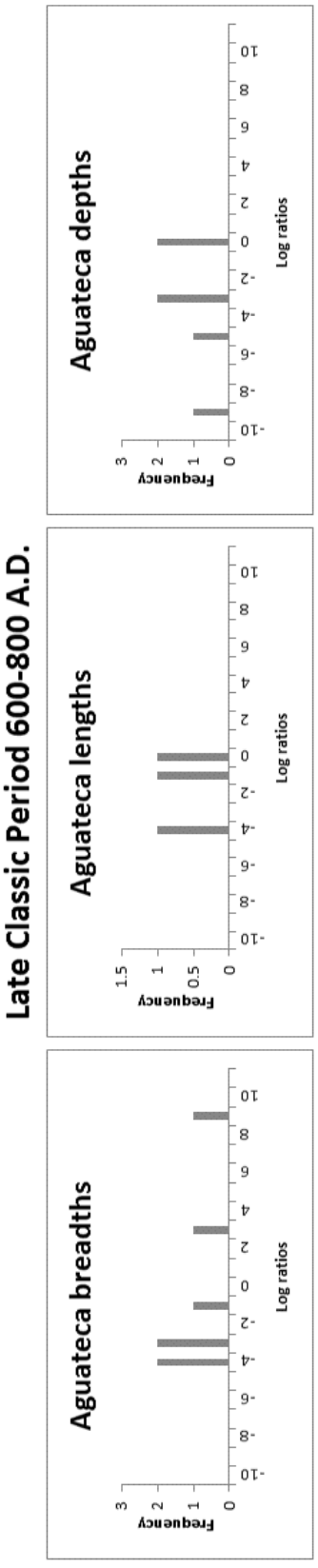


Figure 7-96 Log ratios of Late Classic Aguateca samples compared to the standard for evidence of sex and age cohort.

Material from undated contexts is excluded but two samples from mixed Classic Period deposits are presented; when present the scatterplot icons for these samples are rendered in red to highlight the suspect materials.

Two astragali were recorded. Sample 902AG (circled in green) appears with the female cluster on the left for lateral measurements but marginally closer to the male specimen for medial length. Sample 907AG is in the female cluster for lateral and medial measurements.

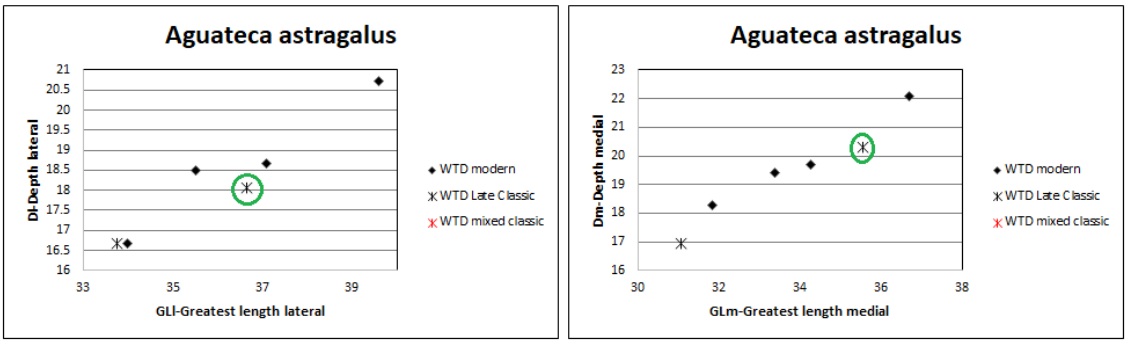


Figure 7-97 Comparison of Aguateca samples using lateral and medial measurements of the astragalus.

No scapula from this assemblage were recorded.

A single humerus was recorded, for Sample 903AG; the shaft was broken GL and GLC measurements are refits. Proximal epiphysis was fused but visible. In Figure 7-98 the GL 193mm falls between the male and female specimens for length. The graph for proximal measurements shows this sample is closer to the adult females for measurements of proximal breadth and depth.

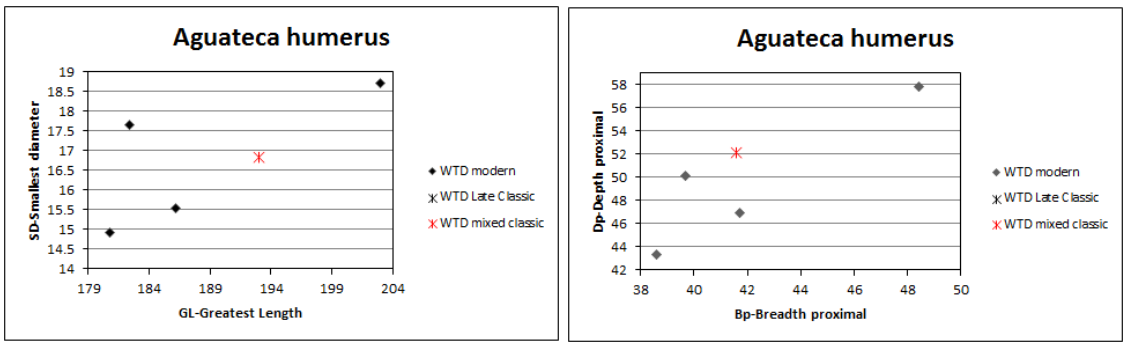


Figure 7-98 Comparison of Aguateca samples using GL, SD, and proximal measurements of the humerus.

For the early fusing distal articulation, distal breadth is slightly larger on the left side of Figure 7-99 while the right-side graph shows the trochlea of this animal is smaller. Since many of the humeri in these collections presented only HT and HTC measurements, this is another clue toward how the prehistoric WTD population of the region may differ from those in present day Florida. While the breadth and depth measurements of the specimen are inconclusive, the length of this humerus, while smaller than the male specimen, exceeds all female specimens.

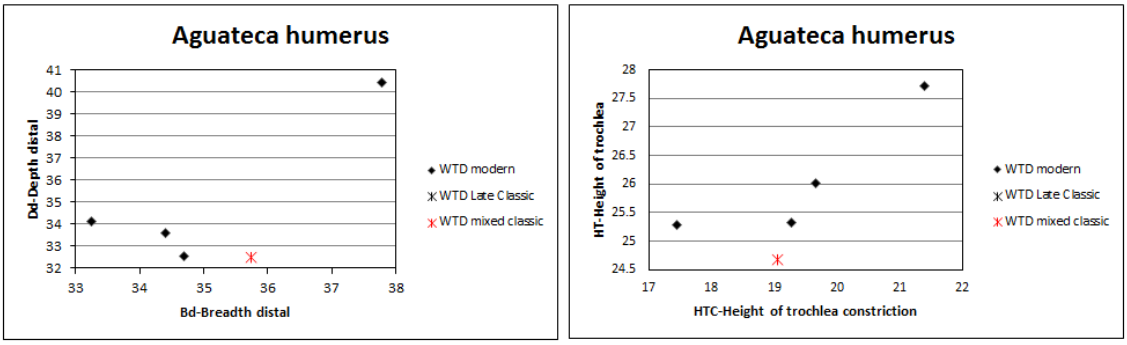


Figure 7-99 Comparison of Aguateca samples using distal measurements of the humerus.

One ulna was recorded and falls between male and female specimens in Figure 7-100.

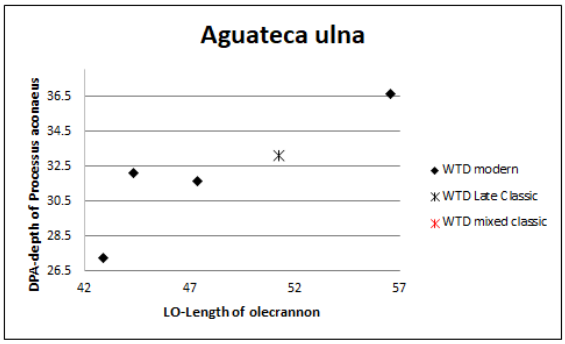


Figure 7-100 Comparison of Aguateca samples using measurements of the olecranon.

Three radii were recorded. Sample 905AG is a proximal radius (mixed classic) noted as large but too eroded on the proximal surface for accurate depth measurements, and is not shown in Figure 7-101. On the left, Sample 909AG, proximal and mixed classic, appears with the female specimens. On the left, Sample 904AG (Late Classic), a distal radius, also plots with the females. This specimen showed a ridge of woven bone on the margin of the ulnar groove, indicating incipient fusion of the ulna to the radius shaft.

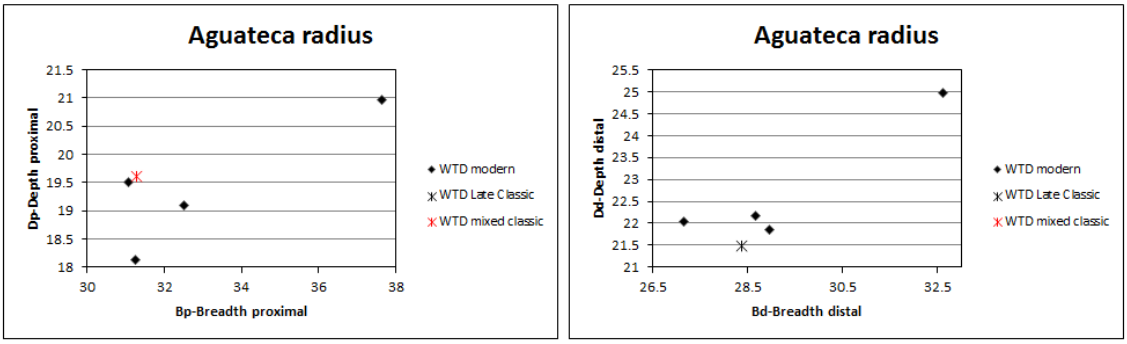


Figure 7-101 Comparison of Aguateca samples using proximal and distal measurements of the radius.

The single calcaneus recorded, Sample 910AG was unfused and severely eroded, the medulla cavity was large, and the cortical bone was thin, indicating a juvenile or young sub-adult. Only the greatest breadth measurement was available, but it was exceptional, 27.11mm as compared to the male specimen's 22.3mm.

7.6 iv Summary of data:

Table 7-12 indicated the presence of one sub-adult or juvenile. One sample presented adult morphology, and five samples that could be sub-adults or represent adult animals. Figure 7-96 indicated the presence of at least one adult male and one sub-adult. All other samples appear to be close to the measurements for the baseline. Scatterplots show one adult male and five samples that may represent adult females or sub-adult males. A single unfused calcaneus is assessed as a juvenile.

7.6 v Punta de Chimino:

Located on a peninsula in Lake Petexbatun, this was a fortified settlement.

Age cohort using epiphysis fusion

Punta de Chimino, Guatemala		< 5 months	≥6 months										< 14 months				≥ 20 months								≥ 30 months						≥ 38 months				Total
Period	Species	humerus shaft only	prox. Metacarpal	prox. Metatarsal	complete 2nd phalanx	astragl us	scapula	distal humerus	prox. Radius	tibia shaft only	femur shaft only	unfused ulna	unfused calcaneus	distal radius	distal metacarpal	distal metatarsal	distal tibia	complete 1rst phalanx	prox. Femur	fused ulna	fused calcaneus	complete metacarpal	complete metatarsal	prox. Humerus	distal femur	prox tibia	complete humerus	complete femur	complete tibia	complete radius	
Late Classic	WTD	0	0	0	0	3	0	1	0	0	0	0	1	0	0	1	0	7	0	0	1	0	0	0	0	0	0	0	0	1	15

Table 7-13 Samples recorded for Punta de Chimino.

Four early fusing elements, one sample definitively young sub-adult or juvenile, and eight samples representing animals 20 months or older. No samples indicate the presence of adult animals in this assemblage.

In Figure 7-102 four ratios are greater than zero, three ratios are -3 and four samples plot below -5. In lengths one ratio is + 4 and two at -1; as there are no fused long bones in this group, these lengths derive from the astragali and calcaneus. For depths, one ratio plots at zero. The other seven ratios plot below, the presence of sub-adult males or adult females within the assemblage is implied.

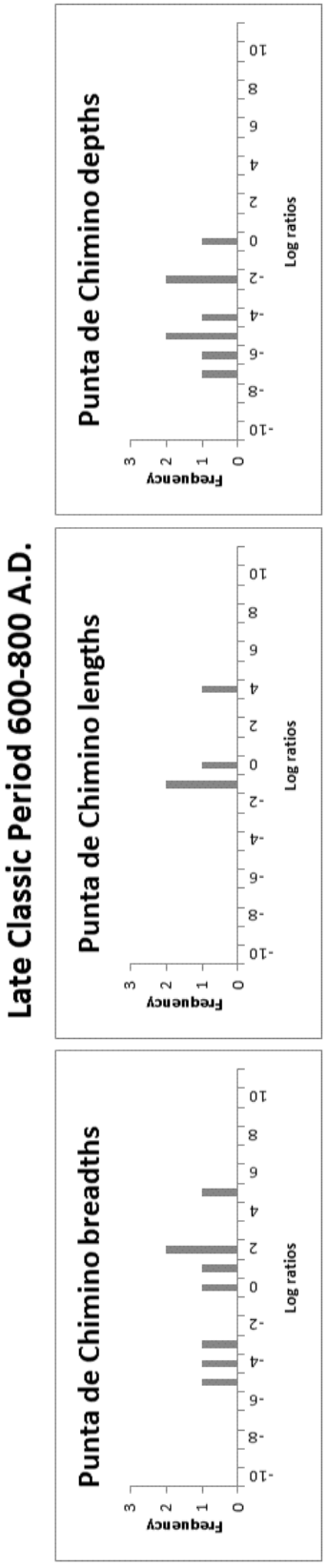


Figure 7-102 Log ratios of Late Classic Punta de Chimino samples compared to the standard for evidence of sex and age cohort.

Three astragali were recorded, Sample 504PC circled in red was damaged and contributed no lateral length measurements. Sample 501PC in the upper right corner

may represent an adult male. Sample 504PC also appears in both graphs within the female cluster.

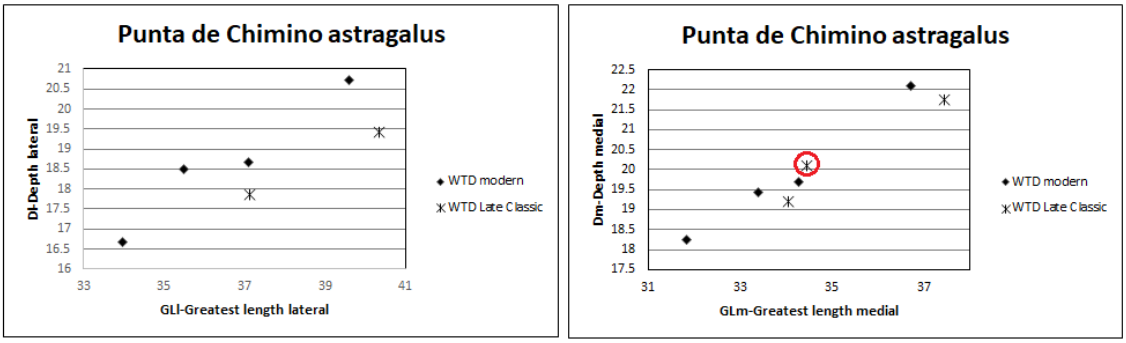


Figure 7-103 Comparison of Punta de Chimino samples using lateral and medial measurements of the astragalus.

A single distal humerus was recorded, Sample 509PC plots closely with the adult females for distal breadth. Measurements of the trochlea are smaller, possibly a sub-adult female.

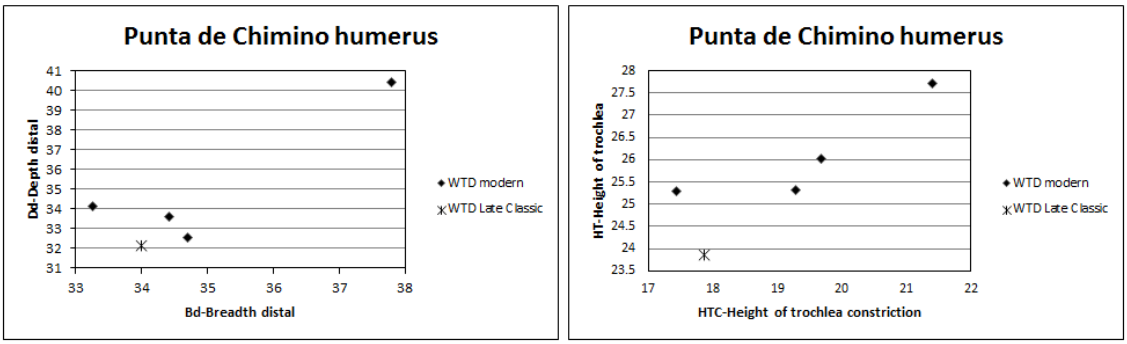


Figure 7-104 Comparison of Punta de Chimino samples using distal measurements of the humerus.

Sample 510PC was listed as almost complete on the original data sheets but had suffered sufficient damage post excavation that a greatest length measurement was not available. However, proximal and distal measurements were of good quality. This sample plots within the mature female cluster for both proximal and distal breadth but below for depth.

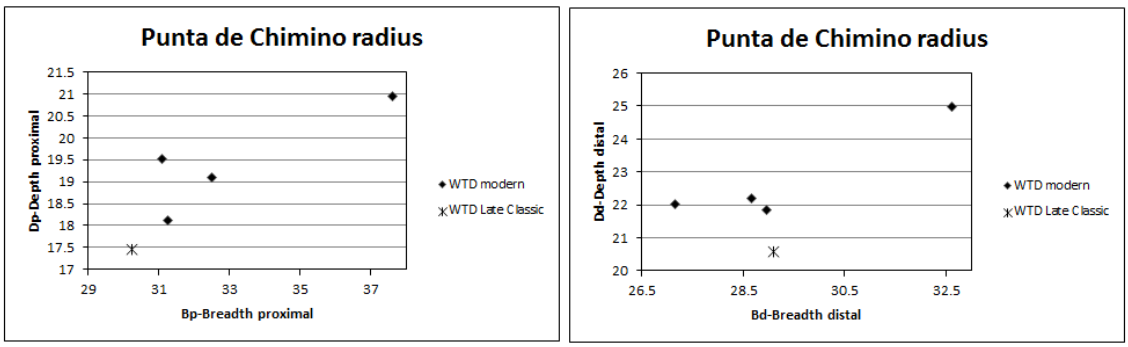


Figure 7-105 Comparison of Punta de Chimino samples using proximal and distal measurements of the radius.

Two calcanei were recorded, both appear in the female cluster.

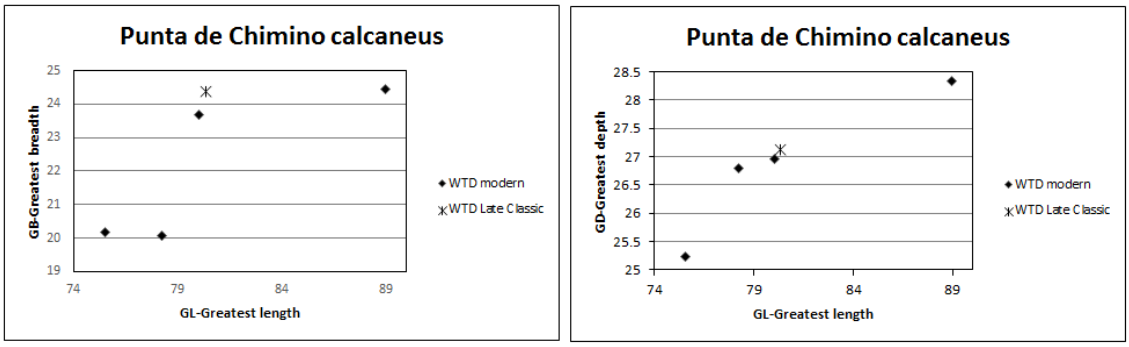


Figure 7-106 Comparison of Punta de Chimino samples using length, breadth, and depth measurements of the calcaneus.

Sample 506PC was unfused and is not shown in Figure 7-106. Sample 503PC was fused, this sample plots with the oldest of the adult female specimens in GB and GD measurements.

Sample 512PC, a distal metatarsal, is larger in the breadth plane than all modern females and within the same range for depth measurements.

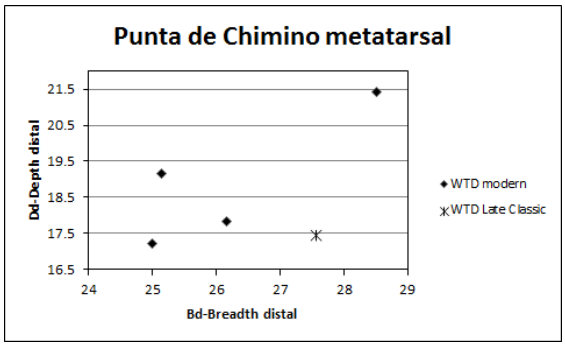


Figure 7-107 Comparison of Punta de Chimino samples using distal measurements of the metatarsal.

7.6 vi Summary of data:

Table 7-13 shows one sample with sub-adult morphology; four samples are early fusing elements and eight samples might represent sub-adult or adult animals. No

skeletal elements in this assemblage demonstrated adult morphology. Figure 7-102 shows four samples in the chart for breadth that are larger than the standard. One sample in lengths is larger than the standard. One sample in depths is -7 and may represent a sub-adult. In the scatterplots two samples may represent adult males but that assessment is not secure. Six samples may be adult females or male sub-adults.

7.6 vii Cueva de Los Quetzales:

The assemblage derives from a cave under the acropolis of Las Payacas. Samples from this Early Classic assemblage derive from a ritual deposit, see Figure 3-5. Table 7-14 shows 17 early fusing elements, six elements are in the 20-month category, two in the 30-month category and two elements showing adult morphology.

Age cohort using epiphysis fusion

| Cueva de Los Quetzales | | |

Figure 7-108 Log ratios of Early Classic Cueva de Los Quetzales samples compared to the standard for evidence of sex and age cohort.

In the chart for breadths four ratios are -7 or below and eleven ratios plot as larger than the standard. The chart for length shows one ratio matches the standard, one is + 4 and two ratios are smaller than the standard. For depths ten ratios plot above zero

and ten samples plot below the standard, this suggests a mix of age categories may be represented in this collection. There is no tail at -10 that would indicate presence of juveniles or young sub-adults in the assemblage.

A single astragalus appears as greater in length than all modern specimens in graphs for lateral and medial measurements, almost certainly representing an adult male.

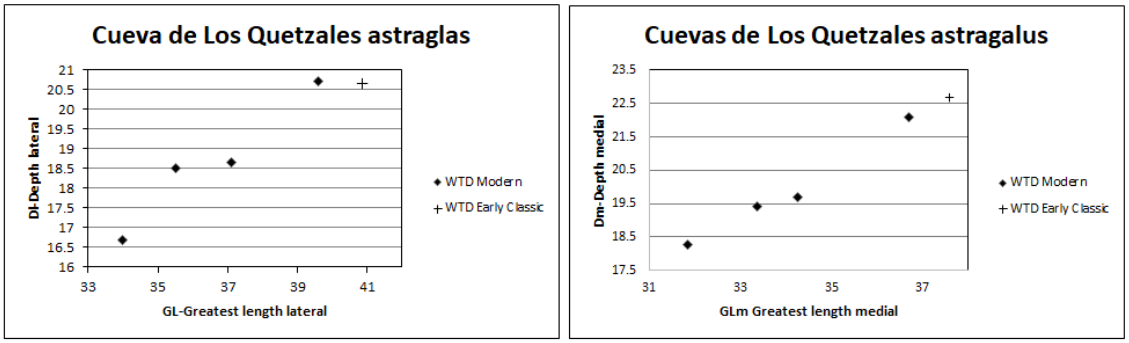


Figure 7-109 Comparison of Cueva de Los Quetzales samples using lateral and medial measurements of the astragalus.

Two scapulae were recorded, both samples plot with the adult females.

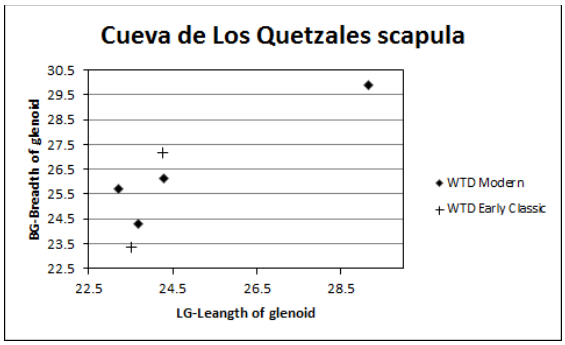


Figure 7-110 Comparison of Cueva de Los Quetzales samples using breadth and depth of the glenoid.

Three distal humeri were recorded, only measurements of the trochlea were available for all three samples, 320CQ (circled in green) plots with the females for breadth but smaller than all specimens for depth, likely a young sub-adult or juvenile individual. Samples 318CQ and 324CQ plot slightly larger than the modern adult females for depth and breadth.

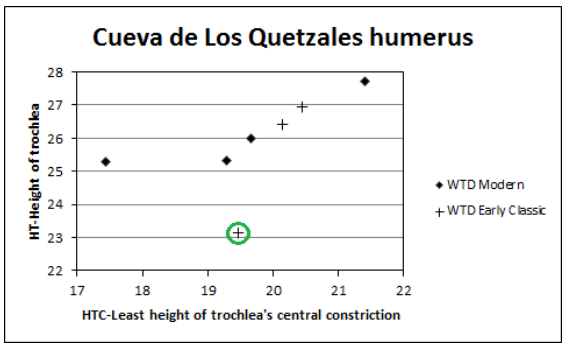


Figure 7-111 Comparison of Cueva de Los Quetzales samples using distal measurements of the humerus.

Seven proximal, one distal, and two almost intact radii were recorded. The GL measurements for samples 322CQ (circled in green) and sample #23CQ (circled in red, in Figures 7-112 and Figure 7-113) are refits, the measurements are considered secure within the standard 3mm for instrument error. Sample 323CQ has fused with the ulna shaft, indicating an older individual. In Figure 7-112 the length and smallest diameter of both samples plot with the largest of the modern females. For proximal and distal breadth, they plot with the male specimen in Figure 7-113. Proximal depth measurements for these two samples are larger than the male specimen, while for distal depth Sample 323CQ plots between the male and female specimens on the right.

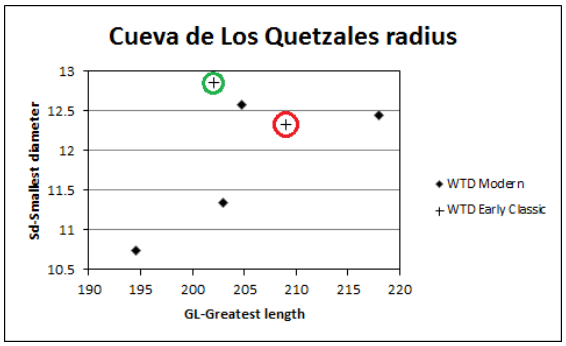


Figure 7-112 Comparison of Cueva de Los Quetzales samples using GL and SD measurements of the radius.

Samples 313CQ and 315CQ appear in the lower left corner of the graph for proximal measurements and are almost certainly female, possibly sub-adult females. In the graph for proximal measurements, Sample 321CQ plots with the adult female specimens.

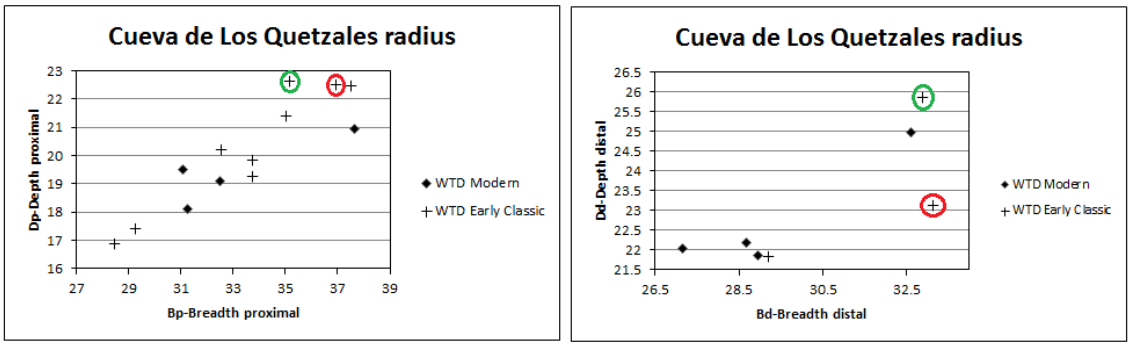


Figure 7-113 Comparison of Cueva de Los Quetzales samples using proximal and distal measurements of the radius.

One ulna was recorded; 314CQ is closer in range to the female cohort than the male. Since the olecranon attachment is fused, the individual is adult or an older sub-adult. How linear growth and bio-mechanical stress impact this element is currently unclear.

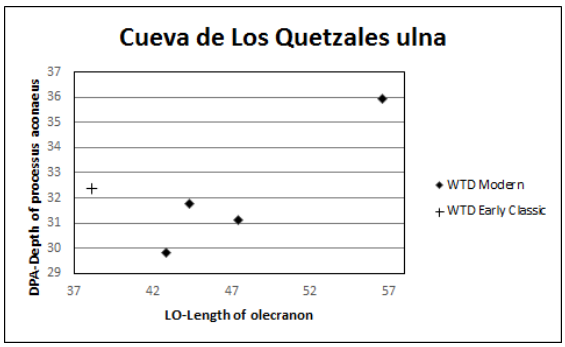


Figure 7-114 Comparison of Cueva de Los Quetzales samples using measurements of the olecranon.

Sample 326CQ plots with the male specimen for breadth but between male and female specimens for depth. Showing a visible distal epiphysis, this animal would represent a young adult or sub-adult male.

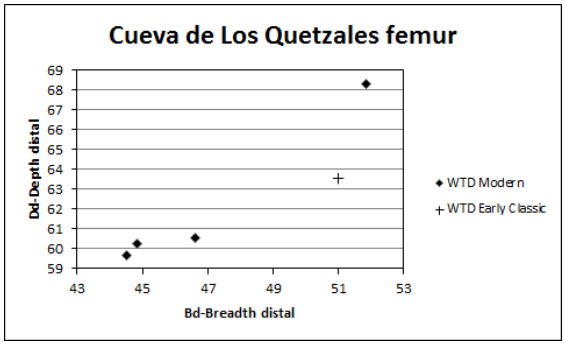


Figure 7-115 Comparison of Cueva de Los Quetzales samples using proximal measurements of the femur.

Five metacarpals were recorded, two proximal samples, and two distal samples and one complete metacarpal. Sample 307CQ is circled in green (Figures 7-116 and 7-117). While this bone is 17mm shorter than the smallest of the modern adult females,

distal breadth measurements on the right of Figure 7-117 plot as larger than the male specimen, while the proximal breadth falls between the modern male and females. The smallest diameter shown in Figure 7-116 and distal depth measurements on the right side indicate an older individual.

