INVESTIGATIONS OF HUMAN GNAWING ON SMALL MAMMAL BONES: AMONG CONTEMPORARY BOFI FORAGERS OF THE CENTRAL AFRICAN REPUBLIC

By

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To the Faculty of Washington State University:

The members of the Committee appointed to examine the thesis of MATTHEW JOHN LANDT find it satisfactory and recommend that it be accepted.

Chair

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Abstract

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Ethnoarchaeology is one way in which archaeologists address questions regarding cultural influences in archaeological collections. This thesis utilizes faunal remains from Bofi foragers in the Central African Republic to help understand the influence of human mastication in archaeological faunal assemblages. Since, Bofi foragers rely on small game animals for the main portion of their protein intake, they provide a contemporary environment in which archaeologists can understand how humans modify the remains of small prey animals. Micro- and macroscopic features of human toothmarks are an under-documented source of taphonomic modification. The quantitative and qualitative results of this analysis indicate that human tooth-mark identification is a viable tool for zooarchaeologists in identifying a human presence in small mammal assemblages.

The underlying question throughout this thesis concerns an archaeologist’s ability to locate the presence of humans in zooarchaeological assemblages by recognizing their subtle influence in archaeological faunal collections. While results from this analysis indicate that humans and other carnivores create similar micro-morphological signatures of consumption,

comparisons of the frequencies and degree of damage between this collection and other reported carnivore gnawed collections indicate that humans consume bone differently than do other predators. By not fully consuming small mammal bone, humans may leave an archaeologically visible signature of their presence and interaction in faunal assemblages.

The results presented in this thesis are strong enough to warrant additional archaeological and ethnographical research in the realm of human and non-human mastication. If future research supports the conclusions presented in this thesis, then archaeologists will be better able to discuss diet breadth models, optimal foraging strategies, behavioral ecology and any number of theoretical topics that include human and small animal interactions.

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Dedication

This thesis is dedicated to my mother and father

who unfailingly continue to show me how much someone can be loved.

Chapter 1: Introduction

"The recognition of hominid food remains in the absence of both artifacts and traces of fire would be extremely difficult, and I would certainly not be competent to make such a diagnosis."

C.K. Brain 1981:55

Archaeologists, by definition, are interested in the past lives and activities (i.e. culture) of the animal *Homo sapiens.* Whether these humanistic chronicles are created via environmental and ecological reconstructions; fossil, bone, ceramic, or stone remains; or through Post-Modernistic prose, it is a common interest in the past life activities of humans that draw and propel archaeological research. If an artifact (be it Clovis or Chacoan, stone or bone) is found in an archaeological context, assumptions are made about how it was modified and deposited by peoples and events of the past. However, if objects are not initially attributed to the activities of humans, then later archaeological interpretations will include only a partial picture of past human behavior.

The research presented in this thesis is directed towards increasing an archaeologist's ability to locate the presence of humans across past landscapes and in archaeological faunal collections that do not show obvious signs of a human presence. Specifically, I describe qualitative and quantitative features of a very specific taphonomic event, namely human mastication. I use microscopic (scanning electron microscope or SEM) and macroscopic analysis of consumption remains from Bofi foragers to provide a diagnostic tool for the analysis of archaeological faunal assemblages. By applying this information to zooarchaeological collections, analysts may be able to distinguish human and non-human deposited small fauna remains in the archaeological record.

This thesis is contextualized in Chapter 2 with a historic perspective of taphonomic studies in archaeological research as well as descriptions and details of relevant taphonomic interpretations of bone modifying events. The purpose of this chapter is to: 1) provide background information so that the final interpretations are better understood and 2) to understand how specific research topics are overlooked. Both of these issues are important as this research is designed to fill a specific gap in an ever-growing body of taphonomic literature.

Within the third chapter I provide the environmental, social and cultural milieu for the Bofi foragers. The faunal assemblage described herein was generated by foragers who occupy a small village in the N'gotto Forest in the Lobaye region of the southwestern Central African Republic (CAR). The forager population lives near, and actively interacts with neighboring Bofi farmers who are more strongly engaged in horticultural activities. As with many equatorial rainforests, the ecosystem itself is very complex. Of particular importance to this thesis is the animal component of the forager subsistence resource base and the way in which those faunal remains are modified via human consumption.

Chapter 4 is divided into subsections that clarify the methodology and SEM procedures of the overall study as well as each of its component parts. The first section is used to describe the procedures for collecting and curating the ethnoarchaeological faunal assemblage. Included in the first section of this chapter is a discussion of the procedure used for obtaining a sample for SEM analysis. Within the second and third portions are summaries of two additional experimental assemblages that I use as control samples. The first control assemblage consists of chimpanzee gnawed turkey bones gathered from the Chimpanzee and Human Communication Institute (CHCI) in Ellensberg, WA. The second control assemblage consists of rabbit bones that were experimentally modified with steel wool.

Chapters 5 and 6 contain qualitative and quantitative descriptions of human mastication damage. Within chapter 5 I focus on the morphology of human tooth marks and steel wool-induced damage in the ethnoarchaeological assemblage. Emphasis is placed on microscopic SEM analysis and the macroscopic frequency and distribution of tooth marks within the ethnoarchaeological assemblage. Chapter 6 is used to place this thesis in a larger research context by drawing comparisons between this original research and published reports of carnivore and omnivore consumption patterns. These comparisons identify diagnostic criteria that can be useful in recognizing human modification of small mammal assemblages.

Within chapter 7 I examine the use of human mastication identification in zooarchaeological assemblages with regards to specific questions:

1) Can human tooth marks and human tooth mark patterning be used as indicators of human subsistence activities that are distinguishable from other carnivore and omnivore mastication events?
2) In what way is this research visible and useful when dealing with the archaeological record?

This chapter concludes with a look at the appropriateness and success of this study as well as proposing recommendations for future research.

Chapter 2: Background in Bone Modification & Taphonomic Studies

"Should it be asked why, amidst the remains of so many hundred animals,
not a single skeleton of any kind has been found entire..."

Buckland 1822:198

Animal bones in archaeological assemblages can be indicators of past environmental conditions (Bromage 1984; Lyman 1994; Nielson-Marsh and Hedges 2000; White and Hannus 1983), subsistence activities (Blumenschine 1988; Bunn 1981; Elkin and Mondini 2001; Lupo and O'Connell 2002; Pickering and Wallis 1997; Singer 1956; White 1953), human hunting and organizational strategies (Binford 1978; Brain 1981; Bunn and Kroll 1986; Hawkes 1991; Jones 1983; White 1953), as well as providing evidence of hominid tool usage (Blumenschine and Selvaggio 1988; Blumenschine *et al*. 1996; Bonnichsen and Sorg 1989; Bonnichsen and Will 1990; Fisher 1995; Lahren and Bonnichsen 1974; Potts and Shipman 1981; Walker and Long 1977). The analysis of faunal remains often includes the recording of damage and modification on bone to document and understand destructive forces that have impacted the bone. Within the last two decades, there has been a large increase in the number of reports and research projects focusing on bone modification processes (Andrews & Cook 1985; Binford 1978, 1981; Blumenschine *et al*. 1996; Brain 1981; Bunn 1981; Elkin and Mondini 2001; Fisher 1995; Haynes 1980, 1983b; Lyman 1994; Miller 1969; Pickering and Wallis 1997; Shipman 1981; Shipman and Rose 1983; White 1992). Since this thesis deals with bone damage resulting from carnivore/omnivore mastication, what follows is a brief account of actualistic studies, SEM analysis and taphonomic criteria for identifying human and carnivore patterning in zooarchaeological assemblages. The final portion of this chapter is useful in placing this thesis in a broader research context of prehistoric small prey exploitation.

In The Beginning - A Brief History of Taphonomy in Archaeology

In 1822, the Reverend William Buckland, in a monograph on a cave at Kirkdale in Yorkshire, England, noted how Pleistocene *hyaenids* might have modified animal bones, and how those bones may resemble hominid modified bones. For the remainder of the nineteenth century, most taphonomic work was limited to the field of paleontology (for review and exceptions see Lyman 1994). Efremenov (1940) originally coined the term “taphonomy” as “the study of the transition [in all its details] of animal remains from the biosphere to the lithosphere.” In other words, taphonomy can be more generally defined as the study of how animals die, become skeletally dispersed, undergo burial, and eventually become fossilized. As Efremenov (1940:93) originally noted, the term can be used to refer to the entire geo-biological process, as well as any part or portion thereof that biases the fossil record. Although paleontologists have utilized taphonomy since the nineteenth century, it wasn’t until the second half of the twentieth century that many archaeologists began taking advantage of studies regarding bone modification processes (Binford 1978, 1981; Bonnichsen and Sorg 1989; Brain 1981; Casteel 1971; Dart 1957; Fisher 1995; Leakey 1971; Lyman 1994; Miller 1969; Singer 1956; White 1952). This ever-growing body of literature describes a variety of actors (humans and carnivores), effectors (tools, teeth, and fire) and the impacts they have on bones and bone assemblages (for summaries see Fisher 1995 and Lyman 1994).

Actualistic Studies

The impetus for growth in archaeologically focused taphonomic studies was the explicit application of actualistic studies. Actualism, is based on uniformitarian principles, and as defined by Lyman (1994), “asserts spatial and temporal invariance of natural laws … particularly those concerned with mechanical, chemical, and physical processes (but not behavioral ones).”

Actualistic studies, as a method for inferring past activities by analogy with current processes, have been implicitly utilized in American archaeology since at least the late nineteenth century (Bettinger 1991; Taylor 1983). Although actualistic ideas were always incorporated in taphonomy and archaeology studies, the explicit use of actualism in archaeological studies during the later portion of the twentieth century generally came in the form of ethnographic analogy and ethnoarchaeology (Binford 1978, 1979, 1980; Brain 1981; Gifford-Gonzalez 1989a; Lyman 1994; Murray and Chang 1981). The use of ethnoarchaeology to focus on actualistic ideas within cultural frameworks has been termed "middle-range research" (Lyman 1994; Raab and Goodyear 1984). Archaeologists generally refer to middle-range research as attempts at theory building, which provide "bridges between statics [of archaeological materials] and dynamics [of cultural behavior]" (Raab and Goodyear 1984).

A History of SEM Analysis in Archaeology

The initial growth of taphonomic studies in the later half of the twentieth century was assisted by the application of a relatively new technology to taphonomic questions. The questions formed around the idea that it might be possible to distinguish between: 1) the ways that humans have used technology to modify bones (Blumenschine and Selvaggio 1988; Bunn 1981; Capaldo and Blumenschine 1994; Fisher 1995; Leakey 1971; Potts and Shipman 1981; Shipman and Rose 1983; Walker and Long 1977) and 2) the way that a variety of carnivores and omnivores modify bones (Andrews and Evans 1983; Blumenschine and Marean 1993; Bonnichsen and Will 1990; Buckland 1822; Elkin and Mondini 2001; Haynes 1980; Pickering and Wallis 1997; Sutcliffe 1970, 1973; Tappen and Wrangham 2000). The crux of the idea among researchers was that if marks made on bone by tool-using humans could be discretely distinguished from marks made by carnivore teeth during consumption, then specific human involvement in faunal assemblages can be ascertained without having either human remains or other human artifacts present (Bunn 1981; Potts and Shipman 1981; Walker and Long 1977). The technological advance that allowed Walker and Long (1977), Potts and Shipman (1981), and Bunn (1981) to make fine distinctions between specimens was their use of a Scanning Electron Microscope (SEM).

The early SEM work by Walker and Long (1977) presented the first microscopically diagnostic criteria for distinguishing between different tool materials used to butcher animals. They were able to distinguish marks left by metal tools from those made by stone tools in their sample. Their original criteria defines cutmarks produced by steel knives, steel axes, and unmodified obsidian flakes as “V-shaped grooves with straight sides that meet in a distinct apex at the bottom of the groove”, while marks left by bifacially flaked stone tools produce “wide irregular grooves…(which)…do not terminate in a single distinct apex and they have concave rather than straight sides” (Walker and Long 1977:608). Although few archaeologists would now attempt to utilize this definition as the sole criterion of human involvement in faunal assemblages, their work remains important as the original and pivotal definition of cutmarks on bone.

The work by Potts and Shipman (1981) supported the tool-mark descriptions made by Walker and Long, and presented new information that allowed microscopic distinctions to be drawn between damage created by tools and by carnivore consumption. Potts and Shipman (1981:577) defined microscopic marks left by tools as “elongated grooves with V-shaped cross-sections…[with]… many fine, parallel striations” in each main groove. They further distinguish chopping and scraping marks as distinct from cutting marks. Chopping marks appear as “V-shaped cross-sections …[with]… small fragments of bone crushed inwards at the bottom of the main groove" without internal parallel striations and scraping marks appear as, "multiple, fine, parallel striations across a broad area of bone rather than confined to a single, elongated main groove" (Potts and Shipman 1981:577). The criteria established by Potts and Shipman (1981:577) for marks left by carnivore teeth are, "grooves with rounded or flat bases" which lack "the fine parallel striations of slicing or scraping marks". They further noted that size may not be indicative of the bone modifier as "fine tooth scratches may be as narrow as cutmarks and usually require magnification of X20-X50 before they can be distinguished from cutmarks" (Potts and Shipman 1981:577). See Figure 2.1 for simplified line drawings of typical damage types explained in the text.

In 1981 Henry Bunn remarked that the high level of taphonomic overprinting on bones from Olduvai Gorge, Tanzania (Leakey 1971) and Koobi Fora, Kenya (Harris 1983) made it very difficult to attribute high levels of bone fracturing in faunal assemblages to a potential causal agent. However, using SEM analysis he went on to show that hammerstone usage by hominids and chewing by carnivores produces distinctive damage to the fractured edges of bone. Bunn (1981:576) stated that "hammer-stone blows produce broad internal flake scars on limb shaft pieces and bone flakes", while damage from carnivore gnawing produces edges where …

> "cracks along which a bone splits open may again be indented and internally flaked at points where force has been applied, but instead of the broad, arcuate indentation produced by hammer-stone fracture, the indentation approximates the relatively small diameter of the carnivore tooth and thus typically shows a scalloped or denticulate edge …"

These three studies (see also Shipman 1981), proved to be a foundation for many microscopic studies of bone surface modifications. By the later third of the 20th century a plethora of reports corroborated some of these initial descriptions regarding carnivore and human modification processes (Blumenschine 1988; Blumenschine and Selvaggio 1988; Bonnichsen

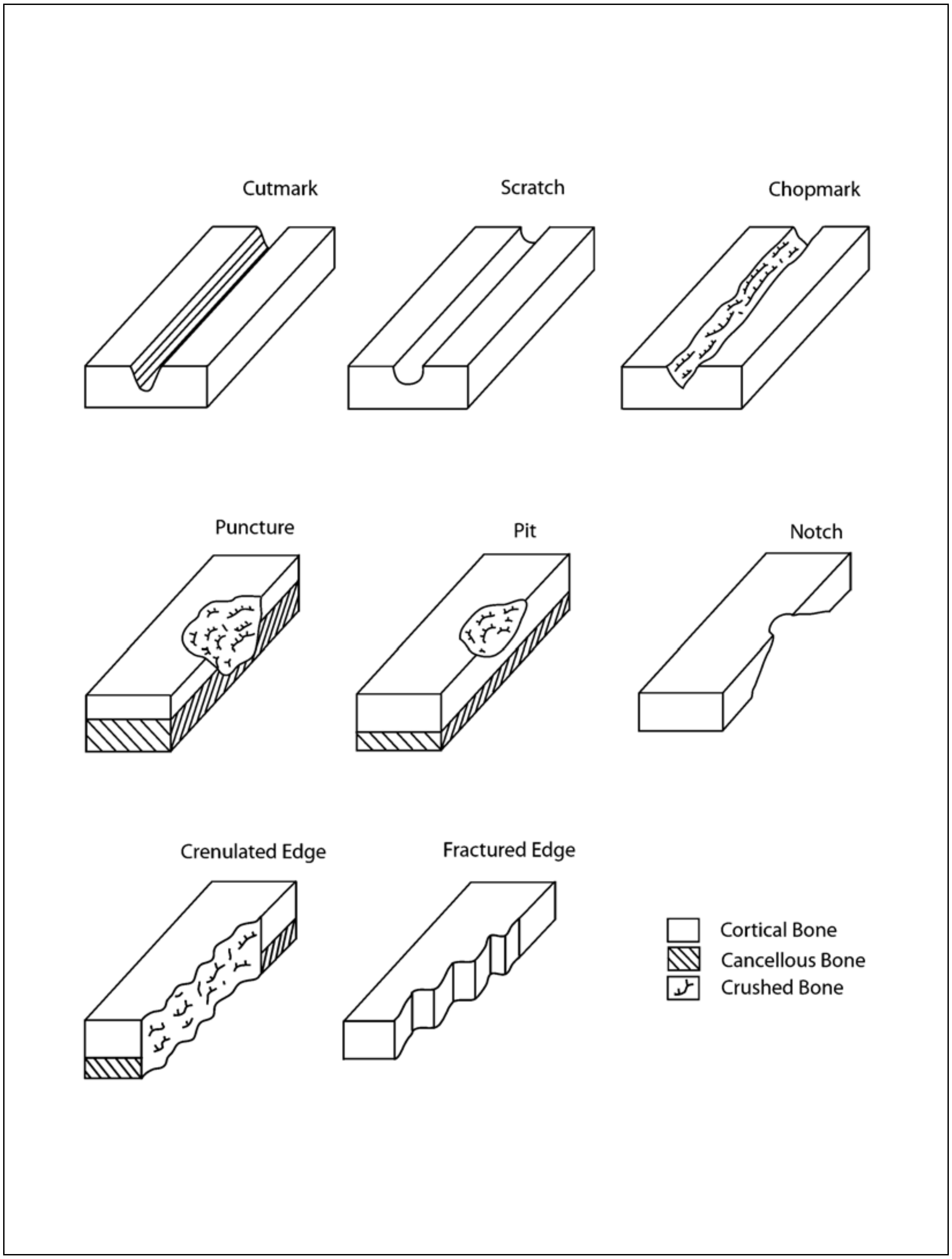

Figure 2.1: Stylistic representations of typical bone damage explained in the text.bone

and Will 1990; Capaldo and Blumenschine 1994; Eickhoff and Herrmann 1985; Gifford-Gonzalez 1989a; Haynes 1980, 1983a; Johnson 1989; Marean and Bertino 1994; Oliver 1993; Russell and Villa 1985). Additional studies identified microscopic criteria for root etching (Binford 1981; Shipman 1981), digestive etching (Andrews and Nesbit Evans 1983; Payne *et al*. 1985; Schmitt and Juell 1994; Shipman 1981), rockfall patterning (Dixon 1984; Oliver 1989), weathering (Andrews 1995; Behrensmeyer 1978; Shipman and Rose 1983) and trampling (Fiorillo 1984, 1987; Andrews and Cook 1985; Behrensmeyer *et al.* 1986; Haynes 1983b).

