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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I hereby declare that this dissertation is all my own work except as indicated in the texts.

Signature: ______________________

Date: September 15, 2017

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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.

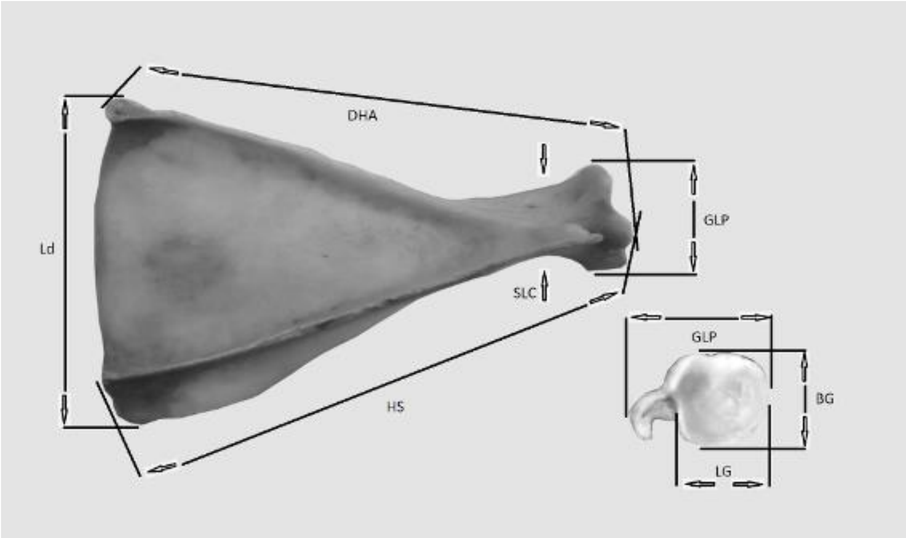

Figure 2-1 Scapula: specimen MVZ31118 from the Museum of Vertebrate Zoology (photo taken by author) and used with permission of MVZ.

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

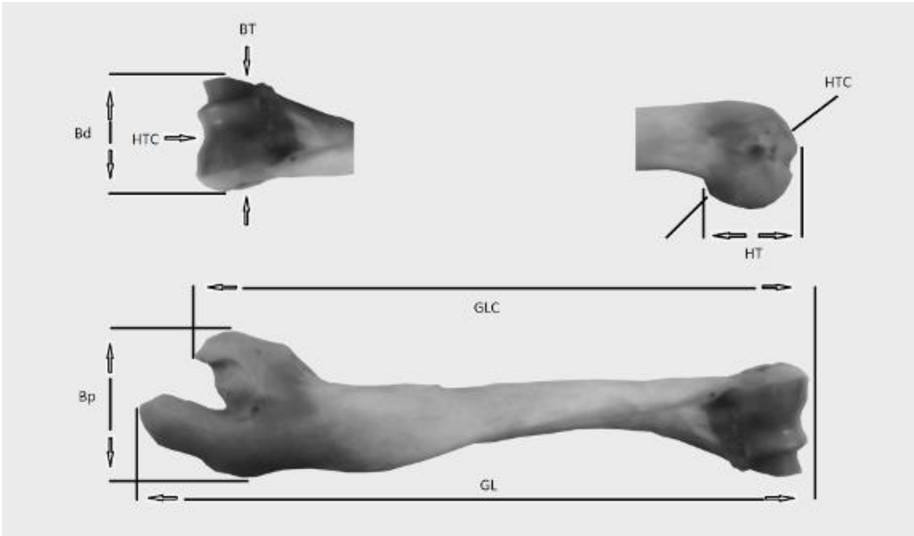

Figure 2-3 Humerus: specimen MVZ31118 from the Museum of Vertebrate Zoology (photo taken by author) and used with permission of MVZ.

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.