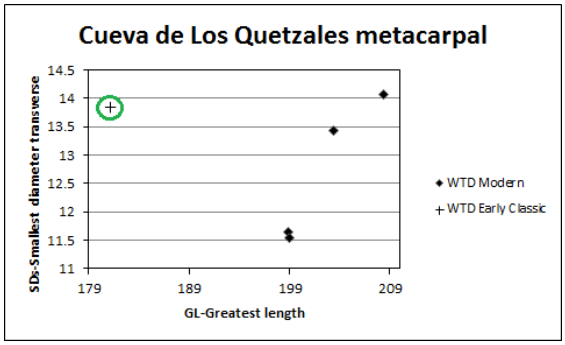


Figure 7-116 Comparison of Cueva de Los Quetzales samples using GL and SDt measurements of the metacarpal.

On the right two distal samples represent adult or older sub adult animals. Their breadth measurements exceed the modern females while the depth measurements fall into the adult female range. One of the proximal samples also matches this pattern, matching the females for depth but exceeding them for breadth. The second proximal sample is smaller than the adult females in breadth and depth, possibly representing a sub-adult.

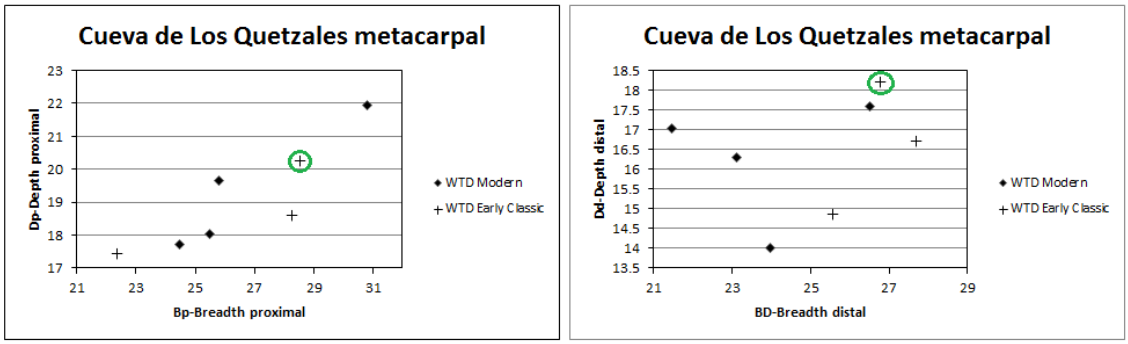


Figure 7-117 Comparison of Cueva de Los Quetzales samples using the proximal and distal measurements of the metacarpal.

7.6 viii Summary of data:

In Table 7-14 no samples indicate the presence of juveniles or young sub-adults, 17 elements are early fusing and six bones are recorded in the 20-month-old or greater category. Four samples show adult morphology. This indicates the animals represented in this assemblage were older sub-adults or adult at time of death. Figure 7-108 shows what appears to be a cluster of smaller animals at the lower end of the bin-range and by a larger grouping on either side of the Standard in the chart for breadth measurements, the presence of adult males in the assemblage is implied. The chart for length shows an

even distribution on either side of the standard. In the chart for depth there is also an even distribution with three samples at or below -6. There is no spike at -10 that would indicate sub-adult or juveniles, and therefore the presence of older individuals in the assemblage is demonstrated. The scatterplots show eight samples that are assessed as adult males, one of which demonstrated an ulna fused to the radius. Sixteen samples are shown that may represent either adult females or sub-adult males, and one sample is most likely a young sub-adult, there appear to be more adult males represented in this assemblage.

7.7 El Mirador Basin, Guatemala:

Southern Maya Lowlands

El Mirador, the assemblage presented derives from the Late Preclassic period. (Thornton & Emery, 2016).

Age cohort using epiphysis fusion

El Mirador, Guatemala		Period	Late Preclassic	Late Preclassic	Late Classic	undated contexts
	Species		WTD	BD	BD	BD
< 5 months	humerus shaft only		0	0	0	0
≥6 months	prox. Metacarpal		1	0	0	1
	prox. Metatarsal		0	2	0	0
	complete 2nd phalanx		0	0	0	0
	astraglus		1	0	0	0
	scapula		2	0	0	0
	distal humerus		1	0	0	1
	prox. Radius		1	1	0	3
< 14 months	tibia shaft only		0	0	0	0
	femur shaft only		0	0	0	0
	unfused ulna		0	0	0	0
	unfused calcaneus		0	0	0	0
≥ 20 months	distal radius		0	0	0	0
	distal metacarpal		0	0	0	0
	distal metatarsal		0	0	0	0
	distal tibia		0	0	0	0
	complete 1rst phalanx		4	0	0	3
	prox. Femur		1	0	0	0
	fused ulna		0	0	0	0
	fused calcaneus		0	1	1	0
≥ 30 months	complete metacarpal		0	0	0	0
	complete metatarsal		0	0	0	0
	prox. Humerus		0	0	0	0
	distal femur		0	0	0	0
	prox tibia		0	0	0	0
≥ 38 months	complete humerus		0	0	0	0
	complete femur		0	0	0	0
	complete tibia		0	0	0	0
	Total		11	4	1	8

Table 7-15 Samples recorded for El Mirador.

Brocket deer represent more than half the recorded samples, only 11 WTD samples are described for this assemblage. Six elements are early fusing, and five appear in the 20-month category. No elements fall in the adult category.

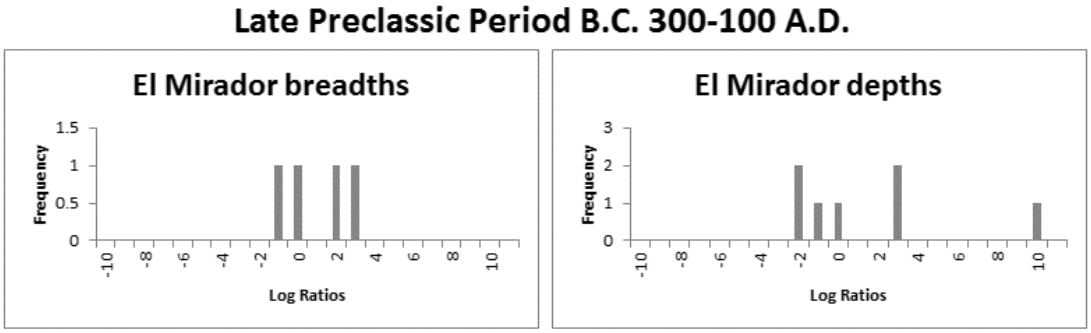


Figure 7-118 Log ratios of Late Preclassic El Mirador samples compared to the standard for evidence of sex and age cohort.

As only an astragalus yielded a length measurement, a histogram for that plane was not possible here. Four samples offered breadth measurements, the ratios derived appear to be in the same range as the largest adult specimens from Big Cypress (see Figure 5-6). A single depth ratio exceeds the modern specimens see Figure 7-120 below.

A single astragalus was recorded. Sample 215M in Figure 7-119 plots as greater than the male specimen.

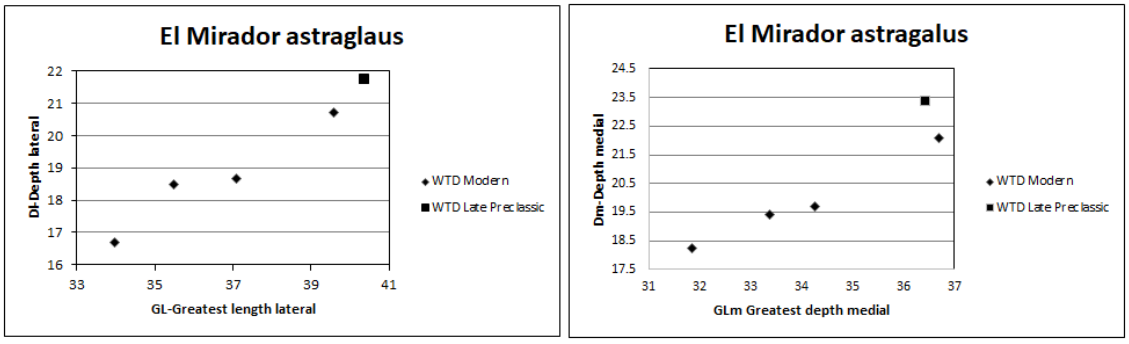


Figure 7-119 Comparison of El Mirador samples using lateral and medial measurements of the astragalus.

Sample 214M in Figure 7-120 exceeds the male specimen. The difference for the scapula in this chart is consistent with the standard sexual dimorphism between adult males and females for this species reported in the literature, even if that result was not apparent in the Baseline Study.

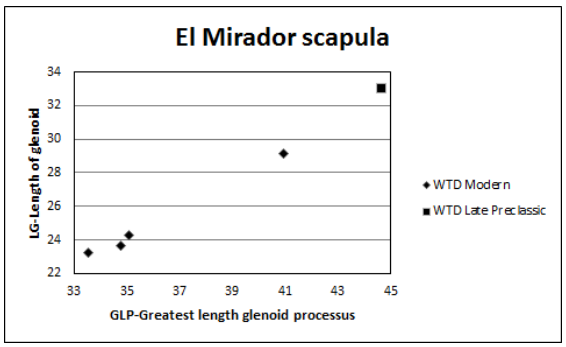


Figure 7-120 Comparison of El Mirador samples using breadth and depth of the glenoid.

Sample 212M in Figure 7-121 plots as greater than the male specimen for breadth, the depth measurement indicating an adult male.

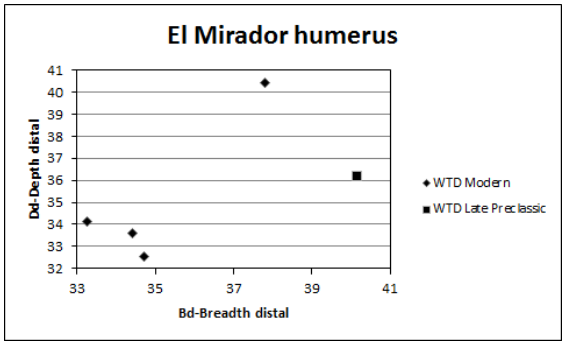


Figure 7-121 Comparison of El Mirador samples using distal measurements of the humerus.

Sample 201M was the only WTD radius recorded for this assemblage and plots with the adult females.

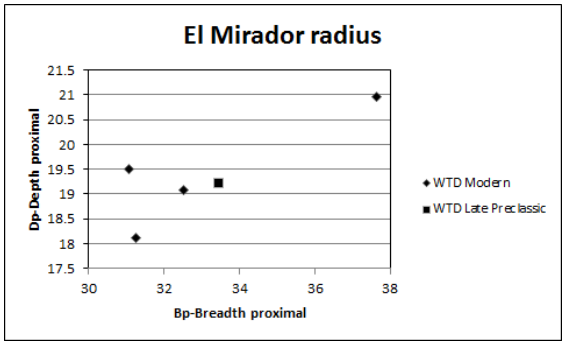


Figure 7-122 Comparison of El Mirador samples using proximal measurements of the radius.

The femur recorded in this collection presented a single proximal breadth measurement denying the use of a scatter plot for assessment, but even with a single measurement it was possible to represent this sample in the log ratios.

7.7 i Summary of data:

Table7-15 shows six early fusing elements and five skeletal elements in the 20 month or greater category; four of those are 1st phalanges. No samples demonstrate juvenile or adult morphology. Figure 7-118, while lacking a chart, for length shows all

breadth measurements are close to the standard, implying the presence of males in the assemblage. Measurements in the chart for depth also cluster with the standard and the presence of older adults in the assemblage is indicated. Scatterplots indicate the presence of three adult males and one adult female or sub-adult male. The samples assessed as adult males in this assemblage are larger than those from other assemblages.

7.8 Copan Valley, Honduras:

Southern Maya Highlands

Located in the Copan Valley, with agricultural soils of significant fertility and pine forested highlands, the materials examined are from an unpublished assemblage (pers. comm. Kitty Emery 2017).

Age cohort using epiphysis fusion

Copan, Honduras		Period	Early Classic	Late Classic	undated contexts
	Species		WTD	WTD	WTD
< 5 months	humerus shaft only		0	0	0
≥6 months	prox. Metacarpal		0	0	0
	prox. Metatarsal		0	0	0
	complete 2nd phalanx		0	1	0
	astraglus		0	0	1
	scapula		1	0	0
	distal humerus		0	0	1
	prox. Radius		0	2	0
< 14 months	tibia shaft only		0	0	0
	femur shaft only		0	0	0
	unfused ulna		0	0	0
	unfused calcaneus		0	0	0
≥ 20 months	distal radius		0	0	0
	distal metacarpal		0	0	0
	distal metatarsal		0	0	0
	distal tibia		0	0	0
	complete 1rst phalanx		0	0	0
	prox. Femur		0	0	0
	fused ulna		0	0	0
	fused calcaneus		2	0	0
≥ 30 months	complete metacarpal		0	0	0
	complete metatarsal		0	0	0
	prox. Humerus		0	0	0
	distal femur		0	0	0
	prox tibia		0	0	0
≥ 38 months	complete humerus		0	0	0
	complete femur		0	0	0
	complete tibia		0	0	0
	Total		3	3	2

Table 7-16 Samples recorded for Copan.

The Early Classic Period yields one early fusing element, a scapula, and two fused calcanei. Late Classic produced three early fusing elements.

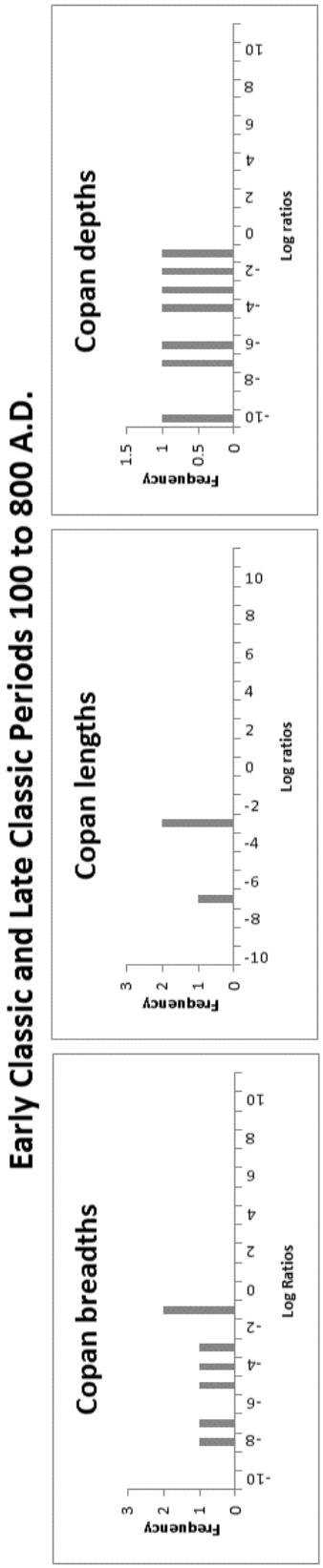


Figure 7-123 Log ratios of Early Classic and Late Classic Copan samples compared to the standard for evidence of sex and age cohort.

In breadths, lengths, and depths all ratios are smaller than the Standard represented at zero on the scale.

A single scapula, Sample 201C, showed an open coracoid process indicating a juvenile animal.

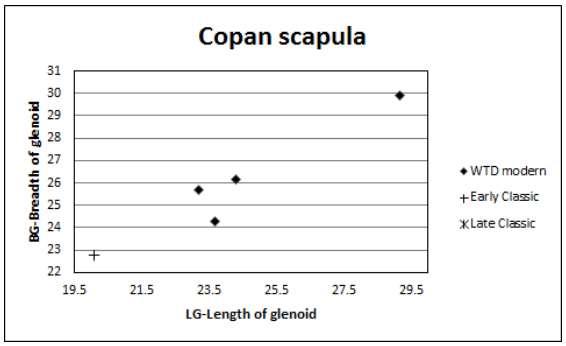


Figure 7-124 Comparison of Copan samples using breadth and depth of the glenoid.

Two proximal radii from the Late Classic are shown above. Sample 200C (circled in green) possibly represents a sub-adult. Sample 207C plots among the adult female specimens.

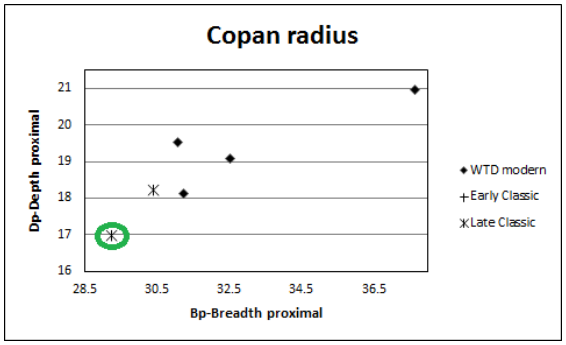


Figure 7-125 Comparison of Copan samples using proximal measurements of the radius.

Two calcanei from the Early Classic Period were recorded, Sample 206C (circled in green on the left) had suffered damage to the ventral portion of the articular surface, but plots with the modern females. For Sample 202C, on the right (modified), greatest breadth was unavailable. While smaller in length than the modern females, the field notes record this sample as quite robust.

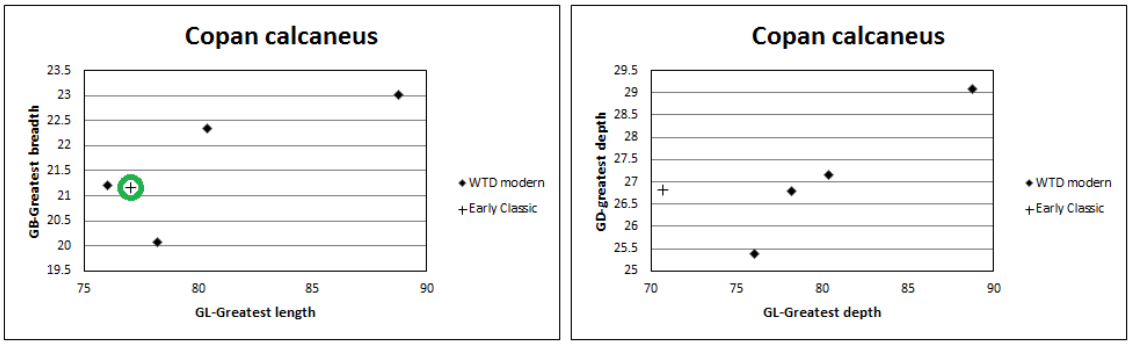


Figure 7-126 Comparison of Copan samples using length, breadth, and depth measurements of the calcaneus.

For the very last collection to be recorded, caudal measurements for the calcaneus, Sample 206C has a greater caudal depth than 202C but both plot as smaller than the modern specimens. Despite the modest measurements for these two samples, Figure 7-127 indicates Sample 206C may be an adult male, and Sample 202C possibly represents an adult female.

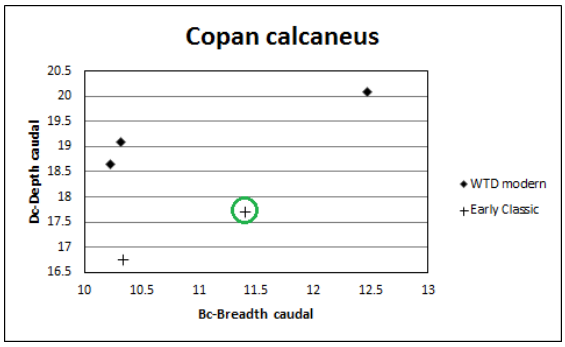


Figure 7-127 Comparison of Copan samples using caudal measurements of the calcaneus.

7.8 i Summary of data:

Table 7-16 shows all WTD bones assessed for Copan are early fusing skeletal elements. Figure 7-123 shows the log ratios for all samples measured fall below the standard measurements. Results derived from the scatter plots show one sample assessed as adult male, two samples assessed as adult females or sub-adult males, one sample that may be a sub-adult and one sample that is assessed as a juvenile. The paucity of the assemblage and divergence in bone size from the baseline population of Florida makes this assessment less secure than some of the other assemblages presented in this chapter. Pohl (1995) notes the WTD from Copan are smaller than deer at other Maya sites and suggests this is a result of intensified exploitation of the species.

7.9 Synopsis

Measurements of bone length and breadth are standard in zooarchaeology, this project has paired measurements of bone depth with those of bone breadth, along with the refitting of broken long bones to increase the available sample size (see

measurements in Chapter 2). The additional complexity created is prerequisite to plotting the presence of age cohorts in the archaeological assemblages and determining if there is any evidence that might support the hypothesis for deer husbandry by the ancient Maya.

This chapter applies three different methods to the evaluation of the archaeological assemblages presented. The first table for each site presents the Cervidae bones recorded for this study along with their chronological framing as determined by the excavators. The bones are sorted by (identified) deer species, the portion of the skeletal element recorded, and age cohort based on predicted epiphysis fusion per Purdue (1983b). The table is interpreted to predict the mortality profile of the recorded samples discussed above. The second method interprets the histograms generated using log-ratios. Interpretation of the charts facilitates understanding how the samples in the assemblage compare to the reference materials and facilitates prediction of how many adult males are present compared to other sex and age classes. Chapter 5 offered sufficient evidence that skeletal growth is not symmetrical on all planes for me to proceed on that hypothesis, and apply the observed asymmetry to interpret the age cohorts present in each assemblage. The third method employs XY scatter-grams for a side by side comparison of the artefacts with the reference specimens selected as the Standard, along with detailed descriptions of the samples to discern the sex and age at death represented in the assemblage. These three methods are then compared to support, refute, and expand on my interpretation of the assemblage.

The recording of osteometrics and analysis of epiphysis fusion are frequently employed in assessing faunal materials. Bimodal scatterplots are widely used in zooarchaeology as a visual demonstration of sexual dimorphism and diachronic variations in population stature. The application of log ratios is an accepted statistical method for evaluating archaeological assemblages and has been used to compare assemblages from different sites to demonstrate population variation across geography and time (Albarella et al. 2009; Sykes et al. 2011).

In the graph below the sites are grouped by region, Copan and El Mirador are single representatives for those two regions – Cueva Los Quetzales (Las Payacas), Cancuen, Punta de Chimino, and Aguateca represent the Petexbatun region – Motul de San Jose and La Trinidad de Nosotros for Lake Peten Itza – El Kinel, La Joyanca, and Piedras Negras, represent the Sierra del Lacondon region. While Tipu Negroman and Lamanai, represent the Southern Maya lowlands in Belize, with San Pedro and Marco

Gonzales representing the cays of Chetumal Bay in Belize. Lastly, Ek Balam stands for the Northern Maya lowlands in Yucatan.

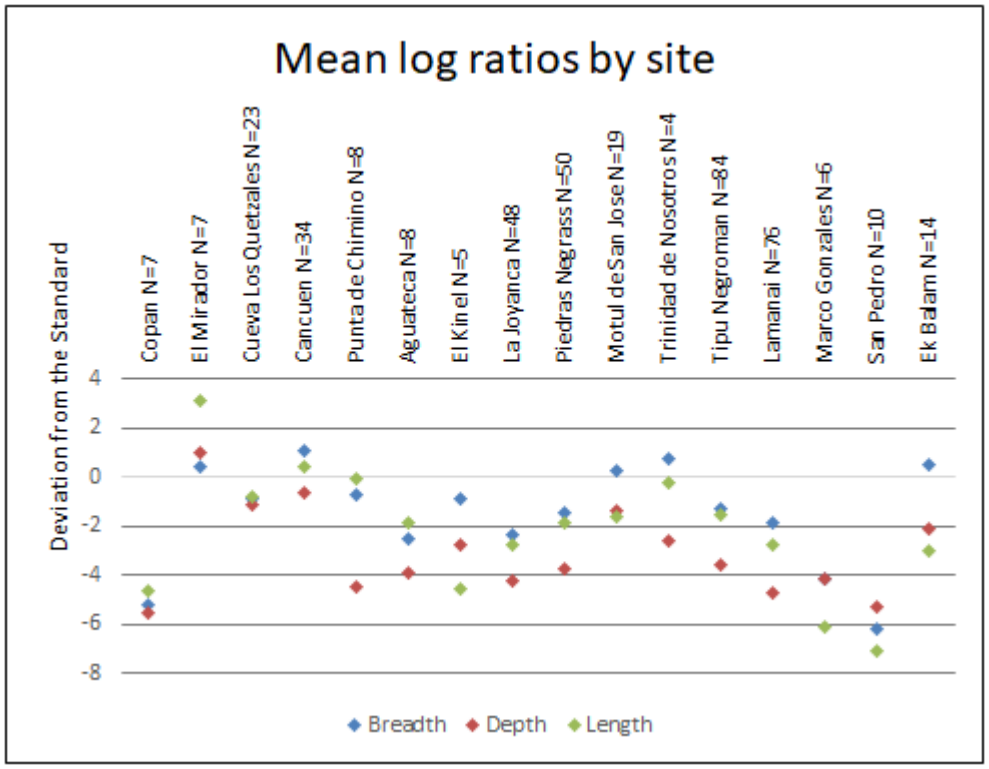


Figure 7-128 Demonstrating log ratio Mean by site and region.

The log ratios for each site are averaged to produce the Mean for each plane of measurement and are displayed above in Figure 7-128. Among the assemblages examined in this study Copan's geology is singular and will be described in the next chapter. At the other end of the graph Ek Balam's assemblage represents a noncultural deposit. A third standout is the very small assemblages from Ambergris Cay, showing a similarity in stature to the samples from Copan. As is the case for the other 13 assemblages, the underlying geology at Ambergris Cay is karst limestone and therefore the nutrient quality of the vegetation should be similar to other assemblages studied. However, it is possible Ambergris Cay lacked a native WTD population per the suggestion of Williams et al. (2009: 52). Emery (1999) suggests some of the WTD consumed at Lamanai may have been derived from the nearby Maya Mountains, composed of an intrusive granite substrate (igneous derived soils); those mountains are also within the catchment area for San Pedro, or as already postulated the samples may represent a third deer species. Figure 7-128 does include the noncultural fauna samples from the Ek Balam assemblage, the Mean for this assemblage demonstrates an equilibrium with WTD stature at other sites demonstrating stature may be broadly comparable across several of the regions with soils derived from limestone.

It should be noted that statistical data illustrates groups of objects rather than the actual objects, and this can be misleading. In Figure 7-128 above and Figure 8-10 in the next chapter. There are inconsistencies in bone morphology between the archaeological samples and the modern specimens. A reference collection of a coherent population with a greater sex and age profile may clarify the nature of any morphological differences between the WTD from Florida and the populations in the Maya culture region. What appears in the previous graphs and charts to be a trend toward smaller WTD stature over time could be a demonstration of regional variations between deer populations or evidence of human manipulation of the environment. Investigating assemblages with greater chronological depth from one site or one region could clarify this point.

Having examined the faunal assemblages in some detail and discerned trends in the mortality profiles and representation of male and female animals within each assemblage, this thesis turns to testing these assemblages for differences in stature over time.

Chapter 8 Analysis of Cervidae Stature:

The previous chapter organized the sites by region with a loose correspondence to Maya cultural periods, specifically pursuing the possible representation of sex and age class in the assemblages. The first section here pursues a tighter chronological organization, excluding materials from uncertainly dated contexts toward the goal of determining if there is evidence to support a change in WTD stature or changes in Maya prey selection over time using log ratios. The second section evaluates the potential of misidentified species to confuse the assessment of WTD stature change over time using measurements of the metatarsal and astragalus from the reference collections in comparison to archaeological samples identified to species.

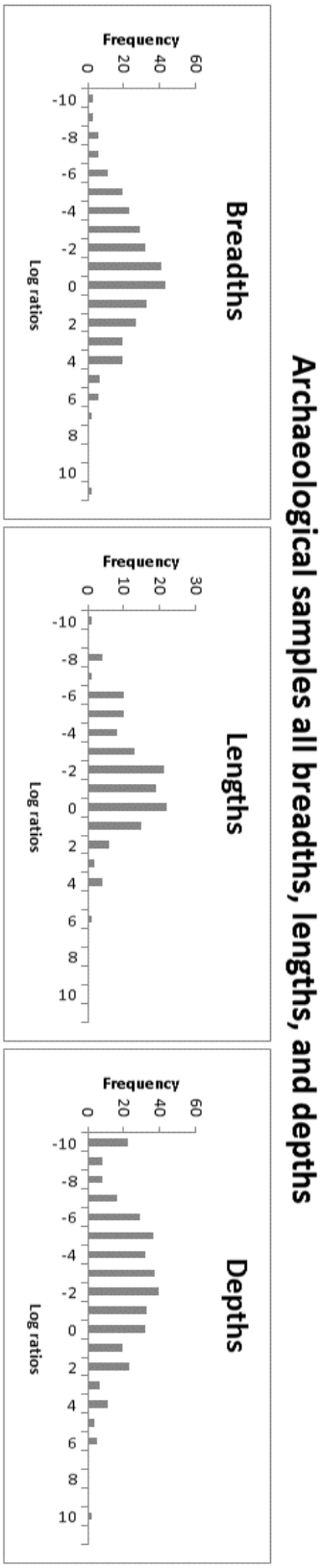


Figure 8-1 Log ratios for WTD from all archaeological assemblages.

The log ratios above represent WTD from all archaeological samples tested using osteometrics. The zero point on the scale represents the Standard generated from four adult WTD from Big Cypress Preserve in Florida. Compared to the log ratios for the reference collection in Figure 5-6 the distribution curves above are remarkably close

to being symmetrical. Only the histogram for depth is slightly skewed to the left and as demonstrated in Chapter 5 this quality is appears to represent the presence of sub-adults within the assemblages. An examination of log ratios representing all the archaeological assemblages in Figure 8-1 is a prerequisite to understanding how these materials are manifested when these samples are sorted by chronological period.

The chart for breadth shows the greatest frequency at zero and a large number of samples plotting as larger than the Standard. While fewer length measurements were available for analysis, the greatest frequency occurs in tight proximity to the Standard, with several samples showing greater length ratios and presumably larger stature for the animals represented. In the age sensitive chart for depth, samples plotting between -6 and -2 are the most frequent, the spike at -10 shows at least 30 samples plot below the scale's limits. This will be explored below, along with the samples demonstrating a size greater than the reference specimens.

8.1 Preclassic WTD:

No assemblages were made available to this research for the Formative Period 2600-1200 B.C. during which nucleated settlements practicing horticulture began to appear, but which predates the appearance of culture traits specific to Maya civilization. Hammond et al. (1979) proposes a link between the intensity of maize cultivation and prey ranking of WTD during this culture phase. The Preclassic Period in the Maya culture area is defined by the appearance of monumental structures organized around a central plaza, the appearance of the Maya calendar, logo-graphic writing, and the beginnings of social stratification. The date-range for the full period is 1000 B.C. to A.D. 100 (see Table 1-1). The earliest of the assemblages interrogated for the project represents Late Preclassic El Mirador 450 B.C. to 100 A.D. (Thornton & Emery), but includes a single Preclassic sample from Lamanai in Belize.