Before the work of Bunn (1981), Potts and Shipman (1981) and Walker and Long (1977) and the application of SEM technology to archaeological questions, taphonomy focused only on macroscopic patterning, and much micro-morphologic detail was likely missed. The use of an SEM in taphonomic analysis has proponents and opponents (see Blumenschine *et al*. 1996; Fischer 1995; Gilbert and Richards 2000, Shipman and Rose 1984). Proponents of SEM analysis argue that the highly detailed three-dimensional black and white images show microscopic features (i.e., linear marks inside a cutmark) not typically visible in macroscopic analysis and can therefore clarify the identification of otherwise ambiguous marks (Bunn 1981, 1991; Bunn and Kroll 1986; Shipman 1981; Shipman and Rose 1983, 1984). The value of this technology in identifying macroscopically ambiguous taphonomic processes offsets an increase in money and time required to complete SEM analysis. However, others believe that an over-reliance on SEM analysis is not warranted due to the prohibitive financial cost and time. SEM analysis typically requires 1) mold-making of large specimens to fit in an SEM vacuum chamber, 2) specialized training for the capturing and interpretation of images, and 3) large film processing and development charges for the analyses of most faunal assemblages (Blumenschine and Marean 1993; Blumenschine and Selvaggio 1988; Blumenschine *et al*. 1996). Further, it is argued that contextual information regarding the mark's anatomical location provides a low cost, high-volume alternative technique (Blumenschine *et al*. 1996).

Some of these objections are no longer valid as SEM technology continues to advance. Many scanning electron microscopes are now connected to computers that capture images and dramatically reduce, or negate the cost of film development. While the cost and effectiveness of mold-making is considered prohibitive for many large animal assemblages, smaller specimens need not be replicated with molds because the vacuum chamber of many scanning electron microscopes are now large enough to accommodate small-sized bones. Thus, for small animal assemblages, SEM analysis need only contend with the costs and time requirements of SEM technician fees. Regardless of the arguments for or against SEM analysis the criteria established by Walker and Long (1977), Potts and Shipman (1981) and Bunn (1981) would have been considerably less definitive at the time had it not been for the combination of a great depth of field and high magnification that are found in the vacuum of an SEM chamber. As Gilbert and Richards (2000:238) note, "micrographs of bone modifications are far more informative than semantic descriptions. A major level of interpretation and subsequent bias is removed by the inclusion of diagnostic imagery."

Carnivore-Mediated Attrition

Research focused on defining the morphological characteristics of modifications left by natural processes has generally emphasized carnivore-mediated attrition. Carnivorous mammals typically modify bones with their teeth, relying on the shape of their teeth and the strength of their jaw in order to gain access to bone nutrients. This contrasts with humans who generally use technology (specifically stone tools and fire) to gain nutrients from large carcasses since at least 2.5 mya.

Carnivore tooth damage was originally defined in opposition to marks left by tools. The established identifications of tooth marks on bone covers an array of animals including African and American carnivores, rodents and herbivores (Andrews & Evans 1983; Binford 1981; Blumenschine 1988; Blumenschine & Marean 1993; Blumenschine & Selvaggio 1988; Brain 1981; Bunn 1981; Elkin & Mondini 2001; Fisher 1995; Haglund *et al.* 1988; Haynes 1980, 1983a; Johnson 1989; Miller 1969; Milner & Smith 1989; Shipman 1981, 1983; Shipman & Rose 1983; Singer 1956; Tappen & Wrangham 2000; White 1992). Rodent and herbivore created bone damage are uniquely identifiable and not easily confused with other carnivore created consumption damage patterns (see Brothwell 1976; Bunn 1981; Fisher 1995; Shipman 1981, 1986; Shipman & Rose 1983; Singer 1956). But some types of damage produced by carnivores and humans can mimic each other.

Carnivore tooth damage can produce striations, furrows, pits, punctures, ragged or crenulated fracture edges, stepped fractures, tooth notches and conchoidal flake scars, bone flakes, and/or polish (Binford 1981; Fisher 1995; Lyman 1994; Pickering and Wallis 1997). As noted by Noe-Nygaard (1989), many of the above types of damage are merely different names for similar processes. Morphologically, ‘pits’ appear in plan view as discrete roughly circular to sub-circular marks that can be visually defined by superficial cortical crushing apparent around the periphery and interior of the mark (Binford 1981; Blumenschine and Selvaggio 1988; Pickering and Wallis 1997, White 1992). Tooth ‘pits’ can be located anywhere on a bone, as the mark does not penetrate beyond the most superficial cortical bone layers. The lack of tooth penetration into the bones surface can result from thick cortical bone and/or a lack of sufficient jaw pressure.

The same perpendicular force (relative to the bones surface) that creates a ‘pit’, leads to the creation of ‘punctures’, which are roughly circular in plan view (Binford 1981; Brain 1981; Haynes 1983a; Pickering and Wallis 1997; White 1992) and are typically initiated by the tip of a canine tooth (though not exclusively) that is forced through the surface of a bone and penetrates all of the cortical bone layers. ‘Punctures’ are more likely to be located on bones and bone portions with a thin cortical bone layer and underlying cancellous bone. For a ‘puncture’ to form the tooth must penetrate the bone’s surface without causing complete collapse of the entire bone portion (i.e., a ‘puncture’ on a small animal humerus must be on the softer and less dense ends as the end must remain intact to imprint the tooth mark, whereas a ‘puncture’ located on the cortical shaft will cause the shaft to fracture and not leave a tooth imprint). The difference between ‘pits’ and ‘punctures’ is a non-quantified amount of crushing damage within the center of the mark due to the location of the perpendicular bite pressure in relation to cortical and cancellous bone (Noe-Nygaard 1989).

‘Notches’ are likely found on bone shafts and bone shaft fragments, as the ‘notch’ is a tooth ‘puncture’ that has caused structural failure and fragmentation of the bone portion. Tooth ‘notches’ are definable as a result of a perpendicular force applied to cortical bone that is not underlain by cancellous bone, which results in the establishment of a fracture. Because non-weathered cortical bone fractures in the same manner as fine-grained stone (Capaldo & Blumenschine 1994; Fisher 1995) tooth notches may appear in conjunction with conchoidal flake scars on fractured edges. ‘Notches’ are often morphologically similar to flake scars on worked stone in that they exhibit a negative bulb of percussion as well as ripple or hackle marks (Andrefsky 1998; Capaldo & Blumenschine 1994; Whittaker 1994). However, as flake scars are at least partially determined by the direction and amount of pressure as well as the relative amount of moisture and decomposition in the bone, these attributes need not be apparent or even present on the bone's fractured surface (Morlan 1984).

When carnivores apply sufficient pressure (either sudden or sustained) to penetrate the thick cortical bone of long bone shafts, the bone fractures and has crenulated, ragged, or irregular edges. The fracture edges often exhibit single and multiple tooth notches that provide a chipped back edge and a serrated appearance (Binford 1981; Bonnichsen & Will 1990; Brain 1981; Bunn 1981, 1989; Bunn and Kroll 1986; Capaldo & Blumenschine 1994; Pickering and Wallis 1997). Published macroscopic descriptions generally focus on two types of damage; crenulated and fractured edges. Crenulated edges are often crushed, ragged and irregular in appearance. Crenulated edges tend to be located in conjunction with cancellous bone matrices as the damage does not result in complete structural failure of bone elements. Fractured edges resulting from mastication are relatively smoother than crenulated edges, although they generally exhibit single and multiple tooth notches that are displayed as chipped back edges with a serrated appearance. Fractured edges are often located along bone shafts were the cortical bone has undergone structural failure during mastication. Structural failure is displayed as adjacent faulting and fracture lines on the bone that radiate from the tooth notches. The association of pits, punctures, and notches with these edges are useful in identifying mastication induced damage (Pickering and Wallis 1997).

Pits, punctures, notches, and fractured edges are typically initiated by pressure applied perpendicularly to the surface of a bone. When jaw/tooth pressure is directed more or less parallel to a bones surface the result is often described as scoring (Binford 1981), striations or gouges (Maguire *et al.* 1980 as quoted in White 1992), and scratches (Bunn 1981; Eickhoff & Herrmann 1985; Haynes 1980, 1983a; Pickering & Wallis 1997; Potts & Shipman 1981;

Shipman 1981; Shipman & Rose 1983). All of these terms are used to describe similar features, which are relatively long, linear grooves with internally smooth surfaces that may vary from v-shaped to u-shaped in cross-section. To alleviate terminological confusion and to distinguish these surface modifications from other types of damage, I will use the term “scratch” or “scratches” to refer to these types of marks.

Many believe it is possible to use bone surface modifications in archaeofaunal assemblages to distinguish different carnivores and omnivores (Cruz-Uribe 1991; Haynes 1983a; Lyman 1994; Pickering and Wallis 1997; Shipman 1983). In theory, this holds great promise for archaeofaunal analysis. However, research thus far indicates that, “efforts to diagnose the taxonomic status of various carnivore actors that have created tooth impressions on bones have been less than convincing” (Pickering and Wallis 1997:1123). There are a number of reasons that the research is, thus far, less than convincing. First, as discussed by Shipman (1983, see also Binford 1981 and Pickering and Wallis 1997) size of tooth mark is not diagnostic to species. The tooth marks of numerous species overlap in size. This does not mean that tooth mark size cannot indicate a possible aggregate of predator size class. Second, researchers have tended to compare the tooth damage of predators that have roughly similar jaw strength and tooth size, thus compounding issues regarding their ability to modify differential zones of bone density and hence their overall bone damaging ability (Haynes 1983a; Lyman 1994).

While a variety of studies have provided useful criteria for identifying general carnivore size-class based on tooth damage in zooarchaeological assemblages, archaeologists cannot clearly distinguish the mastication damage of specific mammalian predators (Dominguez-Rodrigo and Piqueras 2003). The next section of this chapter outlines the types of bone damage that humans are traditionally thought to create during carcass utilization.

Human Produced Taphonomic Damage

Most research aimed at identifying human bone modification has focused on defining morphological characteristics of modifications left by tools (Blumenschine 1988; Bonnichsen and Will 1990; Capaldo and Blumenschine 1994; Gifford-Gonzalez 1989a; Johnson 1989; Oliver 1993; Russell 1985; Shipman and Rose 1983) (for exceptions see Binford 1981; Brain 1981; Elkin & Mondini 2001; Jones 1983; Weisler & Gargett 1993; White 1955). Although the basic descriptive morphology of cutmarks has not changed over the years, certain qualifiers (i.e. shoulder effects, barbs, anatomical context) have been added to further clarify ambiguous identifications. Further, as taphonomic research has looked at the response of bone to an array of stone implements beyond simple cutting tools it has become necessary to further describe these damage types (i.e. chopmarks, scrapemarks, percussion pits, conchoidal flake scars and tool-punctures). Since cutmark characteristics have already been discussed, the following discussion focuses on qualifiers and other types of tool-produced modifications.

Shoulder effects are short grooves associated with a cutmark that result from non-uniform cut strokes where the shoulder of the tool contacts the bone and leaves additional marks during a single stroke (Shipman & Rose 1983). While shoulder effects tend to occur towards the center of a mark, barbs may occur during the initiation or termination of a cutting stroke. The barbs are grooves oriented at an angle (generally acute) to the main cutting motion (Shipman and Rose 1983).

Like cutmarks, scrapemarks are formed by forcing a tool against a bone in a more or less parallel direction to the bone’s surface. However, unlike the single cutmark groove created during a cutting motion, a single scraping motion can produce multiple, generally parallel and closely spaced striations that are relatively shallow, narrow, long and linear (Noe-Nygaard 1989;

Potts & Shipman 1981; Shipman 1981, 1988). While the creation of scrapemarks are discussed in the ethnographic literature as resulting from tissue removal (Binford 1981), it is important to note that natural processes (specifically sedimentary abrasion caused by fluvial action or trampling) can and occasionally do mimic culturally created scrapemarks (Andrews & Cook 1985; Blumenschine & Selvaggio 1988; Fiorillo 1984; Shipman 1988). However, Olsen and Shipman (1988:541) argue that chattermarks and other undulating ripples running perpendicular to the striations are common features of scrapemarks and are "not associated with sedimentary abrasion." Further, they argue that sedimentary abrasion does not consistently create bone surface damage in anatomically meaningful locations.

Chopmarks are formed by applying the edge of a tool perpendicular to a bone's surface, unlike cutmarks and scrapemarks, which are produced by motions more or less parallel to the bone's surface. This motion results in linear V-shaped depressions that are relatively broad in width and short in length compared to cutmarks (Binford 1981; Noe-Nygaard 1989). Although chopmarks are considered to be both highly visible and accurately identifiable indicators of dismembering units (Blumenschine *et al*. 1996), the final shape of any chopmark varies based on the strength and structure of the underlying portion of bone, the shape of the tool, the force of the blow, the presence of tissue (periosteum or muscular) as well as the hand-eye coordination of the hominid (Fisher 1995).

Percussion pits, like chopmarks, are formed by the application of a tool perpendicular to the bones surface. The resulting pits are small, roughly circular depressions with associated microscopic striations located either within the pit, near the edge of the pit or within close proximity to the pit (Blumenschine & Selvaggio 1988; Fisher 1995; White 1992). The striations associated with percussion pits are formed by irregularities in the tool's surface as well as tool or bone slippage during impact. Tool-produced percussion pits can be macroscopically confused with carnivore tooth pits (Blumenschine & Selvaggio 1988; Capaldo & Blumenschine 1994; Fisher 1995; White 1992). But studies have shown that contextual information, including the anatomical location of the mark on bone and associations of other culturally indicative marks (cutmarks, chopmarks, etc.) should be used to clarify identifications.

If the intent of striking a long bone with a stone tool is to achieve access to the marrow cavity, then many percussion pits should be the results of preparatory or failed attempts. When fresh long bones are successfully breached or broken by a hammerstone, the resulting marks are often associated with a conchoidal flake scar. However, Morlan (1984) notes that these attributes may not be present on the bone's fractured surface. To clarify any ambiguity between the human and carnivore generated bone flakes and notches, Capaldo and Blumenschine (1994, see also Pickering and Wallis 1997) originally noted that notches resulting from hammerstones are typically broad with thin flakes removed, while carnivore produced notches are narrower with broader flakes removed. In controlled experiments, these morphological differences, as measured by maximum and minimum depth and breadth, are statistically significant (Capaldo and Blumenschine 1994), and have been supported by work from Pickering and Wallis (1997).

Tool punctures are generally circular, sub-circular or entirely irregular and can result from a projectile point striking the bone (Noe-Nygaard 1989). Noe-Nygaard (1989) suggests that these marks are located in anatomically meaningful locations that relate to killing, such as blows to the chest cavity (e.g., scapula, ribs) or the head. The inconsistency of the final shape of these marks is due in part to the shape of the tool and the amount of tissue attached to the bone. These marks can be confused with tooth punctures left by carnivores. However, carnivore punctures are usually associated with superficial pitting and scratching that would not be displayed by tool punctures (Fisher 1995).

Ethnographic research indicates that humans who are unaided by tools can modify the surface of a bone by relying on their teeth and hands to dismember and consume carcasses. Elkin & Mondini (2001:260) accurately note that, "There are few observations describing the characteristics of human gnawing modifications, and they are generally isolated ethnographic notes." The small number of ethnographic and experimental comments regarding the human consumption of large and small prey, includes birds (Weisler and Gargett 1993), monkey (Jones 1983), goat or sheep (Brain 1981; Elkin and Mondini 2001; Gifford-Gonzalez 1989a; Oliver 1993; Richardson 1980), and caribou (Binford 1978, 1981). Descriptions of these noted modifications generally result in vague and nondescript terminology that has inevitably led to its relegation as a non-functional analytical sidenote and as non-diagnostic in zooarchaeological assemblages (for an exception see Weisler and Gargett 1993; White 1992). This may be due to: 1) researchers using macroscopic analysis which does not allow for microscopic distinctions that may exist or 2) histologic and taphonomic similarities that exist when enamel (tooth) contacts bone (cortical and cancellous).

Only two published reports contain discussions of how those marks may be diagnostic or distinguishable from marks left by other taphonomic processes. Weisler and Gargett (1993) used experimentally derived and archaeologically recovered macroscopic breakage patterns in combination with element frequencies, species composition and depositional information to identify the way in which humans contributed to the extinction of native Hawaiian bird species. Weisler and Gargett (1993) gnawed on cooked bird bones with the intent of experimentally replicating damage observed in an avifaunal assemblage from Moloka'i. Their experimental work indicates that humans can consume the epiphyses of bird long bones with little trouble and that the consumption process produces a "ragged, irregular edge often associated with one or more longitudinal cracks" that usually occur "at or near the epiphysis" (Weisler and Gargett 1993:88). This definition is identical to that used by Binford (1981), Brain (1981) and Pemberton *et al.* (1980) to describe the impact of human mastication on goat, sheep and caribou. Weisler and Gargett's (1993) results indicate that humans can consume portions of avian remains and duplicate macroscopically visible fracture characteristic as recovered from archaeological context. What their research does not address is whether or not humans generally leave evidence of consumption when not in an experimental setting.

Elkin and Mondini (2001) use experimentally derived consumption patterns to control for taphonomic ambiguities in fox and human occupied rockshelters in South America. They provided sheep (*Ovis aries*) ribs, vertebra halves, radii, scapulae, ulnae, humeri, and carpals to captive foxes (*Pseudalopex gymnocercus*) and to humans. While their research indicates a number of similarities between fox and human tooth mark morphology, it does not indicate how they might differ. Further, as with Weisler and Gargett (1993), their experimental results cannot be used to examine consumption damage patterning across the skeleton as the experiment focused only on specific skeletal elements.

Small Animal Subsistence Research

Taphonomic analysis conducted in the last 30 years has increased the accuracy of identifying the presence of tool-using hominids in archaeological assemblages. These studies have also helped archaeologists recognize the influence of other carnivores (both before and after human utilization) in zooarchaeological assemblages. The need to distinguish human tool marks from carnivore tooth marks in early hominid assemblages has guided taphonomic research. Most of the original literature dealing with the identification of different bone modification actors was devoted to faunal materials recovered from Olduvai Gorge (Binford 1981; Bunn 1981; Bunn and Kroll 1986; Marean *et al.* 1992; Marshall 1986; Potts and Shipman 1981; Shipman 1983) and Koobi Fora (Bunn 1980, 1991; Bunn and Kroll 1986; Harris 1983) where the debate has centered around which animal – human or non-human -- had initial, secondary, and perhaps tertiary access to prey carcasses (Blumenschine 1988; Blumenschine and Marean 1993; Capaldo 1997; Jones 1984). Although the debate between "man the hunter" or "man the scavenger" is an especially important driving force in taphonomic studies of cutmarks and carnivore tooth marks, it has also focused research in unintended directions. The most visible human produced bone modifications from Olduvai Gorge and Koobi Fora occur on large prey animals (i.e. *Bovidae, Equidae, Hippopotamidae, Suidae, Proboscidea, Rhinocerotidae*) (Harris 1983; Leakey 1971; Leakey and Roe 1994), which have become the focus of the majority of taphonomic research. Further, since large predators are the obvious competitors for these large prey animals, research has tended to focus on hyaenas and other large carnivores.