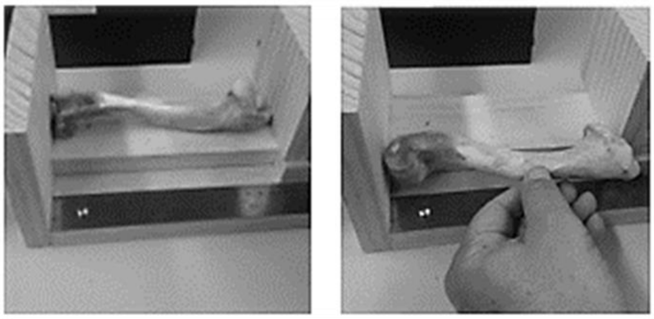

Figure 2-4 Humerus length: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

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.

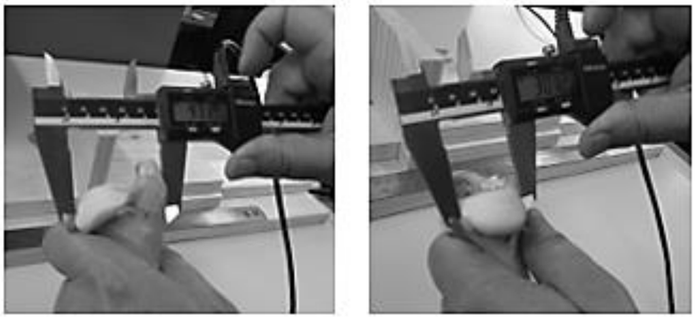

Figure 2-5 Proximal humerus: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

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

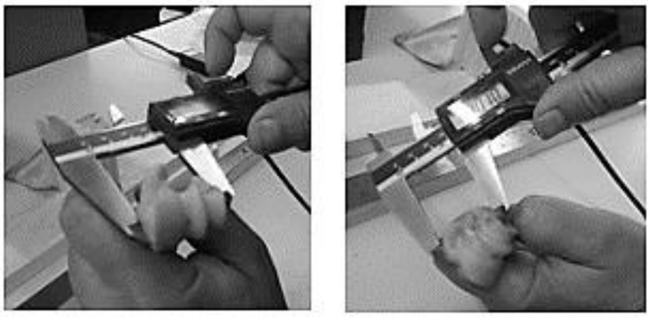

Figure 2-6 Distal humerus: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

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).

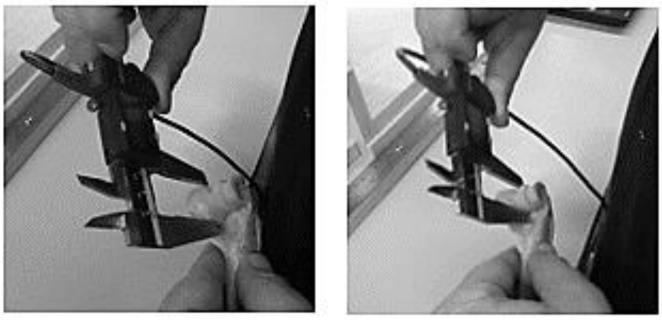

Figure 2-7 Trochlea: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

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.