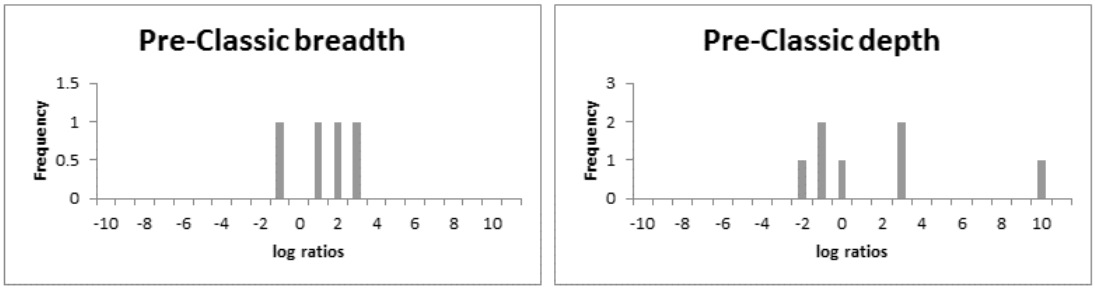


Figure 8-2 Log ratios for the Preclassic Period.

Four of the Preclassic samples are from El Mirador; a single Preclassic sample from Lamanai was described in the data sheet for the original excavation as Cervidae

but, as it plots with the male specimen in Figure 7-30, was included in this evaluation to clarify if WTD stature in the other assemblages is related to regional ecology or to the intensity of human settlement. El Mirador contributed three ratios for breadth, two of which are greater than the Standard. The single Lamanai sample also plots larger than the Standard. One sample from El Mirador appears slightly below the Standard but within the range found for adult specimens from Big Cypress (see section 5.2). The single length ratio available from El Mirador was insufficient to generate a graph for that anatomical plane but the log ratio for this sample is 3.16, significantly larger than the length ratios generated for the male specimen (see section 5.2). In the chart for depth three samples from El Mirador were larger than the Standard, including a scapula plotting at 9.54 on the log ratios scale. One sample from Lamanai and three from El Mirador were below the Standard depth but none are smaller than -2 on the scale and within the range for large adult specimens (see Table 2-1 and section 5.2). All WTD samples dated as Preclassic appear to be larger than WTD samples from other sites. As was demonstrated in the scatter-plots for this assemblage, with a single exception these samples are considerably larger than the modern male specimen, possibly indicating the degree of sexual dimorphism for this ancient deer population may have been consistent with that quality as described in the literature for the species (see section 4.2).

8.2 Early Classic WTD:

The Early Classic is characterized by the political and economic dominance of some dynasties over other monumental centres, continued development of art, writing, and astronomy. Teotihuacan also begins to exert cultural influence at some centres but not at others (Henderson, 1997; Sharer and Traxler, 2006). For the Early Classic Period, 27 samples are from Cueva de Los Quetzales, two samples derive from La Joyanca, and three from Copan's Early Classic assemblage.

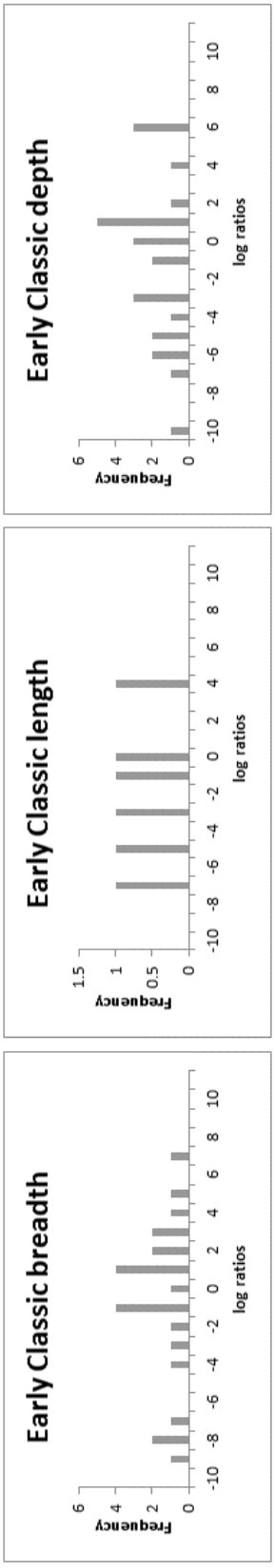


Figure 8-3 Log ratios for the Early Classic Period.

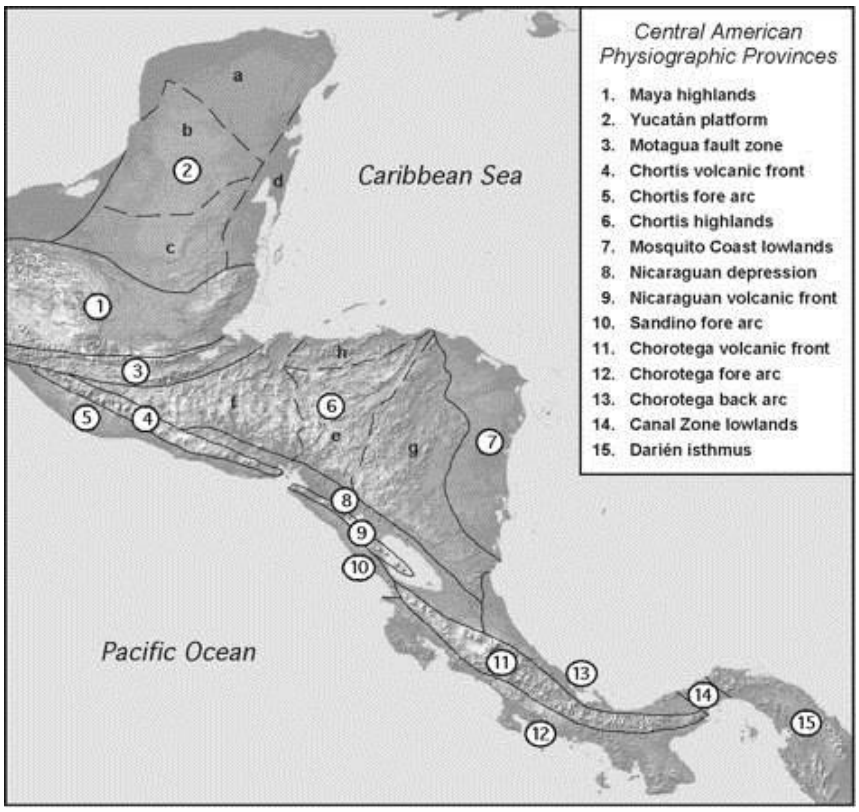


Figure 8-4 Source an overview of Central America's geological and tectonic regions (Marshal, 2007: 5).

Figure 8-4 offers an overview of the geology underlying the Maya culture area. That geology is implicit in soil formation and the nutrient qualities of the forage available to WTD. Pohl (1995) attributes the apparent small stature of the deer from Copan to over hunting. An equally valid explanation is nutrition; while the soils of the valley bottom and alluvial benches at Copan are astonishingly fertile, they have been intensely managed since early prehistoric times. By contrast the soils of the surrounding highlands are the product of igneous and metamorphic geology and are described as nutrient poor soils (Wingard, 1996: Fash, 2001: 43). The other assemblages tested in this research derive from sites with a karst limestone substratum thus available forage at those sites would be richer in calcium than at highland sites.

The larger assemblage included above derives from a ritual deposit at Las Payacas (Cueva de Los Quetzales). Eleven of those samples produced breadth ratios that exceed the Standard implying these animals were larger. The length ratios include two calcanei from Copan (see Figure 7-125) and four length ratios for Cueva de Los Quetzales. These are evenly distributed on either side of the Standard. In the chart for depth the smallest ratio belongs to a sample from Copan. The log ratios from the ritual assemblage imply the presence of mature males and perhaps an older cohort of some of the samples that were assessed as female in Figures 7-111, 7-112, 7-115, and 7-117, and

present breadth measurements that exceed the mature females from Big Cypress but not the female specimens from Clay County. Samples assessed as male (Figures 7-109 and 7-113) exceed the breadth and depth measurements for the Big Cypress male, possibly indicating age at death or individual variation.

8.3 Middle Classic WTD:

The designation of the Middle Classic appears to be a strictly chronological framing, rather than a distinctive period of cultural development (Henderson, 1997). While no published sources specific to WTD from the Middle Classic were available for the synthesis of NISP data in Chapter 4, the data sheets from Piedras Negras did include samples from that chronological period.

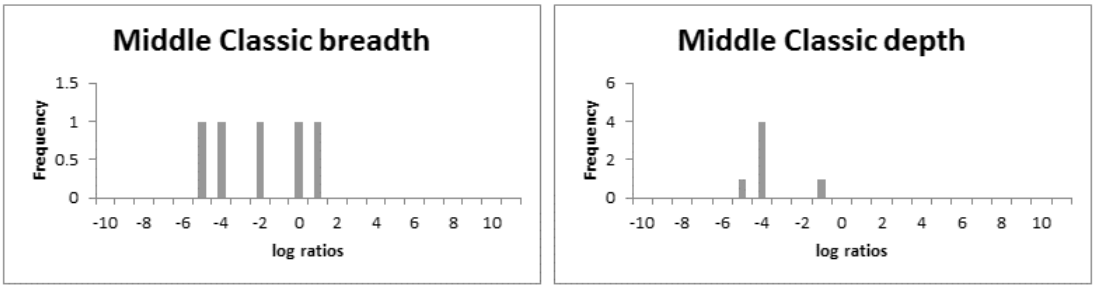


Figure 8-5 Log ratios for the Middle Classic Period.

In Figure 8-5 there are six samples from Piedras Negras. Five ratios for breadth are shown, two are very close to the Standard, the smallest of the ratios is -5.96 and shown in Figure 7-63 to be a close affiliate of the female cohort from Big Cypress. One sample from the Middle Classic produced a log ratio for length 0.4 but single samples are insufficient to generate a histogram for the length plane. Six log ratios were generated for depth, all fall below the Standard. Since no samples in this assemblage demonstrated sub-adult bone morphology these appear to represent adult females (see Table 7-7).

8.4 Late Classic WTD:

A.D. 650 to A.D. 800 (Late Classic Period) represents the greatest development of monumental art and architecture and the demise of Teotihuacan's influence in the region (Henderson, 1997; Sharer and Traxler, 2006).

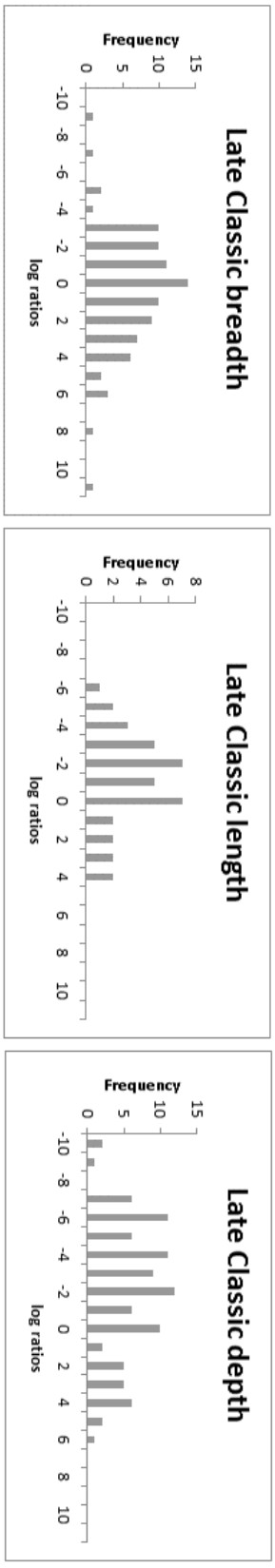


Figure 8-6 Log ratios for the Late Classic Period.

The Late Classic Period is well represented, with 89 samples from seven sites (see Figures 7-48, 7-59, 7-69, 7-79, 7-85, 7-96, and 7-102) contributing ratios for breadth (see Tables 7-6, 7-7, 7-8, 7-9, 7-10, 7-11, and 7-12). Single samples from

Piedras Negras, and Copan generated ratios less than -5.8 (the dissimilarity of Copan to the other sites has been discussed above) but Motul, Cancuen, and Punta Chimino each generated several ratios greater than 3.09. The chart for breadth ratios shows the greatest number of samples match the Standard at zero and a substantial number are markedly larger.

Thirty-eight samples, primarily astragali, generated ratios for length and only one of those samples falls below the range for adult specimens. The ratios for depth are more complex, a total of 95 samples were used to generate log ratios in that plane. The distribution curve for this chart is dissimilar to Figure 5-6, showing depth ratios for the reference collection and indicating older adults or more adult males are represented with few sub-adults or juveniles present in these assemblages (see Tables 7-7 and 7-12). Samples from Late Classic Copan were assessed as adult but were much smaller in stature than the baseline population from Florida. The assemblage from Piedras Negras appears to represent adult females exclusively, and Cancuen produced the largest number of meat bearing long bones from any assemblage and has been assessed in Chapter 7 as dominated by male deer. The presence of a few sub-adults and juveniles has been identified in the archaeological assemblages from this period, including the ritual deposits at Cueva de Los Quetzales.

8.5 Terminal Classic WTD:

The Terminal Classic is described as a period of environmental and political instability. Activity by the elite intensifies political rivalries and war destabilizes some urban centres (see Aguateca). The end of Terminal Classic is signalled by a cessation of monumental construction, and activity by dynastic lineages along with the abandonment of urban centres in the Southern Maya lowlands (Aimers, 2007).

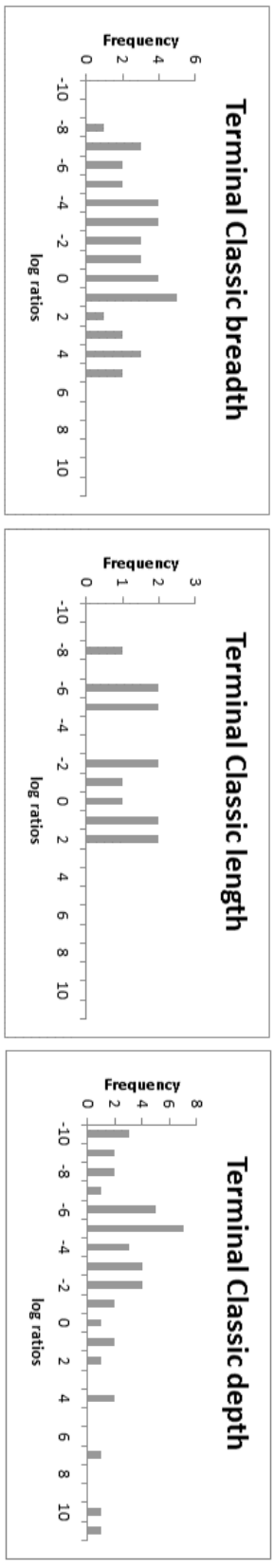


Figure 8-7 Log ratios for the Terminal Classic Period.

Three sites included samples from the Terminal Classic Period, El Kinel produced five samples from contexts designated in the original fauna list as Late/Terminal Classic. Motul offered one sample, La Joyanca's samples were listed as

Terminal Classic, and six ratios from El Kinel and Motul from mixed contexts were excluded from Figure 8-7.

Figures 7-67 and 7-68 in the previous chapter may signal the beginnings of the shift in prey choice during the Terminal Classic (see Table 7-9). The ratios for breadth indicate both small and large deer are present in the assemblage. The chart for length shows most of the ratios in close alignment with the Standard with a second cluster that may be in the sub-adult range. Ratios for depth are interpreted as evidence for the presence of both sub-adult and adult individuals including two log ratios at the upper end of the scale these represent GD (greatest depth) for calcanei. Measurements of calcaneus breadth and depth have been inconsistent throughout the evaluation of the archaeological samples, a larger reference collection with greater diversity for sex and age categories may clarify how these measurements are related to sex and age.

8.6 Postclassic WTD:

From A.D. 1000 to 1500 Postclassic centres resume economic activity but not monumental construction, though previously built structures are maintained at some sites, and political and trade networks are reorganized and expanded (Pendergast, 1981; Aimers, 2007). Leadership remained lineage-based but institutions and kingship had changed (Henderson, 1997: 239). Archery technology is broadly adopted by the Maya during this period along with arrows designed for specific prey (Emery, 1999:75).

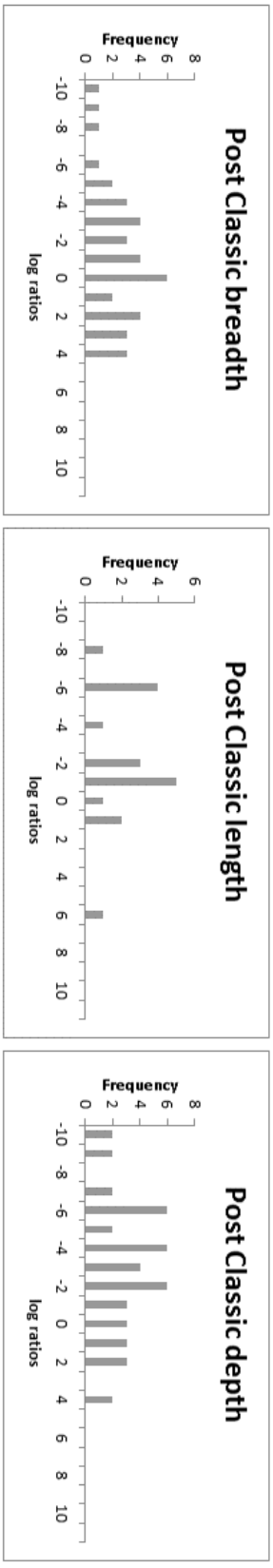


Figure 8-8 Log ratios for the Postclassic Period.

Because inter-regional trade in commodity goods is one of the defining qualities of the Post Classic period (Henderson, 1997; Thornton, 2011); the four sites in Belize are more complicated because not all faunal samples can be assumed to be of local

origin (see Figure 7-12, 7-22, 7-34, and 7-44). The histograms in Figure 8-7 show log ratios for 47 samples from Tipu Negroman, Lamanai, San Pedro, and Marco Gonzales, representing Belize. Single samples representing Motul de San Jose and Trinidad de Nosotros, from Lake Peten Itza in Guatemala are also represented above. Trinidad de Nosotros had three samples from dated contexts suitable for measurement, two 1st phalanges excluded from the tests shown in this paper, and a single distal tibia Sample 801TN. Based on the fusion it was classified as an older sub-adult. Motul's Sample 234MSJ is a proximal femur with a breadth ratio of 1.19 and a depth ratio of 1.43. Plotting greater than the Standard, in Figure 7-54 it was assessed as representing an adult male.

San Pedro (shown in Figure 7-34) showed most of the samples were smaller than the Standard. Sample 608SP had a breadth ratio of -34.91 and a depth ratio of -15.63 (see Figure 7.39). The sample is however assessed as WTD based on the GL measurements, which are significantly larger than specimens of red brocket deer in the museum's reference collections (see Figure 8-9 below). Sample 602SP shows a breadth ratio of -6.51 and a depth ratio of -2.32. Both samples are significantly smaller in breadth, but the depth ratios are less divergent from the Standard.

Marco Gonzales offered only four WTD bones suitable for testing. Three tibiae from Marco Gonzales are close to the Standard for breadth ratios. However, Sample 150MG also demonstrates the pattern seen in the San Pedro assemblage, the proximal radius produced a breadth ration of -8.06 and a depth ratio of -3.28. This reversal of the depth and breadth ratios implies these individuals' stature may not be an aspect of ontogeny (see Figure 7-45), meaning that the animals represented are (A) naturally smaller than other deer recovered at the site by archaeology, and (B) very old in comparison to other samples. Alternatively, this morphology may be indicative of castrated animals. The long bones of adult castrated males tend to be longer and more gracile than is the case for intact males, and this results from delayed fusion of the terminal epiphyses (Davis, 2000). Davis's (2000) article presents data for shaft breadth, and length, but makes no mention of bone depth, though depth measurements are included in that paper's methodology. If expansion of bone width is terminated in tandem with epiphysis fusion, while mechanical stress induced bone remodelling incrementally increases bone depth over time, older castrates might demonstrate this pattern. The pattern might be more visible in free ranging animals than would be the

case for animals subjected to enclosure, however this proposition requires additional study.

The Tipu Negroman's assemblage included 14 WTD samples from the Postclassic. Nine of those samples generated log ratios (seen in Figures 8-7 and 7-12) and of those Sample 414T6 (scapula) produced a breadth ratio of -9.26 and a depth ratio of -7.47; with that exception, all Postclassic breadth ratios are between -6.03 and 2.33. Length ratios however are close to the Standard and show no outliers. The ratios for depth are more variable and consistent with the presence of sub-adult and juvenile individuals in the assemblage.

Lamanai's assemblage produced 44 log ratios from 25 WTD bones for the Postclassic Period (see Figure 7-22). The ratios for breadth plot almost evenly on either side of the Standard. In the chart for length ratios, seven of the samples plot closely with the Standard. Sample 581LA -6.29 and Sample 610LA -6.09 at the lower end of the scale are both calcaneus (see Figure 7-32); the larger breadth ratio derives from a proximal femur Sample 575LA (see Figure 7-28). The ratios for depth trend as smaller than those for breadth or length, indicating that the Postclassic Lamanai assemblage represents more sub-adults than were visible from Tipu.

The WTD from Postclassic Tipu Negroman and Lamanai appear to demonstrate deer populations with a consistent stature variable only by age cohort and sexual dimorphism. As Ambergris Cay may have had no local deer populations or maize cultivation Williams et al. (2009: 50), these resources would need to be imported and the deer bone from San Pedro shows evidence that WTD represent two or more populations. With only four specimens for Marco Gonzales that proposition is also true though the evidence is less compelling.

8.7 Historic Era WTD:

The Historic Era (A.D. 1517 to 1697) begins with the arrival of the Spanish in Yucatan, and subjugation of the Yucatan communities in 1541. However, Spanish attempts to assert control in the Southern Maya Lowlands were met with stiff resistance on several levels. Ceramic forms and patterns of fauna use from the Postclassic Period remain persistent into the 17th century at Lamanai and Tipu (Simmons, 1995; Emery, 1999; Jones, 1999). In the chart below the noncultural materials from Ek Balam are included.

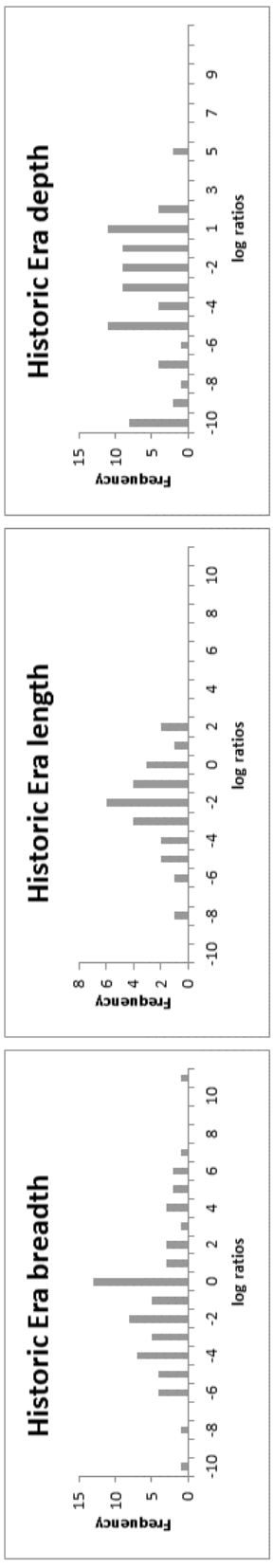


Figure 8-9 Log ratios Historic Era.

Materials of the Historic Era generated log ratios for 74 samples from the sites of Tipu Negroman, Lamanai, and Ek Balam. Materials from Ek Balam predominantly represents an assemblage accumulated independently of human predation. Except for a

single outlier in the chart for length (see Figure 7-1), these samples appear to represent a mix of male, female, adult, and sub-adult animals that are directly comparable in stature to the reference collection. The nature of the deposit makes intrusive material unlikely (see section 3.4 i).

Tipu Negroman contributed 26 samples from the Historic Era and generated log ratios for 14 samples. In Figure 7-11 Sample 307T4 (metatarsal) generated a breadth ratio of -12.45. The ratios for length appear to match or fall slightly below the Standard. Ratios for depth fall on either side of the Standard, except for Sample 307T4 (see above) depth ratio of -12.75, Sample 308T4 depth ratio of -15.99, and Sample 322T4 depth ratio -13.14. There were no breadth ratios for samples 308T4 and 322T4 to offer a comparison via scatterplot, but single measurements are represented in the histograms. These three samples and the ratios generated from them may indicate deer bones if not living animals were imported from beyond the site's catchment area as per Masson and Freidel (2012; 2013) posited exchange networks.

Lamanai offered 75 samples from the Historic Era of which log ratios were generated. There is some interesting variation in the ratios for breadth and depth in Lamanai's historic assemblage. Sample 516LA is a scapula and the single outlier in breadth ratios (see Figure 7-21) with a ratio of -8.32 and a depth ratio of -2.63. Measurements of the scapula were previously shown to segregate the adult male specimen from other cohorts in the collection. However, adult females and sub-adults of both sexes were too tightly clustered for these two measurements to be useful in distinguishing adult females from sub-adults. With that exception, the ratios for breadth show limited distribution on either side of the Standard with nine ratios plotting as larger and 14 ratios that are consistent with sub-adults or small female individuals.

Ratios for length demonstrate three samples as greater than the Standard, but these are modest differences, 1.11, 0.02, and 1.75. A greater number are below zero but these ratios, at -6.02 to -3.31, are rather modest. Overall the length measurements are shorter for the Maya samples, while breadth and depth measurements trend as slightly larger than is the case for the reference specimens from Big Cypress. The chart for depth ratios could indicate a large number of sub-adults in the assemblage. Sample 578LA, a proximal humerus with visible epiphysis indicating a young adult individual, had a breadth ratio of -6.43 that could be construed as a sub-adult. Pairing the morphology and the sample's depth ratio of -27.56 would indicate the individual represents a different WTD population or a different species. Samples 579LA (distal

humerus) and 598LA (distal tibia) did not offer breadth ratios but their depth ratios of -18.59 and -11.68 respectively may also indicate material sourced from a different catchment area; the number of samples demonstrating such gracile dimensions most likely represent a separate population rather than individual variations, even if the nature of these distinctions is currently elusive. Stature in the Postclassic and Historic Era assemblages appears to be similar and this is also true for WTD stature at Ek Balam indicating deer resident at the abandoned site were subject to similar environmental conditions if not direct human intervention.

8.8 Synthesis of WTD Stature:

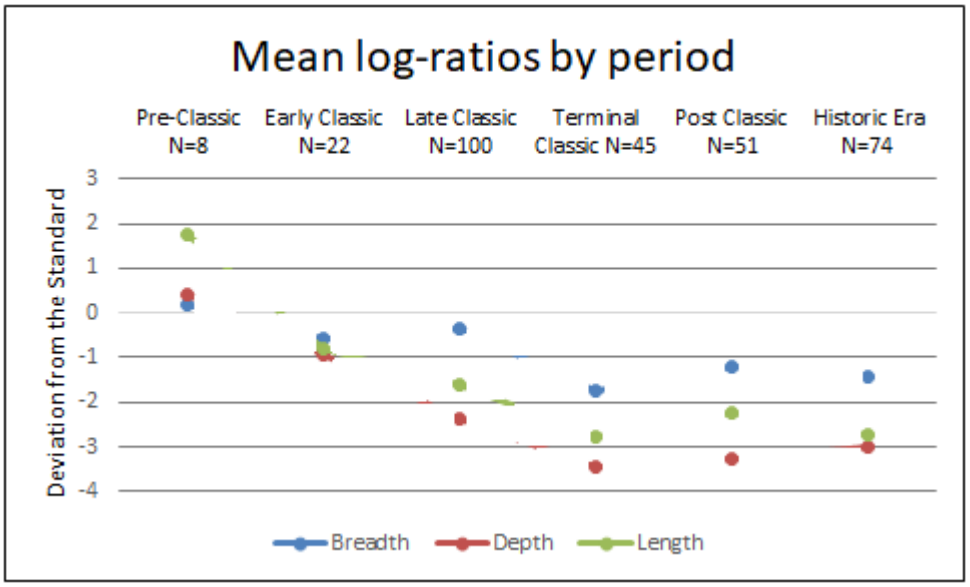


Figure 8-10 Mean of log ratios for WTD by cultural period (outliers excluded).

Admittedly most of the assemblages are quite small, particularly for the Preclassic, with only one length measurement available, and subdividing them into cultural periods exacerbates that limitation. Figure 8-10 attempts to compensate by demonstrating the Mean of log ratios for each cultural period. In that figure the noncultural samples from Ek Balam are excluded for the sake of clarifying how deer stature might reflect Maya cultural practices. Samples from Copan are also excluded as are all outliers smaller than -10 or greater than +10. The exclusion of Ek Balam and Copan significantly changed the profile of the graphic, while removal of the outliers from other sites failed to alter the profile significantly (see Digital Appendix I: log ratio Mean).

Materials from the Middle Classic period are not represented above (see Figure 8-5). As the Mean for Preclassic derives from very few samples (only one length measurement) the Mean for that period is statistically questionable. The Early Classic

through the Historic Era are well represented in this data; however, as all measured samples represent curated materials sample bias cannot be excluded. As the Mean reflects variations in scale rather than the measurements recorded, the pattern observed should be statistically valid. Most striking in Figure 8-10 is the trend line for depths. The majority of Early Classic samples derive from a ritual deposit and were assessed as adult males. The assemblage from Late Classic Cancuen was also dominated by adult males (see section 7.6 ii) but other Late Classic assemblages were assessed to be dominantly adult females (see sections 7.5 ii, and 7.6 vi). La Joyanca's Terminal Classic assemblage (see section 7.5 ii and Figure 7-68) showed a mix of adult females and sub-adults, even though the samples from this assemblage appeared to be unusually large. As was demonstrated in Figure 4-2, the representation of WTD in published faunal assemblages from the Terminal Classic period is at least 45%. The shift in WTD demographic profile suggests the beginning of changing prey selection and possibly social disruption at that site. The representation of sub-adult WTD in faunal assemblages becomes dominant during the Postclassic and Historic Era (see sections 7.2 and 7.3). The trend may signal changes in the demography of the animals targeted, or a general decline in deer stature related to human manipulation of the environment.