The impetus for much of the recent archaeological taphonomic research centered on questions regarding the remains of large prey whose deaths required either a single powerful predator or the coordinated efforts of medium to large predators (i.e., jackals, humans, wolves, etc.). Unfortunately for the discipline of archaeology, this large predator – large prey taphonomic focus has ensured that small mammals are generally overlooked as sources of bone modification agents and as prey (for exceptions see Andrews 1990; Andrews and Evans 1983). This is unfortunate since many ethnographic observations and archaeological collections indicate that small prey animals were an important prey of modern and prehistoric peoples (Crandall and

Stahl 1995; Grayson 1991; Hockett and Bicho 2000; Lupo and Schmitt 2002; White 1953; Yellen 1991).

This dichotomy between large predator and large prey has focused taphonomic research on the human animal only as a tool-using predator. The direction of this research is neither inappropriate, nor unnoticed (Binford 1978, 1981; Brain 1981; Elkin and Mondini 2001; Gifford-Gonzalez 1989a; Jones 1983; Oliver 1993; Richardson 1980; Weisler and Gargett 1997; White 1992;). Since humans do not need to use tools to dismember small prey remains, archaeologists should not expect the carcasses of small fauna to exhibit the same type or degree of butchery damage as that seen on larger prey. Any trace of human mastication on bone in zooarchaeological assemblages is likely accredited to non-human animals or lost in a general carnivore attrition category, as diagnostic characteristics of human mastication have not existed (White 1992).

Concluding Remarks

Research aimed at clarifying the differences between marks left by tool-using humans and those left by carnivore gnawing has had profound impacts on the direction of taphonomic research. It has fueled an ongoing debate concerning early hominid hunting or scavenging behavior (Bunn 1986; Shipman 1986) and hence supplied a richer comparative collection of specific taphonomic marks and models. On the other hand, this dichotomy has taken focus away from numerous avenues of potential research, and thus neglected potential sources of new information.

This thesis is designed in part to begin rectifying some of the missed research opportunities and adding to the growing body of literature dealing with human mastication as a bone modification processes. I continue the explicit use of actualistic studies and of middle-range research by combining taphonomic and ethnographic information. By looking at how humans may alter the zoological portion of the archaeological record unaided by tools, this thesis may bring to light potential areas of research concerning our earliest pre-tool using hominid ancestors. In the next chapter I discuss the ecological and cultural context of the Bofi foragers in the N'gotto forest, Central African Republic.

Chapter 3: Bofi Foragers

> "Like all lives, they can be used as examples or serve as representative types. But ultimately they are unique, individual, impossible to define or replace…"
>
> Schlosser 2002:186

As the previous chapter indicates, the main thrust of this research is designed to be taphonomic in nature. This thesis contains descriptions of mastication damage produced by Bofi foragers who live in the N'gotto Forest in the Lobaye region of the southwestern Central African Republic (CAR) (Figure 3.1). This chapter details the political, natural and social environment in which the Bofi foragers live. The first section begins with background information concerning the social and political history of the Bofi foragers and the Central African Republic. The second section describes the modern geography and environment of the southwestern portion of the Central African Republic. The section on the natural environment is followed by a description of Bofi forager settlement patterns and subsistence techniques. The final section in this chapter discusses tooth modification practices among CAR foragers in general and the Bofi foragers in particular. The ethnoarchaeological subsistence assemblage produced by the Bofi foragers is appropriate for this research since: (1) it was collected in a relatively controlled environment where the number of taphonomic agents acting upon the bones was minimalized and (2) small mammals (< 5 kg) constitute the bulk of the collection.

Culture History

Although the history of other foragers in the Congo Basin is better known (i.e., Aka (Bahuchet 1999; Hewlett 1977; Hudson 1990; Noss 1995; Turnbull 1965), Efe (Mercader *et al*. 2003; Turnbull 1965) and Mbuti (Hewlett 1977; Ichikawa 1999; Turnbull 1965)), there is little detailed information concerning the specific history of the Bofi foragers and farmers in the N'gotto forest (see Fouts 2002; Fouts *et al*. 2001; Hewlett 2001; Lupo & Schmitt 2002), According to Hewlett (2001) there are two ethnolinguistically distinct groups of tropical forest foragers in the N'gotto reserve. The Aka (a.k.a. BaAka, Biaka, Bayaka) who speak a Bantu language, and the Bofi who speak an Oubanguian language. As the Bofi foragers are descendants of the Aka (Fouts 2002), any culture history of the Bofi must begin with the Aka.

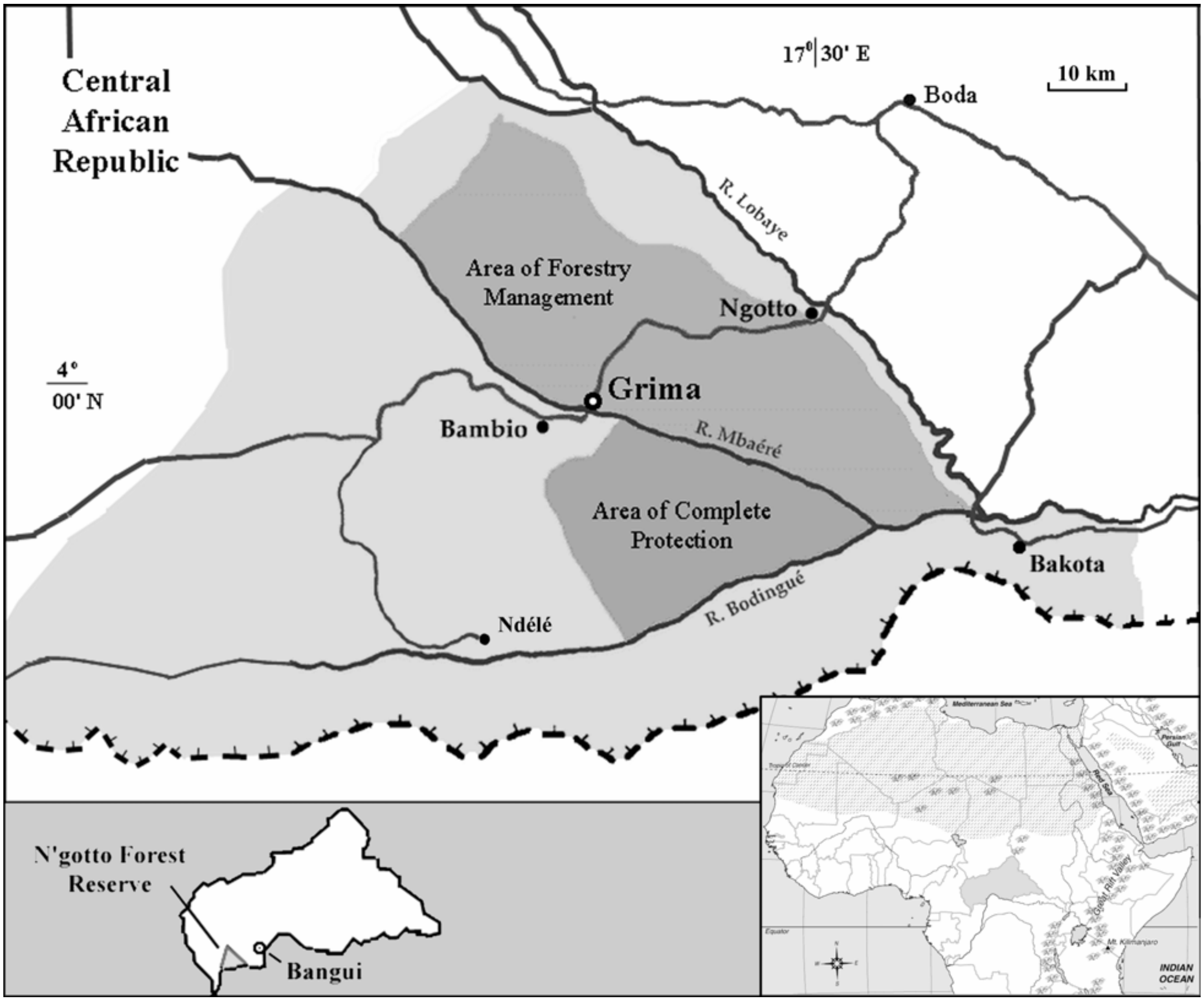

Figure 3.1: N'gotto Forest Reserve in the Lobaye region of the Central African Republic.
Map sources include www.eduplace.com and www.geography.about.com.

The foragers have likely occupied the N'gotto area for a relatively long time. The earliest reference to foragers in the area of central Africa comes from Egyptian pharaohs in the 6th Dynasty (approximately 4,300 years ago), as well as references from the works of Homer, Herodotus and Aristotle (Bradford 1992; Hewlett 2000; Turnbull 1965). However, none of these accounts address the ancient history of the foragers. While many anthropologists believe that Aka foragers lived in the region of the N'gotto Forest before the expansion of Bantu speaking farmers, others argue that foragers could not live for extended periods of time on forest products alone and that their reliance on trade with horticulturalist neighbors is a prerequisite for their continued occupation of the rainforest environment (Bailey *et al*. 1989; Hart and Hart 1996, Headland and Reid 1989). Linguistical and archaeological evidence are not currently strong enough to fully refute or accept either hypothesis (David 1982; Ehret 1982, Ehret and Posnansky 1982; Saxon 1982)

Glottochronological timelines indicate that the Western Bantu expansion into the Congo Basin and surrounding area east of Cameroon likely occurred 5000-4000 years ago, with the Aka-Mbati language descent group splitting off to the northern portion of what is now the Peoples Republic of Congo (PRC) approximately 3500-3000 years ago (Ehret 1982; Vansina 1990). If the foragers were there before the farmers, then they likely provided guidance during this migration of Bantu speaking farmers into and around the rainforests of the Congo Basin. The foragers likely were, as noted by Vansina (1990:56), "the first in the land; the inventors of fire; the teachers about habitats; the wise healers with medicinal plants; sometimes even the first metallurgists; and, on occasion, the first farmers." Although it is unclear what language the forest foragers spoke prior to the Bantu expansion, it is clear that Aka became a common language of both the farmers and foragers of the northern Congo Basin after the arrival of Bantu farmers.

At roughly the same time that the Bantu peoples were migrating eastwards into the Congo Basin, a similar migration of Ubangian speakers was occurring just to the north. These peoples, speaking eastern Adamawa, or Ubangian, migrated from northern Cameroon into the central and southern Central African Republic (Saxon 1982). The Ubangians, in turn, influenced the languages of the adjacent Bantu speaking farmers and forest foragers across the northeastern portion of the Congo Basin. Although the timing of these expansions are not firmly dated, the linguistic and archaeological evidence clearly indicate that by roughly 2500 years ago the northern Congo Basin, which includes the N'gotto Forest, was fully settled by foragers and farmers alike (David 1982; Fouts 2002; Vansina 1990).

The intensification and expansion of colonialization, industry and the exploitation of forest and human resources in the last 700-500 years by Europeans has increased contact between the farmers and the foragers in the Lobaye region of CAR (Gailey 1981; Hewlett 2000). In an effort to maintain and strengthen these economic ties, some of the Aka foragers learned, and later adopted, the Oubanguian language of their Bofi neighbors (Fouts 2002). These foraging people are known as Bofi foragers and consider themselves distinct from the neighboring Aka, although their oral history indicates that they are descendants of the Aka (Fouts 2002; Hewlett 2001). As they have for the past 2500 years, Bofi foragers continue to maintain and nourish close economic ties with their horticulturalist neighbors. These economic ties, which likely began during the original Bantu and Ubangian expansions, continue to be based on exchanges of forest products (e.g., *koko* leaves, *payo* nuts (*Irvingia sp*.), bush-meat, etc.) and labor for wages and manioc (Fouts 2002; Lupo & Schmitt 2002).

The last few centuries have seen numerous changes in political ownership, management and control of the Central African Republic. The French arrived in the Congo Basin in 1885 and acquired possession of Oubangui-Chari (later to become the Central African Republic) in 1894. The French did not consolidate their administrative control of Oubangui-Chari until 1903. In 1910, the French controlled colonies of Chad, Gabon and Oubangui-Chari were joined by Congo and became the Federation of French Equatorial Africa (Noss 1995). In 1946, the French Constitution allowed the Central African Republic (as well as other territories in the Federation of French Equatorial Africa) to create a local governing assembly that was led by Bartholemy Boganda. Independence was officially granted to the Central African Republic in 1960, and the area has been politically unstable since then as presidents are generally empowered by successful coups rather than elections. Although France has continued to maintain strong ties with the unstable politics and economy of CAR, the foragers and farmers of the N'gotto Forest are only indirectly affected by this instability. The Bofi are more heavily impacted by local economic agents in the area, such as lumber and diamond companies and most recently ECOFAC (Ecosystèmes Forestiers d'Afrique Centrale) (ECOFAC 2003; Noss 1995).

ECOFAC began in 1992 as an offshoot of the European Union's 6th European Development Fund (EDF) (ECOFAC 2003). In the early 1990s, the EDF allocated monies to the conservation of tropical forest ecosystems. ECOFAC is the spearhead for that conservation project as it maintains projects and protected districts in Congo, Cameroon, Central African Republic, Equatorial Guinea, São Tomé and Principe, as well as Gabon. One of these protected districts in the Central African Republic, the N'gotto Forest Reserve, was established in 1993 with the intent of: (1) creating areas for biodiversity protection, (2) promoting rational and sustainable economic development, and (3) to encourage conservation across political boundaries (ECOFAC 2003). As part of their conservation program, ECOFAC helped set aside 1,950 km^2 in the northeast portion of the N'gotto Reserve for forest management and 740 km^2 of forest in the southern portion of the N'gotto Reserve for total protection (see Figure 3.1). Upon establishment of these areas, lumber companies, conservationists and ECOFAC guards advancing into the N'gotto Forest have had positive and negative impacts on the lives of the Bofi farmers and foragers. While it is beyond the scope of this project to detail all of the local advantages and disadvantages of such a large politically driven ecological system, there are a few notable rewards that the Bofi foragers take advantage of while maintaining their semi-nomadic way of life and promoting both traditionalistic and original lifestyles.

ECOFAC and the CAR government have placed numerous restrictions on hunting and gathering practices both in the CAR in general and the N'gotto Forest in particular. A few of the more noticeable restrictions include: 1) a limit on the amount of marketable animal flesh procured by the Bofi, 2) a ban on the killing of specific animals, and 3) a ban on certain hunting technologies such as metal snares. The first restriction has resulted in a large black-market bush-meat trade (see Fa *et al.* 2002). The CAR foragers (both Bofi and Aka) are directly involved in this trade as they are responsible for acquiring a large portion of the bush-meat (generally duiker) that is culled from the forests and sold to their horticulturalist neighbors and the commercial meat vendors. Although foragers acquire a large portion of the bush-meat, it is typically the villagers and vendors who assemble and sell bulk quantities of the meat on the black-market. Thus, the foragers are likely to see little profit, and are only slightly impacted, by bush-meat restrictions as they continue to exchange daily meat returns for manioc, cash, and/or debt repayment.

Similarly, the protection of specific endangered plants and animals (i.e., gorilla (*Gorilla gorilla)*, chimpanzee (*Pan troglodytes*) and elephant (*Loxodonta africana*)) has had little effect on the day-to-day living of the Bofi foragers. While ECOFAC is responsible for maintaining patrolling guards in the N'gotto Forest, they are unable to maintain either sufficient numbers of guards, or patrol the entire forest. Thus, while the foragers are aware of restrictions, they are able to avoid patrolling guards and any subsequent penalty. In the N'gotto Forest, the illegalization of plants and animals has likely only resulted in a skewed reporting of gather and capture rates (Fa *et al.* 2002).

The largest impact to the Bofi foragers has likely come from the influx of lumber companies who continually build new roads and bridges throughout portions of the N'gotto Forest. The abandoned roads and downfall clearings created by the lumbar companies are quickly reclaimed by the rainforest. The Bofi foragers utilize many of the old and new lumber roads when traveling through the forest for ease of walking and because they provide expedient routes between overgrown, downfall thickets. The Bofi foragers have been observed utilizing the overgrown clearings for their communal net-hunts and porcupine hunts (both discussed in more detail below) by surrounding thickets with nets or traps and driving the game out of the overgrowth. The lumbar company has unintentionally created areas that certain game species (i.e., duiker and porcupine) prefer for cover. The foragers take advantage of this by occasionally focusing their hunting in these overgrown logged clearings.

Natural Environment

The Bofi foragers occupy forested areas throughout the northern and central portions of the N'gotto Forest Reserve (Fouts 2002; Hewlett 2000; Lupo & Schmitt 2002). The study site for this project was the village of Grima, which is located near the M'Baéré river (locally known as the Ya Ya). Approximately 200 Bofi farmers inhabit Grima (Fouts 2002) and roughly 150 Bofi foragers maintain a semi-permanent village near Grima. The forest around Grima continues to be administered by ECOFAC as a conservation and forest management area. The N’gotto Forest covers approximately 3250 km^2 and is situated between latitude 3°40' and 4°20' N, and longitude 16°40'and 17°30' E. The N’gotto area consists mainly of dense semi-deciduous forest with pockets of naturally occurring open wet-savanna and sections of raffia palm (*Raphia sp.*) swamp forest located along the Lobaye, M’Baéré and Bodingué rivers (ECOFAC 2003).

This portion of Africa has high temperatures and humidity as well as seasonally variable rainfall. The average yearly temperature is 77º F (25º C) with little seasonal variation. Hewlett (2000:14) notes that, “the difference between the high temperature of the warmest month (March) and the high temperature of the coldest month (July) is only 2 degrees C.” Humidity in the area ranges from approximately 90% in the morning to roughly 70% during the day and evening (Hewlett 2000; Hudson 1990). Rainfall annually exceeds 1.6 meters, with most of this moisture (in excess of 20 cm monthly) falling during the rainy season (mid-July to early November) (Hewlett 2000; Hudson 1990). This is balanced by the dry season (December to March) when less than 5 centimeters of rain a month is common (Hudson 1990). Because the N’gotto Forest is climatically stable (i.e., lacking extreme heat and cold variations) the reproduction for all species is not limited to a specific segment of the year and the diversity of plants and animals in the forest remains high.

A complete inventory of wild plants exploited by the Bofi foragers in the area of Grima has not been completed, but information from the Aka foragers near Ndele can likely be applied as a substitute (Hewlett 1977). Sixty-three plant species used as subsistence resources include six species of root crops (i.e., wild yams and manioc tubers), eleven plant species are utilized for their leaves, twelve species of mushrooms are consumed, as well as nuts from seventeen species, and seventeen different fruit bearing plants. The range of plants exploited by the Bofi goes well beyond simple subsistence, as much of their traditional medicines, technologies and material possessions are based on plant materials. Medicinal plants include the bark and roots of many trees, some of which (according to local informants) have been placed under the protection of ECOFAC. The forest provides ample materials for the construction of shelters and tools. Due to the reduced temperature variability in the region many of the exploitable plants (especially those usable for their bark and leaves) are available year-round, although some wild fruits, seeds and nuts are only seasonally abundant due to variation in rainfall (Bahuchet 1988). Only a small fraction of the total number of plants utilized by the Bofi foragers are listed in Table 3.1.