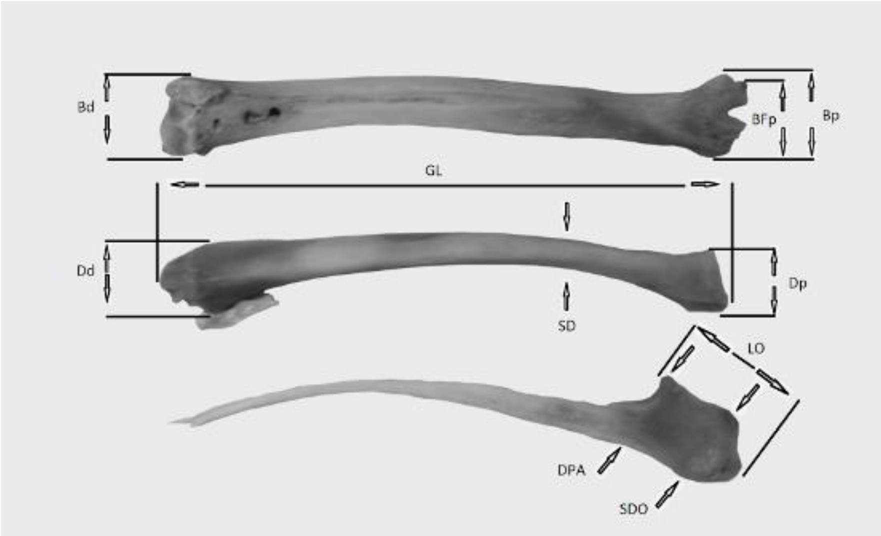

Figure 2-8 Radius and ulna: specimen MVZ32031 from the Museum of Vertebrate Zoology (photo taken by author) and used with permission of MVZ.

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).

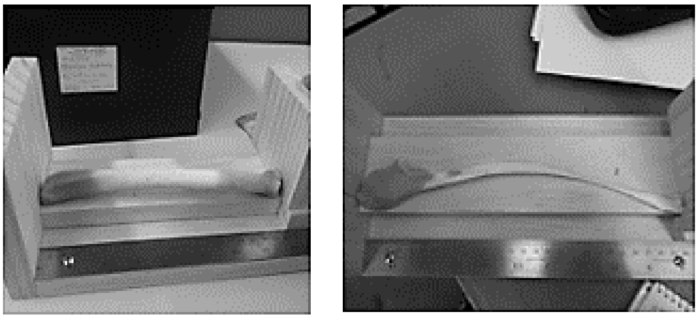

Figure 2-9 Radius length: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

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.

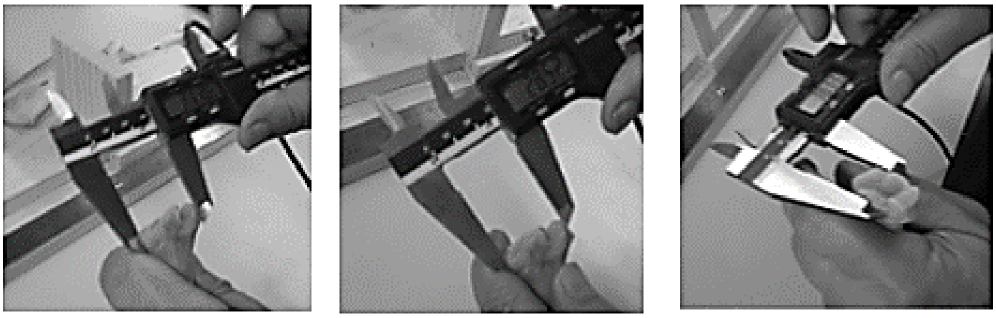

Figure 2-10 Proximal radius: from FLMNH-EAP (photo by Sophie McGraw). Used with permission of FLMNH-EAP.

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

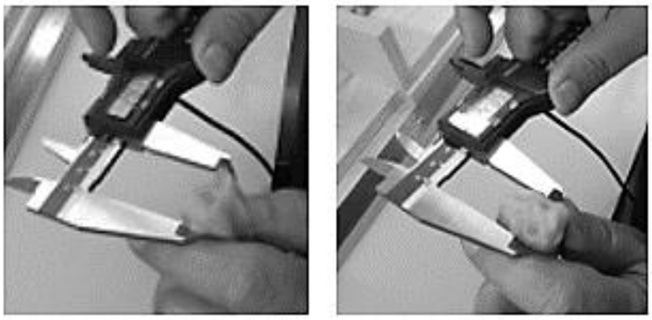

Figure 2-11 Distal radius: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

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.