Statistics are an indispensable tool for the analysis of variable data sets and while the paucity of intact long bones within the assemblages requires the use of a statistical analysis to test for deer stature, the application of size-index-scaling to this research brings the possibility the data subjected to this method will be distorted. Figure 8-11 tests this potential distortion below. The measurements below were taken in millimetres and then averaged to produce the Mean for each period. While Figure 8-10 and all figures in Chapter 7 relied on the specimens selected as the Standard for comparison, the following figures employ the available measurements for all specimens from Big Cypress Preserve, of which 75% are sub-adults.

Astragali were the most abundant skeletal element in all studied assemblages. Each of the modern specimens from Big Cypress is represented by a single astragalus, and as very few samples in the assemblages closely overlapped others (see Figure 7-2 and Figure 7-23 for exceptions), this is presumed to be true for the archaeological samples. The astragalus was hypothesised in Figure 5-9 to be sensitive to ontological age; it's abundance in these assemblages offers a robust set of comparisons that are not available for long bones in these assemblages.

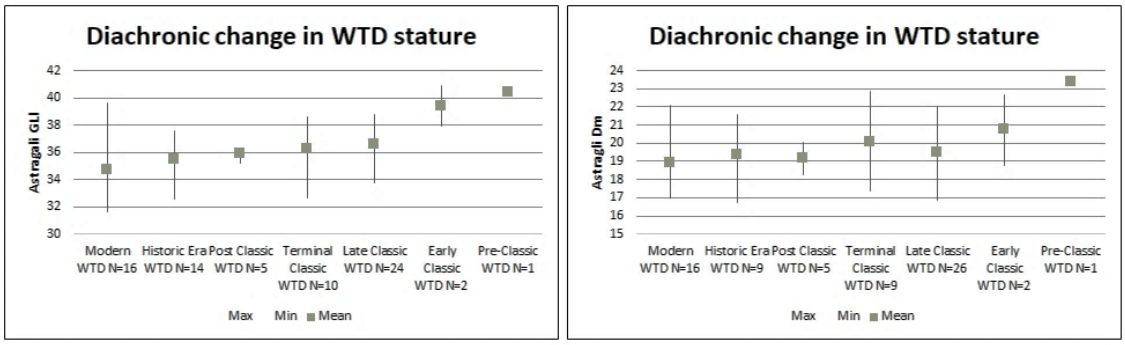


Figure 8-11 Comparing astragalus lateral length (GLl) and medial depth (Dm).

Using the GLl (greatest length lateral) on the left and the Dm (depth medial) on the right, this figure demonstrates the sample from El Mirador, while slightly larger, is in the same range as the adult male specimen from Big Cypress. Both the Mean and the range decline for archaeological samples steadily in the left side graph. In the right-side graph employing the Dm (depth medial), the Preclassic sample more noticeably exceeds the range displayed by the reference specimens. A decline in the Mean parallels measurements for the GLl but the range for each cultural period appears to be more variable.

WTD stature comparing astragali measurments

Reference specimens			Astrag GLl	Quotient	Astrag Dm	Quotient
z:4580	Modern	F	33.98		18.26	
z:4573	Modern	F	37.09		19.69	
z:4703	Modern	F	35.5		19.43	
Mean			35.52		19.13	
z:4571	Modern	M	39.59	111%	22.09	115%
Arch. Samples						
215M	Preclassic		40.39	114%	23.33	122%
303CQ	Early Classic		40.87	115%	22.69	119%
718PN	Early Classic		37.9	107%	18.75	98%

Table 8-1 Discerning archaeological samples representing adult males.

Taken alone Figure 8-10 and Figure 8-11 might suggest a diachronic change in WTD stature but when compared to Figure 5-9 they indicate a change in the age and sex cohorts represented. Table 8-1 compares the measurements of the three largest astragali seen in Figure 8-11 with the WTD from Big Cypress that were used as the standard for calculating log ratios. The Baseline Study's Table 5-1 compared measurements of the humerus, radius, femur, and tibia, derived from Big Cypress's adult specimens, demonstrating the adult male specimen was at minimum 10% larger than the adult females from the same population. Table 8-1 follows the same procedure comparing the three large astragali samples with the measurements of the modern specimens, and demonstrates that while the archaeological samples are larger than the modern

specimens, they do not match the degree of sexual dimorphism predicted in the literature for this species. This interpretation is consistent with my assessments for sex and age cohorts represented in each assemblage (see sections 7-2 ii, 7-2 iv, 7-3 ii, 7-3 iv, 7-4 i, 7-5 ii, 7-5 iv, 7-5 vii, 7-6 ii, 7-6 iv, 7-6 vi, and 7-7i). Astragali are not long bones and their application to discerning the stature of an individual deer as suggested by Purdue (1983a; 1983b) is not supported by my results. In fact, section 5.3 i indicates astragali measurements are more sensitive to ontological age than to sexual dimorphism. Based on the very limited samples available, there is no evidence WTD stature changed over time, and this is consistent with Wolverton's (2008) analysis of how hunting pressure affects WTD stature.

The difficulty in discerning sub-adult males from mature females in the reference collection was demonstrated in Chapter Five and is particularly problematic for astragali. However, this is a consistent problem in osteological studies regardless of skeletal element under study and not unique to WTD (White, 2000: 365). The overall range demonstrated for the archaeological samples is consistent with the reference specimens from Big Cypress and this is quite surprising given the geographic distance between these populations.

8.9 Variations in species stature.

WTD are believed to vary in stature across time and space (Purdue, 1987b; Purdue & Reitz, 1993). The previous section demonstrates the difficulty in distinguishing changes in population stature from representation by sex and age cohorts in the same population. However, some of the deer bone samples in the previous chapter demonstrate differences in size/stature from other samples in the same assemblage, and from the reference specimens from Florida (see section 4.2). In addition to WTD, two species of brocket deer are native to the region making it necessary to determine if the observed variations in size result from misidentification of species, and while James (2013) has produced a dissertation on that topic, the final version of that study was not available to this research.

Species, age, and sex influence the dimensions and morphology of skeletal bone; in this section archaeological samples identified as WTD and brocket deer from sites in Belize are compared to the WTD specimens from Big Cypress and three modern specimens of *Mazama temama*: z:8851, UF 6787 and UF 6888 (see Table 3-7).

The assemblage from Tipu had an especially robust number of samples identified as brocket deer (see Table 7-3), while Lamanai and Marco Gonzales were

notable players in long distance canoe trade (Graham and Bennet, 1989; Graham and Pendergast, 1989). If Ambergris Cay was without a local deer population, it is probable the settlements there imported deer from the mainland (Williams et al. 2009), suggesting deer bones recovered at Marco Gonzales and San Pedro may have derived from some of the same populations accessed by Tipu and Lamanai. Deer bones from San Pedro are considerably smaller than is common at other lowland sites, but samples in that same range are also present in the assemblages from Lamanai and Tipu, though the absence of context dates for San Pedro remains problematic in defining clear parallels. Marco Gonzales was largely abandoned prior to Spanish intrusion, while Lamanai and Tipu remained important polities during the Postclassic and Historic Era, San Pedro was also occupied during the Postclassic and Historic Era. Given these linkages, however tenuous, it makes sense to test the Cervidae material from these sites together.

A significant number of samples from Lamanai and Tipu have not been previously shown because the contexts they derive from were assessed as Postclassic/Historic. However, distinctions between species rather than diachronic variation is the topic for this section, and the lack of segregation between Postclassic and Historic Era materials is less relevant than in previous sections.

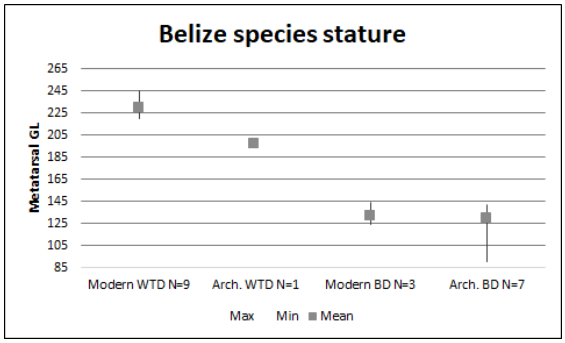


Figure 8-12 Comparing the stature of WTD and brocket deer reference specimens with deer bone identified to species from Lamanai, Tipu, San Pedro, and Marco Gonzales.

N=number of samples and specimens available to this test. Using the GL (greatest length) of the metatarsal, the single intact metatarsal from San Pedro Sample 600SP does not plot within the same range as the complete metatarsals from Big Cypress but is well beyond the length of the red brocket deer (*Mazama temama*) specimens from FLMNH reference collections (see Figure 2-7) or the archaeological samples tagged as *Mazama* in the FLMNH-EAP trays.

A single intact sample is a thin thread to demonstrate any quality, fortunately Chapter Five showed a correlation between length and breadth measurements and that is exploited below in Figure 8-13.

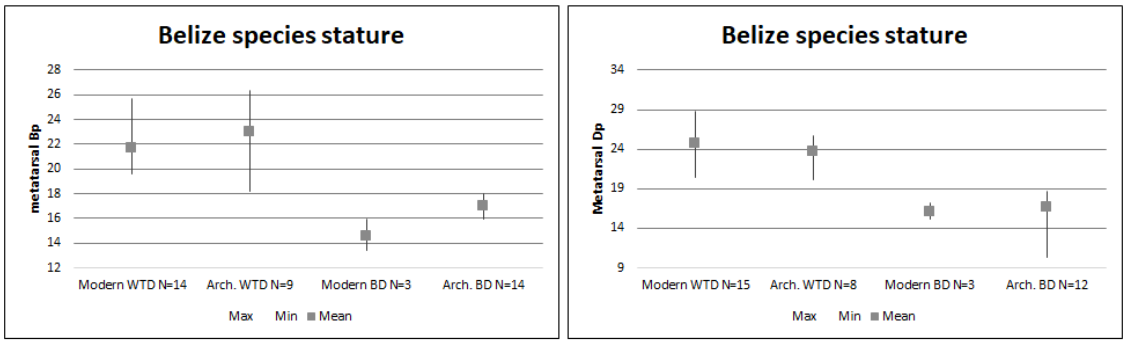


Figure 8-13 Comparing the stature of WTD and brocket deer reference specimens with deer bone identified to species from Lamanai, Tipu, San Pedro, and Marco Gonzales, Belize.

The left side of Figure 8-13 shows how the modern specimen's metatarsals compare to the archaeological samples using Bp (proximal breadth); the Mean of samples identified as WTD is slightly greater than the reference specimens and the total range for the samples is also larger. The modern brocket deer specimens are well below the WTD for both Mean and range, but the archaeological samples identified to this genus overlap the range of WTD samples from Belize if only slightly.

On the right Dp (proximal depth) shows the Mean for 8 WTD samples from the Belize sites is similar to that for Big Cypress while the total range is a bit smaller. The Mean for brocket deer is dissimilar but the total range for brocket deer samples shows less difference from the WTD than might be expected from the difference in metatarsal length. The dimensions and growth patterns of brocket deer are not well understood, though sexual dimorphism is not considered to be a significant factor in adult stature (Geist, 1998). The modern brocket deer specimens all demonstrated distal fusion of the metatarsal, indicating maturity sufficient to be reproductively active. Of the 13 brocket deer samples from Lamanai and Tipu Negroman, only five showed distal fusion, and representing older sub-adults or mature adults, eight unfused samples must represent young sub adults or juveniles. This is consistent with the variation in depth measurements seen in Figure 8-13, assuming that quality is ontological in brocket deer. The sample size for modern brocket deer specimens was too small to test for age related bone growth but it might be implied by these results.

The breadth measurements indicate mass if not withers height is consistent between the ancient WTD populations from Lamanai, Tipu and the modern specimens from Big Cypress Preserve. The brocket deer identified by archaeologists are markedly

different in size from the WTD in Florida but there is some overlap with archaeological samples identified as WTD. The morphology of the metatarsal appears to be distinct for the mature cohort in the reference collection of these two species; all of the samples identified to species by archaeologists and demonstrating distal fusion were consistent regarding this morphology.

The astragalus is not a long bone, it is however more abundant and much more frequently intact in the assemblages I recorded than any other skeletal element except the 1st phalanx. Figure 8-14 combines the astragali from the Postclassic and Historic Era previously seen in Figure 8-11 for comparison with the brocket deer in the reference collection and samples identified as brocket deer or *Mazama* by archaeologists.

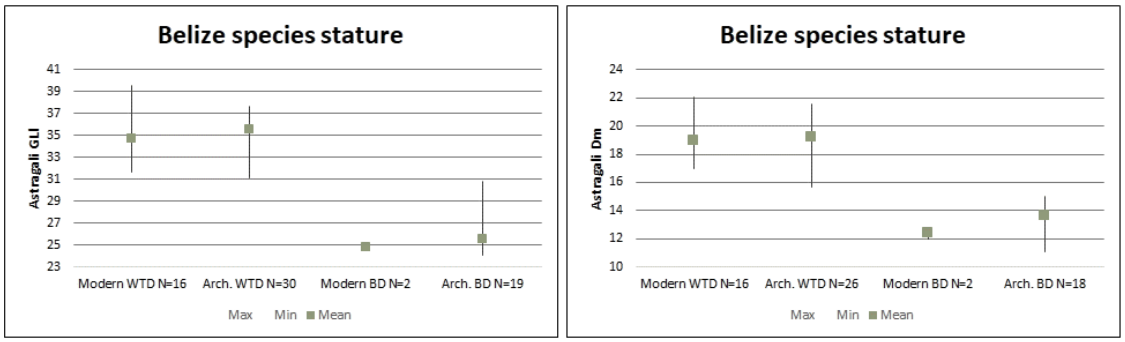


Figure 8-14 Astragali comparing the stature of WTD and brocket deer reference specimens with deer bone identified to species from Lamanai, Tipu, San Pedro, and Marco Gonzales, Belize.

There is significant variation between the Mean for WTD and the Mean for brocket deer, as was the case for metatarsal Bp and Dp but there is less difference in the total range between the archaeological samples identified as WTD or *Mazama*. As the brown brocket (*Mazama pandora*) is not accounted for among the reference specimens I recorded, that species may be obscuring the difference. Whether it's natural prehistoric range includes Belize has not been confirmed.

8.10 Synopsis:

Chapter 7 assessed each quantified assemblage and the samples recorded for evidence of sex and age cohort with some success. The first section of this chapter analysed those findings by cultural period, finding more evidence supporting a change in prey selection over time than was available to support chronological changes in WTD stature. Deer samples from Copan and San Pedro did indicate differences in population stature possibly related to underlying geology and the nutrient value in local forage. Without a more robust cohort of adult males in the reference collection it is not

currently possible to test for differences in the degree of sexual dimorphism between the modern and ancient populations.

The second portion of the chapter tested modern specimens of WTD and red brocket deer against archaeological samples identified as WTD and brocket deer/*Mazama* sp. Since distinguishing between the two brocket deer species is imperfectly understood in faunal identification, the sole reliable predictor for red brocket deer may be long bone length, though bone morphology cannot be discounted.

The nonmetric variation of WTD metatarsals described in Chapter 6 is only identified for older sub-adult and adult female specimens. The male specimen did not display this morphology. The 1st phalanx morphology appears to be distinct to species in all sex and age cohorts but as this skeletal element was not used to test stature or sex it would be redundant to expand beyond what has been demonstrated in Chapter 6. No differences in astragalus morphology were observed during recording of the bone metrics, but the scatter plot in Figure 6-1 comparing astragalus length with depth does suggest there is morphological variation between Cervidae species.

Having discerned possible patterns in the representation of WTD by sex and age cohort at the 16 sites reviewed in this document, the next chapter fits that information within the framing of previous scholarship.

Chapter 9 Discussion:

The intention of this research was to pursue quantifiable evidence as to whether or not WTD (*Odocoileus virginianus*) had been domesticated by the Pre-contact Maya. 'The Traditional Role of Women and Animals in Lowland Maya Economy' was published within the festschrift for Dennis E. Pulston (Pohl et al. 1982), introducing the proposal that Maya women were participants in the production of economic and social capital through domestic husbandry of animal protein. During the previous decade challenges to the United States' cultural narratives around race, sex, and class shifted research paradigms in archaeology to include non-elite residences and economic patterns (Joyce et al. 1993; Powis et al. 1999; Nickels, 2008). Within that reframing, the possible domestication of WTD was especially interesting as remains of this wild species appeared to become more abundant in fauna assemblages associated with large urban centres, and contradicted some entrenched ideas:

- Development of urban centres equates with the over exploitation of local resources and the collapse of the natural ecosystem.
- Provisioning of large human populations requires domesticated/subjugated plant and animal species dependent on humans for reproductive success.
- Agricultural production is not compatible with large-bodied and free-ranging wildlife.

The existence of large urban centres in tandem with apparently growing (or at least not failing) populations of large herbivores contradicts these ideas and many underlying assumptions about human civilization and its consequence to natural ecosystems. A reasonable hypothesis might be that the ancient Maya had domesticated WTD and this species had been managed exclusively for meat production as there was no indigenous dairy tradition or evidence these animals were used for traction.

What evidence can be found for animal domestication among the ancient Maya? The process of animal domestication remains imperfectly understood; early theorizing regarding Eurasian domesticates was founded on the persistence of animal husbandry throughout the historical record, attempting to work out the evolution of the practice from that foundational knowledge (Terrel et al. 2003).

Domesticated dogs *(Canis lupus familiaris)* were participants in the original human migration into the Americas. Management of that species for economic products ranging from meat to pelage is historically documented (Blick et al. 2016). The Maya kept two types of dogs, a large type for hunting and guard duties and the smaller

Techichi maintained for meat production (Landa, 1566; Hammond & Clutton-Brock, 1994; Foreman, 2011). Llama *(Llama glama)* and alpaca *(Vicugna Pacos)* were domesticated in the Andean region for meat, wool, and traction. More to the point the non-native Mexican Turkey *(Meleagris gallopavo)* has been identified at Preclassic Period El Mirador, indicating that animals (or at least this species) were managed for primary production from an early date at Maya Centres before the arrival of the Spanish. Landa (1566) identifies the presence within Maya farmyards of several species (including deer) both native and non-native (Landa, 1655: 57), describing these species as *animales domésticos.* This word choice may not be as straight forward as it first appears, as usage of the term domestic (at least within the English language) has variously referenced both animals and humans participating within a household as 'domestic' (Leach,2003). No other Spanish chronicles appear that describe deer as *domésiticos*, either because the practice was not observed, or because world view (patriarchal and euro-centric) failed to recognize a familiar type of animal in an unfamiliar role.

The Maya had developed and used a written language from the Middle Preclassic Period 400 B. C. until Bishop Landa ordered the burning of their libraries in 1562 (Timmer, 1997). The remains of that literature are limited to three manuscripts in European Museums, and a fourth recently recovered from a cave by looters (Thompson, 1972; Milbrath, 2002; Vail, 2006), the dynastic texts carved on stone monuments (Proskouriakoff, 1960; Thompson, 1960; Stuart, 1984). As well as two narrative texts, *Popol Vuh* and *The Book of Chilama Balam of Chumayel*, written in Spanish after the immolation (Roys, 1933; Goetz & Morely, 1950; Tedlock, 1996). Nothing suggests literacy was common among the Maya, and it is believed all books were of ritual narrative or astronomical observations (Sharer and Traxler, 2006: 125). A less direct but possibly more literal narrative for the Maya remains in the surviving murals and ceramic decoration. However, while Eurasian narratives and art typically represent animals, wild and domesticated, as chattel and metaphors for human wealth and political power, or as natural elements oppositional to human civilization, Maya art remains ambiguous in this regard (Pohl, 1985; Carr, 1996).

Without adequate historical sources, the hypothesis of deer domestication requires alternative methods of investigation that may demonstrate physical evidence for animal husbandry. Except for dogs and turkeys, faunal analysis in the Maya culture area has failed to identify intrusive vertebrate species that might indicate domestic

animals prior to the introduction of Eurasian domesticates. Since WTD are endemic from South America to the Boreal Forests this is hardly surprising. Tame animals including WTD in Maya households are, however, an ethnographic fact (Hammond & Clutton-Brock, 1994 :820). The descriptions of *otros animales domésiticos* by Landa (1566: 57) suggests the practice is a continuation from antiquity.

Attempts to show deer domestication by the Maya have relied on the methods used for researching Eurasian animal domestication. An essential premise of Eurasian animal husbandry is control of animal reproduction via the slaughter of females past prime breeding age and young males or the castration of the latter for production of wool or draft animals. Selected males are maintained intact for breeding purposes, along with a cohort of young breeding females (Bökönyi, 1969; Mignon-Grasteau et al. 2005). The maintenance of sufficient breeding animals ensures continued production and an accumulation of wealth representing future prosperity. A primary signal of this type of herd management strategy is a mortality profile dominated by older females and young males (Payne & Bull, 1988). Identification of this mortality profile depends on identifying the age at death and discerning the sex ratio represented by each age class in an assemblage using dental eruption and wear per Payne (1973), epiphysis fusion per Clutton-Brock (1999), or a combination of the two per Zeder and Hesse (2000). Dental wear methods are frequently used, as the diagnostics are fairly simple for a novice to absorb and because disarticulated mandibles are frequent in urban European assemblages. The same cannot be said of Mayan assemblages—during this study, out of 1100 samples in 16 Maya assemblages, only one intact mandible was observed.

The application of epiphysis fusion, while useful in assessing juveniles and sub-adults, is not applicable in assessing the age of skeletally mature samples (Hambleton, 1998: 108; Needs-Howarth and Hawkins, 2016: 8), and Purdue's (1983b) excellent study did not attempt to identify skeletal markers in WTD for age greater than 38 months. Aside from sexual dimorphism, the only WTD skeletal elements morphologically distinctive to sex are the frontal bone and pelvis, both of which were uncommon in Maya assemblages observed. As deer antler is shed annually, a tabulation of antler artefacts recovered by archaeology cannot serve as proxy for the number of male deer taken by hunters.

WTD are presumed to vary in stature over time and space (Purdue and Reitz, 1993; Wolverton, 2005; Wolverton & Cornelius, 2007b). WTD are sexually dimorphic (Geist, 1998: Miller et al. 2004). Sexual dimorphism in the species is reduced by inter

individual competition for nutrition (Geist, 1971; Wolverton, 2008). Given the species reported potential for stature variation due to shifts in local climate and population density, initial plans were to test WTD for variations in stature over time using osteometric comparison and log ratios. The first method can be applied without use of comparative specimens, though its utility is limited. The second requires comparative specimens of the species under study; a representative sample of known age and sex is optimal. Morphometric studies also have potential to discern changes in bone morphology and specimen stature and sex (Zeder, 2006) and this might indicate if deer populations were under human management. While the recording of WTD osteometrics is not uncommon (pers. com. Martin Whelker 2016) and at least two attempts have been made at osteometric analysis for WTD from the Maya area (Soto Toral, 1998; James, 2013). Those studies were limited to the osteometrics published in 1976 (Von Den Driesch). A purely American methodology of osteometrics specific to WTD was developed by Purdue (1987b), but other American researchers have expanded on those metrics (Jacobson, 2003; Wolverton and Cornelius, 2007; Wolverton, 2007, 2008; Wolverton et al. 2008; Wolverton et al. 2009; Densmore, 2009) though the nomenclature for the measurements in these studies has been quite fluid. To my knowledge, no one working with Maya fauna has applied Purdue's (1987b) measurements, investigated the ontology of WTD, or tested archaeological WTD samples against a modern population of known age and sex. The identification in this study of morphological differences between WTD and red brocket deer (*Mazama temama*) appears to be unique within the literature for Maya archaeology.

WTD are a highly successful species in the Americas. Their economic value to the indigenous human societies is demonstrated in the ritual narratives throughout their natural range. Among the Maya, deer are ritually linked to maize, rain, and the culture's archetypal Hero Twins, demonstrating both a cultural identity and an economic paradigm (Goetz and Morely, 1950; Pohl, 1981, 1995; Tedlock 1996; Foreman, 2011: 34). If WTD expanded into environmental niches previously occupied by mega fauna as proposed by Geist (1998) and Wolverton et al. (2009), anthropogenic alteration of the environment is implicit in the radiation of this species into new habitats (Emery et al. 2008).

Several published sources regarding the environmental requirements of WTD were studied for information on the nutrition and habitat requirements for reproductive success. It was determined the natural social organization of this species was a poor

match for the development of a herd and pasture type of husbandry, but did not prohibit a barnyard type of maintenance that is typically the realm of women in Europe. This in turn suggests why portrayal of WTD in the 'role of domesticate' may have been excluded from the monumental art and ritual narrative as the Maya reserved such narrative for dynastic succession typically within the male sphere of social and economic life (Joyce,1993).

9.2 Results:

My initial interest in the reference collection was limited to the collection of metric data from modern specimens of known age, sex, and the use of that data to create a baseline for the application of log ratios. The analysis of any morphology specific to sex and age of those specimens was a distant second. However, results from the initial analysis contradicted several key papers describing use of the astragalus to determine WTD stature (Purdue, 1983b; Wolverton, 2008). It appears Purdue (1983b) was mistaken about termination of astragali growth at six months.

Soto-Toral's (1989) unpublished dissertation describing measurements of the glenoid to discern sex had seemed useful but in fact shared a similar flaw, namely these early fusing skeletal elements are subjected to considerable mechanical stress during locomotion. The resulting micro-fractures in laminar bone trigger osteoblasts and the formation of additional cortical bone to strengthen the structure resulting in greater bone surface and dimensions (Skedros et al. 2003). As shown in this paper's Figure 5-11, while it is possible to use these metrics to distinguish adult male WTD from other sex and age classes, these measurements were not successful in distinguishing adult females from sub-adult males.

It was therefore necessary to study the modern collection in some detail before comparisons could be made to archaeological samples. As is the case for all living tissue, bone is dynamic and in constant flux. Osteometrics are frequently used to discern variables in ancient human populations; the success of this method has hinged on the careful study of morphological trends in discrete populations curated by scientific institutions (White, 2000: 339). In Britain, similar studies have been created for domestic animals (Davis et al. 1996; Albarella et al. 2009; Popkin et al. 2012). Large osteological collections of post cranial bones devoted to wild animals do not appear to be common, the FLMNH-EAP collection of WTD being an exception with considerable potential for additional investigation. The repository for Purdue's (1983a; 1983b) original data, and the materials employed to generate that data is currently unknown.

Evidence for morphological variations between deer species and age-related changes to WTD bone morphology were unexpected. My observations that fusion of the radius to the ulna suggests this quality represents a common pathology rather than ontological development. Similar findings for Wapiti *(Cervus candensis)* by Knight (1963) and for goats *(Capra hircus)* by Zeder & Lapham (2010), support that hypothesis. However, once this pathology is understood, there remains significant potential to estimate the age class of individuals demonstrating this quality.

Measurements of caudal breadth and depth of the calcaneus and of a notation designating the plane specific to the smallest diameter are my unique contributions. Previous study of human skeletal adaptation to mechanical stress left me wondering why foundational texts for zooarchaeology did not address the topic of occupational stress in animals. The caudal measurement proved to be sensitive to ontological age within the reference collection and is supported by similar findings of Skedros et al. (2004) for mule deer (*Odocoileus hemionus* ssp.), though that research compared thickness of the cortical walls rather than measurements of the calcaneus anatomical structure (lumps and bumps). Even though Bc (caudal breadth) and Dc (caudal depth) were not widely applied to the archaeological materials in this study, there is potential for identification of age class and pathology consistent with confinement or restricted movement (see Figure 5-40). Metatarsal buttresses per Thomas and Grimm (2011) are less clear for determining age in WTD, and the application to species identification requires more study. Similar morphological variations between the 1st phalanx of WTD and red brocket deer (*Mazama temama*) requires additional testing. No post cranial skeletal elements for brown brocket deer specimens were positively identified for inclusion within the comparative materials. Variations in bone morphology between closely related species are rarely clear (Bosseneck, 1963; Jacobson, 2003). Some or all of these findings may constitute reinvention of the wheel, but given the disconnect between predigital sources and current research methods weighted toward on-line literature, no sources offering clear descriptions of these morphologies for deer were identified during my research.

The primary research goal for this research was to identify changes in population stature and sex ratios within the assemblages, but because determining sex via bone size requires identifying the ontological age of the sample being assessed, determining the age cohort for each sample was a necessary first step in that process. A review of the context types and deposit formation represented by the archaeological materials studied

would be a valuable addition to this research. The retention of the original catalogue numbers in my data sheets is intended to facilitate such inquiry at a later date. The chronological depth and diversity represented in the assemblages reviewed is limited by what reference materials and archaeological assemblages were accessible during the data collection phase. The assemblage from Preclassic Period El Mirador was small, and while the samples seemed to be exceptional, Table 8-1 shows those samples are 12 to 15 percent larger than the adult female specimens from Big Cypress and comparable in stature to the adult male from that collection. Samples from Copan's Early Classic and San Pedro's Postclassic/Historic era assemblages were significantly dissimilar in stature to other assemblages, demonstrating regional variation in WTD stature that is potentially an indication of nutrient value in the local forage. It is also possible the Cervidae samples from these two sites do not represent WTD. The presence of a third deer population at San Pedro may be indicated by the variation in length measurements. Of the three deer-species available to the ancient Maya, only *Mazama pandora* is not represented within my reference collections. Therefore, it is not possible to identify or eliminate the presence of this species within the assemblages studied for this paper. It is equally possible these animals represent WTD trade from a different catchment area or habitat (Williams et al. 2009; Thornton, 2011; Masson and Freidel, 2012).

Initially the side by side comparison of modern specimens selected as the standard, with measurements of the archaeological samples, suggested WTD stature in the Maya culture region declined over time. However, testing of the Mean for log ratios by site in Figure 7-128 implicates regional variations in available nutrition are more significant for WTD stature (see section 7.9). Figure 8-10 does suggest the cultural paradigms for Maya prey selection changed after the Terminal Classic.

9.3 Hypothesised WTD domestication:

The assumption that herd management strategies follow the Eurasian model of culling animals once secondary production falls below optimum levels is unlikely, as there is no documentation suggesting secondary products derived from WTD. However, the maintenance of a breeding cohort for primary production cannot be discounted (Reitz and Wing, 2008). Postclassic and Historic Era assemblages from the four sites in Belize indicate a spike in the number of sub-adult males harvested (see Table 7-3 and Table 7-4). A subset of these assemblages shows some individuals that are comparable in stature to the WTD of the Classic Period, and these could represent a mature breeding cohort.

Late Classic assemblages may suggest adult females were the preferred target for consumption; this may have been a cultural choice or the result of curation bias, rather than a deliberate effort by the Maya to suppress WTD reproduction. Sub-adults and juveniles are present in these assemblages but the number of samples assessed as immature indicates the young were not specifically targeted. As is shown in the tables in Chapter 7, most of the assemblages are dominated by early fusing skeletal elements, thus distinguishing adult females from sub-adult males by size in these assemblages is quite tentative.