Table 3.1: Some plants commonly exploited by the Bofi foragers. Sources include Bahuchet (1984, 1988, 1999), Ichikawa and Terashima (1996) and Noss and Hewlett (2001).

Common/Local Name	Latin Name	
wild yam	*Dioscorea*	sp.
koko leaves	*Gnetum*	*africanum*
koko leaves	*Gnetum*	*buchholzianum*
nut / payo	*Irvingia*	sp.
general fruit	*Dioscorea*	sp.
wild pepper	*Piper*	*guineense*
parasol tree / kombo	*Musanga*	*cecropioides*
tree / ngata	*Mryianthus*	*arboreus*
cordage / kosa	*Manniophyton*	*fulvum*
ngongo	*Megaphrynium*	*macrostachyum*
rattan	*Eremospatha*	sp.
rattan	*Ncistrophyllum*	*secundiflorum*

Reports from ECOFAC indicate that the N’gotto Forest contains more than 115 species of mammals, which includes 13 primate species and an additional 320 species of birds (Dethier and Ghuirghi 2000). As with the plant species, a complete list of exploitable animal resources is not yet finished for the Bofi foragers. But a partial list of animals commonly exploited by the

Bofi foragers in southwestern CAR indicates that a wide range of prey is available (Table 3.2) (Dethier and Ghuirghi 2000; Hudson 1990; Lupo and Schmitt 2002; Noss 1995). Hunting by the foragers is directed mostly towards twenty-eight different species of game, and of those, approximately seventy-five percent have a live weight under 20 kg. Another three-quarters of those weigh less than 5 kg. The percentages of small prey animals would certainly increase if birds, reptiles, fish, crustaceans, and insects were included (including honey from eight different species of bee) that the Bofi and Aka foragers exploit (Hewlett 2000). Because hunting focuses on small prey, the Bofi foragers are considered small game specialists.

While a wide array of prey are available, the most common prey species, in the diet of the Bofi foragers are blue duiker (*Cephalophus monticola*), brush-tailed porcupine (*Atherurus africanus*) and giant pouched rats (*Cricetomys gambianus*) (Dethier and Ghuirghi 2000; Hudson 1990; Lupo and Schmitt 2002; Noss 1995). Larger duiker and pigs are pursued when they are encountered, but these opportunities are rare. The most common larger-sized prey include the Red-flanked duiker (*Cephalophus rufilatus*), Bay duiker (*C. dorsalis*) and Peter's duiker (*C. callipygus*)(Noss and Hewlett 2001).

Subsistence Activities

With such a large array of small animal resources at their fingertips, the Bofi have numerous methods of acquiring the different game species. While the shifting seasons of the N'gotto Forest does not impact the availability of prey (Noss 1995), the seasonal precipitation patterns influence hunting techniques (Lupo & Schmitt 2002). As with other forest foragers of the Congo Basin, the Bofi primarily use cooperative net hunts to acquire small artiodactyls (mostly blue duiker). During these hunts many men, women and children cooperate to acquire

Table 3.2: Mammals commonly exploited by foragers in CAR.
Sources include Hudson (1990), Kingdon (1974), Lupo and Schmitt (2002), and Noss (1995).

Common Name	Latin Name		ave. live weight kg.
Artiodactyls			
* Blue duiker	*Cephalophus*	*monticola*	5
Red-flanked duiker	*Cephalophus*	*rufilatus*	13
White-bellied duiker	*Cephalophus*	*leucogaster*	13
Water Chevrotain	*Hyemoschus*	*aquaticus*	13
Peter's duiker	*Cephalophus*	*callipygus*	20
Bay duiker	*Cephalophus*	*dorsalis*	22
Bushbuck	*Tragelaphus*	*scriptus*	50
Rodents			
* murid rats and mice	*nonspecific*		<1 kg
Cuvier's Fire-footed squirrel	*Funisciurus*	*pyrrhopus*	0.2
African Giant squirrel	*Protoxerus*	*stangeri*	0.6
African giant forest rat	*Cricetomys*	*emini*	1
* Giant Pouched rat	*Cricetomys*	*gambianus*	1
* Brush-tailed porcupine	*Atherurus*	*africanus*	3
Primates			
Galagos	*Galago*	*sp.*	1
Potto	*Perodicticus*	*potto*	2
Moustached Guenon	*Cercopithecus*	*cephus*	4
Black-cheeked White-nosed Geunon	*Cercopithecus*	*ascanius*	6
Greater White-nosed Guenon	*Cercopithecus*	*nictitans*	7
De Brazza's Guenon	*Cercopithecus*	*neglectus*	8
Colobus monkeys	*Colobus*	*sp.*	11
Mangabeys	*Cercocebus*	*sp.*	12
Carnivores			
Civet	*Civettictis*	*civetta*	3
Two-spotted Palm Civet	*Nandinia*	*binotata*	3
Genet	*Genetta*	*sp.*	3
Long-snouted Mongoose	*Herpestes*	*naso*	3
Marsh Mongoose	*Atilax*	*paludinosus*	3
Black-legged Mongoose	*Bdeogale*	*nigripes*	3

* indicates animals used in this thesis for analysis

game by hanging and moving nets or by beating the brush to drive game into the nets (see Hewlett 1977 for an in-depth account of net-hunting among the Aka). Although net hunts can occur year-round, they are more often executed in the dry season. Net hunts can occur during the wet season, but water saturation of the nets both weakens the natural fiber and makes the net heavier to carry (Hudson 1990; Lupo & Schmitt 2002).

Larger-sized prey animals are intentionally driven away from the nets as they are likely to damage the nets. A hunter more commonly takes these larger animals with metal-tipped spears upon encounter. While prey animals are taken year round with spears, foragers are more likely to undertake a focused spear hunt during the wet season as animal tracks and trails are more readily discernible (Fouts 2002, Hudson 1990).

Smaller rodents and carnivores (porcupine, rat, mouse and civet) are mostly taken with small snares and individual net traps. These prey often avoid the large nets and are difficult to drive or flush. Fire is commonly used to drive these small animals out of their burrows and into either individual purse snares or the hands of a hunting partner.

Traditional hunting (since at least the early 1900's) of monkeys and larger birds was undertaken with a bow and arrow, but the crossbow has largely replaced the bow in most areas in the last sixty to seventy years (Hewlett 1977). Crossbows are not now widely used, as they are being replaced with shotguns. Shotguns are often used to procure monkeys, but the gun and ammunition are expensive.

All of the above hunting techniques rely on active participation by one or more individuals, and it should be noted that many foragers also take part in and utilize passive hunting techniques in the form of trap-lines. Although trap-lines are set-up year round, they are most commonly utilized during the wet season because the habitual prey pathways are more readily discernable. Snares and trap-lines are also preferred by foragers and villagers because they reduce the hunters exposure to rain and do not require daily attention (Fouts 2002; Hudson 1990). Traditional traps and snares utilized natural fiber cordage to form the noose. However, more recent traps utilize metal wire as a noose material. The metal does not decay as rapidly in the moist forest undergrowth and is therefore less likely to break under the weight of a struggling animal. The disadvantage of using wire snares is that it is more expensive than natural fiber and more animals are likely injured and maimed while escaping, than with the traditional fiber cordage (Noss 1995).

Both men and women are involved in the daily gathering of resources. Forays into the forest are typically undertaken by the family unit (husband, wife, non-weaned infants, and those children able to keep up), which remains in close proximity to each other. While in the forest, both men and women are continually engaged in gathering activities that involve the collection of plant and animal subsistence resources as well as medicinal and technological materials (i.e., fiber for cordage, firewood, etc.) (Fouts *et al*. 2001; Fouts 2002). The net hunt is an exception to the individual family foray as multiple family groups (often the majority of the village) are required to increase the efficiency of the nets and make the effort worthwhile (Lupo and Schmitt 2002). During the daily family forays, the men tend to focus on hunting game while the women focus on gathering other forest resources. Since the family and most other foragers remain in close proximity throughout the day, they are all aware of and involved in each other’s gathering activities. Although the exact amount and type of gathered resources may vary depending on the season, the foragers typically trade one-third of their gathered subsistence products with neighboring horticulturalists at the end of the day. Most of the daily trade with villagers involves manioc, which makes up the bulk of the forager carbohydrate intake (Fouts 2002; Lupo & Schmitt 2002).

Animal Butchery Patterns

When prey are acquired by the Bofi, the animal is butchered and eventually cooked for consumption. Since different butchering and cooking techniques influence consumption patterns, the following section outlines butchery and cooking practices for four of the most common Bofi prey species. The blue duiker, giant pouched rat and brush-tailed porcupine are treated in similar, although not identical fashion. The differences will be emphasized in the following description. The murid rats and mice are treated differently by the foragers and so will receive specific focus here.

The following description of typical butchering events occurs in the forest shortly after prey capture. Hudson (1990) reports that blue duiker (as well as other prey) are commonly divided by the Aka into roughly nine segments depending on the amount of meat shared. According to Hudson (1990), after the carcass is eviscerated, the initial butchering consists of an initial separation of the head and most of the neck from the rest of the duiker's body. The body is then split sagitally through the vertebral column into two equal halves. Further butchery results in a removal of the hind- and forelimb from their respective halves and a separation of the ribcage from the vertebral column (Hudson 1990). These portions form the basic units of exchange for hunters involved in the capture and kill of the duiker. These butchery divisions are similar to those observed among the Bofi.

These butchery-units are further reduced into food-units for trade and redistribution before cooking and consumption in the village or camp. The food-units vary considerably in size as they are differentially shared among family members and neighbors before cooking. Most meat portions are boiled, presumably to stretch the relatively small units among household and camp members.

The initial field preparation of giant pouched rats (GPR) and brush-tailed porcupines (BTP) differs from that of the blue duiker (BD), although the final dismemberment is similar. Both the GPR and the BTP are roasted over open-flame in the field before dismemberment. This effectively removes the hair and quills of the respective animal. Whether butchery occurs in the field or at camp, both the GPR and BTP are divided into nine portions. Although not identical to the butchery of the BD, the differences as reported in Hudson (1990) and observed in the field are slight and consist of a shift in the way the animal's body is divided. Whereas the BD body is sagitally split, the GPR and BTP are not. The vertebral columns of the GPR and BTP are chopped transversely through the spine, leaving the ribs attached to their respective thoracic vertebrate, but separating the abdomen from the torso just behind the last rib (Hudson 1990).

Foragers who do not go into the forest may occasionally hunt murid rats and mice (MRM). The MRM are unique among the prey animals since they are typically roasted over open flames. After roasting, the animal is pulled apart and maybe shared among the individuals who are present and/or helped in the hunt. Because of the minimal preparation effort the MRM are not technically divided into "butchery-units."

Settlement Pattern

As noted by Hudson (1990:48) in reference to the Aka, "the ecological setting is well-suited to a foraging strategy. Temporal and spatial variability in the availability of particular resources exists, but their overall distribution makes the shifting of residential camps to the resource area a viable solution in almost all cases." What follows is a brief description of the camp movements of the semi-nomadic Bofi foragers with special attention to the dry season. The period of time when the faunal assemblage used in this project was collected.

For forest foragers in and around the N’gotto Forest, seasonal camp movements vary depending on the local environment as well as labor demands of local farmers. For example, the Aka living near Ndélé occupy separate villages near farms from August through October, while the Aka associated with Bokoka, are generally near the farming village from November to February (Hewlett 2000). The differential timing of these foraging groups is based on the availability and abundance of village resources (i.e., wages, manioc) as the acquisition of forest resources (i.e., duiker, honey, etc.) becomes more or less important (Hewlett 2001). In spite of these local variations there are some commonalities among the seasonal movements of the foragers in the N’gotto region. The end of the dry season (May – June) is the time of planting, and is a lean time for most of the local villages (Hewlett 2000). But the mid to late dry season in the forest is associated with successful net hunts, abundant honey and the ripening of many fruits and nuts. Consequently, for those foragers who leave the villages behind, the end of the dry season is a time of plenty (Hewlett 2000).

Although there is not yet a report specifying the annual settlement pattern of the Bofi associated with Grima, observations taken during four field seasons provide a baseline for seasonally variable settlement patterns. During the wet season (June – October) the majority of foragers live in a permanent camp near Grima. Small hunting camps are occasionally established in the forest during this time, but they are generally short in duration (a few days to a week). Towards the end of the wet season and the beginning of the dry season foragers tend to stay near the village to work in the farmer’s fields. As the dry season progresses they begin transitioning to relatively longer duration remote forest camps. In the mid to late dry season the foragers are mostly located in remote forest camps as they participate in communal net hunts. As the wet season commences, they return to a permanent camp near Grima.

Expectedly, the size of forager camps will vary depending on the time of year and the expected labor and subsistence activities. The semi-permanent villages of the wet season typically include anywhere from 10-100 individuals. Since these semi-permanent villages generally act as staging areas for either communal net hunts or field labor for neighboring villagers, the number of foragers present varies considerably (Hudson 1990). Temporary hunting camps differ in that they are used as focal points for short-term (days to weeks) forest forays while obtaining forest products, especially meat, for subsistence and trade. The remote forest camps are typically small, comprised of one or two families and are moved regularly (Fouts 2002), although some camps may have as many as 20 families (Lupo 2004:personal communication).

The previous discussion is not meant to imply that the Bofi foragers follow a specific seasonal movement, as do the Nunamiut (Binford 1978) and Ariaal (Fratkin and Roth 1996) in environments with strongly defined climatic seasonal variation. Rather, the lack of strong seasonal variation (excepting the precipitation) allows the foragers to capitalize on temporally or spatially unique resources (i.e., an exceptionally productive honey season), which may alter their settlement patterns. Since their decisions regarding subsistence and settlement patterns are based on climatic and economic variables that can fluctuate daily, they can appropriately be described as nomadic (Hewlett 1977; Hudson 1990)

Tooth Modification Practices

As this thesis is concerned with human created tooth marks it is necessary to discuss cultural traits that may create uniqueness in that patterning. It is important to note that some Bofi foragers practice traditional tooth shaping of the maxillary incisors when they enter adulthood. The Bofi foragers do not also practice shaping of their mandibular incisors as do the Aka (Walker and Hewlett 1990). To fully shape the maxillary incisors, the foragers chip or break-off both the mesial and distal corners, leaving the incisor pointed from the occlusal surface to the gum-line. Field observations indicate that there is a great deal of variability in this practice as some foragers have fully shaped upper incisors while others have only one tooth partially shaped (i.e., one corner of one incisor is removed). This practice is culturally designed to increase the attractiveness of the individual and is practiced by both men and women (Walker and Hewlett 1990). In a survey of 54 adolescent and older (216 potential upper incisors) Bofi foragers near the village of Grima from October - November 2003 roughly two-thirds (68.5%) had at least one modified upper incisor (Table 3.3).

Table 3.3: Raw numbers regarding tooth modification among a sample of fifty-four Bofi foragers age 13 – 60 during the fall of 2003.

	Upper Insicors					
	Lateral Right	Central Right	Central Left	Lateral Left		
Shaped	39	32	33	39	143	66.20%
S - Missing	2	9	8	1	20	9.26%
Partial	1	1	2	1	5	2.31%
Unshaped	12	11	11	13	47	21.76%
U - Missing	0	1	0	0	1	0.46%
	54	54	54	54	216	
					216	

The categories of ‘S-Missing’ and ‘U-Missing’ are assumptions based on contextual information from the individual forager’s mouth (see Appendix D). If three teeth were ‘Shaped,’ and one tooth was missing, then it is assumed that the missing tooth had previously been shaped. If that is a reasonable assumption, then a full thirteen percent (13.5%) of the foragers who had modified their maxillary incisors are now missing at least one tooth. This stands in contrast to the 1 forager who is missing an ‘Unshaped’ tooth.   While tooth modification may influence the rate of tooth loss, periodontal disease has been shown to have a significantly bigger contribution to tooth loss among foragers (Walker and Hewlett 1990). Whether or not cultural patterns of tooth modification have significantly altered the taphonomic signature of Bofi tooth marks on bone will be addressed in chapter five.

Conclusions

This chapter provided some historical, political, ecological and cultural context concerning the Bofi foragers. The Bofi foragers of the N’gotto Forest are nomadic small game hunters. In the last few thousand years they have adapted to the spread and introduction of swidden horticulture and governmental programs. Their lifestyle is certainly not the same today as it was a century ago, let alone thousands of years ago. This research does not attempt to use the Bofi as a model case study for all human-small animal interactions. The Bofi foragers represent one point along a range of human behavior by which it is possible to address the effects of human mastication on small mammal remains. Using the Bofi as an example will provide archaeologists another method of locating human activities in zooarchaeological assemblages. The following chapter describes the methodological approach for acquiring the Bofi faunal collection. Specific emphasis will focus on field collection methods as well as lab controls and sampling strategies.

Chapter 4: Assemblage Methodologies and Experimental Control Descriptions

> "A great deal of taphonomic information is encoded in the damage on bone surfaces;
> all that we need to decode it are the proper techniques, good control samples, and
> an adequate understanding of the processes by which bones are damaged."
>
> Shipman 1981:381

Within this chapter I describe the Bofi faunal assemblage and two experimental control assemblages. The first section of this chapter includes a brief description of the Bofi faunal assemblage and focuses on field methodologies as well as methodological and analytical techniques used in selecting an SEM sample. Because of a concern regarding taphonomic overprinting and accurate identification of mastication damage the second and third sections each contain descriptions of two individual control assemblages, which includes the rationale behind their selection, the applied methodologies, and the analysis of each assemblage.

Bofi Faunal Assemblage

The forager faunal assemblage analyzed in this thesis was gathered during the dry season in December 1999 and January 2000. During this two-month period foragers occupied a semi-permanent village near Grima and many of them also moved between a series of non-permanent hunting camps established in the forest that were generally occupied for a few weeks at a time (Lupo and Schmitt 2002). Information on Bofi forager hunting and subsistence activities was gathered through observations (via focal follow), interviews, and bones collected from individual meals. Daily systematic assemblages of bone refuse were made directly from the consumer and/or the consumer's family. The bone assemblages were collected from Bofi foragers in the semi-permanent village of Grima and from a short-duration remote forest camp. Thus, these two assemblages are useful in drawing distinctions between the consumption patterns of two different settlement types.

Bones were collected each day that researchers were in Grima or the remote camp. Researchers asked the foragers to place whatever remained of their meal (if anything) into plastic bags that were collected the next day. Part of the rationale behind this bone collecting strategy was to avoid any possible influence of attrition and destruction from local hunting dogs. The impact of dogs in scavenging, dispersing, destroying and otherwise complicating the taphonomic record of faunal assemblages are well known (Binford 1981; Hudson 1990; Munson and Garniewicz 2003; Payne *et al.* 1985; Zietz 2003). Since the bones in this assemblage were gathered before being discarded into nearby middens, the addition of any non-human tooth damage was avoided. The collected bone specimens were then cleaned with steel wool, mild detergent and water before being allowed to dry. After drying, the bones were examined and recorded in the field before being transported to the zooarchaeological laboratory at Washington State University. Because field cleaning included the use of steel wool, the taphonomic signature of human tooth marks may have been altered. The issue of potential taphonomic overprinting is discussed in more detail in a later section of this chapter.