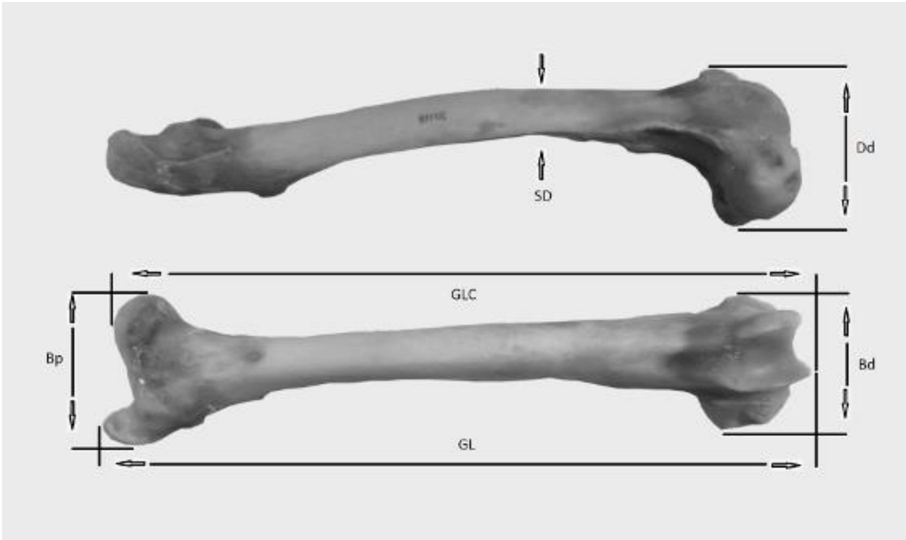

Figure 2-13 Femur specimen MVZ31118 from the Museum of Vertebrate Zoology (photo taken by author) and used with permission of MVZ.

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.