The assemblages from Cancuen and Cueva de Los Quetzales appear to be comprised of adult males (see sections 7.6 ii and 7.6 viii). Whether the sex of the individuals represented in these assemblages is related to context type or some other variable is not currently clear. Present day Maya hunters use specific vocabulary distinguishing deer by antler morphology, age, coat colour and species but reportedly have no vocabulary specific to male and female deer (Jorgensen, 1995). This could be interpreted as a lack of interest in deer breeding or animal husbandry. However, until recently several Asian languages, including Japanese and Mandarin, lacked sex-specific nouns, while being intensely patriarchal and supremely aware of prescribed sex and gender identities. Whether this might also be true of one or more of the Maya languages is not known by this author, but the ancient Maya maintained domesticated turkeys, dogs, and bees, therefore a lack of terminology corresponding to Eurasian practices of animal husbandry cannot be taken to imply an absence of animal husbandry.

The results from previous isotope studies discerning dietary differences between individual WTD show the ratio of deer with an enriched C^4 diet compared to deer with a C^3 diet has been relatively constant from the Preclassic through the Postclassic Periods (White et al 2001a). Based on those results, any deliberate human provisioning of WTD with maize is (A) of long standing antiquity and (B) shows no change in frequency that might parallel the intensification of venison consumption over time by the Maya. A single sample from San Pedro is suspected to represent a castrate. Historical sources describe Maya castration of *Techichi* dogs for fattening (Tozzer 1941, citing Landa, 1566). Occupation of the settlement at San Pedro was persistent through the Postclassic into the Historic Era, and the introduction of Spanish practices of animal husbandry cannot be excluded.

Chronicles documenting Cortes's travels in the Petén region described deer on the local savanna unafraid of human hunting. Cortez reports he was informed the deer in

that area belonged to the God, Carr (1996), and proposes these areas were similar in function to game reserves protecting a core breeding population (Pohl, 1985: 138; Carr, 1996: 251). The frequent representation of sub-adult males in the terminal and Postclassic periods might support this theory. Sub-adults are habitually ejected from the maternal forage patch prior to delivery of the new fawns. Young males normally range further afield than their sisters, and unaccustomed to human predation would be especially vulnerable as they moved outside the protected zone to establish their own breeding territories.

Pohl and Feldman's (1982) original posit that WTD were raised by women within Maya households as a source of social and economic capital is consistent with Landa's (1566) account. Proposed domestication of WTD as a source of provisioning the Maya's urban centres may be overly dependent on models acclimatized to animal domestication in central Eurasia (Henderson, 1997: 2; Feinman et al. 2016). That said, identification of pathologies consistent with confinement should be identified and pursued (O'Regan and Kitchener, 2005). Unlike Athena, no domesticated deer sprang from the forehead of *X-Balam-Que* (Jaguar-deer), but the intersections of the human and nonhuman worlds are often too nuanced to be detected by Western economic paradigms (Valadez Azúa, 1992; Sykes, 2014).

Even though genetic studies have recently had great success at identifying progenitor populations (Luikart et al. 2001), a search for a domesticated WTD lineage seems unjustified, as any truly domesticated population would have failed without human management during the past 450 years or been subsumed into wild stocks.

Archaeology is essentially anthro-centric, we are interested in the people. Their animals are only of interests so far as they reflect human society and the cultural values it is organized around (which *societies' values* is another topic). Faunal assemblages typically contain several species and a variety of disarticulated skeletal elements with relationships too tentative to identify beyond species and age class. Compared to methods employed in human osteology, methods for assessing the age cohort of mature ungulates is surprisingly thin. Sample size is one criteria for determining if detailed analysis is warranted, available resources for that analysis is another. Project leadership allocates resources for analysis based on possible outcomes, the research designs and excavation techniques used; all are fundamentally based on anticipated results and the estimated value to future work. This also applies to the selection of which bones receive curation at facilities easily available to researchers.

Comparison of samples from multiple assemblages is one solution; there is, however, some risk that details about local conditions and deposit formation will be obscured by conflating the resulting data. Documenting changes in deer stature over time may likewise be a casualty of comparing assemblages from different locations, but comparing samples from assemblages this diverse across time and space is an uncertain process even when working with a single species. The comparison of metatarsal lengths is especially tentative (see Figure 8-12). More robust are the breadth and depth measurements in Figure 8-13, which do support the pattern seen for lengths. Working with archived faunal material presents many advantages, the opportunity to examine materials in greater detail being just one. However, legal statutes regarding antiquities and the transport of cultural artefacts across national borders is limiting to research of this type; of the several overseas institutions I contacted seeking access to archaeological samples only the Universidad Autónoma de Yucatán and FLMNH-EAP responded positively. The Maya faunal materials at the Florida Museum of Natural History, while quite excellent, are representative samples and curated for purposes other than osteometric analysis. Complete assemblages offering more chronological depth and a wider range of context types for each site would allow more certainty regarding the distribution of WTD sex and age cohorts that were present.

Professional and amateur archaeological journals are full of articles documenting the arrival of one species or another in this or that ancient society, as well as methods and materials used to test the origins of domestication. Wild animals are less commonly described beyond noting their economic value 'kilo calories' or application to leveraging human social rank, i.e. 'fox hunting'.

WTD were sufficiently important in the Maya economy for inclusion in cultural narrative and social identity (Goetz and Morley, 1950; Pohl, 1995; Tedlock, 1996; Foreman, 2011). The data presented demonstrates representation of WTD by sex and age cohort fluctuated across time and or communities, but what does this tell us about the Maya and their society?

'. . . de los cuales dan el pecho a los corzos, con lo que crían tan mansos que saben írseles al monte jamás, . . .' (Landa, 1566: 57) 'and let deer suck their breast, by which means they raise them and make them so tame that they never go into the woods' (Tozzer, 1941: 127) cited in (Pohl and Feldman, 1982: 305). The translation of this line is perhaps diagnostic of the difficulty interpreting the faunal remains left by the ancient Maya. Reitz and Wing (2008: 305) record that Castilian aristocrats nursed small

dogs at breast for cosmetic purposes, and this may suggest Landa was drawing a parallel between the Maya and the highest level of Spanish society. Despite ethnographic and historical sources from around the globe describing human women nursing animals of many kinds (Baumslag, 1986: 621; Reitz and Wing, 2008: 300). Landa's (1566) statement blurs a perceived separation between human and animal lives, causing distress among some modern readers that has been taken so far as to suggest Landa (1566) was attempting to dehumanize the Maya as part of a political agenda. On the contrary, scholarship proposes Landa (1566) argued before the Spanish Crown that the Maya were fully human (Timmer, 1997). It also contradicts Landa's directly stated intent. The point being, that despite a greatly expanded world view, modern readers are not without cultural biases, and that unexamined bias may influence not only our conclusions but the directions that we investigate.

Chapter 10 Conclusions:

What does it mean? The evidence supports the posit WTD stature is variable by geographic region (see Figure 7-128), but fails to demonstrate changes in stature over time as suggested by Purdue and Reitz (1993), Compton (1999), and Wolverton (2005). A misunderstanding in those papers regarding growth of the astragalus as described in section 5.3 i may be implicated, but it is equally possible the assemblages tested in this research lack sufficient chronological depth for changes in population stature to be clearly visible to my methods. Figure 8-10 consolidates the log ratio data presented in Chapter 7 and demonstrates that prey selection did change over time. Whether that change was motivated by resource depression, new hunting technology, or Postclassic period reorganization of Maya society is not clear.

Work that remains to be done: Current literature regarding deer osteology is both insufficient and outdated. Rumph's (1975) unpublished but detailed description of the WTD skeleton was a late addition to my resources and may prove useful at a later date. The two brocket deer species in Mexico, Belize, and Guatemala are understudied. The species identification and biology of neo-tropical Cervidae are especially troublesome as taxonomic reorganization has outpaced corresponding research in the physiology and anatomy of newly defined species. Osteological research differentiating between adult age classes for ungulates in general is currently inadequate for addressing nuanced questions about resource management and manipulation by prehistoric communities.

The reference collection was recorded with the intention of creating a Standard by which size-index-scaling might be applied to Maya deer, which was successful. While this material has also been usefully applied in this study to determining sexual dimorphism and ontological development of WTD, a more detailed and expanded study of the reference collection specific to these two topics would be invaluable to archaeologists.

Evidence suggesting morphological differences in the first phalanx of red brocket deer (*Mazama temama*) and WTD are tentative and require additional study. The species variations in post cranial bones I identified in chapter 6 have not been previously reported in zooarchaeology. Complete crania for brocket deer are well represented at museums contacted during this research, the same cannot be said for post cranial bones. No post cranial skeletons specific to brown brocket deer (*Mazama pandora*) were identified in the collections and this lack must be addressed. The listed

taxonomy in museum collections presents an additional though not insurmountable hurdle to identifying brocket deer specimens for study. Expanding the number of specimens is an essential step in determining if the observed morphology is a quality related to species, subspecies, or unsubstantiated.

The same must be said for WTD; the single specimen MVZ98889 (*Odocoileus virginianus truei*) from El Salvador may represent either a pathological alteration of the 1st phalanges, an environmental adaptation, or a morphology specific to that subspecies. Identifying institutions with substantial collections of post cranial WTD bones was problematic during the first two years of this research. Fortunately that situation has changed. A better understanding of habitat-related size variation and sexual dimorphism for WTD is needed. The reference collection at FLMNH-EAP has a number of partial WTD skeletons from Florida as well as WTD specimens from nearby states that were not examined during data collection. While complete skeletons were required to create a basic understanding of species morphology, additional study of partial skeletons may clarify questions about population stature in relationship to landscape management as well as investigation of nonmetric traits related to age at death.

It would be useful to compare WTD bones from highland sites and whether soil geology is directly relatable to deer stature. Postclassic and historic samples show the most variation in size and morphology within the same period. Is this pattern repeated at other settlements representing the same periods? Genetic testing may also be relevant in determining which species are in fact represented, and isotope studies may clarify whether samples are of local origin or imported from different environments.

While the pathologies related to confinement and 'over-load stress' are frequent subjects for faunal analysis of domesticated animals, the literature describing these qualities is relatively thin for non-domesticates (Bendrey, 2007); possibly because so much of that literature is dedicated to economies based on domestic animal production. The prehistory of North America is, however, quite different in that regard. If we propose to understand how the Maya conceived of and managed their resources, it is essential we learn if and how the physiology of these animals was altered by interacting with human communities. Masson (1999) proposes WTD were kept in pens and provisioned with maize for fattening; if such was the case pathologies consistent with confinement and nutritional deficiency should be visible in some samples. Identifying these pathologies may require in-depth study of the anatomy that exceeds Rumph (1975) excellent but limited study.

Some of the deer bone samples from Cancuen and all of the samples from Cueva de Los Quetzales are known to derive from ritual contexts, and those assemblages were assessed to be dominated by adult males. With these two exceptions, my project ignored context type in favour of examining sex and ontological age of the samples represented in the assemblages. Whether or not Maya hunters targeted selected cohorts of WTD for specific kinds of social performance has not been addressed in this study but would be a valuable addition to distinguishing ritual from economic activity.

Final statements: While questions about resource management can be viewed in multiple ways, the scientific paradigm is often weighted with invisible assumptions regarding the juxtaposition, if not conflict, between the human and non-human worlds. Valdez-Azúa (1992: 52) argues the reproductive potential of dogs *(Canis lupus familiaris*), plus that their omnivorous diet required human intervention to keep the population manageable, while turkeys *(Meleagris gallopavo),* the second confirmed domesticated vertebrate on the landscape, required human protection to be reproductively successful. Hence, these two-species operated in separate cultural categories and a specific concept of animal domestication did not evolve in the Americas (Valdez- Azúa, 1992: 54). By contrast, Eurasian agriculture uses crop waste for animal fodder. In turn animal waste is used to maintain soil fertility and thus a system of interdependent relationships has evolved into a technology that mimics naturally occurring systems, almost always at the expense of local plant and animal species external to that web of relationships. As a consequence of the complexity of agricultural technology and its central importance to urban life, those paradigms have become imprinted on political and economic paradigms of Eurasia in forms as fundamental as patrilineal inheritance and the social value of preserving fertile women by excluding them from violent conflict, as compared to the expenditure of young men in organized violence.

One of the proposed outcomes of this study was possible evidence that the social transitions leading to animal domestication might be more visible in Maya archaeology than has been the case in Eurasia (see section 1.6). The evidence in this study suggests that prey selection of WTD by sex and age cohort varied between settlements, perhaps as part of a community narrative or over time. If the shift is diachronic it may represent exactly the sort of social change that has been invisible in Eurasia, and suggest lines of investigation that might be applied to animal domestication on a broader scale.

Hammond et al. (1973) proposes consumption of WTD was linked to maize cultivation. Interpretation of the Popol Vuh suggests deer and maize were mythically linked via the Hero Twins representing a cultural and economic identity (Tedlock, 1996). Maya dynastic lineages are theorized to have operated as intermediaries between the human and non-human worlds; political and social influence was dependent on the success of harvest cycles and exploits in battle (Henderson, 1997: 146). The capture of deer for ritual and social celebration may have been a metaphor in that intervention with the divine. The data presented indicate dynamic changes in the sex and age of deer represented in the assemblages. whether those differences are related to alterations of the social metaphor over time or represent different community narratives remains unclear. Assuming deer hunting was an elite activity, whether ritual or economic, a cessation of hunting by dynastic lineages at the end of the Terminal Classic would effectively remove a significant anthropogenic check on deer population growth.

The evidence shown for a shift in prey selection from adult females to sub-adult males in the Terminal Classic could be interpreted as evidence for herd management or WTD domestication. However, I believe that interpretation ignores the natural attributes of the species. WTD appear to prosper best in proximity to human farms and gardens. The extirpation of large predators around human settlements and prohibitions on hunting, whether ritual or legal, has a negative impact on deer populations, increasing intra-individual competition for nutrition while reducing reproductive competition. This in turn may lead to diminished diversity of other plant and animal species where deer populations exceed the environment's carrying capacity (Roony & Waller, 2003).

Why should we care? Tropical environments present significant challenges to resource management for modern nation states. Current economic models are founded on Eurasian agricultural traditions that evolved on landscapes dominated by seasonal extremes in solar radiation and temperature. In the Maya culture area, solar radiation is relatively constant throughout the year, seasonality is determined by alternating dry and wet periods, and temperature is a function of altitude rather than latitude. Especially problematic in the region is the dispersal/leaching of soil nutrients by seasonal rain.

Are we asking the wrong questions? The Pre-Columbian Maya were one of the great civilizations of antiquity, politically and economically persistent well into the historical period. The culture thrived in what are now the Mexican states of Quintana Roo, Campeche, Yucatan, Tabasco, Chiapas, as well as the modern nation states of Belize, Guatemala, Honduras and El Salvador. Understanding how that civilization

managed its natural resources potentially offers real world applications to sustainable development for the modern states in that region. WTD appear to have been a key element in Maya economic and social organization. The rate of deer reproduction compares favourably with most domesticated mammals. The nutritional requirements and amount of space needed for successful reproduction, however, exceed the resources of conventional farming, but this limitation may in fact be related to landscape management regime rather than the total of available resources. The Optimal Foraging Model presumes a hierarchy of prey choice based on caloric expenditure and return of equal or greater caloric value for that investment. However, within archaeology, that model rarely factors in the cost of overexploiting local resources in terms of water quality, soil fertility, available fuel for cooking and industry. As a self-managing resource WTD would have been an invaluable addition to the Maya's extensive agricultural fields and orchards. Given the fragility of tropical soils, is it possible the ancient Maya managed their landscape to preserve such resources, and that WTD were a component of that landscape management rather than an end-product?

The Maya are not the only civilization in the Americas that depended on WTD for a significant portion of animal protein (Smith, 1974; Noble, 1985; Stewart and Finlayson, 2000; Pavao-Zuckerman, 2000). Currently WTD exist in pest-level numbers in rural and suburban communities in the eastern United States and Canada (Roony and Waller, 2003; Creacy, 2006). This might suggest there are sustainable and viable alternatives to factory farms for modern society.

The goal of this research was to examine variables for WTD sex and stature that had previously evaded quantification and to create new knowledge about this species and its relationship with human communities sharing the landscape. While the modern WTD reference collection is very small and includes only one adult male specimen, given the geographic distance between Florida and Central America the modern specimens were surprisingly comparable in stature to the archaeological samples. Use of osteology to assess the sex of juveniles and sub-adults is problematic for most mammals, and that difficulty has been amply demonstrated in this study. However, my observation of nonmetric traits and species morphology has mitigated these obstacles, if only slightly.

The posit WTD may have been domesticated, managed as a resource, or possibly kept in captivity has been made by several authors: Pohl and Feldman (1982), Carr (1996), Masson (1999), Masson and Peraza-Lope (2008). Ethnographic research

by Hammond and Clutton-Brock (1994) supports Landa's (1566) description of deer residing in Maya farm yards. The published NISP data suggests WTD remains become increasingly visible at Maya sites over time in relationship with growing cultural complexity and expanding human populations. However, a degree of curation bias must be assumed for the assemblages used in this study, current Maya studies are multifaceted and while the role of WTD in ancient economies are shown to be significant in Table 4-1 and Figure 4-2, thus far the methods developed to study animal husbandry in the Near East have not demonstrated a clear trend either for or against domestication of WTD. One fault lies in the nature of the assemblages curated at FLMNH-EAP, as these could neither be representative of deer over the full length of any given site's human occupation, nor represent all WTD recovered in those assemblages. At the beginning of this project most of the museums and institutions contacted demonstrated reluctance to initiate new relationships outside their existing academic networks. Some of that reluctance might be related to Nationalist sentiments or requests for the repatriation of antiquities to their counties of origin. Regardless of the motivating logic, for a research question of this kind 'representative samples' cannot be considered representative.

A second problem lies with the foundational premises of researching animal domestication, i.e. we know from historical sources which animal species were domesticated in Eurasia. During archaeology's early years, this produced a degree of bias regarding which species were tested as possible domesticates. Because the herd and pasture model holds centre-place in western narratives of cultural expansion and conquests, that bias is entrenched within both the literature and popular imagination. It is possible this narrative (when unexamined) may be misdirecting our questions about what impulses supported the development of urban life/cultural complexity in Mesoamerica, or how the ancient Maya viewed and interacted with the nonhuman world.

Eurasian animal husbandry typically exploits young males at the expense of other cohorts in the population, and it can be argued that Eurasian's human societies are organized around the same or similar principals, but Maya civilization evolved on a trajectory independent and quite unique from that observed in Eurasian (Henderson, 1997: 2), and we have no evidence Maya communities considered young males a type of surplus production. The mortality profiles identified in this research suggest quite the

opposite, and this possibly refers to an unfamiliar metric for valuing human members of Maya society.

Osteometrics are time consuming, and the dearth of published metric data for this important species has been a significant obstacle toward any research concerning WTD as they are represented in the archaeology. While the reference collection employed for this study is vanishingly small, its inclusion in an open access data-base is a step toward improving our knowledge of both this species and the human communities dependent on WTD for material provisions. Several pathologies common to WTD have been described that may be investigated for clues to defining older individuals represented in archaeological assemblages, and these may be a step toward improving how we discern age-class among ungulates in general. The manual for measurement in this document is intended to mitigate the variables of inter-worker variation. If successful, the comparisons of data from multiple workers and sites may facilitate more confident analysis of trends in stature, age, as well as how male and female WTD are represented in faunal assemblages.

In terms of proving or disproving that WTD were domesticated by the ancient Maya as a means of providing animal protein to their urban populations, this study has failed. It has however succeeded in discerning male and female WTD in the faunal assemblages using log ratios and by comparing the osteometrics of archaeological samples with the modern reference specimens. The usual caveats about distinguishing sex among sub-adults and juveniles have been addressed by the tables that were designed to categorize ontological age by epiphysis fusion. The combination of these methods in my analysis does offer a degree of confidence that Maya hunters targeted specific cohorts of WTD populations. It also suggests the criteria Maya hunters applied to prey selection was variable; this quality is worth exploring as it might be related to changes within either the political or economic organization of Maya society.

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Appendix A reference collection field notes:

The Univ. of Florida’s Natural History Museum has a collection of modern WTD of know age and sex. Complete or nearly complete skeletons are available; measurements of the crania and pelvis were not in my original plan, but given the available resource recording these seems useful. At least part of this exercise is to make myself familiar with the diagnostics of this species. The Florida deer are a distinct population and I anticipate surprises.

This is one part of a larger project attempting to define the population demographic of WTD harvested by the ancient Maya. In particular, these measurements are aimed at creating a species specific base-line of measured skeletal elements. WTD are an adaptable species able to thrive in a variety of environments and ecosystems. As has been recorded by other scholars (Purdue –Wolverton --Rietz) their stature and habits vary from region to region.

Notes on data generated: at Mr. Quitmyer’s suggestion I have included a column each for whether each element is fully fused and whether the epiphysis is readily visible. This information could be coded for analysis, and I considered coding my data sheets directly. However, in terms of making my data available to other researchers and other projects that option would add a level of confusion. So male=M, female=F, fused epiphysis=F, unfused=U, visible suture lines=V, nonvisible suture lines=I. My column headings should clarify what is being described. Dr. Sykes sent me a data table by Ruth Carden from a similar study of fallow deer of know age and sex, and I have chosen to map my recording methods along a similar track. Since this is about creating a base-line reference, an exhaustive measurement of every element is not required. Where possible I have measured only elements from the right side of each animal, but not all skeletal elements were available for every specimen. Where necessary I recorded the left side; which side is recorded is included in the data-sheet. Where it was required to substitute and element from the opposing side appears in the descriptions below.

In general the measurements to be taken are GL greatest length, Bp greatest breadth proximal, Dp greatest depth proximal, SD smallest diameter (in whatever plane diameter is smallest) per Davis (1996) Bd greatest breadth distal, Dd greatest depth distal. Measurements specific to certain bones are as follows:

Scapula: HS height of the scapular spine, from the proximal margin of the scapula to the most distal point on the glenoid lip. DHA diagonal height from the posterior proximal corner to the most distal point of the glenoidal lip. LD greatest dorsal length the top edge of the scapula rim. SLC smallest length of the scapular Cullum/neck. GLP greatest length of the glenoid. LG greatest length of the glenoid cavity (measured with the reverse side of venire calipers). BG greatest breadth of the glenoid; per Von Den Driesch (1976) page 74-75
Humerus: BT least breadth of the trochlea; Von Den Driesch 1976 page 76. HT height of the trochlea and HTC least height of the trochlea constriction Popkin et al. (2012) page 1778.
Ulna: LO length of the olecranon. DPA depth across the process anconeus. SDO smallest depth of the olecranon, Von Den Driesch (1976) page 79-80.
Pelvis: measurements of the acetabulum LA, LAR using the reverse side of the calipers, per Von Den Driesch (1976); in theory measurement of the acetabulum can serve as a proxy for the femoral head similar the example of Soto-Toral (1998) using the glenoid articulation of the scapula.
Astragalus: GLl greatest length lateral, GLm greatest length medial, Bd greatest breadth distal, Bp greatest breadth proximal, Dl greatest depth lateral, Dm greatest depth medial per Von Den Driesch (1976). Also included is Purdue's ASLEN (1983) with a special note this measurement does not appear in Von Den Driesch but has been used by a number of American scholars Purdue (1983, 1987); Wolverton (2005, 2007, 2008) Jacobson (2003) Densmore (2009) unpublished. The designation has changed with each scholar based on their research needs; for the purpose of my research the least length of the medial constriction is labeled Lcc along the lines of Von Den Driesch's methodology.
Calcaneus: GL greatest length, GB greatest breadth Von Den Driesch (1976) page 90. GD greatest depth Purdue (1987)
Phalanges: even with complete and curated skeletons identifying artiodactyl phalanx beyond element is difficult. With archaeological specimens I expect it to be impossible. However, in terms of creating a baseline for measurements they potentially offer additional if not very precise data. For this reason I have included GL, Bp, Dp, SD, Bd, and Dd for the first and second phalanges of each animal recorded in the reference collection where possible.
Mandible: length of the molar row per Von Den Driesch (1976) page #8 the length and breadth of each molar when available.
Crania: circumference of the antler burrs proximal and distal to the cranial vault per Von Den Driesch (1976) page # and
Other notes "absent" is used in reference to nonattached articular elements of the bone being described. "Missing" means the bone is not in the box.
Equipment used: digital venire calipers were used for all measurements that did not exceed 200mm. An osteo-board was used

for measurements exceeding 200mm; there is a 3mm difference in measurements taken with the osteoboard from those taken with the calipers. For circumference measurements of the antler burr a flexible measuring tape was used, and instrument error of 2mm should be anticipated.
Specimen z:4576 female 2yrs old. Collier City, measurements taken from right side.
Scapula: the notch between the end of the scapular spine and the glenoid articulation seems very sharp. All landmarks are present.
Humerus: All landmarks are present; proximal condyles are fully fused but the fusion line is distinct.
Radius: All landmarks are present.
Ulna: All landmarks are present.
Metacarpal: All landmarks are present; proximal articulation fully ossified; distal fusion line not visible, condyles fully ossified, distal end of the metacarpal shaft not fully ossified.
Pelvis: All required landmarks are present. sagittal suture of ischium is not fused, tubera ischiadica not fully ossified.
Femur: All landmarks are present; femoral head and trochanter are fully ossified; distal condyles are fully fused suture line is visible, condyles are not fully ossified. Left femur is extensively discolored consistent with weathering.
Tibia: All landmarks are present; fully fused, proximal suture line is visible both proximal and distal articulations are not fully ossified.
Metatarsal: All landmarks are present. proximal articulation fully ossified. Distal condyles fully fused, epiphysis line is faintly visible. Distal end of the shaft around epiphyseal line not fully ossified.
Mandibles: right mandible missing. Left mandible present, molars 1, 2, 3 are present and fully erupted.
Phalanx: missing.
Specimen z:4571 male 3.5 yrs. Old from Collier County. Measurements taken from the right side.

Scapula: All landmarks are present; robust the notch between scapular spine and the glenoid shaft is larger and wider than in the females.
Femur: All landmarks are present; proximal condyles are fully fused, epiphyseal line is visible
Radius: fully formed proximal and distal articulations are still greasy and not fully ossified.
Ulna: All landmarks are present.
Metacarpal: All landmarks are present; distal fusion complete, fusion line faintly visible.
Pelvis: All required landmarks are present; suture in the sagittal plane is unfused.
Femur: All landmarks are present; proximal condyles fully fused, suture line visible/distal condyles fused, suture line visible, distal surface of condyles and shaft not fully ossified.

Tibia: All landmarks are present; all elements fused; proximal fusion line clearly visible, both proximal and distal ends of the bone are not fully ossified.
Metatarsal: All landmarks are present; completely fused and fully ossified.
Phalange: there are 14 phalanx in this box missing are one 1rst and 1 2nd phalange. Two 1rst and two 2nd phalanx are not fully ossified. All landmarks are present.
Cranium: proximal and distal circumference of antler burr; measurement taken with a flexible measuring tape per Von Den Driesch 1976.
Mandible: right side only. All three molars are present as are pre molars 1 and 2; light staining M1 shows wear.
Specimen z:4703 female 3.5yrs Collier County. Measurements taken from the left side.
Scapula: all landmarks are present the glenoidal notch is wider on this sample than two previous females.
Humerus: fully fused, suture lines are barely visible. The trochanter of the right humerus is missing and there is disorganized bone remodeling and deformation of the proximal articular surface of the right humerus therefore all measurements were taken from the left side.
Radius: All landmarks are present; proximal and distal ends are fully fused but not fully ossified. The distal articulation between radius and ulna has fused but is not ossified.
Metacarpal: All landmarks are present; fully fused, no visible suture lines; quite remarkably virtually the entire surface of the right metacarpal has demineralized. The proximal and distal ends of the left metacarpal are also de-ossified though not as completely.
Pelvis: All required landmarks are present. Pelvis is completely fused no visible sutures.
Femur: fully fused and no visible suture lines.
Tibia: fully fused, no visible sutures.
Metatarsals: fully fused no visible sutures
Astragalus: fully fused no visible sutures
Calcaneum: fully fused no visible sutures
1rst phalanx: eight one of which has a broken surface exposing the medullary cavity
2nd phalanx: seven in total one of which is notably demineralized.
No mandible or cranium available.
Specimen z:4711 male 1.5 years Collier City-Big Cypress National Park. Measurements taken from the left side.
Scapula: right scapula is broken; only the LD is available. Left scapula intact all landmarks available.
Humerus: proximal epicondyles unfused, GL, GLC, Bp, and Dp, are unavailable; distal epiphysis line is visible. Shaft of the right side is broken.
Radius: distal articulation unfused GL. Bd, Dd, are unavailable.