The number of bones collected from the field for the 1999-2000 Bofi forager assemblage is shown in Table 4.1. Due to the small sample size of the civet, monkey, pangolin, tortoise and turtle remains, only the blue duiker (BD), brush-tailed porcupine (BTP), giant pouched rat (GPR), and murid rat and mice (MRM) bones are used in this analysis. My analysis began by assigning tooth-marked and non-tooth-marked status to the remains based on macroscopic criteria established by Binford (1978, 1981), Blumenschine and Selvaggio (1988), Bonnichsen & Will (1990), Brain (1981), Capaldo & Blumenschine (1994), Haynes (1980, 1983a), Fisher (1995), Johnson (1989), and Pickering & Wallis (1997) with special attention given to the descriptions of Elkin and Mondini (2001) and Weisler & Gargett (1993). Assuming that these definitions of mastication damage are applicable to the Bofi foragers, then this assemblage has 487 identifiable bones damaged by mastication (Table 4.1 and Appendix A). Using these macroscopically identified tooth-marked bones as a springboard for further research, I selected a sample of bones for SEM analysis. The results of SEM analysis are useful in comparing characteristics of human tooth marks to carnivore tooth marks and to verify macroscopic identifications of tooth marks.

Table 4.1: 1999/2000 Bofi forager faunal assemblage counts of Blue Duiker (BD), Giant-Pouched Rat (GPR), Brush-Tailed Porcupine (BTP), Murid Rats and Mice (MRM), Monkey, Pangolin, Tortoise and Turtle (TT), and Civet, and non-identifiable (NID) bones.

	BD	GPR	BTP	MRM	Monkey	Pangolin	T/T	Civet	NID	Total
Non-Tooth Marked	916	538	182	199	56	49	17	12	24	1993
Tooth-Marked	254	129	77	27	7	11	0	3	0	508
Total	1170	667	259	226	63	60	17	15	24	2501

The following description outlines a technique used to define a sample for SEM analysis within the Bofi faunal remains. BD remains are used as an example of the sampling technique throughout this section. Specific attention is made to insure that the different probabilistic sampling techniques are applied in a manner consistent with activities reported from the field. Any discrepancies in sampling technique application between prey species are noted in the text.

A simple random sample of tooth-marked bones is likely to provide a representative group by which to assess the amount and types of micro-morphological damage associated with human tooth marks. This would effectively meet one goal of this project, which is to delineate a sample whereby the micro-morphology of human tooth-mark patterning can be tested. However, “when the population we wish to make inferences about can be readily divided into different subpopulations, it is often advantageous to select sub-samples separately from each subpopulation" (Drennan 1996:87). The Bofi faunal assemblage contains a large number of ribs. More than one third (40.6 %) of all the mastication damaged BD bones are ribs or rib portions. Whether this is due to a higher number of ribs per animal skeleton, their cultural selection based on some notion of importance, or the structure of the bone and attached muscles as they relate to consumption is unclear at this point. What is clear, it is that a simple random sample of bones from a single agglomerated species may not truly represent differential tooth mark patterning that may exist between skeletal elements because of bone density or cultural habits. I utilize a stratified random sample to gain an accurate picture of the micro-morphology of human tooth marks between a variety of skeletal elements.

To stratify the assemblage of tooth marked bones, I utilized the nine ethnographic butchery-unit descriptions from chapter 3. For the purposes of this research, it is assumed that during consumption each section of an opposing skeletal half will be treated, as is the other half. In other words, the left and right forelimbs are held in equal regard, as are the right and left sections of ribs, with respect to consumption practices. Thus, following work by Hudson (1990) these nine butchery-units can be condensed to five basic analytical units that consist of: 1) the head and neck, 2) both forelimbs, 3) both hindlimbs, 4) both sections of ribs and sternums, and 5) both halves of the vertebral column. With a known number of bones included in each analytical-unit, it is possible to determine a number of proportion percentages, standard deviations and confidence levels in those proportions (Drennan 1996). It is then possible to derive sample size estimates given a number of specific confidence intervals and error ranges for each species in each location (Drennan 1996:139-145). Although only results for the BD bones are shown in Figure 4.1, the same mathematical principles can be applied to the other species.

Estimated sample sizes overestimate the actual population size for the BD bones in the Bofi assemblage at the highest levels of confidence. This does not mean that it is not possible to select a sample from the relatively small species specific populations in the Bofi assemblage, only that the amount of confidence placed in those samples as representative of a larger whole is limited.

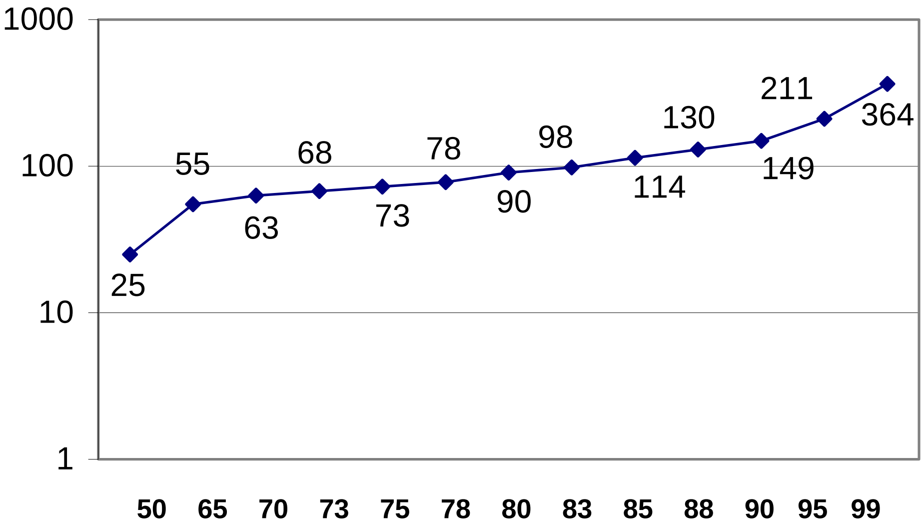

Figure 4.1: Estimated sample sizes for BD given a 95% confidence in sample proportion distribution and 11.4% error range. Bottom row (x-axis) indicates confidence levels in representativeness of sample, while the left side (y-axis) indicates total number of bones required for SEM sample.

Using this method as a guideline for my SEM sample, a 65% confidence level was chosen to provide a greater than average chance of representing the collection as a whole, while minimizing SEM technician time. This resulted in a total of fifty-five BD bones (Table 4.2), twenty-one BTP bones, twenty-six GPR bones, and nine MRM bones being selected for micro-morphological analysis. With the mastication damaged bones placed in their respective analytical-units, each tooth-marked bone was assigned an individual number from which a random sample was drawn. A series of random numbers were determined without replacement for each butchery unit by species using www.random.org/sform.html.

The bones selected as part of the SEM sample were initially viewed with a 10x hand lens and strong lighting to identify areas with and without modification. Analysis of those areas was then supplemented with an Image Analysis Workstation (IAW) and a SEM. Both the IAW and SEM are housed in the Electron Microscopy Center, Department of Biological Sciences at Washington State University, Pullman, WA. The IAW consists of a Wild-Heerburg Dissecting Scope that is connected to a Color Image Analysis CCD MicroImage videosystem where the elusive image is collected with an NIH Image capturing system. Many specimens viewed via SEM are gold-coated to provide an even distribution of scattering electrons. The bones used in this research were not gold-coated. Preparation of the BD, BTP, GPR, and MRM bones for the SEM consisted only of dehydration and desiccation to remove excess water and grease to meet vacuum requirements of the SEM specimen chamber. A descriptive summary and analysis of the bone modifications are located in the following chapter.

Table 4.2: Assemblage bone counts as divided with reference to ethnographic division of blue duiker. Isolated teeth, generic metapodials, and non-identifiable (NID) bones are not included.

Analytical-Units	Tooth-Marked	SEM Sample
Head	27	8
Forelimb	33	9
Hindlimb	16	5
Vertebrae	71	15
Ribs	106	18
Total	253	55

Rabbit Cleaning Experiment

The bones in the Bofi assemblage were cleaned in the field with tools that potentially modified the evidence of human mastication. To understand the influence of specific cleaning methods I created a control assemblage. On separate occasions I cooked, cleaned and modified (via abrasion with steel wool) the bones of two domestic rabbits (*Oryctolagus cuniculus*). The experimental cleaning process mimics the field cleaning methods used in the CAR.

I used rabbit bones as a substitute since blue duiker remains are not readily available in Pullman, WA. Despite differences in overall physical morphology between these animals, rabbits are an appropriate proxy for blue duiker. Both rabbit (Hockett and Bicho 2000; Quirt-Booth and Cruz-Uribe 1997; Shaffer and Gardner1995; Thomas 1969) and blue duiker (Fouts 2002; Hewlett 2000; Hudson 1990; Lupo & Schmitt 2002; Noss 1995) have been and are used by humans as a source of food. Both animals are widely distributed and abundant in their respective homelands. Since both mammals are of relatively equal body sizes (live weights: blue duiker = 5 kg and rabbit = 3 kg) the surface of their individual skeletal elements should react in similar fashions to processes of modification even though the exact form of each skeletal element differs.

The two domestic rabbits (R1 and R2) used in this study were raised in St. Marie's, ID. They were approximately six weeks old at the time of butchering, which allows them to grow to roughly five pounds (Williams personal communication 2002). These rabbits were not fully mature, as indicated by the unfused epiphyses of their limb bones. It is not clear if the age of the animal and the amount of cortical bone growth (perhaps as a proxy for bone strength or bone density) affects the amount of bone surface damage. That question will need to wait for further taphonomic investigation. The rabbits were acquired, frozen, from a local butcher and were not skeletally complete. The head and neck were removed at approximately the last cervical vertebrate, and the feet were removed by chopping through the shaft of the ulna-radius/tibia-fibula.

The first rabbit (R1) was slow roasted for one and a half hours. The second rabbit (R2) was roasted for one hour. The cooking process resulted in minimal carbonization of the exposed bone ends. After removing a majority of the muscle tissue by hand, all of the bones were steeped until remaining tendons and ligaments could be pulled off by hand. Special care was taken with all of the right side ribs of R1 and the entire right half of R2 to insure that the bones remained unmarked during tissue removal so they could function as an unmodified control group.

The entire group of R1 bones was allowed to air dry before 11 arbitrarily selected bones were photographed with the IAW and SEM and then subjected to steel wool abrasion. All of the bones (n = 19) from the left side of R2 were subjected to steel wool abrasion before drying. This was done to insure that the adhering tissue was included as an influence in the cleaning process, since I am unaware of which bones in the Bofi assemblage may or may not have had adhering tissue when cleaned. The R2 bones were then allowed to air dry. Steel wool abrasion was controlled in a unidirectional, bi-directional, and multi-directional fashion upon separate, specific and discrete loci of both R1 and R2 in an attempt to gain control over potential damage resulting from field cleaning activities (see Appendix C). The scrubbing process was controlled by the amount of time the bone was scrubbed; never exceeding 10 seconds or 12 passes in the same area. No quantifiable measurements were taken with regard to the amount of variability in pressure during the scrubbing process with either rabbit. In a non-quantifiable manner, the pressure varied from light (the weight of the steel wool) to moderate. The areas of modification were then again photographed via IAW and SEM. No special procedures were required of the rabbit bones beyond basic dehydration before being viewed by the SEM. SEM pictures were taken on an arbitrary sample of 11 bones (including ribs, scapula, humerus and femur) from R1 and 8 R2 bones (including ribs, scapula, humerus, radius, ulna, femur, and tibia/fibula) to understand the surface features of the bones before and after purposeful modification.

Analysis of the rabbit bones after scrubbing with a steel wool indicates two major types of bone surface damage regardless of whether the bone was dry or not before being cleaned. The first noticeable type of modification was elongate linear or curvi-linear striations that often occurred in clusters (Figures 4.2 A & B). Microscopically these striations appear as v- or u-shaped grooves with smooth internal surfaces. I will refer to these marks as ‘cleaning scratches’ or CS. Measurements on the CS were taken across their width at the widest observable point since it represents a proxy for the combination of forces contributing to the damage (Shipman 1983; Shipman & Rose 1983). Thirteen of the 19 sampled rabbit bones exhibited CS. Measurements were recorded for 77 individual marks whose average and median measurements are both 0.03 mm in width. The smallest recorded mark is 0.01 mm in width while the largest mark measured at 0.10 mm (Figure 4.3). Most of these striations are not visible to the unaided eye and are only noticeable at microscopic levels (see also Shipman and Rose 1983b).

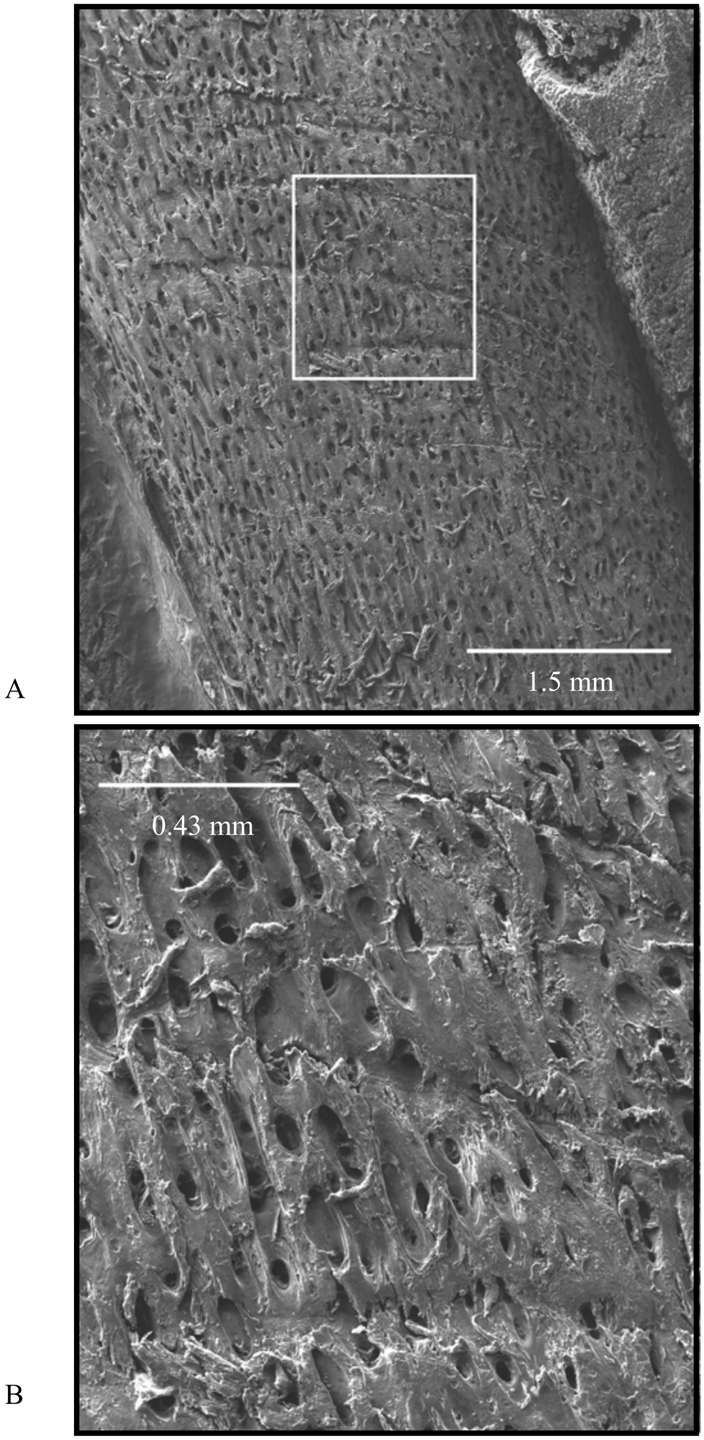

Figure 4.2: SEM photograph of marks left by scrubbing on the shaft of a rabbit femur. Magnification for A (top) is 20x. B (bottom) is a higher magnification photo (70x) of the boxed area in the top photo.

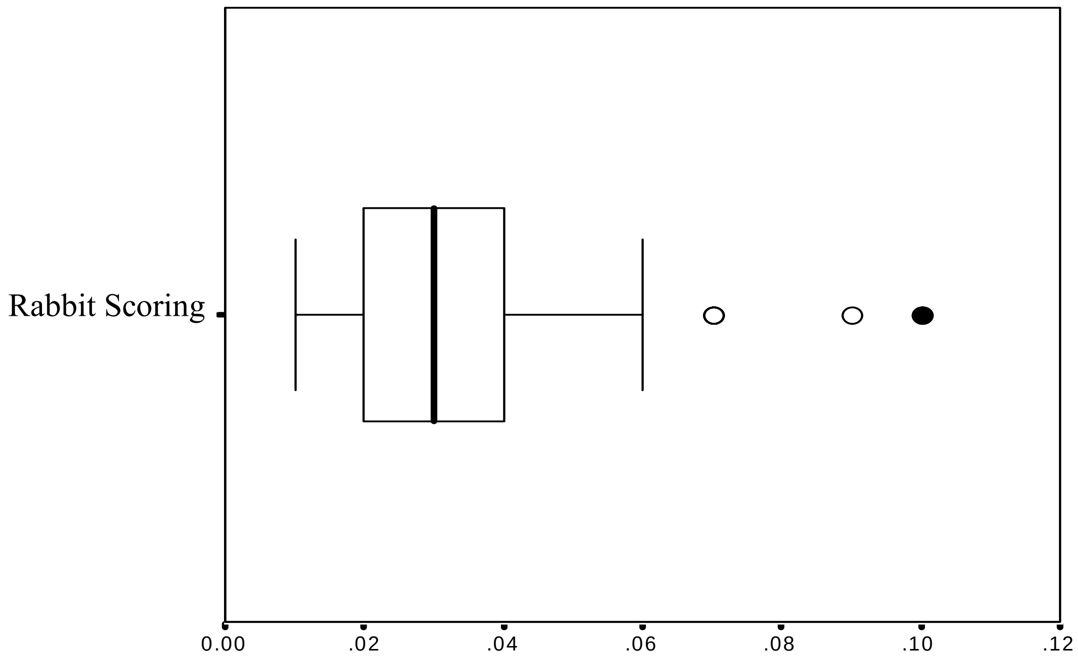

Figure 4.3: Scale is in millimeters. Box and Whisker Plot of mark width left during cleaning by steel wool on rabbit bones. N = 77

The second resultant modification is considerably more subtle than the abrasion marks. As shown in Figure 4.4 A & B, the abrasiveness of the steel wool will often result in the removal of superficial cortical bone layers creating a smoothed or polished surface. This type of bone surface modification is most easily observed on fractured edges where the resultant break has been rounded and cantilevered bone fragments have been removed (Figure 4.5 A & B). Smoothing or polishing on non-edge surfaces are difficult to identify, as the analyst must be familiar with the microscopic surface features of bone (i.e., identification of scrubbing on 4.4 B without 4.4 A). However, as an aid, individual bones will generally exhibit one or more modified surfaces that show both striations and polishing (see Figure 4.4 B, upper right corner). All of the scrubbed and SEM analyzed rabbit bones exhibited some degree of smoothing.