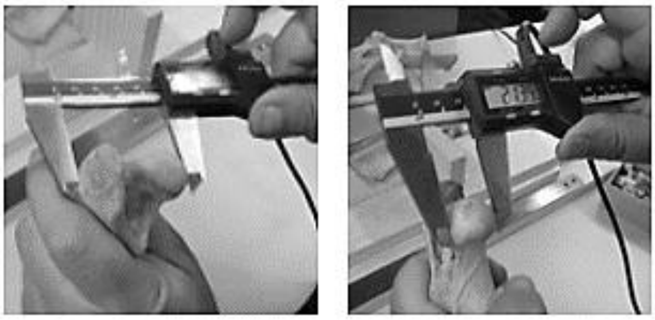

Figure 2-14 Proximal femur: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

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

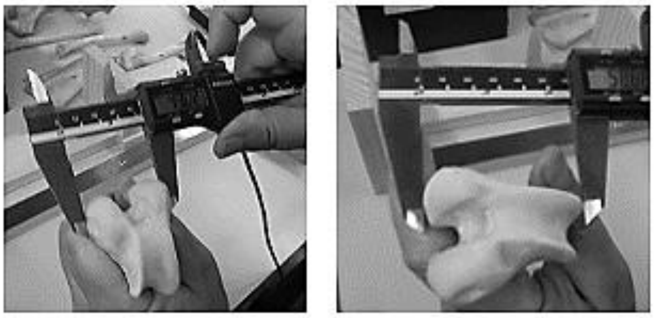

Figure 2-15 Distal femur: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

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

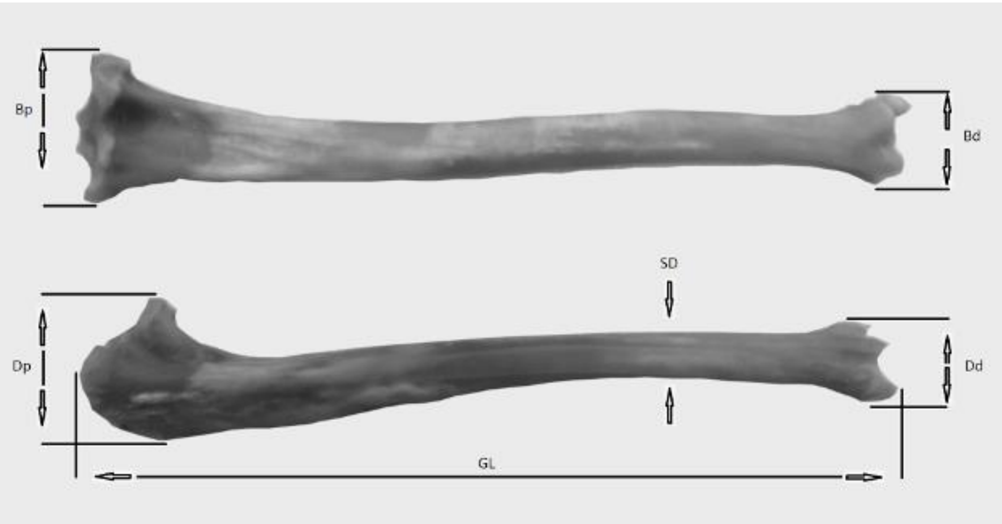

Figure 2-16 Tibia: specimen MVZ31118 from the Museum of Vertebrate Zoology (photo taken by author) and used with permission of MVZ.

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

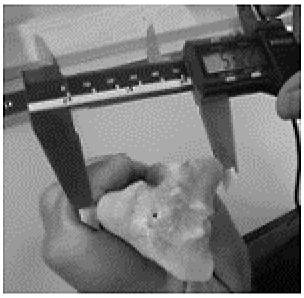

Figure 2-17 Proximal tibia: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

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).

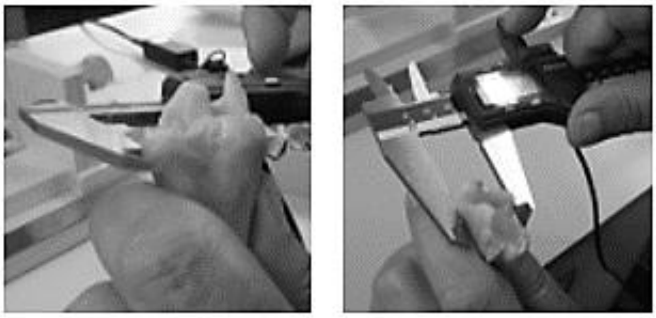

Figure 2-18 Distal tibia: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

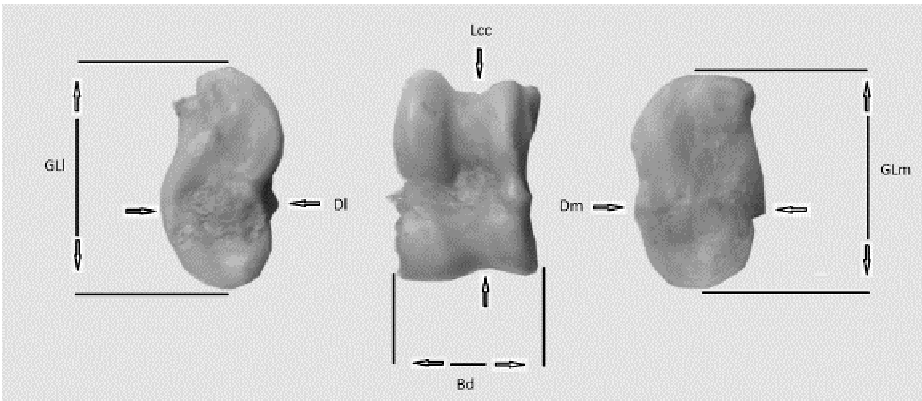

Figure 2-19 Astragalus: specimen MVZ31118 from the Museum of Vertebrate Zoology (photo taken by author) and used with permission of MVZ.

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).