Ulna is not fused to radius; acromion is not fully developed GL and LO are not available.
Metacarpal unfused, GL, Bd, Dd, BFd unavailable.
Pelvis fully developed, suture on the sagittal plane is unfused.
Femur: proximal and distal articulations are unfused only SD is available.
Astragalus: all landmarks are present.
Calcaneum is not fully formed superior crest is missing, GL is unavailable
Tibia: proximal and distal articulations are not fused only SD is available.
Metatarsal: distal articulation is unfused GL, Bd, Dd, and BFd are unavailable
Mandible: left side only—M1, M2 fully erupted. M3 partially erupted L & B unavailable.
Crania: antler burrs are robust.
Specimen z:3590 male recorded as adult with no given age in the goldenrod sheets but as a sub-adult in the public data-base. All major long bones are unfused and or incomplete but M3 is fully erupted. From Marion County 1981 measurements taken on the right side.
Scapula: all landmarks present
Humerus: proximal condyles unfused no GL, Bp, or Dp available. Left humerus is broken.
Radius: Distal articulation is absent, GL, Bd, Dd are unavailable.
Ulna: olecranon is incomplete only LO and DPA available.
Metacarpal: distal condyles are unfused and absent.
Pelvis: broken and incomplete, acetabulum is intact.
Femur: proximal and distal ends of the bone are unfused only SD is available.
Tibia: proximal condyles are unfused; only SD, Bd, and Dd are available.
Astragalus present.
Calcaneum is incomplete, superior crest is missing GL not available.
Metatarsal: distal condyles unfused and absent.
Phalanges 1 and 2 are present.
Cranium: Antler burrs are missing
Mandible: molars 1, 2, and 3 are present. M3 is fully erupted
Specimen z:4579 male 1.5 years from Collier County
Scapula: all land marks present;
Humerus: proximal condyles unfused.
Radius: distal condyles unfused
Ulna: not completely developed.
Metatarsal: distal condyles unfused
Pelvis: All required landmarks are present; not completely developed acetabulum is available
Femur proximal and distal condyles unfused.
Tibia: proximal and distal condyles unfused
Astragalus: present

Calcaneum: superior crest is missing GL unavailable.
Metatarsal distal articulation unfused and missing
Phalanges 1 and 2 present All landmarks are present.
Right mandible is absent left mandible has M1-M3
Crania: burr is broken close to the vault circumference measurement not available
Specimen z:4580 female 4yrs from Collier County
Scapula: all land marks are present
Humerus: all land marks are present
Radius: all landmarks are present
Ulna: all land marks are present
Metacarpal: all land marks are present
Pelvis: All required landmarks are present; fully formed suture in the sagittal plain is fused.
Femur: all land marks are present
Tibia: all land marks are present
Astragalus: present
Calcaneum: fully formed all land marks are present.
Metatarsal: all land marks are present
Phalanges 1 and 2 present.
Mandible: molars are erupted and show wear.
Specimen z;4573 female 5yrs from Collier County 1985
Scapula: all landmarks present
Humerus: all landmarks present
Radius: all landmarks present
Ulna: all landmarks present right ulna is fused to radius, and left ulna is not fused.
Metacarpal: all landmarks present
Pelvis: all landmarks present all elements are fully developed, sagittal suture is fully fused.
Femur: all landmarks present
Tibia: all landmarks present
Astragalus: all landmarks present
Calcaneum: fully developed
Metatarsal: all landmarks present
Phalanges: all eight 1rst and all eight 2nd phalanges are present there is some demineralization present.
Mandible: right mandible only; molars 1-3 fully erupted and showing wear.
Specimen z:4574 female 2.5-3yrs from Collier County 1985
Scapula: all landmarks present
Humerus: proximal condyles absent GL, Bp, and Dp are unavailable.
Radius: all landmarks present, distal epiphysis is visible
Ulna: right is fully developed though a fusion line is visible on the superior end of the olecranon. The left olecranon is missing the superior crest.
Metacarpal: all landmarks present distal suture visible
Pelvis: unfused required landmarks are present

Femur: All landmarks are present; fully fused proximal and distal epiphysis are visible
Tibia: fused, proximal epiphysis is open
Astragalus: present
Calcaneum: fully formed, suture at superior end is closed but visible; all landmarks are present.
Metatarsal: distal epiphysis is closed but visible all landmarks present.
Phalanges 1 and 2 present; all landmarks are present.
Mandible: right mandible is missing M1 and M3, teeth are measured from the left mandible.
Specimen z:4572 female 3yrs from Collier County
Scapula: all landmarks present
Humerus: all landmarks present proximal articulation is fused, epiphysis are closed but visible.
Radius: all landmarks present no visible sutures
Ulna: all landmarks present, no visible sutures, not fused to radius
Metacarpal: all landmarks present no visible sutures
Pelvis: all landmarks present sagittal suture is closed but visible
Femur: all landmarks present. Proximal suture closed and partially obscured; distal epiphysis is fused and not visible.
Tibia: all landmarks present. Proximal sutures are fully closed but visible distal suture is fused and invisible.
Astragalus present
Calcaneus: fully formed all landmarks present
Metatarsal: fully fused with no visible epiphyseal lines; all landmarks present.
Phalanges: some demineralization is observed.
Mandible not present.
Crania: NA
Specimen z:4578 male 2yrs collier county
Scapula: all landmarks present
Humerus: proximal condyles unfused.
Radius: distal condyles unfused.
Ulna: superior crest of olecranon is unfused and absent
Metacarpal: distal condyles are unfused.
Pelvis: incomplete; all required landmarks are present.
Femur: proximal and distal epiphysis unfused only SD available.
Tibia: proximal articulation is unfused
Astragalus present
Calcaneus: superior crest unfused and absent GL not available.
Metatarsal: distal articulation unfused
Phalanges 1 and 2 all landmarks present but the surface is not fully mineralized.
Mandible: left only; M3 missing.
Specimen z:4569 female no age recorded (all long bones are fused with closed epiphysis) left tibia is broken, right mandible is missing. Measurements taken from the right
Scapula: all landmarks are present.

Humerus: all landmarks are present
Radius: all landmarks are present
Ulna: all landmarks are present
Metacarpal: All landmarks are present.
Pelvis: broken-- all required landmarks are present
Femur: fully fused all landmarks are present
Tibia: right-side all landmarks are present left side broken
Astragalus: present
Calcaneus: all landmarks are present
Metatarsal: fully fused all landmarks are present
Phalanges: about slightly more than half of phalanges 1 and 2 are either incompletely ossified or demineralized.
Specimen z:4567 female no age given from Liberty County; sagittal suture of pelvis is fused, M3 is erupted and shows wear. Public data-base identifies individual as pregnant at time of death.
Scapula: all landmarks are present
Humerus: all landmarks are present, all epiphysis are obscured
Radius: all landmarks are present, all epiphysis are fused.
Ulna: all landmarks are present the superior crest of the olecranon is intact but very short. Neither side is fused to the distal radius.
Metacarpal: all landmarks are present all epiphysis are fused and obscured
Pelvis: complete and fused all landmarks are present.
Femur: all landmarks are present proximal epiphysis closed, distal epiphysis is obscured.
Tibia: all landmarks are present all epiphysis are closed. Possible pathology: there are bony spurs projecting from the lip of the proximal epiphysis.
Astragalus is present
Calcaneum: all landmarks are present
Metatarsal: all landmarks are present all epiphysis are closed.
Phalanges: all landmarks are present
Specimen z:4577 male 12 months from Collier County 1985
Scapula: all landmarks are present; the fusion line of the coracoid process on both R and L is still partially open.
Humerus: proximal condyles are absent epiphysis is unfused. Distal condyles are fused epiphysis is open.
Radius: proximal articulation is fused; distal articulation is unfused and absent.
Ulna: superior crest of the anconeus is unfused and absent.
Metacarpal: proximal articulation is closed; distal condyles are unfused.
Pelvis: all required landmarks are present
Femur: proximal and distal condyles are unfused and absent; only SD is available.
Tibia: proximal and distal condyles are unfused and absent; only SD is available.
Astragalus: present
Calcaneum: superior crest is unfused and missing GL unavailable.

Metatarsal: proximal articulation is present distal condyles are unfused and absent.
Phalanges: all landmarks are present.
Mandible: M1 and M2 are erupted M3 is in its crypt; superior ramus is broken.
Crania: antler bur is present but only sufficiently long for one circumference measurement.
Specimen z:4700 female age 27 m or 2yrs and 3months from Collier County acquired 1985
Scapula: all landmarks are present.
Humerus: proximal condyles are unfused.
Radius: distal condyles are unfused
Ulna: superior crest of the olecranon is unfused and absent.
Metacarpal: distal condyles unfused.
Pelvis: incomplete, all required landmarks are present.
Femur: all landmarks are present; the distal and proximal epiphysis are closed, but visible.
Tibia: proximal condyles absent; distal epiphysis closed.
Astragalus: present
Calcaneus: all landmarks are present; fusion line of the superior crest is visible.
Metatarsal: proximal articulation fused; distal condyles are absent.
Phalanges: present.
Mandible: left mandible missing; right mandible is missing M3.
Crania: present.
Specimen z:2773 female 1.5yrs Clay County 1979
Scapula: all landmarks are present.
Humerus: proximal condyles unfused.
Radius: distal articulation unfused and absent.
Ulna: superior crest of the olecranon unfused and absent.
Metacarpal: proximal articulation present; distal condyles unfused and absent
Pelvis: shattered; right acetabulum is intact
Femur: right femur proximal condyles fused epiphysis is open distal condyles unfused and absent. Left femur both proximal and distal condyles are unfused
Tibia: proximal articulation unfused and absent distal articulation closed.
Astragalus: present
Calcaneus: superior crest is fused suture is visible
Metatarsal: proximal articulation fused, distal condyles unfused and absent.
Phalanges are boxed and sided :D 1rst and 2nd phalange are medial from rear foot (useful if anyone wants to duplicate.)
Mandible: right side only M1 and M3 are missing P1-P3 are encrypt
Crania: Shattered
Specimen z:4708 Female 12 months from Collier County right mandible is missing
Scapula: all landmarks are present.

Humerus: proximal condyles unfused and absent; distal condyles fused epiphysis is open.
Radius: proximal articulation fused distal articulation unfused and absent shaft of both right and left is not totally ossified.
Ulna: superior crest of olecranon is unfused and absent.
Metacarpal: proximal articulation complete, distal condyles unfused and absent.
Pelvis: incomplete; all required landmarks are present.
Femur: proximal and distal condyles are unfused and absent.
Tibia: proximal and distal condyles are unfused and absent
Astragalus: present
Calcaneus: superior crest is unfused no GL available.
Metatarsal: proximal articulation fully fused distal condyles are unfused and absent
Phalanges: 1rst phalange proximal epiphysis is open; 2nd phalange proximal suture is closed and visible.
Mandible: M1 and M2 are present M3 is encrypt, superior ramus is incomplete
Crania: NA
Specimen z:4781 female 2yrs Collier County
Scapula: all landmarks are present; left scapula is broken.
Humerus: proximal condyles fused, epiphysis are open. All landmarks are present.
Radius: all landmarks are present
Ulna: all landmarks are present
Metacarpal: all landmarks are present
Pelvis: is complete sagittal suture is unfused
Femur: all landmarks are present proximal and distal epiphysis are fused and open.
Tibia: all landmarks are present proximal epiphysis are open
Astragalus: present
Calcaneum: superior crest is fused epiphysis is visible
Metatarsal: all landmarks are present all epiphysis are closed
Phalange: all landmarks are present
Mandible: M1-M3 are present and fully erupted.
Crania: NA
Specimen z:4702 female 2.5yrs collier County measurements taken from the left
Scapula: all landmarks are present.
Humerus: proximal condyles are unfused and absent; right humerus is broken.
Radius: all landmarks are present distal epiphysis is closed but visible.
Ulna: superior crest is present but suture is partially open.
Metacarpal: all landmarks are present; distal condyles are fused epiphysis is closed.
Pelvis: all required landmarks are present
Femur: all landmarks are present. Proximal and distal condyles are fused, epiphysis are closed but visible.

Tibia: proximal articulation is fused suture is open.
Astragalus: present
Calcaneum: all landmarks are present. Superior crest is fused, suture is visible.
Metatarsal: all landmarks are present.
Phalange: all landmarks are present
Mandible: left mandible only—M1-M3 present and unworn.
Crania: NA
Specimen z:4709 female 2yrs Collier City
Scapula: all landmarks present notch between scapular spine and the neck of the glenoid is wide.
Humerus: proximal condyles are unfused no GL or GLC available.
Radius: distal articulation is unfused
Ulna: superior crest of olecranon is missing
Metacarpal: all land marks are present, distal epiphysis is closed
Pelvis: incomplete required landmarks are present
Femur: proximal fusion complete proximal epiphysis is open, distal condyles are absent.
Tibia: proximal condyles are unfused and absent.
Astragalus: present
Calcaneum: all landmarks present; suture of superior crest is fused but visible.
Metatarsal: all landmarks are present, distal epiphysis is closed.
Phalange: present
Mandible: right side only ascending ramus broken. M1-M3 fully erupted
Crania: NA
Specimen z:4705 female 3.5 from Collier County 1985
Scapula: all land marks present.
Humerus: all landmarks are present.
Radius: all landmarks are present.
Ulna: all landmarks are present.
Metacarpal: all landmarks are present.
Pelvis: required landmarks are present.
Femur: all landmarks are present.
Tibia: all landmarks are present.
Astragalus: present.
Calcaneum: all landmarks are present.
Metatarsal: all landmarks are present.
Phalange: all landmarks are present.
Mandible: missing
Crania: missing
Specimen z:2850 female 3.5yrs from Clay County FL
Scapula: all landmarks are present.
Humerus: all landmarks are present.
Radius: all landmarks are present.
Ulna: all landmarks are present.
Metacarpal: all landmarks are present.

Pelvis: complete, broken along sagittal axis, suture in the sagittal plane is fused; all required landmarks are present.
Femur: all landmarks are present.
Tibia: all landmarks are present.
Astragalus: present
Calcaneus: all landmarks are present.
Metatarsal: all landmarks are present.
Mandible: both sides present, M1-M3 present fully erupted and showing wear, the normal staining of the dentine above the gum line appears to have been altered. See photos
Crania: NA
Mazama sp.
UF No. 6787 Guatemala, Peten, Tikal: partial skeleton all present elements are axial.
Metacarpal R complete SD is distal transverse plane just superior to condyles. No left side.
Pelvis complete both sides present sagittal suture unfused relevant landmarks recorded.
Femur complete both sides present proximal and distal epiphysis are fused but partially open. SD is inferior to proximal articulation.
Tibia incomplete; proximal epiphysis unfused and missing, distal ends of both are broken and missing. Only the SD of left tibia is viable.
Metatarsal complete proximal and distal epiphysis are fused and invisible SD is superior to the distal epiphysis.
UF No 6788 Skull and partial axial skeleton Guatemala Peten, Tikal female--Present in box complete cranium, L&R mandible, R metacarpal, R metatarsal, unsided tibia distal articulation only L&R astragalus, L&R calcaneus, seven 1st phalanx six 2nd phalanx. Measurements for phalanges taken from left side of left hind foot as determined by researcher. The SD for this species appears to be in the sagittal plane for phalange 1&2 both front hand hind feet.
UF No. 6608 skull and partial skeleton West Indies, Trinidad, ST. Patrick, Sipara Forest: Male Present in box complete cranium L&R mandibles, left side pelvis, L metatarsal proximal epiphysis is fused distal epiphysis is unfused but has been glued into place, L astragalus complete, L calcaneus superior crest unfused but glued into place, phalange 1-2-3 glued into articulated position and phalange 1-2-3 disarticulated. Phalange 1 proximal epiphysis is unfused but glued into place. Mandibles M3 is encrypt length of molar row unavailable M2 is missing from the right mandible measurements for M1 and M2 taken from the left. Compared to the animals from Tikal this is a large animal.
UF No 6795 *Mazama* a. male: Guatemala, Peten, Altar De Sacrifios. Box contains cranium, mandibles, scapula, phalanges.
UF No 6609 *Mazama* a. female West Indies, Trinidad, Nariva Tabaquit: box contains cranium, L&R mandibles, L&R metacarpals, L&R metatarsals, astragali, and calcanei, distal articulation of tibia L?, the distal ends of both radius the left is suitable for limited measurements, eight phalange 1 and eight phalange 2

UF No 6610 *Mazama* a. male. Trinidad, Mayaro, Guayaguayare: box contains cranium pedicles broken, L&R mandibles, metacarpals, metatarsals, astragali, calcanei, phalanges.
Environmental Archaeology reference collection *Mazama* UF:1440 *Mazama* sp. This box is multiple individuals sharing a common reference number requiring me to record the specimens as I would an archaeological collection.
Ref100 scapula *Mazama* sp. Distal 30% scapular spine is broken scapular neck and glenoid articulation only.
Ref101 scapula *Mazama* sp. Distal 40% scapular spine is broken. Lateral glenoid lip is eroded.
Ref102 humerus *Mazama* sp. Proximal 20% articulation only.
Ref103 radius *Mazama* sp. Proximal 80% very white and glossy possibly cooked, distal end has been destroyed by scavengers [teeth marks are not typical of dog] proximal end has also been gnawed.
Ref104 radius *Mazama* sp. Proximal 20% posterior lip is either eroded or possibly not completely ossified.
Ref107 ulna *Mazama* sp. Proximal 40% ulna shaft broken and missing, olecranon complete, robust, superior crest present prominent muscle scars.
Ref108 ulna *Mazama* sp. proximal 30% shaft broken, superior crest missing DPA only.
Ref109 metacarpal *Mazama* sp. proximal 60% post excavation breakage of shaft. Anterior surface shows only traces of carpal fusion. Posterior surface has a broad shallow groove.
Ref110 metacarpal *Mazama* sp. distal 70% shaft has been split laterally refit for measurements. Anterior surface has a pronounced groove where the carpals have fused, posterior surface presents as almost flat from distal end to midway up the shaft SDs is suspect.
Ref111 metacarpal *Mazama* sp. complete, anterior groove becomes obscure near center of shaft, posterior groove is wide. Deeper near the proximal end of the shaft but present the entire length.
Ref112 and 113 are possibly the same individual distal end of shaft is broken and missing, anterior groove is sharply defined and asymmetrical, posterior groove is marginally deeper.
Ref120 calcaneus *Mazama* complete single peak photo
Ref121 calcaneus *Mazama* sp. complete double peak photo
Ref122 phalanx1 *Mazama* sp. complete SD is on transverse plane
Ref123 phalanx1 *Mazama* sp. complete SD is on transverse plane
Ref124 phalanx2 *Mazama* sp. complete
Ref125 phalanx2 *Mazama* sp. complete
Specimen z: 8851 from Dos Pilas, Peten, Guatemala collected in 1993 almost complete skeleton.
Scapula all landmarks are recorded
Humerus SD on transverse plane 2/3 from proximal end.
Radius SD on transverse plan 1/3 from proximal end
Femur SD smallest diameter is 1/3 from proximal and slightly diagonal to the transverse plane.

Tibia SD on the transverse plane just superior to the distal articulation.
Specimen z:7930-147 Listed as male *Mazama americana*, no other data available. present in carton: complete metacarpal, metatarsal, and calcaneus. The measurements of this specimen are anomalous falling between WTD and other brocket deer specimens.

Appendix B assemblage field notes:

#1. La Joyanca Cervidae Metrics Dec 18 2014

Prof Emery provided me with the list of all Cervidae excavated at La Joyanaca Guatemala on 12/16/14; at a glance the majority of samples recorded don't look encouraging. However, that's on paper and the Joyanca collection is only one of thirteen collections in residence. Reality is often disappointing, but I should be able to pull some data, maybe a lot of data out of the assembled collections. The reference collection for example is not what I had hoped for in terms of statistics, but I wanted to get my hands on WTD bone and learn more about their shape, proportions, and physio-geometry. The latter was wildly successful; the Central American deer may be different than the Florida population; Irv also said I might look at the Key Deer. That would be better after I've worked with the archaeological material for a bit. I'

For now, I am recording the original line number, the context information recorded on the bag, and the dates listed in the spread sheet. The measurements will be recorded on my own spread sheet and a written description of the element being measured will be written here.

The original data sheet provided by Dr Emery listed 9 skeletal elements identified as *Mazama* americanus, 23 as Cervidae, 7 as artiodactyl, and 317 as Odocoileus virginianus for a total assemblage of 359; 84 samples presented one or more viable osteo-landmarks for measurement and were recorded.

Line # 39: metacarpal with proximal articulation and most of the shaft GL, Bd, Dd, and BFd unavailable; the shaft was complete to the epiphysis line so the SD could be recorded.

Line # 52: humerus proximal and distal ends are missing only SD could be measured.

Line # 262: antler base and pedicle (robust) only wide enough for the measuring tape to go around once; no distal measurement available.

Line # 194a: radius proximal end modified artifact Bp, Dp, BFp, and SD taken.

Line # 194b: radius distal end; in the same bag as 194a, roughly 10% but I don't see a description for a distal radius with these context numbers on the Cervidae recording sheet. Also in the bag a few shaft fragments

Line # 221: phalanx 1 complete, slight erosion on the distal articular edges, Bd not available.

Line # 236 distal condyles of the humerus lateral edge of condyle is eroded; greatest breadth distal and breadth of the trochlea are unavailable.

Line # NA left metatarsal not found in the data sheet. Roughly 80% complete distal shaft broken above epiphysis, proximal articulation is broken (trowel trauma) but fits together very neatly. The measurements should be acceptable.

Line # 225 Left humerus most of the shaft, head of the caput, and the fragment of the trochlea; only SD is valid.

Line # 243 proximal third of a left metacarpal; very weathered Bp and Dp only.
Line # 238 distal end of phalanx2
Line #234 proximal end of radius Bp, Dp, BFp, and SD taken.
Line # NA bag description OP122 E6-6 7-1-6-2 832 (197) unable to find corresponding description on the data sheet: distal articulation of the tibia, approximately 5% complete Bd and Dd taken.
Line # 216 OPE 121 Base Bud T5 partial calcaneus no viable measurements available.
Line # 35 Phalanx all landmarks are available full recording.
Line # 69 Phalanx all landmarks are available.
Line # 84 metatarsal proximal end and 50% of the shaft Bp, Dp, and SD taken.
Line # 85a phalanx1 described as almost complete, missing chip at proximal end Bp could not be taken all other landmarks were recorded.
Line # 85b phalanx 1 same bag as 85a same provenance all landmarks present and recorded.
Line # 207 scapula neck and glenoid, scapular spine and notch are broken. SLC, BG, LG, AND GLP are recorded.
Line # 176 ulna broken DPA only
Line # 52 metacarpal 20# proximal Bp and Dp recorded.
Line # 127a four phalanx2 in the same bag: all landmarks present
Line # 127b all landmarks present
Line # 127c all landmarks present and blacked
Line # 127d unfused proximal facet, significant chip in the distal articulation no measurements recorded.
Line # 125 phalanx all landmarks present
Line # 159 astragalus 90% complete depth medial unavailable
Line # 160 astragalus complete noticeably wider across the proximal breadth
Line # 161 astragalus complete all landmarks are present.
Line # 172 tibia distal end with fragments of shaft 20% Bd and Dd only.
Line # 165 calcaneus almost complete 80% no GL available.
Line # 167 calcaneus 40% no GL available.
Line # 76 astragalus complete, all landmarks are present; significant weathering of cortical surface.
Line # 75 astragalus complete all landmarks are present excellent preservation.
Line # 199 astragalus complete all landmarks are present
Line # 200 astragalus 95% all landmarks are present.
Line # 192 metatarsal 80% complete trowel trauma shaft is broken into four pieces that fit together perfectly; proximal articulation is broken laterally, distal condyles are fully fused, epiphysis invisible. Bp, Dp, and SD are unavailable, GL is a refit and should not be used as statistical data.

Line # 23 scapula neck and glenoid acromion process broken and lip of the glenoid eroded past reasonable use as a measurement SLC and BG recorded.
Line # 162 calcaneus complete all landmarks are available.
Line # 174 tibia distal end and four shaft fragments.
Line # 106 humerus shaft approximately 70% SD only.
Line # 154 scapula glenoid articulation only LG, BG' and GLP recorded
Line # 192 metatarsal four individuals in the bag only 194a was sufficiently intact for measurement. Bp, Dp and SD recorded the smallest diameter on these specimens seems slightly lower on the shaft than on the Florida deer.
Note to self: there should at least five acetabula in 124 go through the first drawer and see if you can find them.
Line # NA [Ope. 124 T6 6F26 (676)] Bag in the Ope. 124 drawer is labeled as not a priority. Mostly long bone shaft fragments but contains eight measurable samples not matched to the La Joyanca sheet. Complete calcaneus identified here as *Cervidae*, distal portion of astragalus identified here as *Cervidae* 40%, one complete 1rst phalange, two almost complete 1rst phalange 85% and three complete 2nd phalanx identified here as *artiodactyl.* Complete elements are remarkable for the muscle scars and evidence of bone remodeling.
Line # NA [Ope. 124 T6 6F26 (641)] *Mazama americanus* metacarpal 60% complete trowel trauma sample does not appear on Kitty's sheet, greatest length is a refit—smallest diameter is a refit.
Line # 90 astragalus charred from medial surface to the constriction. Lateral surface shows minor erosion. All land marks present.
01/06/15 first drawer of Ope. 130
Line # 339 Tibia distal articulation and 20% of the shaft Bd and Dd only.
Line # 253 humerus distal condyles only browned Bp, Dp, and SD not available.
Line # 346 scapula neck and part of the glenoid edges of the glenoid are too eroded to measure BG, GLP, or LG
Line # 345 2nd phalange complete charred all landmarks present.
Line # 343 1rst phalange eroded 75%
Line # 342 match with data sheet uncertain metatarsal 90% present broken in four pieces' distal condyles missing measurements are from refit.
Line # 361 metatarsal *Mazama* 85 distal shaft and condyles. Condyles too eroded for the BFd. The SD on this sample was nearer the distal end of the shaft and on the transverse plan. In WTD it is typically closer to the proximal end and on the sagittal plane. The difference could be a function of gait and species habitat. It is however impossible to be certain as the bone is incomplete.
Line # 274 humerus broken in half, radiating fractures around the break (trowel trauma) all landmarks except GL and GLC are available.

Line # 319 tibia almost complete broken in half GL is a refit, proximal epiphyseal line is fused but visible. Distal end is severally weathered, all landmarks are present.
Line # 310 scapula section of neck and glenoid notably the scapular spine was in good shape only ASG measurement was available.
Line # 315 calcaneus superior crest is broken off and missing no GL available.
Line # 314 calcaneus complete all landmarks are present.
Line # 297 1rst phalange complete all landmarks are present.
Line # 295a Phalange 1 complete all landmarks present two 1rst phalange in a small bag 295a is larger than 295b both appear to be rights
Line # 295b Phalange 1 complete all landmarks present.
Line # 298 Phalange 2 complete all landmarks are present charred.
Line # 316 calcaneus 70% complete superior crest is broken and missing.
Line # 277 humerus distal condyles and shaft 70% shaft is severely weathered SD not advisable.
Line # 286 mandible 30% molars 1-3
Line # 285 mandible 20% molars 2 and 3
Line # 338 ulna olecranon only superior crest is fused
Line # 332 phalange 1 all landmarks are present surface is highly weathered.
Line # 331 phalange 1 complete surface weathered small spot of charring at distal articulation all landmarks are present.
Line # 320? Ulna inferior portion of the olecranon: there are only two ulnas listed in Ope 130 specimens from lines 338 and 320 both are described as fused. The sample in the bag is heavily eroded. The superior crest of the olecranon is missing approximately where I would expect the suture line for the crest, however this may be biota exploiting the structural weakness of the bone.
Line # 313 astragalus almost complete medial surface is weathered all landmarks are present. Specimen is markedly smaller than other astragali in this collection.
Line # 275 humerus distal end surface is too weathered and eroded for any measurements except HTC
Line # 296 Phalange 2 complete all landmarks present
Line # 318 calcaneus complete all landmarks are present.
01/0915 Going back through the first few drawers today primarily to check the bags marked as non-priority for relevant samples.
Line # NA no description on data sheet [Op. 244 str.14] Astragalus heavily weathered all landmarks are present.

#2. Tipu Belize Jan. 13, 15 notes (some Lamanai samples mixed in) total 939 skeletal elements listed on the data sheet
T252:5 bag labeled as 'deer' not listed on original data sheet metapodial one section mid-shaft a second piece from the distal end of the shaft no viable osteo landmarks on either fragment. Second

bag T252:2 also labeled deer proximal shaft of the humerus unfused no viable measurements.
T191 phalange 1 Odocoileus complete all landmarks recorded
T278.3 Calcaneum species *Mazama* a. a. complete all landmarks recorded.
T278.5 astragalus *Mazama* a. almost complete medial surface damaged DM and Bp unavailable.
T279.5 phalange 2 *Mazama* a. complete. Miss identified on sheet as proximal phalanx
T249-1 pelvis: *Mazama* a. acetabulum almost complete relevant landmarks are preserved
T276.36 humerus *Mazama* a. trochlea and 80% of the shaft trochlea is significantly eroded SD, Bd, Dd, and HTC are recorded.
T276.15 metatarsal proximal articulation and 40% of shaft.
T276.16 femur shaft only SD recorded.
T194.10 humerus shaft only
T194.13 phalange 2
T174.2 metapodial identified as *Mazama* a. Morphology is doubtful anterior groove is virtually non-existent-posterior groove is wide and shallow more U-shaped than any deer specimens I've seen.
NOTE: get a hold of a *Mazama* a. skeleton and figure this out.
T178.4 *Mazama* a. radius proximal 20% sheet describes this sample as complete with an unfused distal epiphysis. This bag contains only the proximal end not more than 20% of the bone is visible.
T178-3 *Mazama* a. phalange 1 complete all landmarks recorded
T176-2 radius proximal *Mazama* a. a. proximal 70%
T176-3 astragalus complete *Mazama* a. a. all landmarks recorded
T176-4 phalange 2 Odocoileus v. complete all landmarks recorded.
T173-4 tibia Odocoileus v. distal 35% SD Bd Dd recorded.
T173-7 phalange 1 almost complete
T146-9 Phalange 2 almost complete all landmarks present and recorded.
T276-18 metapodial: description on data sheet for this catalog number list sample as innominate, species *Mazama* a. Anterior groove almost invisible, posterior groove is wide and shallow, shaft morphology is greater in breadth than in depth consistent with metacarpal from the *Mazama* a. sp. z:7930 from the museum's reference collection.
T276-19 scapula misidentified as innominate (see above) species *Mazama* a. Scapula neck and glenoid, body and spine of the scapula is broken; SLC, GLP, LG, and BG only.
T276-21 femur misidentified as cranium Odocoileus v. Femoral head has been glued into place, proximal epiphysis is closed; distal end is missing 80% SD and depth of femoral head only.
T232-084 metacarpal not listed on excel sheet proximal 40% probably *Mazama* a.
T232-086 tibia not listed on excel sheet distal end and part of shaft 25% SD, Bd, and Dd only. Almost certainly *Mazama* a.

T050-06 astragalus Odocoileus v. badly weathered medial surface mostly missing Dm medial depth unavailable.
T043-20 calcaneus not listed on excel sheet probably *Mazama* a. all landmarks are recorded.
T043-25 phalange 1 one of the duplicates complete all landmarks present.
T043-26 Phalange 1 a duplicate all landmarks present and recorded
T030-15 phalange 1 *Mazama* a. complete all landmarks recorded
T039-12 calcaneus *Mazama* a. complete all landmarks recorded
T0040-51 metatarsal *Mazama* a. distal 30%
T040-52 metatarsal *Mazama* a. distal 10%
T046-11 phalange 1 artiodactyl complete all landmarks recorded possibly *Mazama* a. not on excel sheet
T53-8 metatarsal Odocoileus v. proximal Bp, Dp, and SD only
T053-0 metacarpal proximal refitted and glued not listed on excel sheet Bp and Dp only
T037-12 phalange 2 complete all landmarks are recorded. charred
T043-15 scapula Odocoileus v. glenoid only BG, LG, and GLP only. One of the duplicates
T043-24 phalange 1 complete all landmarks recorded. One of the duplicates
T043-28 phalange 2 complete all landmarks recorded. One of the duplicates
T046-3 humerus distal condyles only Bd, Dd, BT, HT, and HTC recorded.
T046-1 astragalus *Mazama* a. complete all landmarks recorded.
T046-2 astragalus *Mazama* a. almost complete all landmarks recorded.
T033-1 metacarpal *Mazama* a. distal 10% Bp, and Dp only
T002-2 bovid phalanges historical material.
T058-2 radius *Mazama* a. shaft only pathology bone remodeling around what looks like a lateral fracture on the posterior surface. Note this 'pathology' is now understood to indicate possible fusion of ulna to radius, though a clear demonstration of this process is not documented for the species (amended 12/20/16).
Box-3
T083-21 ulna not listed on excel sheet tag identifies it as Odocoileus v. catalog number not written on specimen. A blue tag in the bag identifies this as lot T-33 Neither lot number appears on the provenance sheet. This is a very robust specimen; shaft broken, superior crest of olecranon missing. DPA only viable measurement.
T083-21 Metacarpal not listed on excel sheet; tag identifies it as *Mazama* a. catalog number not written on specimen. A blue tag in the bag identifies this as lot T-33 Neither lot number appears on the provenance sheet. Same lot and catalog number as above. Complete specimen: shaft is broken GL is a Refit all landmarks are present and recorded.
T143-26 humerus Odocoileus v. distal condyles and portion of shaft 25%. Epiphysis is fused but open.