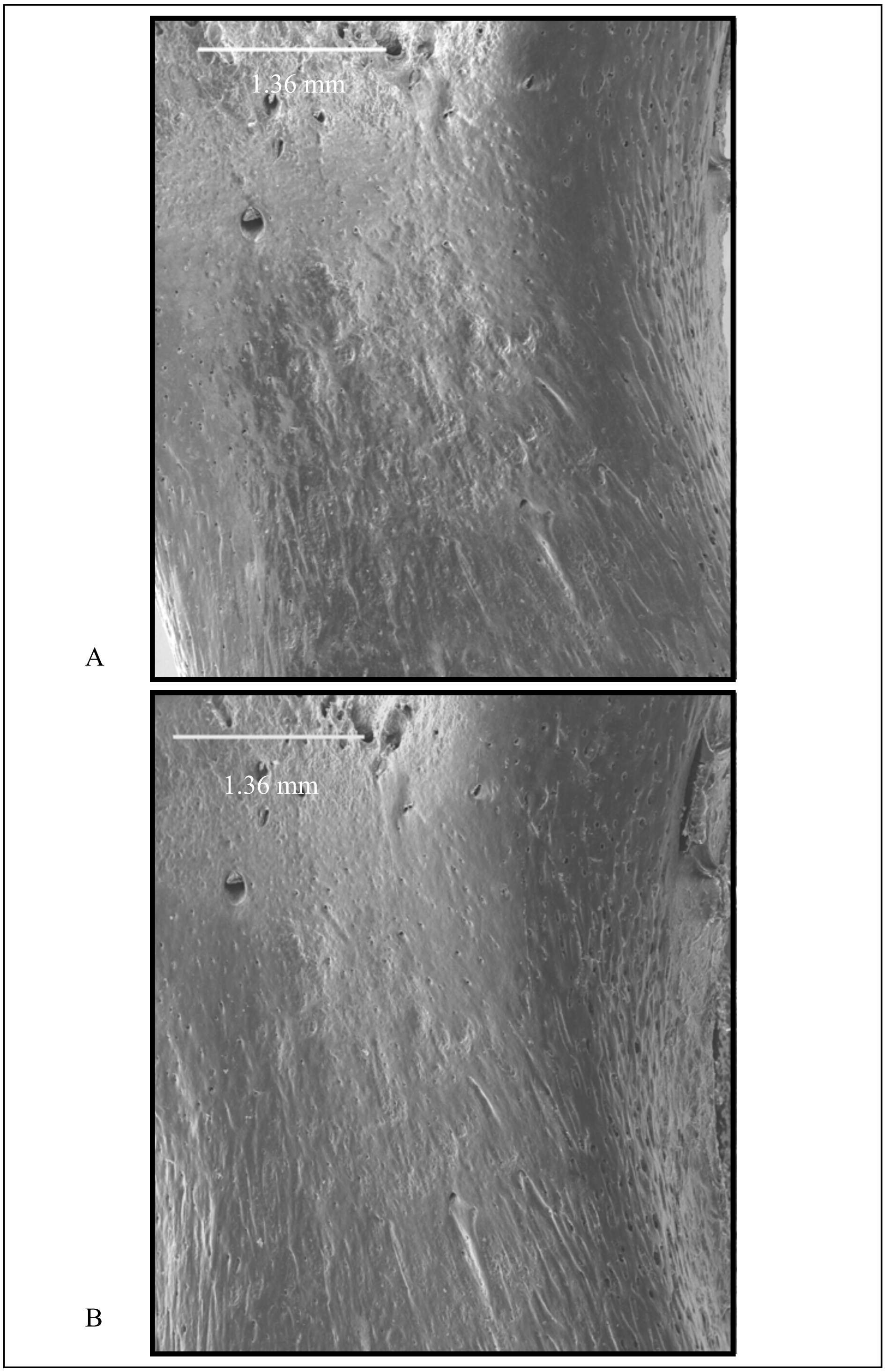

Figure 4.4: SEM photographs of: A) before scrubbing with steel wool and B) showing polish left by steel wool on the neck of a rabbit scapula. Magnification for both pictures is 22x.

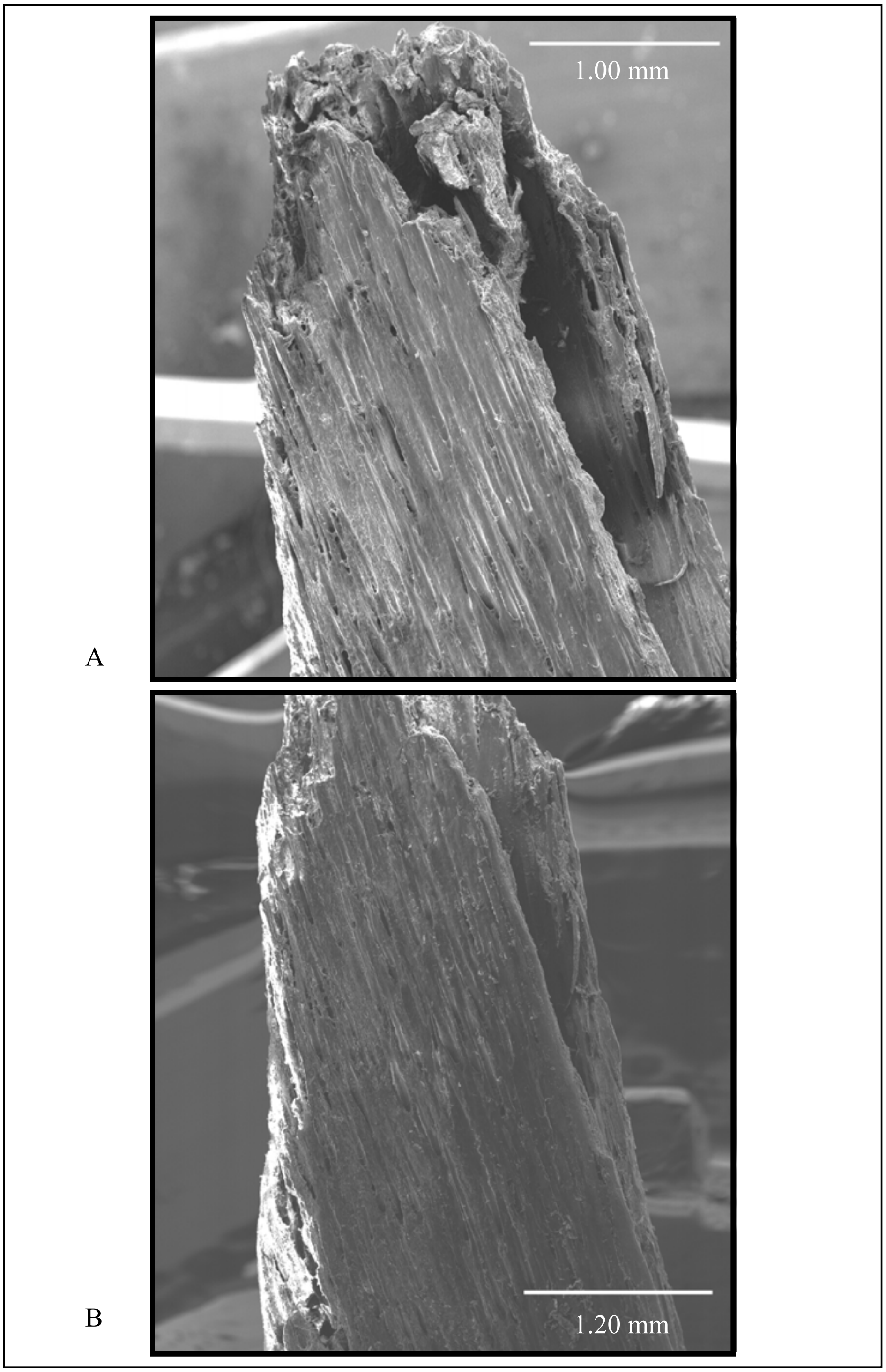

Figure 4.5: SEM photographs showing A) unmodified midshaft fracture of a rabbit rib and B) rounded edges left by scrubbing with steel wool. Magnification for photo A is 30x and photo B is 25x.

Results from the Bone Cleaning Experiment

Assuming the steel wool induced damage in the rabbit control group approximates the modifications left during field cleaning of the Bofi faunal assemblage, then there are a number of implications from this cleaning process that need to be reconciled with regards to the identification and accuracy of morphological features of human tooth marks in the Bofi forager collection. First, can the cleaning process and its associated marks mimic or otherwise provide false identifiers for hominoid mastication damage? Cleaning activities can produce small isolated or grouped linear scratches. Any relatively small linear groove (approximately ≤ 0.10 mm in width), whether it is isolated or in a cluster (parallel, perpendicular or angled to the majority of marks) in the Bofi faunal assemblage, may have been produced by post-collection scrubbing. However, it might be possible to identify small scratches as a result of mastication or field cleaning based on contextual information regarding the marks anatomical location (e.g., scratches on a long bone shaft where little muscle is attached being likely candidates for cleaning), the nearest neighboring mark (e.g., many fine multiple marks indicating cleaning, while a single groove ending in an area of cortical crushing indicating human mastication), and any observable polishing or rounding of edges as further support of cleaning.

As noted above, the cleaning process removes external cortical bone layers. This smoothing of the bone can potentially erase any pre-existing marks that do not extend beyond these superficial layers and remove or reduce edges and shoulders of marks that extend further into the cortical bone (refer to Figure 4.4 A & B, see also Behrensmeyer *et al.* 1986). The second question to be asked of the Bofi assemblages is how the cleaning process and its associated polishing have modified or removed marks in the Bofi faunal assemblage? Without measurements on either tooth mark size or scrubbing intensity before, during and after field cleaning it is impossible to quantify the impact of scrubbing in the Bofi assemblage. It is possible that the removal of superficial cortical bone will result in a smaller size range of tooth marks as the bone surface is removed by scrubbing. However, it is also feasible that the tooth mark becomes larger when the crushed shoulders of the mark become smoothed. Smoothed shoulders should be observable under microscopic examination, thus removing those marks from the sample if necessary. This unavoidable field oversight provides an interesting test case. The scrubbing and subsequent loss of external bone layers may unintentionally mimic post-depositional events (weathering, sediment abrasion, etc.) that alter bone surfaces and unintentionally provide a more accurate 'archaeological' pattern. However, until future studies allow comparisons to be drawn between multiple human tooth marked collections it will be impossible to test this idea.

Chimpanzee Feeding Experiments

Only two publications deal specifically with the identification of human tooth marks (Elkin & Mondini 2001; Weisler & Gargett 1993), and I am not aware of any reports that deal with tooth mark descriptions on small mammal bones in the same size-range as those in the Bofi assemblage. Washington State University does not have a comparative collection of tooth marked bones, and since I had reservations about morphological signatures of tooth marks, I enlisted the aid of another control sample to clarify micro-morphological features. This section details the second control assemblage, which consists of chimpanzee modified turkey bones. There are a few publications detailing macroscopic captive chimpanzee tooth marks on larger-sized prey (Pickering and Wallis 1997) and wild chimpanzee created bone assemblages (Plummer and Stanford 2000).

Since the identification of human tooth marks in the archaeological record has implications for studies of early hominoid subsistence strategies, my intention is to clarify hominoid as well as hominid subsistence remains from those of other carnivores. Pickering and Wallis (1997) have provided an impetus for hominoid and carnivore comparisons with work among captive chimpanzees (*Pan troglodytes*). In 1997 Pickering and Wallis published on their controlled feeding experiments involving a population of zoo chimpanzees and numerous goat (*Capra hircus*), deer (*Odocoileus virginianus)* and bovine (*Bos* sp.) ribs. They suggest that the macroscopic identification of mastication damage and the differential form of dentition (i.e., bunodont versus carnasial) may serve as a foundation for discussing how early hominiod mastication may be distinct from tooth marks left by obligate carnivores.

Plummer and Stanford (2000) discuss the bone remains of 5 red colobus monkeys taken during a chimpanzee hunt in Gombe National Park, Tanzania. Their work suggests that the largest prey of chimpanzees rarely exceeds 10 kg and that chimpanzees will generally consume the bones of prey animals. However, they note that some carcasses are abandoned before being totally consumed and utilized if there are enough prey resources to satisfy the needs of the group. Plummer and Stanford (2000) do not discuss mastication damage morphology, but they do take note of the frequency of different tooth damage types on their relatively small sample. Both articles (Pickering and Wallis 1997; Plummer and Stanford 2000) articulate a need to identify hominoid resources in the archaeological record based on characteristics of modern chimpanzee mastication damaged assemblages.

In an effort to clarify hominoid as well as hominid resources and since the Bofi faunal assemblage consists of small-sized prey, I collected a sample of chimpanzee modified small prey remains as a comparison. With help from the researchers and technicians at the Chimpanzee and

Human Communication Institute (CHCI) at Central Washington University, Ellensburg, WA, assemblages of chimpanzee (*Pan troglodytes*) modified turkey (*Melleagres gallopavo*) remains were collected on two separate occasions. Washoe, a female chimpanzee, who is approximately 38 years old and the matriarch at CHCI, consumed the turkey (Fouts personal communication 2002).

Thanksgiving is the only time of year at the CHCI when the chimpanzees are allowed meat in their diet due to a number of appropriate social and scheduling concerns. Due to the excitement caused by the holiday meal, human interaction concerns, and facility requirements I was unable to personally observe chimpanzee feeding behavior and/or personally collect the remains. Since the turkey remains were shipped to me, I am unaware of how much turkey (meat and/or bone) Washoe was originally given and how long she may have chewed on any individual skeletal element, although I was told that the remains were removed from the enclosure upon her first losing interest in them (Fouts personal communication 2001). Consequently, I cannot speak with confidence about chimpanzee preferences regarding skeletal distribution or localization of tooth marks. Because the remains arrived with adhering tissue (i.e., muscles, tendons and ligaments), I cleaned and dried the bones before analysis. To facilitate the removal of tissue with minimal surface modification, the turkey bones were steeped in water until the tissue could be removed by hand without the aid of tools and then allowed to air dry. Since I was the only one to remove tissue and potentially modify the bones after the chimpanzees, there are no other actors or influences with regards to bone surface modification.

The resulting assemblages of turkey bones (NISP = 31) consist entirely of upper and lower limb elements that are mostly intact (from CHCI 2001) as well as a number of unidentified long bone fragments (mostly from CHCI 2002) (Appendix B). While the assemblage is not appropriate for describing preferential skeletal selection and consumption by chimpanzees, it is useful for obtaining comparative information regarding characteristics of omnivore tooth marks on small-sized prey with the understanding that avian bones differ from mammalian bones in a number of histological ways (McKee and Nanci 1993; Nicholson 1996; Rensberger and Watabe 2000, Roach 1997).

Focusing microscopically on the assemblage makes it possible to observe morphological features that might otherwise go unnoticed (Blumenschine & Marean 1993; Shipman 1983, Shipman & Rose 1983). Because of the fractured nature of the bones and the relatively small size of complete turkey bones, dehydration and desiccation were the only requirements before the bones were viewed with the SEM. To observe tooth mark characteristics, an arbitrary sample of one-third of the assemblage (or 14 bones) was microscopically examined. Selected elements include numerous long bone fragments, two fibulas, two femurs, a tibiotarsus, an ulna, and a carpometacarpus. After drying, the bone surface was examined using the same 10x hand lens, IAW, and SEM utilized with the rabbit cleaning experiment.

Description of Damage by Chimpanzees

Crenulated and fractured edges are the most obvious type of macroscopic mastication damage on the turkey bones, occurring on roughly one-third of the assemblage (Table 4.3). Tooth damage on intact bones in the 2001 collection of chimpanzee tooth-marked bones (CHCI 2001) is macroscopically evident by crenulated edges that are located on the proximal and distal ends of long bones (Appendix B). Of the 10 long bones in CHCI 2001, six display minimal mastication modification on the epiphyseal ends. The second year collection of bones (CHCI 2002) are mostly fragmented and poorly identifiable. Epiphyseal ends of most elements are destroyed and only remain intact on one fibula. In CHCI 2002, only four of the fourteen bones exhibit any macroscopic crenulations, although twelve display fractured edges. CHCI 2001 displays more crenulated edges than fractured edges, which contrasts sharply with CHCI 2002. The distribution of crenulation and fracturing damage amounts between CHCI 2001 and CHCI 2002 is significant (d.f. = 1, $\chi^2 = 7.304$, $p \leq 0.01$).

Table 4.3: Counts and percentages of damage types for CHCI 2001 and CHCI 2002. Microscopic damage is only reported for the SEM sample.

	Macroscopic Damage		Microscopic Damage		
	Crenulated Edges	Fractured Edges	Pits	Notches	Scratches
CHCI 2001	6	1	4	3	4
N = 17	60%	8%	15%	60%	31%
CHCI 2002	4	12	23	2	9
N = 14	40%	92%	85%	40%	69%
Total Counts	10	13	27	5	13

Microscopic analysis indicates that three types of damage (pits, notches and scratches, as defined in Chapter 2) are consistently found in association with both the crenulated and fractured edges (Table 4.3). The SEM sample of turkey bones resulted in measurements of thirty-two tooth pits on fourteen of the sixteen selected bones (Table 4.4, Figure 4.6 a). Measurements on the tooth pits were taken as the maximum linear dimension (MLD) between crushed borders as a proxy for tooth mark size and amount of bone damage. The largest mark is roughly seven and a half millimeters in diameter, while the smallest diameter tooth pit is less than half of a millimeter in size. For comparison purposes, this range of measurements centers around two and a half millimeters in diameter.

The second category of microscopic damage for the chimpanzee modified avian collection is tooth scratches (Table 4.4, Figure 4.6 b). Scratches occurred on roughly half (53.8%) of the sampled turkey bones in association with fractured edges, crenulated edges and tooth pits. Of measured tooth scratch marks on the turkey bones, the widest mark measured slightly less than one millimeter in width while the smallest was less than a quarter of a millimeter in breadth. The median and average width is approximately four-tenths of a millimeter.

Table 4.4: Combination of size measurements of tooth damage in SEM sample of CHCI 2001 and CHCI 2002 chimpanzee modified turkey bones. 'N' refers to the number of bones.

Mark Type	N	Minimum (mm)	Median / Mean (mm)	Maximum (mm)	Std. Dev. (mm)
Pits	27	0.40	2.25 / 2.33	5.08	1.09
Notches	5	1.71	3.85 / 4.55	7.61	2.39
Scratches	13	0.17	0.34 / 0.42	0.98	0.27

As others have suggested, the identification of both pits and scratches in association with fractured or crenulated edges is likely a diagnostic characteristic of carnivore modified assemblages (Pickering and Wallis 1997). The association of pits and scratches is reported here because they are both consistently found together and in conjunction with fractures and crenulated edges. All of the crenulated and fractured edges have pits and/or scratches. Further, approximately one-third (35.7 %) of the sampled bones exhibit *both* pits and scratches in association with these damaged edges. The fragmented long bones exhibit more tooth pits and scratches than do the complete bones, with microscopic mastication damage localized adjacent to the fractures. However, the microscopic damage displays no significant differences in distribution with regards to CHCI 2001 and CHCI 2002 (d.f. = 1, $\chi^2 = 0.396$, $p \leq 1$).