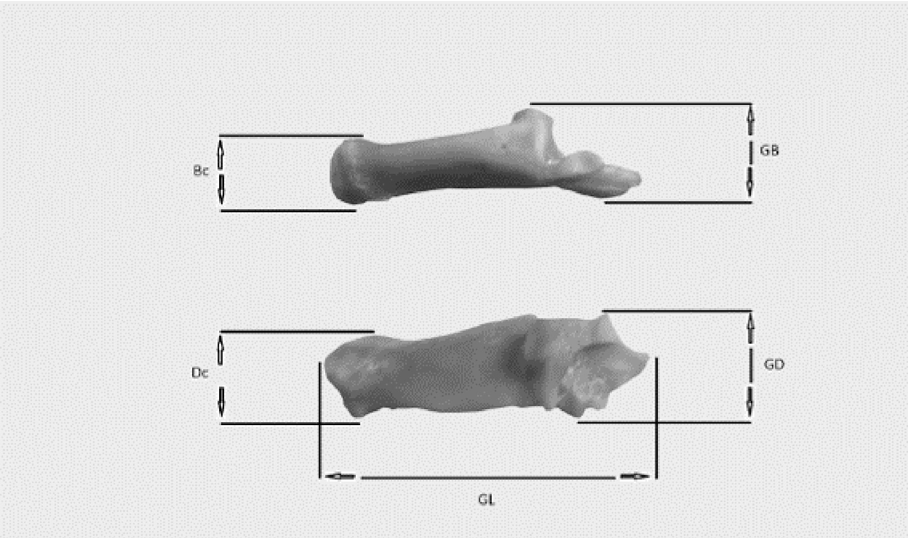

Figure 2-20 Calcaneus: specimen MVZ31118 from the Museum of Vertebrate Zoology (photo taken by author and used with permission of MVZ).

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.

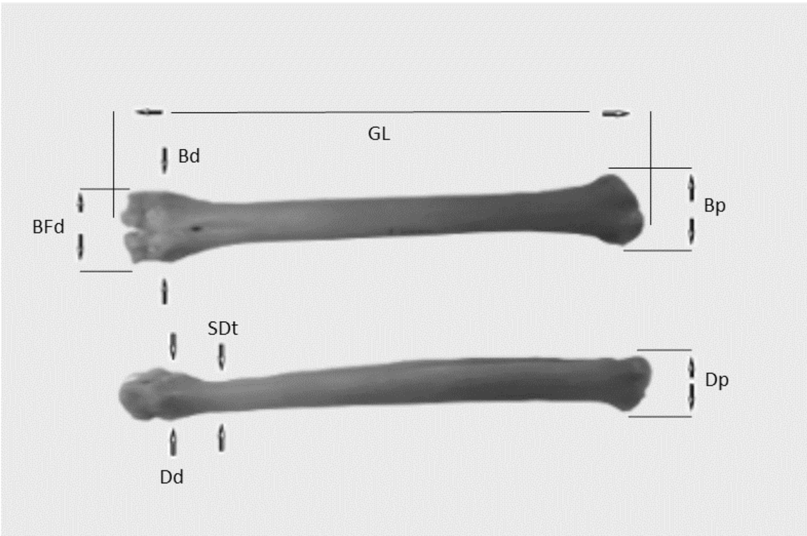

Figure 2-23 Metacarpal: specimen MVZ 31118 from the Museum of Vertebrate Zoology (photo taken by author) and used with permission of MVZ.

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.

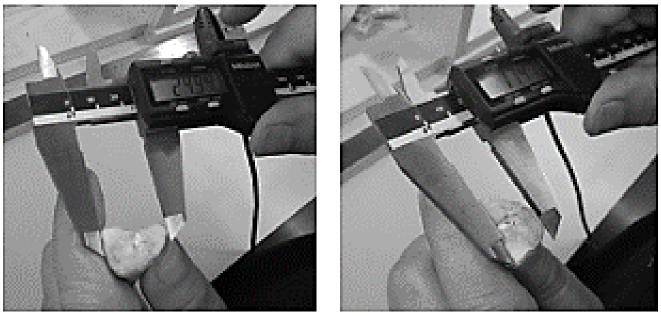

Figure 2-24 Proximal metacarpal: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

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.