T143-198 femur *Mazama* a. femoral head only; epiphysis fused and clearly visible.
T143-80 metacarpal *Mazama* a. sp. Proximal articulation and shaft. A large chip is missing from the posterior side of the articulation measurement is viable.
T143-10 metacarpal *Mazama* a. sp. Proximal articulation 10%
T143-8 ulna *Mazama* a. sp. Superior crest missing, shaft broken.
T143-13 scapula *Mazama* a. sp. Glenoid and portion of the neck.
T143-17 phalange 2 *Mazama* a. sp. Almost complete all landmarks recorded.
T143-19 phalange 1 *Mazama* a. sp. Complete all landmarks recorded
T143-15 astragalus *Mazama* a. sp. Almost complete, all landmarks are recorded
T143-21 astragalus *Mazama* a. sp. Almost complete proximal medial corner is broken off and missing.
T143-79 calcaneus Odocoileus v. complete trowel-trauma all landmarks recorded.
T143-87 Phalange 1 Odocoileus v. complete.
T143-86 phalange 2 Odocoileus v. complete
T142-18 tibia Cervidae probably *Mazama* a. not listed on excel sheet. Proximal epiphysis fused and closed. Proximal surface is notably eroded Bp not viable. Shaft has been broken and repaired with glue GL is a refit. Distal articulation is well preserved. Tibia repacked in top of the crate.
T287 tag says *Mazama* a. no catalog number on the bones; one fragment of long bone, calcaneus, two first phalange, no correspondence to any deer bones listed on sheet under T287. This bag will be repacked on top of the crate.
T426-5 scapula *Mazama* a. distal portion neck and glenoid only.
T426-3 calcaneus *Mazama* a. complete all landmarks recorded
T426-12 phalange 1 *Mazama* a. almost complete all landmarks recorded.
T426-10 Phalange 1 *Mazama* a. almost complete all landmarks recorded.
T469-9 calcaneus Odocoileus v. almost complete superior crest missing GL not available.
T469-1 tibia *Mazama* a. distal end 20%.
T462-5 scapula Odocoileus anterior edge part of the glenoid BG only.
T462-4 astragalus Odocoileus almost complete all landmarks recorded.
T464-1 radius *Mazama* a. distal and 60% of shaft.
T464-3 phalange 1 Odocoileus complete
T425-6 radius Odocoileus distal end 40%
T461-2 astragalus *Mazama* a. extra small complete
T413-1 metacarpal distal 60%
T280-11 tibia *Mazama* a. a distal 80% proximal end missing refit
T280-10 tibia not on excel sheet cross section is squarish might be sheep.

T282-8 metatarsal *Mazama* a. listed as metacarpal III+IV the deep anterior groove and almost flat posterior surface lead me to think this is a metatarsal rather than a metacarpal.
T285-17 calcaneus Odocoileus v. complete all landmarks recorded.
T285-15 radius *Mazama* a. proximal articular surface and portion of shaft roughly 25%.
T285-13 metatarsal *Mazama* a. proximal end of shaft 30%
T285-20 phalange 1 Odocoileus v. complete all landmarks recorded.
T285-14 phalange 2 *Mazama* a. a. complete.
T411-1 calcaneus described on the list as phalanx Odocoileus v. definitely not Cervidae. Set aside per Kitty's instructions.
T295-1 radius *Mazama* a. proximal 40% Pathology: a ridge of woven bone alongside a deep groove on posterior surface. Possibly evidence fora lateral fracture.
T295-2 metatarsal *Mazama* a. a. distal 40% broken refit.
Box-6
T319-1 humerus *Mazama* a. a. distal considerable erosion on both lateral and medial sides of the trochlea. Cut marks on the trochlea surface.
T319-6 tibia *Mazama* a. distal articulation only.
T376-011 astragalus *Mazama* a. not listed on excel sheet. Will repack on top of the box.
T395-2 calcaneus *Mazama* a. a. listed on sheet no catalog number on sample. Repacked on top of the box.
T366s-33 phalange 2 Odocoileus complete. listed on sheet no catalog number on sample. Repacked on top of the box.
T314-3 radius *Mazama* a. a. proximal 50% distal measurements unavailable.
T397-2 calcaneus *Mazama* a. a. inferior portion 60% GL unavailable.
T361-002 metatarsal Cervidae; small enough to be *Mazama* a. a. SD was problematic, taking the measurement on the transverse plane was smaller than the smallest diameter on the sagittal plane however the SD on the transverse is significantly higher up the shaft than other samples of *Mazama* a. The distal condyles are unfused but the proximal epiphysis is closed. T361 is not listed on the excel sheet.
T396-39 calcaneus Odocoileus v. ink on specimen is almost illegible. Superior crest is missing GL unavailable.
T396-61 femur *Mazama* a. a. femoral head Dp only.
T396-1 metacarpal *Mazama* a. complete all landmarks are recorded.
T396-19 phalange 1 *Mazama* a. a. complete: first encounter with this element described as *front phalanx*.
*Lot number 366: none of the specimens in this bag have catalog numbers at least one specimen is misidentified as *Mazama* a.
T366 astragalus Cervidae almost complete. No catalog numbers on any specimens in this bag. [T366-77] is listed as astragalus *Mazama* a. there are no other astragali listed for lot 366. This specimen is closer to Odocoileus in size and morphology.

T366-6 scapula *Mazama* a. glenoid only LG and BG only no catalog number on this specimen.
T366-7 scapula *Mazama* a. neck and glenoid. SLC only
T366-1 humerus *Mazama* a. distal 80% no catalog number on specimen.
T366-73 femur *Mazama* a. a proximal femoral head and 80% of shaft. No catalog number on specimen.
T366-9 femur *Mazama* a. distal articulation 20% Bd and Dd only no catalog number on specimen.
T366-23 femur *Mazama* a. femoral head only no catalog number.
T366-12 tibia *Mazama* a. a proximal 20% no catalog number on specimen.
T366s-90 ulna *Mazama* a. complete olecranon minor erosion on medial surface shaft broken and not in bag. Specimen 90 is described as complete. No catalog number on specimen. There are three ulna listed on the sheet for lot#366 two described as complete and one described as a fragment. In no case am I 100% certain of the match.
T366-63 ulna *Mazama* a. a. superior crest broken medullary cavity exposed. Only DPA available.
T366-76 radius *Mazama* a. a proximal 80% no catalog number on specimen.
T366-64 metacarpal *Mazama* a. a complete all landmarks recorded no catalog number on specimen
T366-65 metacarpal *Mazama* a. a. distal 40% no catalog number on specimen.
T366-66 metatarsal *Mazama* a. a proximal 90% no catalog number on specimen.
T366-68 metacarpal *Mazama* a. a proximal 70% no catalog number on specimen.
T366-69 metatarsal *Mazama* a. a proximal anterior surface approximately 20%
T366 metacarpal *Mazama* a. proximal 40% no catalog number on specimen. No matching description on Kitty's excel sheet. Test number 411T6.
Test numbers: three-digit sequence capitalize initial for site and box number from sequence.
T366-48 scapula Odocoileus v. glenoid only no catalog number on sample.
T366-47 scapula Odocoileus v. glenoid only no catalog number on sample.
T320-1 astragalus *Mazama* a. a. almost complete all landmarks recorded.
T320-02 astragalus *Mazama* a. a.75% medial distal corner missing.
Box 8 Cervidae Excel sheet stops at lot T596 context sheet ends at lot # T790
T730-020 metacarpal *Mazama* a. proximal 60% not listed on Kitty's excel sheet.

T732- astragalus Odocoileus v. not listed, no catalog number on specimen, all landmarks recorded.
T708-005 tibia *Mazama* a. distal 60% articular projections are notably eroded Bd is suspect. Not listed on Cervidae sheet.
T730 femur Odocoileus v. shaft only SD only no catalog number on specimen not listed on Cervidae sheet.
T697-05 radius Odocoileus v. complete all landmarks recorded beautiful preservation. No catalog number on specimen paper tag in bag. GL taken with calipers.
T721-01 femur *Mazama* a. almost complete Bd and Dd are refit. No catalog number on specimen.
T675 tibia Odocoileus v. distal 20% no catalog number available.
T730 femur *Mazama* a. proximal 75% including femoral head no catalog number available.
T692 scapula *Mazama* a. glenoid and neck considerable post excavation polishing no catalog number available.
T692 astragalus *Mazama* a. complete all landmarks recorded.
T692 femur *Mazama* a. proximal 25% Dp and Bp no catalog number available.
T698-032 metacarpal proximal 70% not matched to sheet.
T675 astragalus Odocoileus v. complete no catalog number available not listed on Cervidae sheet.
T699 calcaneus Odocoileus v. almost complete GL suspect no catalog number available.
T695 tibia Odocoileus v. proximal 40% no catalog number available.
T695 astragalus Odocoileus almost complete medial side is eroded all landmarks recorded.
T732-017 metacarpal *Mazama* a. proximal 60% catalog number on paper tag.
T691-02 tibia *Mazama* a. distal 30% Bd and Dd recorded.
T676 femur Odocoileus v. proximal 10% Dp only
T676 pelvis *Mazama* acetabulum relevant landmarks recorded.
T678 phalange 1 Odocoileus v. almost complete missing a chunk of the lateral proximal articular surface. No catalog number available.
T626 phalange 1 Odocoileus v. complete no catalog number available.
T626 calcaneus *Mazama* a. complete. No catalog number available.
T626 radius *Mazama* a. complete. No catalog number available.
T685 scapula *Mazama* a. glenoid only, charred. No catalog number available.
T685 phalange 1 *Mazama* a. complete no catalog number available.
T676 astragalus *Mazama* a. complete.
T685 Phalange 1 Odocoileus v. complete.
T685 astragalus Odocoileus v. complete some erosion around margins. No catalog number available.
T731-21 calcaneus *Mazama* a. complete, catalog number present. ☺ Box seven some catalog numbers are present lot# still exceeds Cervidae sheet.
T632-51 metatarsal *Mazama* a. proximal 40%.

T653 Phalange 1 Odocoileus v. complete no catalog number available.
T658 metacarpal *Mazama* a. proximal 30% no catalog number.
T502-3 metacarpal *Mazama* a. proximal 80% distal condyles unfused. Not listed on Cervidae sheet.
T502-4 metatarsal *Mazama* a. proximal 50% not listed on Cervidae sheet.
T502-2 humerus *Mazama* a. distal 80% condyles seem particularly undefined. Cross-section shows the cortical bone is very thin suggesting the animal was young. Species ident is tentative.
T502-1 radius *Mazama* a. complete. Not listed on Cervidae sheet.
T502-9 calcaneus Odocoileus v. complete, not on Cervidae sheet.
T502-11 scapula Odocoileus v. neck, glenoid, lower portion of scapular spine 50% complete.
T633 tibia *Mazama* a. distal 40% SD, Bd, Dd only. No catalog number available.
T635 tibia *Mazama* a. distal 80% SD, Bd, Dd only no catalog number available.
T635 scapula *Mazama* neck only, no catalog number available.
T635 phalange 1 *Mazama* a. mostly complete, minor erosions around distal and proximal articulations. No catalog number available.
T635 metatarsal *Mazama* a. proximal 25% only anterior surface.
T635 metacarpal *Mazama* a. almost complete distal condyles missing.
T632-4 phalange 1 Odocoileus v. almost complete, some erosion on the proximal medial surface Bp unavailable.
T632-3 astragalus *Mazama* a. almost complete.
T631-16 tibia Odocoileus v. distal 10%
T674-19 tibia *Mazama* sp. distal 30%
T637 astragalus Odocoileus v. complete.
T637 phalange 1 Odocoileus v. complete, remarkable for a tortoiseshell patina. Organic matrix still present in cortical bone.
T507-1 tibia *Mazama* almost complete, proximal end missing possibly unfused.
T633-22 metacarpal *Mazama* a. complete.
T652-01 calcaneus Odocoileus superior crest missing no GL available.
T674-20 calcaneus *Mazama* sp. Complete.
T653 metatarsal Odocoileus v. proximal 40% quite weighty.
T637-003 calcaneus Odocoileus v. almost complete minor erosion over entire surface.
Box 9
T733 phalange 1 Odocoileus complete.
T770-18 metacarpal *Mazama* sp. Bp and Dp recorded.
T770-14 Astragalus Odocoileus v. complete.
T763-99 astragalus *Mazama* sp. Superior lateral sheered away cut-mark.
T763-48 Phalange 1 *Mazama* sp. complete.
T763-47 phalange 1 *Mazama* sp. Almost complete slight erosion around the distal articulation.
T763-155 phalange 1 *Mazama* sp. Complete.

T763-46 calcaneus *Mazama* sp. Complete.
T788 astragalus Odocoileus v. distal 70% superior medial corner missing, GLM DM and Bp unavailable.
T788 calcaneus *Mazama* complete/
T733 humerus *Mazama* sp. Distal condyles only.
T776-03 radius *Mazama* a. distal Bd and Dd unavailable. Pathology? A double groove on the posterior surface seems remarkable.
T790-10 calcaneus Odocoileus v. GB unavailable.
T783-3 radius Odocoileus v. distal 80% GL and SD are refit Bp and Dp are unavailable.
T733-27 metatarsal Odocoileus proximal shaft split laterally Bp, Dp, and SD are refit.
T766 radius *Mazama* sp. Distal
T778-01 metatarsal *Mazama* sp. Complete anterior groove plainly visible.
T778-12 phalange 2 *Mazama* sp. complete.
T778-10 scapula *Mazama* sp. Neck and glenoid only
T783 metacarpal *Mazama* sp. Distal epiphysis unfused Dd and Bd are suspect.
T783 astragalus *Mazama* sp. Almost complete
T771-001 metacarpal *Mazama* sp complete
*T771-02 tibia *Mazama* sp. Distal 50% post-excavation wear of the articular protrusions. Pathology: posterior surface approx. three centimeters from joint is a lump of smooth cortical bone indicating healed trauma.
T771-003 Ulna Odocoileus v. complete olecranon GL not available.
T809 Astragalus Odocoileus v. complete.
T810-17 Astragalus *Mazama* sp. complete
T810-18 Astragalus *Mazama* sp. Complete
T795-06 Astragalus *Mazama* sp. Almost complete no Dm available.
T795-18 radius *Mazama* sp. Distal 20% Bd and Dd only.
T810-002 femur *Mazama* sp. Proximal femoral head present and fused trochanter absent. Distal articulation missing. Muscle scars are prominent.
Box-12
T734-005 humerus *Mazama* sp. Almost complete, trochanter missing GL and Bp unavailable.
T810-01 calcaneus Odocoileus v. complete
T143-2 humerus *Mazama* sp almost complete reference collection
T143-14 astragalus *Mazama* sp. Complete
T143-20 calcaneus *Mazama* sp. Almost complete
T143-11 ulna *Mazama* sp. Complete olecranon superior crest fused.
T168-71 scapula *Mazama* sp. 30% glenoid, neck and posterior margin. Not on list, date undetermined.
T168-20 scapula *Mazama* sp. 20% glenoid and neck.
LA916.54 metatarsal *Mazama* sp. Complete; refugee from another collection. I'll take the measurements now in hopes that I can added it to the right collection later.

T143-1 metatarsal *Mazama* sp. Complete.
T568-4 metatarsal *Mazama* sp. Proximal 80% distal epiphysis is unfused.
T168-74 metatarsal *Mazama* sp distal 30% not on list.
T168-77 metacarpal *Mazama* sp. Almost complete GL is refit. Not on Cervidae list.
Box-11 no relevant samples
Box 13
T674-21 astragalus: Label says *Mazama* but morphology is atypical however sample is stained and eroded. Not on the Cervidae list.
T730-22 astragalus Label says *Mazama* but morphology is atypical; the ear-like structures seem unusually distinct.
T732-02 metacarpal *Mazama* sp. Proximal 30%
T778-07 humerus *Mazama* a. distal 30% Dd is suspect.
T730-10 radius *Mazama* a distal 40%
Box-14
T426-2 humerus *Mazama* a. almost complete minor erosion on the proximal articular surfaces GL is suspect.
T426-6 radius *Mazama* a. complete.
T194-7 metatarsal *Mazama* a. complete.
T462-8 calcaneus *Mazama* almost complete superior crest is missing GL unavailable. Morphology of lateral side of the articulation is odd normally there is a tri peaked form this is more a single peak followed by a low platue, photo taken.
T143-27 ulna Odocoileus v. olecranon in excellent shape superior crest is present fusion line invisible, shaft missing.
T058-1 radius Odocoileus v proximal 60% erosion around the anterior lip of proximal articulation.
T143-77 radius Odocoileus v distal 30%.
LA916.35 radius Odocoileus v. bagged with T058-1 and T143-77 will measure now and hopefully include these measurements with the right collection. Posterior surface is eroded. Significant lipping of the articulation.
T591-1 femur Odocoileus distal 30% not on Cervidae list catalog number on bone, bag labeled as Odocoileus.
LA916-33 tibia artiodactyl almost complete from another collection bag label says Odocoileus but very small for a WTD tibia, the muscle scars are extremely prominent I would guess peccary rather than WTD.
LA834-7 calcaneus artiodactyl almost complete. Label says Odocoileus more from the intrusive collection.
Context questions: T462 excel sheet lists as mid-16th century but Table 3.6 list as early historic. Are they the same?
T464 excel sheet late post classic table3.6 lists as post classic same question—need some context information to clarify how fine a time line is available.
T366 is listed as 12-13th century in excel T366S is not defined and I thought I should ask.

I've divided the lot numbers without dates in two groups, lot numbers that don't appear on the excel sheet you sent me.
T143, 626, 632, 631, 633, 674, 675, 676, 678, 734, 766, 788, there are around a dozen more that I found dates for in the docs you gave me for cross referencing.
The second group are just lot numbers without dates and that also didn't appear on in the cross reference: T40, 46, 50, 58, 83, 146, 245, 279, 285, 288, 295, 361, 425, 426, 469, 507, 568, 591, 652, 653, 658, 691, 697, 699, 708, 721, 770, 771, 776, 790, and T809.
As we have already discussed, I found a number of specimens labeled as *Mazama* or Odocoileus that do not appear on the Cervidae id sheet that I suspect are a different type of artiodactyl (in my notes); specimens with catalog numbers that are also not listed and a number that had no catalog numbers to match that I think are probably deer but my lack of experience is good reason to doubt. If there is a list of all cataloged specimens I can delete any that I have mis identified. It's a robust data set but I don't want to sacrifice anything I don't have to.
La Joyanca: I'm still missing dates for Op.244 str.14, Ope.124 T6 6F26 (676), Ope.124 T5 6F11 Basurero (2631), Ope.122E6-6T-1-6-2 832 (197), and Ope. 122GE-5-T3-73 861 (24), these were all marked as low priority, but I'm not sure what that means in terms of my project.

#3. Trinidad De Nosotros Guatemala Feb. 05,15
Initial sheet did not include *Mazama sp.* or dates
6 WTD samples 1 *Mazama*
800TN phalanx1 *Mazama sp.* Complete significantly weathered.
801TN tibia *Odocoileus sp.* Distal 30% entire surface is granulated.
802TN metatarsal *Odocoileus sp.* proximal distal epiphysis unfused juvenile no more than 24 months distal measurements unavailable proximal articulation is broken Dp and SD only.
803TN phalanx1 *Odocoileus sp.* complete surface granulated surface kind of chalky.
804TN calcaneus *Odocoileus sp.* complete.
805TN calcaneus *Odocoileus sp.* complete.
drawer1 complete
#4. El Mirador Guatemala Feb 09/15
200M calcaneus *Mazama* sp complete.
201M radius Odocoileus sp proximal 30%
202M femur Odocoileus sp. Proximal 30% Dp only
203M metatarsal *Mazama* a proximal 20% Bp and Dp only refit
204M radius *Mazama* almost complete distal epiphysis unfused. No GL, Bd, Dd
205M humerus *Mazama* a distal 80% proximal condyles absent cortical bone extremely thin suggesting a very young animal.
207M metatarsal *Mazama* a proximal 50% rodent gnawed
Drawer two

208M phalanx1 Odocoileus sp complete.
209M calcaneus *Mazama* sp complete superior crest fused.
210M radius *Mazama* a proximal 70% trowel trauma.
211M metacarpal Odocoileus v proximal 80% unfused Bd and Dd unavailable SD is suspect. Smallest diameter on unfused metacarpals is consistently higher on the shaft than on fully fused specimens. This is also true of *Mazama* metacarpals and metatarsals.
212M humerus Odocoileus v. distal 10% condyles only.
213M scapula Odocoileus v distal 40% neck and partial glenoid. Spine is too eroded for ASG, glenoid is broken LG and BG unavailable.
214M scapula Odocoileus v distal 10% partial glenoid.
215M astragalus Odocoileus v complete.
216M metacarpal *Mazama* sp. Proximal distal condyles broken. This specimen is listed as unknown provenience possibly (0352, 0364,0384, 0391).
217M radius *Mazama* sp proximal 20% This specimen is listed as unknown provenience possibly (0352, 0364,0384, 0391).
218M radius *Mazama* sp proximal 25% posterior edge of specimen is too eroded for valid measurements BP only. This specimen is listed as unknown provenience possibly (0352, 0364,0384, 0391).
219M phalanx1 *Mazama* a complete. This specimen is listed as unknown provenience possibly (0352, 0364, 0384, 0391).
220M 219M phalanx1 *Mazama* a complete. This specimen is listed as unknown provenience possibly (0352, 0364, 0384, 0391).
221M 219M phalanx1 *Mazama* a complete. This specimen is listed as unknown provenience possibly (0352, 0364, 0384, 0391).
222M phlanx1 Odocoileus v. complete
223M phalanx1 Odocoileus v almost complete; not matched to data sheet. Possibly misidentified and as phalanx2, the distal articulation with its distinctive shape has been broken. The smallest diameter on this specimen is in the transverse plane not the sagittal plane indicating it is a phalanx1.

#5. Aguateca Guatemala Feb. 12,15
900AG phalanx1 Odocoileus v complete.
901AG phalanx1 Odocoileus v complete.
902AG astragalus Odocoileus v complete.
903AG humerus Odocoileus v almost complete broken in three places GL and GLC is a refit GLC taken with calipers GL taken with osteoboard board is typically 4mm greater than same measurement with calipers. Proximal epiphysis is closed but visible.
904AG radius Odocoileus v distal 70% pathology: slight ridge along the ulnar groove more interesting is the groove itself is almost filled with woven bone.
905AG radius Odocoileus v proximal 40% serious erosion on posterior surface only Bp available.
906AG phalanx1 Odocoileus v complete
907AG astragalus Odocoileus v complete.

908AG ulna Odocoileus v complete olecranon superior--crest fused, GL unavailable.
909AG radius Odocoileus v proximal 80% distal end broken.
910AG calcaneus Odocoileus distal 70% superior crest absent no GL available, medial surface eroded GB unavailable.
#6. El Kinel Feb. 13, 15
300SL metatarsal Odocoileus sp almost complete 95% broken into three pieces the posterior edge of the proximal surface is absent Dp unavailable Bp suspect, GL is a refit and suspect.
301SL tibia Odocoileus sp distal 30% Bd and Dd only.
302SL astragalus Odocoileus v almost complete 80% listed as a talus all landmarks are present.
Drawer2
303SL humerus Odocoileus distal 25% medial surface of condyle is eroded no BT available.
304SL phalanx1 Odocoileus complete. Ventral surface has a pronounced arch.
305SL metatarsal Odocoileus v proximal 15% cut crosswise possible to create a bone tube of some kind. Multiple cut marks on the posterior and medial surface.
306SL phalanx1 Odocoileus v complete original sheet describes rodent gnawing (nothing detected but normal weathering by this researcher).
307SL phalanx1 Odocoileus v complete.
#7. Punta de Chimino notes Feb. 17 2015
500PC phalanx1 Odocoileus complete.
501PC astragalus Odocoileus v complete.
502PC astragalus Odocoileus v complete.
503PC calcaneus Odocoileus v complete, superior crest fused.
504PC astragalus Odocoileus v. almost complete superior lateral corner missing GLl and Bp unavailable.
505PC phalanx Odocoileus complete.
506PC calcaneus Odocoileus almost complete superior crest absent GL unavailable, erosion around articular surface GB suspect.
507PC phalanx Odocoileus v. distal proximal end broken medullary cavity exposed cortical bone thick/mature individual?
508PC phalanx Odocoileus v. complete
509PC humerus Odocoileus v. distal 25% cut marks.
510PC radius Odocoileus v. listed as almost complete in the bag 7 fragments, distal end intact proximal articulation splint longitudally, proximal measurements are refit GL unavailable.
511PC phalange Odocoileus v. complete.
512PC metatarsal Odocoileus v. distal 60%
513PC phalanx1 Odocoileus v. complete.
#8. Marco Gonzales Feb. 19 2015
Island site with no native deer population. No data sheet yet available no dates atm.
150MG radius Odocoileus v. proximal 20% significant erosion.

151MG tibia Odocoileus v. distal 30% posterior surface of the shaft is absent. Bd and Dd only.
152MG tibia Odocoileus v. complete minor erosion not sufficient to inhibit measurements. Proximal epiphysis is fused but visible, a series of cut marks on the posterior surface are not sufficiently deep for the artifact to be used as a rasp.
153MG tibia Odocoileus v. distal 50% deep longitudal grooves in both anterior and posterior surfaces.

#9. Piedra Negras Feb 24 2015

700PN phalanx1 Odocoileus almost complete proximal medial corner absent no GL or Bp available.
701PN calcaneus Odocoileus articular segment 30% GB and GD only.
702PN phalanx2 Odocoileus v. complete.
703PN phalanx2 Odocoileus v. almost complete
704PN phalanx1 *Mazama* a. complete.
705PN phalanx2 Odocoileus v. complete.
706PN astragalus Odocoileus v. almost complete.
707PN metacarpal Odocoileus v. distal 50% iron staining.
708PN phalanx1 Odocoileus v. complete prominent muscle scaring.
709PN Phalanx1 Odocoileus v. complete prominent muscle scaring.
710PN Phalanx2 Odocoileus v. complete.
711PN Phalanx2 Odocoileus v. complete.
712PN Phalanx1 Odocoileus v. complete. More gracile than other specimens.
713PN phalanx1 *Mazama* a. complete. Minor erosion and root etching.
714PN scapula *Mazama* a. glenoid only LG and BG available.
715PN astragalus Odocoileus almost complete significant erosion particularly on the posterior medial edge. Matching data sheet problematic—no provenience number on specimen floatation sample in this bag was PN54A-3-3 no astragali in the data sheet has this number however description matches pn54A-3-2.
716PN astragalus Odocoileus v. complete.
717PN astragalus Odocoileus v. complete.
718PN astragalus Odocoileus v. complete. The lateral side of this specimen seems rather gracile.
719PN calcaneus Odocoileus v. 95% GD unavailable gracile superior crest's suture is just barely visible.
720PN scapula Odocoileus v. 30% glenoid and scapula neck good preservation but considerable post excavation breakage more than 16 separate fragment in the bag with specimen.
721PN radius Odocoileus v. proximal 50% much lighter than other samples in collection porcelain sheen possibly cooked though no burn marks. Intrusive?
722PN phalanx1 Odocoileus v. complete.
723PN phalanx2 Odocoileus v. complete.
724 PN phalanx1 *Mazama* a. complete. Problematic match tag number looks like 23G not like 23E however there are a limited number of

Mazama specimens listed and this is the closest match to the specimen.
725PN phalanx1 Odocoileus v. complete
726PN phalanx1 Odocoileus v. almost complete.
727PN phalanx1 Odocoileus v. complete.
728PN calcaneus Odocoileus v. inferior 70% superior crest broken no GL available.
729PN calcaneus Odocoileus v inferior 50% fragment GD only.
730PN femur Odocoileus v. proximal 10% femoral head Dp only.
731PN phalanx1 Odocoileus v. complete multiple cut-marks
732PN phalanx 1 Odocoileus v. complete
733PN tibia Odocoileus v. distal 20% significant trowel trauma Bd is suspect incised grooves on both anterior and posterior surfaces.
734PN radius Odocoileus v. distal 70% proximal articulation broken Bp, Dp, and BFp are refit missing part of the shaft SD not available.
735PN femur Odocoileus v. proximal 20% femoral head and trochanter epiphysis fused but open.
736PN humerus Odocoileus v. distal 50% one of two distal humeri in this bag listed as 1 of 2.
737PN humerus Odocoileus v. distal 40% two of two significant erosion of lateral surface of the joint BT unavailable.
738PN femur *Mazama* a. shaft 80% SD only.
739PN phalanx1 Odocoileus v. complete.
740PN phalanx1 Odocoileus v. complete.
741PN phalanx1 Odocoileus v. complete.
742PN phalanx1 Odocoileus v. complete. There is no assigned date for this sample. Some of the original documentation for this site's dating has been lost (personal comm. Emery 2015). However, the bag containing this sample also had a Bos Taurus femur indicating this level is probably historical.
743PN Astragalus Odocoileus v. 80% significant erosion specimen is desiccated and crumbly to touch measurements are suspect.
744PN Phalanx1 Odocoileus v. complete.
745PN phalnax2 Odocoileus v. complete.
746PN phalnax2 Odocoileus v. complete.
747PN phalnax2 Odocoileus v. complete.
748PN astragalus Odocoileus v. complete
749PN astragalus Odocoileus v. complete. No assigned date on the spread sheet but cattle bones in the bag suggest a historical date.
750PN radius Odocoileus v. proximal 40% no date listed.
751PN Radius Odocoileus v. complete GL is refit all landmarks are recorded.
752PN scapula Odocoileus v. glenoid and scapular neck 30% minor abrasion of glenoid rim.
753PN metacarpal *Mazama* a. distal 20% specimen is very small distal condyles are fused indicating at least two years of age.
754PN humerus Odocoileus v. distal 80% shaft is too fragile for measurement, distal condyles are eroded.