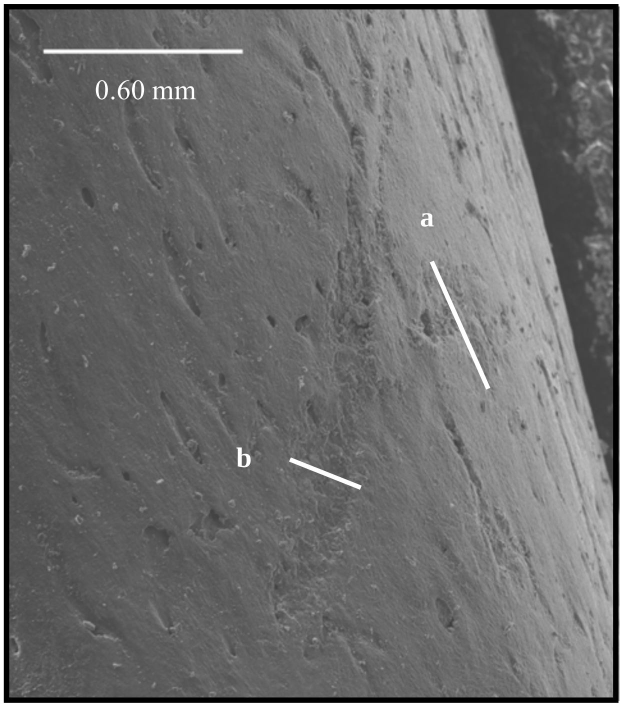

Figure 4.6: SEM photograph of tooth mark pit (a) and tooth mark scratch (b) by a chimpanzee on a turkey fibula at a magnification of 50x.

Analysis of Chimpanzee Modified Avifauna

Although the CHCI 2001 bones have been impacted by chimpanzee mastication, the minimal amount of damage occurring on the softest portions of the bones and the relatively minimal damage across all of the bones likely indicates that Washoe was not actively consuming bone or attempting to gain nutrients within the bone (i.e., marrow and grease) as a source of nutrition. Two reasons that captive chimpanzees may not actively consume turkey bone include: 1) a low appetite level and/or 2) being unaccustomed to consuming bone. If the chimpanzee was not consuming bone as a source of nutrition, then it is likely that the tooth marks in CHCI 2001 are only incidentally on the bone as a product of meat removal.

The heavy mastication induced fracturing damage reflected in CHCI 2002 indicates that Washoe was either actively consuming the softer bone portions or attempting to gain nutrients located within the bone. The consumption patterning in CHCI 2002 may indicate: 1) an increased appetite level, 2) boredom, and/or 3) familiarity with bone breakage while obtaining nutrition. Boredom can likely be eliminated as the turkey bones were not left in the enclosure beyond Washoe's initial waning of interest. If Washoe was gnawing bones, then the tooth marks in CHCI 2002 are actively produced and should not be considered incidental, which contrasts sharply with CHCI 2001.

Macroscopically, this faunal assemblage shows a high level of variation in the bone-modifying behavior for one chimpanzee. The macroscopic variation between CHCI 2001 and CHCI 2002 may be the result of a number of consumption behaviors including; 1) appetite level, 2) amount of nutrient attached to and within the bone, and 3) duration of exposure. Given the relatively small sample, the distribution of crenulation and fracturing in the CHCI assemblage is suggestive of a link between mastication induced fracture damage resulting from active bone gnawing behavior while minimal crushing damage directed towards epiphyseal ends may be linked to incidental contact between teeth and bone during consumption of tissue.

Conclusions

Regarding the cleaned rabbit bones, it was noted that field cleaning with steel wool both modifies and removes external bone layers. While all of the bones in the Bofi assemblage were cleaned in the field, the full impact of this practice on the Bofi forager faunal assemblage cannot be fully known. Analysis in the following chapter will clarify the impact of steel wool with regards to the Bofi faunal assemblage.

The CHCI avian faunal assemblages clearly point out that a large amount of variation will potentially exist in taphonomic studies. While the information on tooth mark micro-morphology will be useful in later discussions regarding inter-assemblage variation, it is not possible to address chimpanzee consumption patterns in a broader context due to the nature of the CHCI collection. Since differential consumption behaviors were not controlled for in this assemblage, future research will need to be focus on a variety of prey-size classes to understand the way in which consumption patterns may vary for chimpanzees in particular and hominoids in general. Future research may also indicate if it is possible for multiple chimpanzees in different settings to produce an even greater range of macro- and microscopically diverse behavior. Unfortunately, it is unwise to speak in broader terms regarding the relationship of chimpanzee element selection and tooth mark patterning across bones with relation to faunal remains.

The specific methodologies used in the Bofi faunal assemblage and two experimental assemblages used as research controls were described in this chapter. Each of the above sections outlined individual components, analytical methodologies and selection rationale within the bounds of this research so that the appropriateness of each assemblage can be independently determined. The analytical results of the two control assemblages were also included herein. While each of the faunal assemblages are independent, it is the combination of results from each assemblage that speak to the appropriateness of the final results of this thesis concerning the identification of human mastication in zooarchaeological assemblages. With that in mind, the following chapter provides descriptions and comparisons regarding intra-assemblage analysis for the Bofi forager faunal assemblage.

Chapter 5: Bofi Assemblage Descriptions and Intra-Assemblage Analysis

"While some time ago archaeologists often interpreted carnivore-inflicted damage as human
modifications, more recent studies have tended to do the opposite,
generally interpreting any tooth damage as carnivore-generated"

(Elkin and Mondini 2001:260-261)

Within this chapter I describe the results of analysis of the mastication damaged Bofi forager faunal assemblage. There are three subsections that follow. The first subsection describes details of macroscopic damage for the blue duiker (BD), brush-tailed porcupine (BTP), giant pouched rat (GPR), and the murid rats and mice (MRM) bones that exhibit mastication damage. The second subsection provides details of the microscopic damage acquired via SEM analysis for each of the four mammals, including a discussion of the impact of field cleaning. The final subsection draws upon the entire mastication damaged collection for intra-assemblage variation comparisons regarding preferential consumption patterns among skeletal elements, placement of tooth marks on long bones and the amount of element damage. The final portion of this section draws comparisons between Grima and the remote camps with regards to mastication damage frequencies.

Macroscopic Descriptions of the Bofi Assemblage

The most obvious type of macroscopic damage on BD, GPR, BTP and MRM bones resulting from human mastication activities are punctures, fractures and crenulated edges, which are defined in Chapter 2 (Table 5.1). The BD bones with mastication damage (N = 254) are largely complete and there is only 1 unidentifiable long bone fragment (Appendix A). Mastication damage on intact bones is largely localized on proximal and distal ends that generally resulted in the removal of minimal to moderate amounts of cancellous bone tissue (e.g., removal of trochanters, and ends of ribs). The crenulated edges of most of the mastication damaged GPR bones (N = 129) is similar to that described by Weisler and Gargett (1993) where entire long bone epiphyses are removed as well as the ends of other bones (e.g., innominate crests, rib halves). Although BTP meat is highly desired among the Bofi (Hewlett 2001) the sample of tooth marked bones (N = 77) is smaller than might be expected when compared to the BD. The BTP bones damaged during mastication are mostly complete and damage is generally limited to the proximal and distal ends. This damage is discernible in crenulated edges as well as tooth scratching and tooth punctures that resulted in the removal of small to moderate amounts of cancellous bone tissue. Entire epiphyses were only occasionally removed by mastication. Even on the small MRM bones (N = 27) there is little fragmentation of whole bones, and most of the mastication damage is limited to the proximal and distal ends. This damage is discernible in crenulated edges that resulted in the removal of small amounts of cancellous bone tissue but did not result in the removal of epiphyseal ends.

The distribution of crenulated and fractured edges (see Table 5.1) with respect to all four species analyzed here is significant (d.f. = 3, $\chi^2 = 15.37$, $p \leq 0.01$). However, this significant distribution is mostly due to the relatively high level of fracturing seen in the MRM portion of the assemblage. This may be a product of the relatively small size of the bones, or because the MRM bones are not butchered and/or prepared in the same way as are other animals with regards to sharing and distribution among foragers (see previous discussion in Chapter 3). If the fragile MRM bones are removed from analysis, the distribution of crenulated and fractured edges is not significant at a 0.05 level of significance (d.f. = 2, $\chi^2 = 5.54$, $p \leq 0.1$).

Table 5.1: Macroscopic and microscopic mastication damage types within the Bofi forager faunal SEM sample. Macroscopic counts refer to number of occurrences. Microscopic counts represent the number of bones with damage and not the number of occurrences of damage types.

SEM Sample	Macroscopic Damage (# occurrence)		Microscopic Damage (# of bones)				Bones with Evident Field Cleaning
	Crenulated Edges	Fractured Edges	Pits	Punctures	Notches	Scratches	
BD N = 55	88	14	38	6	-	38	33
GPR N = 26	37	13	23	-	8	18	16
BTP N = 21	32	3	16	1	5	17	16
MRM N = 9	5	6	3	-	-	4	4
Total Counts	162	36	80	7	13	91	71

Results of Macroscopic Analysis

If the CHCI assemblage is accurate and applicable to the Bofi assemblage with regards to macroscopic damage patterning, then the tendency of mastication-damaged bones in the forager faunal assemblage to be crushed rather than fractured may indicate that most of the damage is a result of ‘incidental’ mastication damage rather than purposeful intent to consume bone. While the intent of any actor may not be absolutely known, this macroscopic damage pattern in conjunction with a discussion regarding the amount of element damage (see comparison discussion at the end of the chapter), may point towards a human consumption pattern.

Microscopic Descriptions of the Bofi Assemblage

Microscopic damage is consistently found in association with the crenulated and fractured edges. This section focuses on describing the variable size ranges for pits, punctures, notches, and scratches in the SEM analyzed portion of the Bofi faunal assemblage. As previously noted, field cleaning (FC) may have impacted this collection of human tooth damaged faunal remains. Since individual human tooth mark identifications are made based on a combination of macro- and microscopic characteristics, it was possible to simultaneously examine each bone for evidence of field cleaning and mastication damage. Although all of the bones were cleaned in the field, by clarifying the visibility of field processing on the sampled bones it is possible to distinguish bones that were intensively cleaned from those that were not. Thus, the tooth marks that were more visibly altered by field cleaning can be identified and contrasted against those marks that were not. Future research that provides finer controls on cleaning practices will need to elucidate the degree and significance to which these cleaning practices overwrite taphonomic signatures. Notes regarding the variation in size caused by field cleaning are embedded within the discussion.

Measurable pits were observed on forty-four of the fifty-five (80%) BD bones sampled for microscopic analysis (Figure 5.1, Table 5.1). Six of the fifty-five (11%) BD bones had measurable tooth punctures and none of the bones exhibited tooth notches. Measurements of the seventy-nine tooth pits and sixteen tooth punctures are recorded in Table 5.2. The largest mark is slightly larger than four millimeters in diameter, while the smallest diameter tooth pit is less than one quarter of a millimeter in size. Roughly 60% of the BD bones selected for microscopic analysis clearly evidenced either polish or scoring that resulted from cleaning practices.

Of the twenty-six GPR bones sampled for microscopic analysis, twenty-three (88%) had measurable pits (Figure 5.2). None of the bones had punctures, although eight (31%) had measurable tooth notches. I measured a total of eighty tooth marks where the largest mark is slightly larger than four and a half millimeters in diameter, while the smallest tooth pit diameter

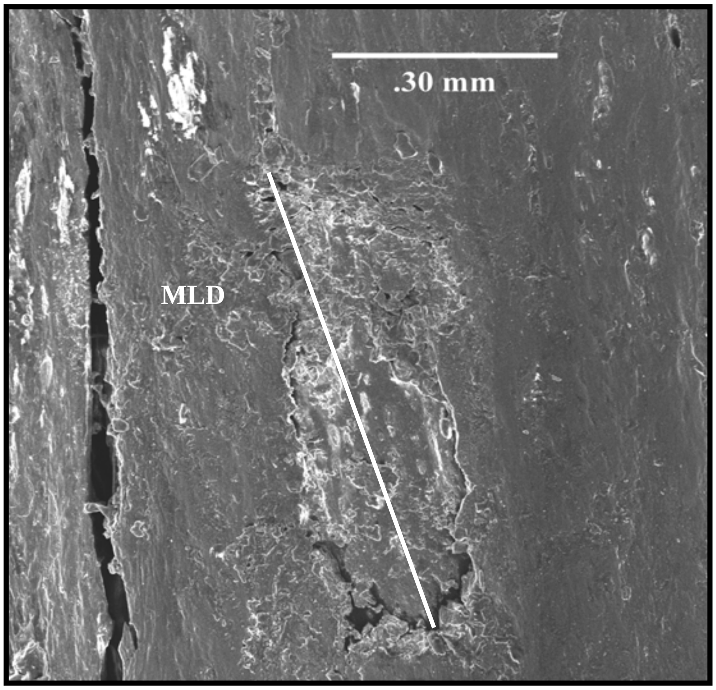

Figure 5.1: SEM photograph of tooth mark pitting by Bofi forager on a BD rib at a magnification of 100x.

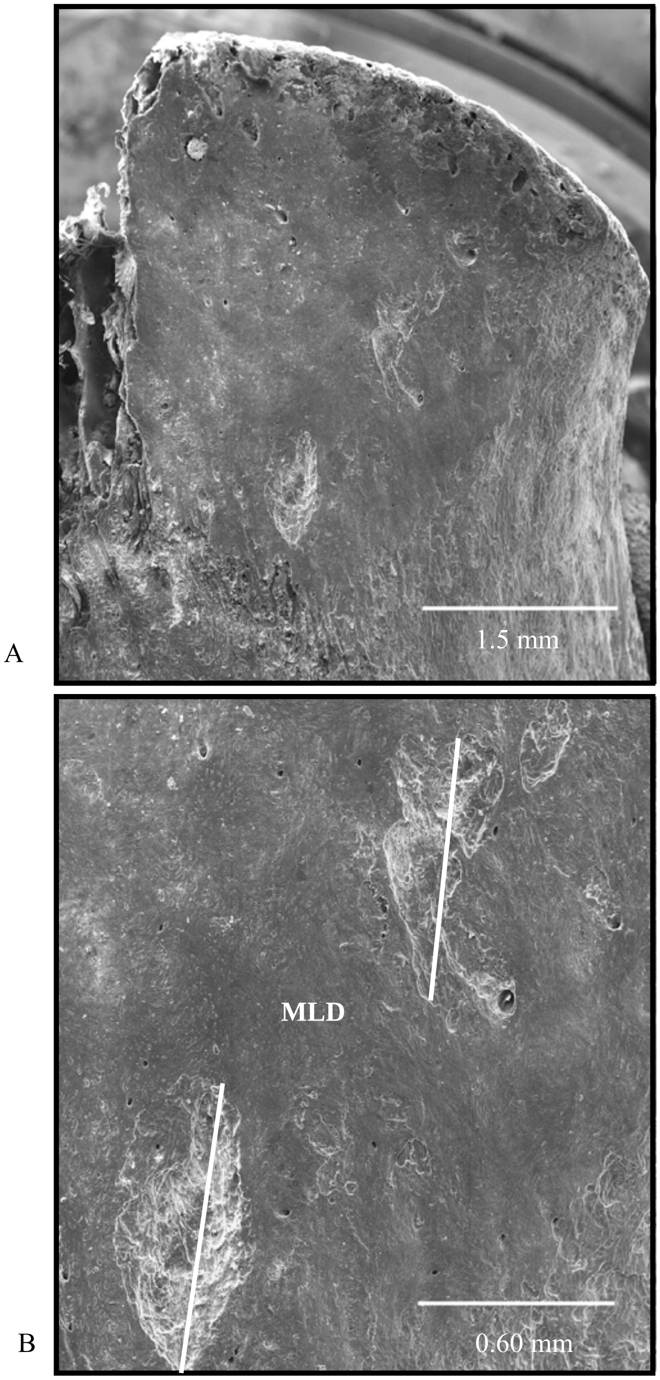

Figure 5.2: SEM photograph of tooth pits by a Bofi forager on the innominate of a GPR at a magnification of 20x (A) and 50x (B).

Table 5.2: Size measurements of tooth pits and punctures with and without visible evidence of field cleaning (FC) in the Bofi forager BD SEM sample. N = total number of measured marks.

BD Pits and Punctures	N	Minimum (mm)	Median / Mean Width (mm)	Maximum (mm)	Std. Dev. (mm)
Pits without visible FC	26	0.21	0.61 / 1.04	3.02	0.83
Pits with visible FC	53	0.14	0.62 / 0.80	2.5	0.51
Punctures without visible FC	7	0.87	1.02 / 1.95	4.18	1.32
Punctures with visible FC	9	0.29	1.36 / 2.19	4.31	1.67
Total	95	0.14	0.76 / 1.08	4.31	0.94

Table 5.3: Size measurements of tooth pits and notches with minimal and strong evidence of field cleaning (FC) in the Bofi forager GPR SEM sample. N = total number of measured marks.

GPR Pits and Notches	N	Minimum (mm)	Median / Mean Width (mm)	Maximum (mm)	Std. Dev. (mm)
Pits without visible FC	22	0.71	1.52 / 1.89	4.60	1.45
Pits with visible FC	48	0.48	1.48 / 1.36	2.00	0.65
Notches without visible FC	6	0.18	0.86 / 0.85	1.99	0.50
Notches with visible FC	4	0.19	0.84 / 0.92	3.21	0.59
Total	80	0.18	0.86 / 0.996	4.60	0.71

is less than one quarter of a millimeter in size (Table 5.3). Of the GPR bones selected for microscopic analysis, 60% exhibited either polishing or scoring that is the result of field cleaning. Eight of the twenty-three bones (35%) marked with shallow pits do not display evidence of field cleaning. All of the sampled bones exhibited pits and/or scratches in association with crenulated and fractured edges regardless of cleaning practices. Approximately one-third (38%) (10 of 26 total bones) of the sampled bones exhibit *both* pitting and scratching in association with damaged edges.

Twenty-one BTP bones were sampled for microscopic analysis, seventeen had measurable pitting. Measurements on thirty-five tooth pits show that the largest mark is slightly larger than one and a half millimeters in diameter, while the smallest diameter tooth pit is less than one quarter of a millimeter in size (Table 5.4, Figure 5.3). This range of measurements centers slightly below one millimeter in diameter. Sixteen (76%) of the BTP bones selected for microscopic analysis exhibited either polishing or scoring. Four of the seventeen bones (24%) marked with shallow pits did not display cleaning damage.

Table 5.4: Size measurements of tooth pits, punctures, and notches with and without visible evidence of field cleaning (FC) in the Bofi forager BTP SEM sample. N = total number of measured marks.