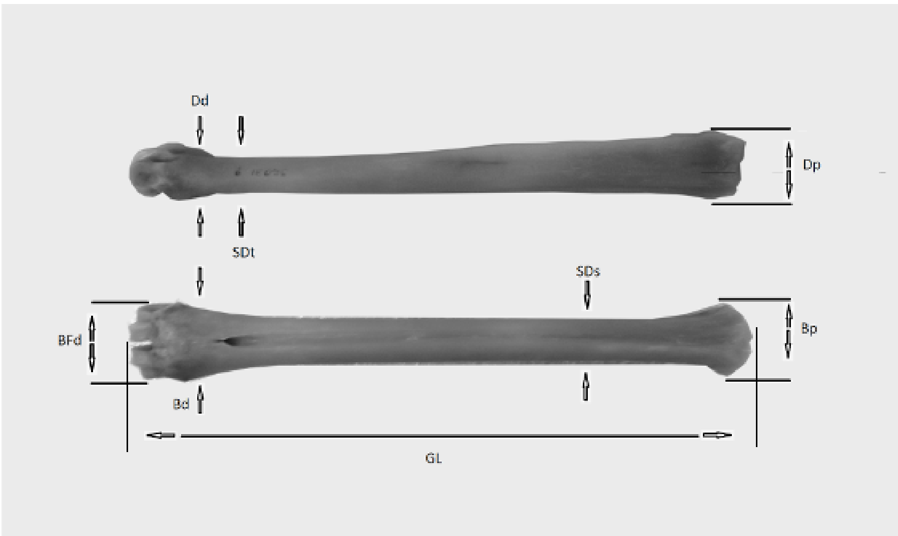

Figure 2-26 Metatarsal: specimen MVZ31118 from the Museum of Vertebrate Zoology (photo taken by author) and used with permission of MVZ.

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.

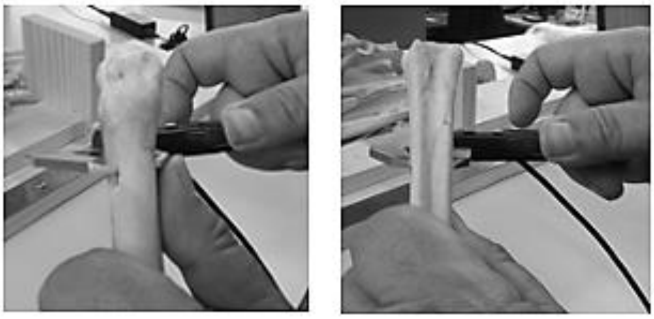

Figure 2-27 Smallest diameter of the metatarsal: from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Sophie McGraw and used with permission of the FLMNH-EAP.

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.

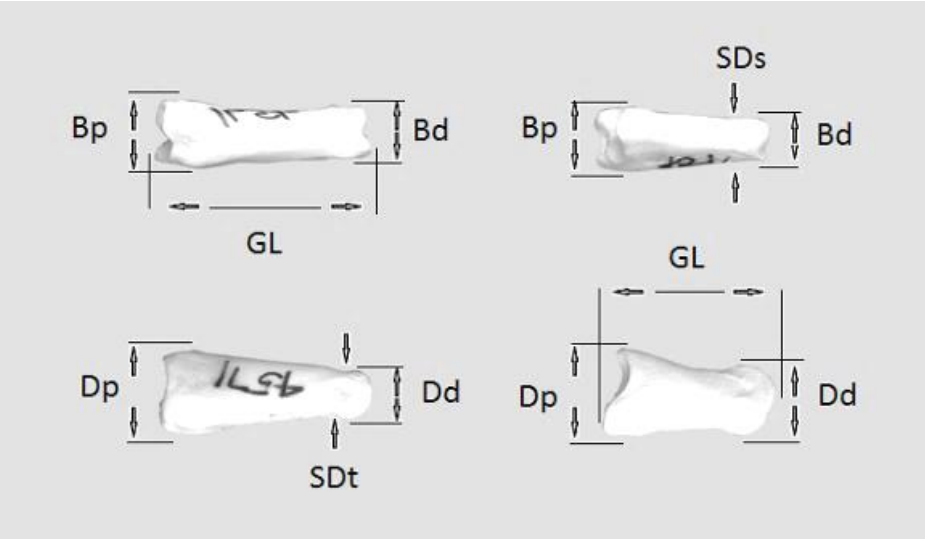

Figure 2-28 1st and 2nd phalanges: specimen FLMNH Z: 4571 from the Florida Museum of Natural History, Environmental Archaeology Program (FLMNH-EAP). Photos taken by Nicole Cannarrozzi and used with permission of the FLMNH-EAP.

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.