755PN astragalus Odocoileus v. almost complete significant weathering of medial and lateral surfaces.
756PN astragalus Odocoileus v. complete. Beautifully preserved the bone feels good in the hand medial side has a slight arc/concave surface (not artifact).
757PN astragalus Odocoileus v. almost complete.
758PN astragalus Odocoileus v. complete burned/calcined.
759PN radius Odocoileus v. proximal 10%.
760PN scapula Odocoileus v. glenoid and scapular neck.
761PN phalanx1 Odocoileus v. complete pathology distinctive hook like spur on the inferior surface.
762PN phalanx1 Odocoileus v. complete.
763PN phalanx2 Odocoileus v. almost complete considerable erosion
764PN phalanx1 Odocoileus v. almost complete 1 of 2 minor erosion on this specimen should not impact measurements, second specimen is too degraded for useful recording.
765PN phalanx1 Odocoileus v. complete.
766PN radius Odocoileus v. proximal 30% the .5 value on the data sheet is optimistic. Minor erosion around the lip should not impact measurements.
767PN humerus Odocoileus v. distal 80% distal epiphysis is fused but open.
768PN astragalus Odocoileus v. almost complete.
769PN phalanx1 Odocoileus v. complete.
770PN phalanx2 Odocoileus v. complete.
771PN phalanx1 Odocoileus v. complete 1 of 2 right side
772PN phalanx1 Odocoileus v. complete 2 of 2 left side
773PN metatarsal Odocoileus v. proximal 80% distal condyles absent. Minor breakage proximal posterior edge of articulation.
774PN tibia Odocoileus v. distal 20% broken SD suspect.
775PN astragalus Odocoileus v. complete.
776PN radius Odocoileus v. distal 90% proximal articulation is present but refit is not viable for measurement.
777PN humerus Odocoileus v. distal 20% trochanter only. Thin layer of concretion over most of the surface.
778PN calcaneus Odocoileus v. complete.
779PN phalanx1 Odocoileus v. complete. Proximal epiphysis fused but open animal is under one year.
780PN phalanx2 Odocoileus v. complete.
781PN phalanx2 Odocoileus v. almost complete
782PN phalanx1 Odocoileus v. almost complete.
783PN phalanx1 Odocoileus v. complete.
784PN ulna Odocoileus v. inferior potion of olecranon, superior crest absent.
785PN radius Odocoileus v. proximal 80% only missing the distal articular surface.
786PN astragalus Odocoileus complete. Not listed on sheet. No dates available.

787PN astragalus Odocoileus v. almost complete tag list it as mammal long bone does not match description of listed astragalus with that provenience number. Currently orphan.
788PN astragalus Odocoileus v. complete.
789PN calcaneus Odocoileus v. complete
790PN phalanx1 Odocoileus v. complete.
791PN phalanx Odocoileus v. complete.
792PN phalanx Odocoileus v. almost complete.
793PN phalanx1 Odocoileus v. complete no date.
794PN phalanx1 Odocoileus v. complete.
795PN phalanx1 Odocoileus v. complete.
796PN phalanx1 Odocoileus v. almost complete. Significant erosion around the proximal articulation makes GL suspect all other measurements are sound.
797PN calcaneus Artiodactyl almost complete. Tag identifies this as Odocoileus, I am 90% sure this is a peccary. Superior crest is absent and GL is unavailable, shaft has a slight curve that is quite distinctive, texture of cortical bone is porous and without any of the ridging typical of Odocoileus. Sample has been rebagged and tagged.
798PN phalanx1 Odocoileus v. almost complete. Significant erosion all measurements are sound.
799PN phalanx1 Odocoileus v. almost complete. Lateral proximal facet is broken GL suspect. Specimen is remarkable for its smooth almost polished texture. No date available.
800PN phalanx2 Odocoileus v. complete.
801PN phalanx1 Odocoileus v. almost complete. Artefact! Distal end is perforated Bd is unavailable.
802PN phalanx2 Odocoileus v. complete.
803PN phalanx2 Odocoileus v. complete. Prominent muscle scars/attachments.
804PN astragalus Odocoileus v. almost complete, significant weathering of cortical surface and minor erosions. All measurements are sound.
805PN astragalus Odocoileus v. distal 75% superior portion broken GLl, GLm, LLMc, and Bp unavailable.
806PN astragalus Odocoileus v. complete.
807PN phalanx1 Odocoileus v. complete. Proximal epiphysis is fused but partially open.
808PN phalanx1 Odocoileus v. complete.
809PN phalanx2 Odocoileus v. mostly complete minor erosion.
810PN astragalus Odocoileus v. complete extensive weathering no date listed.
811PN astragalus Odocoileus v. complete extensive weathering no date listed.
812PN phalanx2 Odocoileus v. complete.
813PN radius Odocoileus v. proximal 50%
#10. Cancuen Mar. 07,15

900C femur *Mazama* sp 90% trochanter absent, lateral condyle broken attempted refit failed. First relatively intact long bone for *Mazama*. Smallest diameter is one third down from femoral head.
901C tibia Odocoileus distal 30% Bd and Dd only. Cat.# 412-415 all from same individual (412-419 probably all from same indiv.); large individual
902C radius Odocoileus proximal 60% minor erosion around articular facet.
903C radius Odocoileus proximal 80% E. Thortnon notes: *very large individual; possibly for Sr analysis*
904C femur Odocoileus distal 30% modified. Very prominent muscles attachments. shaft cut and snapped horizontally through middle of shaft; incised groove incised around circumference of shaft just below break; cut mark on lateral side of lateral condyle very large individual.
905C metacarpal Odocoileus 75% significant trowel trauma.
906C metatarsal Odocoileus 50% shaft split lengthwise in three places; original data sheet records four fragments only three are in the bag. The missing frag represents 25% of the shaft. Measurements are from refit.
907C humerus Odocoileus distal 30%.
908C calcaneus Odocoileus complete.
909C metatarsal Odocoileus proximal 70% large individual
910C metatarsal Odocoileus proximal and distal ends of the same bone missing a cross section of mid shaft. Lateral distal condyle is broken off BFd is a refit. smaller individual than #1309 (MNI = 2)
911C metacarpal Odocoileus distal 25% epiphysis closed but still visible. Bone is browned inside and out.
912C femur Odocoileus proximal 10% femoral head only Dp available.
913C tibia Odocoileus proximal 15% epiphysis fused but visible.
914C tibia Odocoileus distal 60% multiple shallow cut-marks on anterior side of shaft
915C metacarpal Odocoileus 25% distal.
916C femur Odocoileus distal 25%. Epiphysis visible but fused.
917C femur Odocoileus distal 25% Epiphysis visible but fused, cut-marks on anterior shaft.
918C tibia Odocoileus proximal 30% epiphysis fused but open. Multiple cut-marks on posterior surface possibly an artifact.
919C femur Odocoileus proximal 30% epiphysis fused and obscure.
920C radius Odocoileus proximal 40% pathology a ridge of rough woven bone parallel to the ulnar groove.
921C radius Odocoileus distal 50% almost certainly the distal end of sample 920C the pattern of ridged woven bone continues.
922C ulna Odocoileus olecranon superior crest unfused and absent.
923C tibia Odocoileus proximal 10% significant erosion on the lateral edge of articular surface Bp suspect.

924C tibia Odocoileus distal 40% SD is a little higher up the shaft than usual but it's a bigger usual animal.
925C femur Odocoileus (Huge) proximal and distal ends refit for GL and SD failed.
926C tibia Odocoileus proximal 40% beautiful tortishell patina on these samples.
927C tibia Odocoileus distal 50%
928C scapula Odocoileus distal 40% spread sheet lists this specimen as almost complete. Sample observed in the bag scapular neck and glenoid complete, large section of scapular spine, another section of the anterior margin no refit possible.
929C humerus Odocoileus distal 80% proximal end absent. A series of cut-marks mid-shaft.
930C calcaneus Odocoileus complete
931C astragalus Odocoileus complete.
932C metacarpal Odocoileus proximal 50%
933C metatarsal Odocoileus almost complete lateral condyle broken off bagged and cataloged separately as 1212 perfect refit. GL taken with osteo-board (remember) board measurements are 4mm greater than those taken with digital calipers.
934C phalanx1 Odocoileus complete
935C phalanx2 Odocoileus complete left side. Sample bag 1211 contained two phalanx2 a left and a right that might be one individual. The right side specimen is listed below as 936C.
936C phalanx2 Odocoileus complete Right side.
937C femur Odocoileus distal 30% Dd only. Very eroded, shaft cut through at 90 degrees.

#11. Motul de San Jose 03/17/15 Accession number630

After being down with the flu for 20 days I'm back in the lab. No data sheet available, flying solo. Things I want to watch for are variations in calcaneus morphology. Abundance of particular elements.
200MSJ astragalus Odocoileus v. complete.
201MSJ phlanx1 Odocoileus v. almost complete 95% perforated, pitted and weathered.
202MSJ phalanx1 Odocoileus v. almost complete 90% specimen is weathered cut-marks and erosion at distal articulation Bd and Dd unavailable.
203MSJ radius *Mazama* a. proximal 30%.
204MSJ metacarpal Odocoileus v. proximal 25% modified perhaps as an awl, score marks on posterior surface. Posterior edge of proximal surface is eroded Bp only.
205MSJ phalanx1 Odocoileus v. almost complete, pitted, cut-marks on medial surface.
206MSJ phalanx1 Odocoileus v. complete prominent muscle scars. Bag contains phalanx2 possible the mate to this specimen.
207MSJ phalanx2 Odocoileus v. almost complete, hole bored in dorsal surface (probably not man made). Mate to 206MSJ?

208MSJ phalanx1 Odocoileus v. complete.
209MSJ ulna Odocoileus v. shaft broken 90% of olecranon anterior corner of superior crest is significantly eroded.
210MSJ calcaneus Odocoileus v. complete, comparative photo taken.
211MSJ calcaneus Odocoileus v. superior crest missing, unfused. In spite of the apparent age difference from 210MSJ demonstrated by the unfused superior crest, 211 is a larger specimen. Comparative photo taken.
212MSJ phalanx1 Odocoileus v. complete. Four phalanges are in the bag, two Phalanx1 one phalanx2 and one phalanx3 representing most of a complete foot. The muscle scars on this specimen are less distinct than specimen 213.
213MSJ phalanx1 Odocoileus v. almost complete prominent muscle scars see 212, possible pathology around distal condyles SDt suspect. Cut-marks on proximal dorsal surface.
214MSJ phalanx2 Odocoileus v. complete, articulates with phalanges 1 and 3
215MSJ phalanx2 Odocoileus v. complete
216MSJ phalanx2 Odocoileus v. almost complete 95% cut-marks on dorsal surface.
217MSJ astragalus Odocoileus v. 65% lateral proximal corner is broken and missing.
218MSJ astragalus Odocoileus v. complete.
219MSJ phalanx1 Artiodactyl almost complete. Provenience only very robust dorsal surface is more rounded than typical for Odocoileus.
220MSJ scapula Odocoileus v. 45% four fragments glenoid almost complete LG, BG and ASG only
221MSJ radius Odocoileus v. distal 40% carved
222MSJ astragalus Odocoileus v. complete
223MSJ astragalus Odocoileus v. complete
224MSJ scapula Odocoileus v. distal glenoid and scapular neck
225MSJ phalanx2 Odocoileus v. complete
226MSJ phalanx2 Odocoileus v. complete
227MSJ phlanax1 Odocoileus v. complete
228MSJ phalanx1 Odocoileus v. complete pathology/bone spur superior to distal condyles.
229MSJ femur Odocoileus v. proximal shaft has been cut remarkable preservation.
230MSJ acetabulum Odocoileus v. this is the first intact archaeological specimen, I’ve seen quite robust.
231MSJ calcaneus Odocoileus v. superior crest present articulation presents a single peak. Photographed for reference.
232MSJ humerus Odocoileus v. distal 80% proximal end missing trowel trauma.
233MSJ scapula Artiodactyl distal 20% glenoid and scapula neck, glenoid process is broken or unfused could be peccary or Odocoileus v.

234MSJ femur Odocoileus v. proximal 40% articulation and portion of shaft some fragmentation of trochlea, minor erosion over all, epiphysis is fully fused and obscured. Individual is mature but seems rather small.
235MSJ calcaneus *Mazama* sp. Complete articulation has double point photographed for reference.
236MSJ radius *Mazama* sp. Proximal 80% distal epiphysis unfused, label identifies specimen as Odocoileus v. clearly that is not the case here.
237MSJ calcaneus Odocoileus v. almost complete, articulation has a single peak. Photographed
238MSJ Metatarsal Odocoileus v. proximal 80% complete distal end missing probably unfused have added the SDt-SDs measurements to metapodials.
239MSJ astragalus Odocoileus v. complete

#12. Lamanai 03/19/15

No data sheet available however at least the first tray of specimens has individual catalog numbers. First bag is Odocoileus specimens that have been previously examined.
500LA metatarsal Odocoileus v. proximal 20%. SDt is suspect.
501LA metacarpal Odocoileus v. proximal 20%
502LA radius Odocoileus v. proximal 30% minor erosion around the articular surface cut-marks.
503LA calcaneus Odocoileus v. almost complete single peak photographed for reference.
504LA calcaneus Odocoileus v. almost complete, fused epiphysis is open, single peak photographed for reference.
505LA calcaneus Odocoileus v. proximal 60% articulation broken.
506LA calcaneus Odocoileus v. distal 70% unfused superior crest missing articular peak broken GB only.
507LA calcaneus Odocoileus v. distal 70% unfused superior crest missing, articulation presents a single peak photo for reference.
508LA calcaneus Odocoileus v. distal 60% unfused, superior crest missing large notch eroded from shaft, miniscule second peak. Photo for reference.
509LA calcaneus Odocoileus v. almost complete, fused, double peak, photo for reference.
510LA humerus Odocoileus v. distal 15% articulation only, minor erosion along lateral lip.
511LA humerus Odocoileus v. distal 10% posterior surface of shaft and condyles missing considerable erosion.
512LA tibia Odocoileus v. distal 9% articulation only small-ish
513LA tibia Odocoileus v. distal 30% small portion of attached shaft.
514LA tibia Odocoileus v. distal 50% fused but epiphysis open.
515LA tibia Odocoileus v. distal 30%
516LA scapula Odocoileus v. distal 30% glenoid and neck only.
517LA scapula Odocoileus v. distal 20% glenoid only.

518LA calcaneus Odocoileus v. distal 50% shaft broken cortical bone is thin enough to suggest juvenile.
519LA metatarsal Odocoileus v. ? proximal .3 posterior surface missing Bp only.
520LA ulna Odocoileus v. articulation only 20% shaft broken body of the olecranon missing.
521LA ulna Odocoileus v. articulation only 20% shaft broken body of the olecranon missing.
522LA astragalus Odocoileus v. missing inferior medial corner.
523LA astragalus Odocoileus v. complete.
524LA astragalus Odocoileus v. complete.
525LA astragalus Odocoileus v. complete.
526LA astragalus Odocoileus v. complete. Six astragali were in the bag, one of which was too damaged for measurement another was missing three of the six landmarks.
527LA phalanx1 Odocoileus v. complete, 1 of 23
528LA phalanx1 Odocoileus v. complete long and gracile.
529LA phalanx1 Odocoileus v. complete
530LA phalanx1 Odocoileus v. complete
531LA phalanx1 Odocoileus v. complete
532LA phalanx1 Odocoileus v. complete
533LA phalanx1 Odocoileus v. complete
534LA phalanx1 Odocoileus v. complete
535 LA phalanx1 Odocoileus v. complete
536 LA phalanx1 Odocoileus v. complete
537 LA phalanx1 Odocoileus v. complete
538 LA phalanx1 Odocoileus v. complete
539 LA phalanx1 Odocoileus v. complete
540 LA phalanx1 Odocoileus v. complete
541 LA phalanx1 Odocoileus v. complete
542 LA phalanx1 Odocoileus v. complete
543 LA phalanx1 Odocoileus v. complete
544 LA phalanx1 Odocoileus v. complete
545 LA phalanx1 Odocoileus v. complete
546 LA phalanx1 Odocoileus v. complete
547 LA phalanx1 Odocoileus v. complete
548LA phalanx1 Odocoileus v. complete
March 22 2015 second drawer (916).
549LA tibia Odocoileus v.? distal 30% shaft is split longitudally, minor erosions around articular lip. Very small individual but larger than mainland *Mazama*'s. so far the deer from this site are much smaller than other Maya collections observed.
550LA ulna Odocoileus v. proximal 30% superior crest missing, no cavity in olecranon. Shaft broken.
Drawer three (916) Four complete phalanges, one of which [916-24] is either pathological or severely eroded. Given the nodules of woven bone I favor pathology. I am excluding 24. 21, 20, and 26 have been recorded.

551LA phalanx1 Odocoileus v. complete. Polished.
552LA phalanx1 Odocoileus v. complete.
553LA phalanx1 Odocoileus v. complete, polished.
554LA humerus Odocoileus distal 90% proximal articulation missing, otherwise preservation is stellar, bone seems unusually gracile.
555LA ulna Odocoileus v. proximal 50% superior crest present shaft broken.
556LA astragalus Odocoileus v. complete.
557LA calcaneus Odocoileus v. almost complete, fused, single peak, photo.
558LA calcaneus Odocoileus v. inferior portion unfused, superior crest missing breakage around the articular wing GD suspect. Photo
559LA femur Odocoileus v. distal 20% condyles only considerable erosion Bd and Dd suspect.
560LA astragalus Odocoileus v. almost complete.
561LA tibia *Mazama* a. proximal 90% polished epiphysis fused but open, significant erosion Bp is suspect.
562LA humerus Cervidae proximal 20% unusually good preservation for proximal humerus. Tag in bag says *Mazama* but specimen is more in the WTD size range, very few of these bags have any tags. Second Cabinet ☺ equine metapodial and cattle bones in first tray.
563LA phalanx1 Odocoileus v. complete, no catalog number available.
564LA Radius Cervidae proximal 50% could be *Mazama* or Odocoileus
565LA phalanx2 Odocoileus v. almost complete medulla cavity is exposed, no catalog number available.
566LA phalanx1 Odocoileus v. complete.
567LA astragalus Odocoileus v. almost complete.
568 LA astragalus Odocoileus v. almost complete.
3-24/15 second tray *Mazama* ulna
569LA ulna *Mazama* sp. Shaft broken, olecranon complete, superior crest present.
570LA phalanx1 Odocoileus v. almost complete, minor breakage of distal articulation.
571LA Phalanx1 Odocoileus v. almost complete, proximal lateral surface broken.
3rd tray
572LA phlanx1 Odocoileus v. almost complete. No catalog number available.
573LA calcaneus Odocoileus v. distal 80% no catalog number available superior crest missing, medial condyle broken GD only. Double peak, photo.
574LA phalanx1 Odocoileus v. complete
575LA femur Odocoileus v. almost complete, significant erosion on medial and lateral edges of distal condyles, trochanter is broken and missing, distal and proximal epiphysis are fused and obscured.

576LA tibia Odocoileus v. almost complete 95% cavity in the proximal shaft, significant erosion proximal-anterior portion of articular surface.
577LA tibia Odocoileus v. distal 20% odd little layer of the cortical bone photo taken.
578LA humerus Odocoileus v. proximal 20% humeral head and trochanter, epiphysis fused but visible, significant erosion on lateral surface of humeral head.
579LA humerus Odocoileus v. distal 20% shaft broken possibly the distal end of 578LA good preservation of cortical bone.
580LA ulna Odocoileus v. proximal 50% olecranon is complete, shaft is broken.
581LA calcaneus Odocoileus v. almost complete gracile single peak photo
582LA calcaneus Odocoileus v. complete, single peak photo.
583LA calcaneus Odocoileus v. complete single peak and mesa, photo 3/25/15 cabinet 2, tray 6, single plastic bag, tag says Odocoileus v. tibia. Bag contains 1 proximal radius, 1 complete calcaneus I identify as Odocoileus v. 1 complete metatarsal I identify as *Mazama* sp. One complete tibia identified as artiodactyl (LA 916:33) possibly peccary or pig definitely not Odocoileus or *Mazama* sp. One distal femur (LA912:47 artiodactyl probably peccary or pig.
584LA metatarsal *Mazama* a. complete
585LA radius Odocoileus v. proximal 20%
586LA calcaneus Odocoileus v. complete.
3rd cabinet 2nd tray
587LA calcaneus Odocoileus v. distal 80% unfused superior crest missing double peak photo
588LA astragalus Cervidae almost complete, probably Odocoileus v. but very small individual, no catalog number available.
589LA tibia Cervidae distal 10% barely enough surface to measure. Specimen is heavily pitted and friable. No catalogue number available.
590LA acetabulum Cervidae anatomical feature is complete, second intact acetabulum.
591LA femur *Mazama* a. almost complete femoral head is unfused GLC, Bp, and Dp unavailable.
592LA femur *Mazama* a. proximal 20% femoral head and trochanter only.
593LA tibia *Mazama* a. proximal 20% minor erosion
594LA radius *Mazama* a. distal 50%
595LA calcaneus *Mazama* a. complete, single nob-like peak photo
596LA femur *Mazama* a. almost complete cortical surface of femoral head and trochanter are almost completely dissolved. Bone is bleach-white as if it has been cooked and mottled with green staining. There are no identifying marks on either the bone or the bag it was in. Almost certainly a modern intrusion, bagged and tagged.
597LA metatarsal *Mazama* a. complete.

03/27/15 Fri. last two trays
598LA tibia Cervidae distal 20% Bd and Dd only. Bag is labeled WTD contains two femur shafts without articular ends and a burned distal humerus that are greatly larger than this tibia could be goat but my best guess is *Mazama* a.
599LA phalange1 Odocoileus v. complete.
600LA metacarpal *Mazama* sp. complete.
601LA radius *Mazama* sp. Proximal 90% significant ridging along the ulnar groove probably a mature animal.
602LA radius Odocoileus v. distal 30%.
603LA ulna Odocoileus v. proximal 30% superior crest is missing, shaft is broken, cut-marks on medial surface, gnawing marks.
604LA tibia Odocoileus v. proximal 20% articular facets only.
605LA ulna Odocoileus v. proximal 50% olecranon is complete large individual.
606LA ulna Odocoileus v. proximal 30% shaft is broken superior crest present, robust with prominent muscle scars, minor erosion of superior anterior edge of crest.
607LA ulna Odocoileus v. proximal 50% shaft is broken Olecranon is almost complete, significant degeneration medial and lateral surface along fusion line of superior crest.
608LA humerus Odocoileus v. distal 60% lateral edge of distal condyle missing possibly chopped off in butchering. Possible gnaw marks. Constriction of the trochlea seems unusually smooth.
609LA humerus Odocoileus v. distal 50% broken mid shaft, gnaw marks lateral edge of trochlea.
610LA calcaneus Odocoileus v. complete single peak, photo
611LA calcaneus Odocoileus v. articulation and inferior portion of shaft, double peak photo.
612LA calcaneus Odocoileus v. articulation and inferior portion of shaft, single peak and mesa photo.
613LA calcaneus Odocoileus v. complete. Single peak photo
614LA astragalus Odocoileus v. almost complete.
615LA astragalus Odocoileus v. almost complete
616LA astragalus Odocoileus v. lateral surface intact 70% chop and cut-marks on medial inferior surface.
617LA astragalus Odocoileus v. complete cut-marks on medial surface.
618LA tibia Odocoileus v. distal 70% joint end has been gnawed Bd unavailable.
619LA metatarsal Odocoileus v. proximal 50%
Last tray specimens without provenance I'll record them anyway.
620LA radius Odocoileus v. proximal 40% no provenance available. Bone is white and chalky two separate islands of woven bone appear on posterior surface.
621LA astragalus Odocoileus v. complete no provenance available.
622LA astragalus Odocoileus v. almost complete no provenance available.

623LA astragalus Odocoileus v. almost complete no provenance available.
624LA astragalus Odocoileus v. almost complete no provenance available.
625LA calcaneus Odocoileus v. complete no provenance available, single peak, photo.
626LA calcaneus Odocoileus v. inferior portion, superior crest missing no provenance available, single peak, photo.

#13. Ek Balam 04/02/15

700EB metacarpal Odocoileus v. proximal 90%
701EB calcaneus Odocoileus v. complete, one of a pair possibly from the same individual, articular facets of the second specimen are broken leaving no viable measurements. At 82mm this seems to be a large individual.
703EB femur Odocoileus v. [?] distal 50% suspiciously large individual, prominent muscle scars, medial condyle to degraded for Bd, gnawing marks probably dog.
704EB humerus Odocoileus v. Proximal 70% suspiciously large individual. Humeral head and trochlea are unusually well preserved, no discernable gnawing marks
705EB humerus Odocoileus v. more normal size for this species. Significant destruction of the trochlea, thinness of cortical bone suggests a younger animal, clear gnaw marks possibly by dogs, possible cut-marks.
707EB metatarsal Odocoileus v. proximal 60% significant trowel damage.
709EB femur Odocoileus v. proximal 30% epiphysis fused but clearly visible
711EB scapula Odocoileus v. distal 40% glenoid and scapular neck
713EB ulna Odocoileus v. proximal 50% superior crest missing.
714EB ulna Odocoileus v. proximal 60% posterior corner of superior crest broken and missing. Pathology deep groove superior to the lip of medial side, bone weathering is pronounced. Notched on anterior edge of ulna shaft.
*716EB phalanx1 Odocoileus v. complete, pathology: dense lump of woven bone on proximal inferior surface.
719EB calcaneus Odocoileus v. complete on (the gracile side).

#14. Cueva De Quetzales 3/31/15 Cave site

First tray: three scapulae in tray with grouped with Cervidae material only one of which was Cervidae.
300CQ metacarpal Odocoileus v. distal 20%
301CQ metacarpal Odocoileus v. distal 60% gnaw marks on condyles.
302CQ scapula Odocoileus v. distal 40 scapular neck and glenoid.
303CQ astragalus Odocoileus v. complete large individual.
304CQ acetabulum Odocoileus v. beautiful preservation.
Second tray
305CQ radius Odocoileus v. proximal 30%.
306CQ metacarpal Odocoileus v. proximal 70% broken in five fragments.
307CQ metacarpal Odocoileus v. complete minor erosion at distal end scattered gnawing marks.
308CQ phalanx1 Odocoileus v. complete
309CQ phalanx2 Odocoileus v. complete
310CQ acetabulum Odocoileus v. broken in half and refitted with glue, measurements should be valid.
Third tray: nada

Fourth tray: one probable *Mazama* a. scapula no viable landmarks. Sample listed as Las Pacayas, mixed context? Bagged separately.
311CQ metacarpal Odocoileus v. proximal 90% distal condyles are unfused otherwise perfect preservation.
312CQ radius Odocoileus v. proximal 90% distal end of the bone is missing. possible gnaw marks?
313CQ radius Odocoileus v. proximal 50% erosion of articular lip.
314CQ ulna Odocoileus v. proximal 40% shaft broken, superior crest missing.
315CQ Radius Odocoileus v. proximal 60%--Las Pacayas LQ1A-4-1 unclear if this is intrusive or a subset? Recorded can be discarded later.
316CQ radius Odocoileus v. proximal 60% post excavation erosion posterior edge of articulation.
*317CQ radius Odocoileus v. proximal 50% large individual. Pathology posterior proximal surface remodeled bone possible infections, medial surface-rodent gnawing
4/01/15 sixth and final tray
318CQ humerus Odocoileus v. distal 10% condyles only.
319CQ phalanx1 artiodactyl complete listed on tag as artiodactyl almost certainly Odocoileus. Pathology, extensive bone remodeling on the ventral-medial facet.
320CQ humerus Odocoileus v. distal 60% good preservation.
321CQ radius Odocoileus v. distal 50%
322CQ radius Odocoileus v. almost complete, 4 fragments from the distal end have been refitted and glued into place, one or more fragments from the anterior surface are missing, Dd is suspect.
323CQ radius Odocoileus v. almost complete, appears to have been broken in half and refitted with glue, lower portion of the ulna shaft has fused with the radius, older individual. Extensive bone remodeling posterior proximal surface, some post excavation chipping of proximal lip.
324CQ humerus Odocoileus v. distal 70% almost entire shaft is intact. Proximal end missing, medial surface of trochlea severely eroded.
325CQ radius Odocoileus v. proximal 40% SD not available, extensive bone remodeling on posterior surface, numerous cut-marks on posterior surface indicative of bone work.
326CQ femur Odocoileus v. distal 30% epiphysis is fused but clearly visible, cut-marks indicative of bone working.
327CQ phalanx2 complete tagged as artiodactyl almost certainly Odocoileus v.
328CQ scapula Odocoileus v. distal 40% no species ID on tag. Scapula neck and glenoid only scapula neck is very short.
#15. San Pedro 4/01/15 ACC#0754 Island site Belize
Cabinet one, first tray
600SP metatarsal Odocoileus v. almost complete. very gracile, SD for this specimen is on transverse plane near the distal condyles.

Fifth tray
601SP mandible Odocoileus v. M2, M3 present. M2 missing
602SP scapula Odocoileus v. distal 40% very gracile, better preservation than is common for this element more than 50% of the posterior margin is present, scapular spine is also preserved.
Second cabinet first tray
603SP humerus Odocoileus v. distal 60% very weathered proximal head missing.
604SP humerus Odocoileus v. distal 15% trochlea only no shaft medial surface significant post excavation erosion.
3/02/15 Bottom tray, this tray has only been sorted to taxa, so I will bag and tag as I go.
605SP tibia artiodactyl distal 90% proximal head is unfused and missing.
606SP metacarpal artiodactyl almost complete, medial distal condyle broken so distal breadth measurements are not viable. Almost certainly Odocoileus v. Very gracile specimen.
607SP astragalus Odocoileus v. complete.
608SP calcaneus artiodactyl complete. Specimen is an interesting orange-ish shade., almost certainly Odocoileus v. rather gracile, single peak: Photo
Third cabinet bottom tray
609SP phalanx1 Odocoileus v. complete
610Sp metacarpal Odocoileus v. almost complete shaft is broken mid-way refit is good enough for a confident GL.
611SP femur Odocoileus v. proximal 40% shaft has been cut through suggesting bone working.
612SP phalanx2 Odocoileus v. complete
That's all of San Pedro ☺
#16. Copan 3-31-15
No data sheet to work from calcaneus measurements have been altered, now taking greatest breadth and depth from articulation/inferior Bc (breadth caudal), Dc (depth caudal) and the most superior end GBs, GDs this may or may not add information to be considered.
200C radius Odocoileus v. proximal 20% posterior lip eroded Dp suspect, specimen has a polished aspect and is very white; possibly cooked.
201C scapula Odocoileus distal 30% scapula neck and glenoid surface, glenoid process is unfused, most inferior tip of scapular spine is unfused, very young and small animal possibly *Mazama* sp. Rather than Odocoileus v.
202C calcaneus Odocoileus v. almost complete, medial wing of the articulation has been broken or cut away, small individual quite dense. Single peak Photo
203C astragalus Odocoileus v. complete.
204C humerus Odocoileus v. distal 10% dark iron staining.

205 phalanx2 Cervidae complete. Identified as artiodactyl on the label, Odocoileus v. is most likely.
206C calcaneus Odocoileus v. almost complete breakage/erosion of ventral surface makes BD -Dc unusable. Single peak photo.
207C radius Odocoileus v. proximal 10% articulation only.