BTP Pits Punctures and Notches	N	Minimum (mm)	Median / Mean Width (mm)	Maximum (mm)	Std. Dev. (mm)
Pits without visible FC	5	0.33	0.71 / 0.69	1.33	0.40
Pits with visible FC	30	0.23	0.75 / 0.81	1.67	0.36
Punctures without visible FC	-	-	-	-	-
Punctures with visible FC	1	2.60	-	-	-
Notches without visible FC	1	3.67	-	-	-
Notches with visible FC	4	0.58	1.39 / 2.13	5.15	2.12
Total	41	0.23	0.75 / 1.03	5.15	0.93

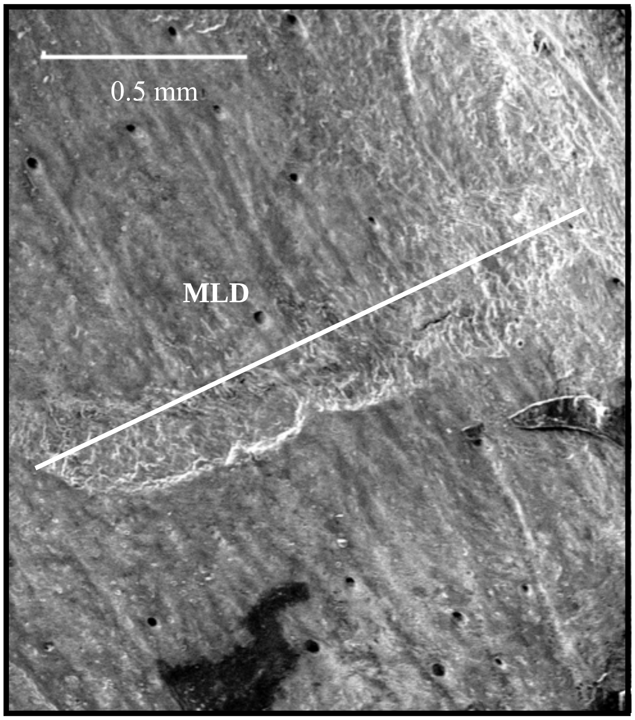

Figure 5.3: SEM photograph of tooth pitting by Bofi forager on a BTP ulna at a magnification of 60x.

Of the nine MRM bones sampled for microscopic analysis, three (33 %) have measurable tooth pits that are located in close proximity to crenulated and fractured edges. I measured five tooth pits where the largest mark is slightly larger than one millimeter in diameter and the smallest diameter tooth pit is less than one quarter of a millimeter in size (Figure 5.4, Table 5.5). For comparative purposes, this range of measurements centers below half a millimeter in diameter. Field cleaning was displayed on four of the nine (44%) mouse bones selected for microscopic analysis.

Table 5.5: Size measurements of tooth pits with and without visible evidence of field cleaning (FC) in the Bofi forager MRM SEM sample. N = total number of measured marks.

MRM Pits	N	Minimum (mm)	Median / Mean Width (mm)	Maximum (mm)	Std. Dev. (mm)
Pits without visible FC	4	0.20	0.39 / 0.53	1.13	0.44
Pits with visible FC	1	0.22	-	-	-
Total	5	0.20	0.22 / 0.47	1.13	0.40

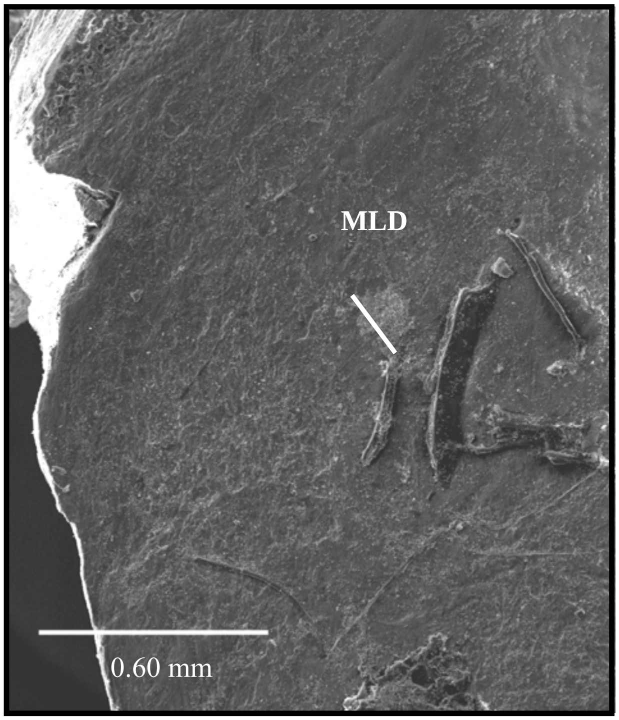

Figure 5.4: SEM photograph of pit mark left by a Bofi forager on a MRM mandible of a mouse at a magnification of 50x.

Scratch marks were observed on thirty-eight of the fifty-five BD bones (Table 5.1). Seventy-eight scratches were measured with the largest being less than three-quarters of a millimeter in width and the narrowest measuring less than one-tenth of a millimeter wide. The center of that range is less than one quarter of a millimeter (Table 5.6, Figure 5.5). Thirty-eight BD bones (70%) did not exhibit evidence of field cleaning (FC). The forty-two scratches that are not associated with FC generally occurred as single marks in association with fractured edges, crenulated edges and tooth pitting. The size range for scratches which are and are not associated with FC are shown in Table 5.6.

Table 5.6: Size measurements of tooth scratches with and without visible field cleaning in the Bofi forager BD SEM sample. N = total number of measured marks.

BD Scratches	N	Minimum (mm)	Median / Mean Width (mm)	Maximum (mm)	Std. Dev. (mm)
Total	78	0.02	0.15 / 0.18	0.63	0.13
Without Visible Field Cleaning	42	0.05	0.22 / 0.27	0.63	0.13
With Visible Field Cleaning	36	0.02	0.09 / 0.09	0.15	0.04

Eighteen of the twenty-six SEM analyzed GPR bones exhibit scratching (Figure 5.6). Width measurements for the scratches are located in Table 5.7. Ten of the twenty-six GPR bones (38%) exhibit *both* pitting and scratching in association with damaged edges. Four of the eighteen scratched bones do not display any evidence of FC. The scratch marks that do not appear associated with damage from FC generally occur as single or paired marks near crenulated edges and fractures. Sixteen of the sampled GPR bones (62%) exhibit polishing and/or scoring that is associated with field cleaning. The twenty-two tooth scratches not

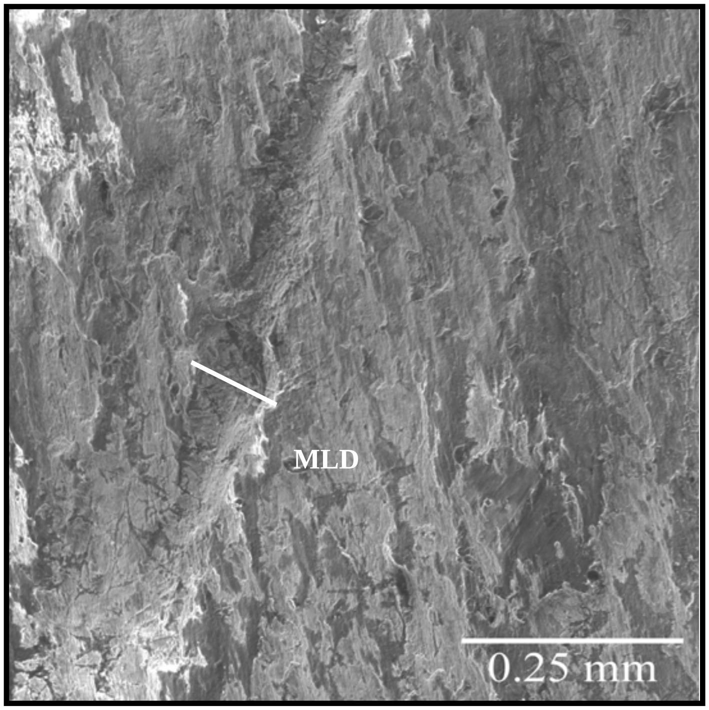

Figure 5.5: SEM photograph of tooth scratch by Bofi forager on a BD tibia at a magnification of 120x.

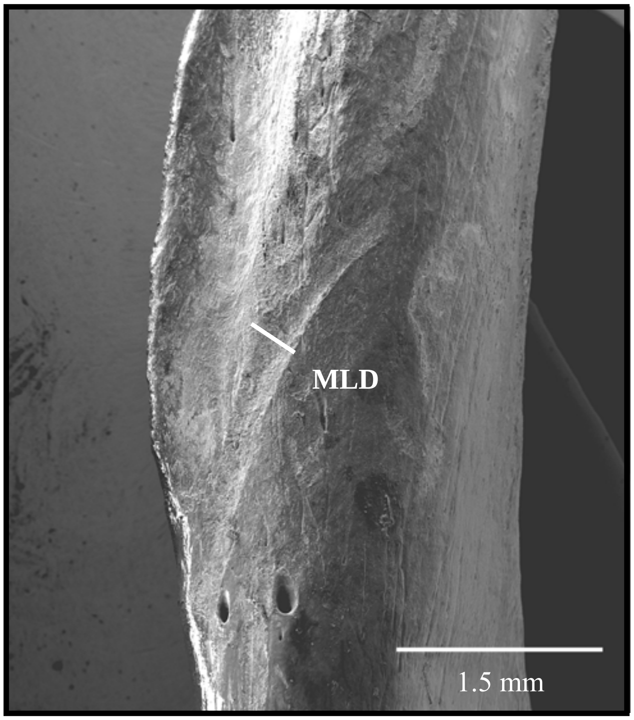

Figure 5.6: SEM photograph of tooth scratch by Bofi forager on the pubic ramus of a GPR at a magnification of 20x.

Table 5.7: Size measurements of tooth scratches with and without visible field cleaning in the Bofi forager GPR SEM sample. N = total number of measured marks.

GPR Scratches	N	Minimum (mm)	Median / Mean Width (mm)	Maximum (mm)	Std. Dev. (mm)
Total	99	0.004	0.05 / 0.07	0.34	0.07
Without Visible Field Cleaning	22	0.05	0.13 / 0.15	0.34	0.09
With Visible Field Cleaning	77	0.004	0.04 / 0.04	0.121	0.03

associated with FC occurred on twelve (54%) of the sampled rat bones in association with crenulated edges and tooth pits

Scratching was observed on seventeen of the twenty-one BTP bones (Table 5.1). Sixty-nine scratches were measured with the largest being less than half of a millimeter in width and the narrowest measuring less than one-hundredth of a millimeter wide (Figure 5.7, Table 5.8). Five BTP bones (24%) did not exhibit evidence of FC. The thirteen scratches that are not associated with FC generally occurred as single marks in association with fractured edges, crenulated edges and tooth pits.

Four of the sampled nine MRM bones exhibit polish and/or scratches that are the result of cleaning. There are no scratches in the MRM portion of the assemblage that cannot be linked to FC practices. The maximum size of FC marks on the MRM bones is less than one-tenth of millimeter (Table 5.9), which provides further support for the original FC size estimates gathered from the experimental rabbit cleaning assemblage.

Table 5.8: Size measurements of tooth scratches with and without visible field cleaning in the Bofi forager BTP SEM sample. N = total number of measured marks.

BTP Scratches	N	Minimum (mm)	Median / Mean Width (mm)	Maximum (mm)	Std. Dev. (mm)
Total	69	0.005	0.03 / 0.06	0.47	0.07
Without Visible Field Cleaning	13	0.027	0.14 / 0.17	0.47	0.12
With Visible Field Cleaning	56	0.005	0.03 / 0.03	0.09	0.02

Table 5.9: Size measurements of tooth scratches with and without visible field cleaning in the Bofi forager MRM SEM sample. N = total number of measured marks.

MRM Scratches	N	Minimum (mm)	Median / Mean Width (mm)	Maximum (mm)	Std. Dev. (mm)
Total	13	0.05	0.03 / 0.03	0.09	0.03
Without Visible Field Cleaning	-	-	-	-	-
With Visible Field Cleaning	13	0.05	0.03 / 0.03	0.09	0.03

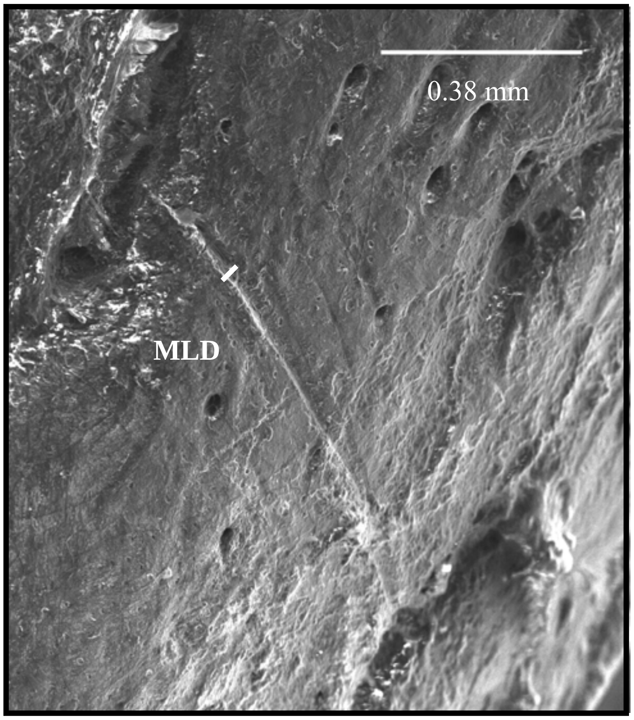

Figure 5.7: SEM photograph of tooth scratch by a Bofi forager on a BTP ulna at a magnification of 80x.

Results of Microscopic Analysis

Figure 5.8 includes all of the measured tooth punctures (N = 17), pits (N = 189) and notches (N = 15) for all four species in the SEM analyzed portion of the collection. Tooth punctures range from below one to greater than four millimeters in MLD. Given the small samples on mostly BD remains, tooth puncture means display the most amount of variation. Pits vary in MLD from near zero to over three millimeters in size. Except for pits located on the MRM bones the mean tooth pit size is consistent across the assemblage. Although the tooth notches display the largest range in MLD, the mean hovers near one and a half millimeters.

Interestingly, the largest tooth marks are not on the bones of the largest animal. Although the BD (5 kg) remains exhibit tooth marks around four millimeters in maximum size, the GPR (1 kg) and BTP (3 kg) bones both exhibit marks that are around five millimeters in MLD. This is likely due to the overall robustness and shape of the individual animal elements, where the smaller but relatively broader GPR and BTP bones are more apt to retain large tooth marks than are the more lithe BD elements. Similarly, the relatively fragile and noticeably smaller MRM bones (< 1 kg live weight) are unlikely to retain tooth marks of any comparable size as in this sample where only the smallest tooth pits are retained. However, the overall differences in size range and means between the populations of punctures, pits and notches by species are likely not momentous as the differences are typically less than a single millimeter. Although FC altered the surfaces of bone in the Bofi assemblage, it does not appear to have altered the overall size ranges of tooth punctures, pits and notches in a way that would change macroscopic identification of mastication damage.

Figure 5.9 displays all of the measured tooth scratches (N = 259) in the SEM sample for all four species of animal. Most noticeable in Figure 5.9 is the lack of any MRM tooth scratches.

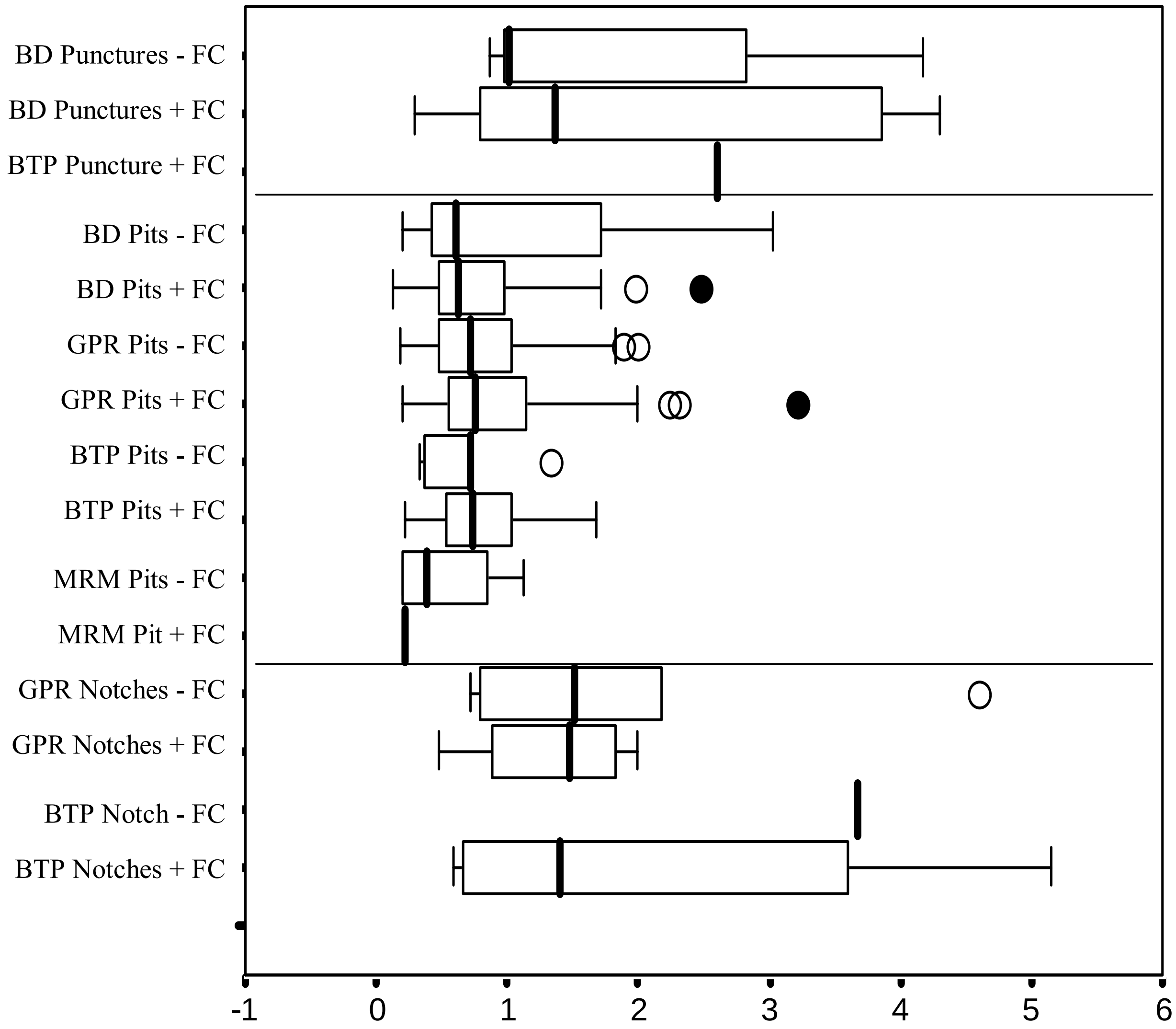

Figure 5.8: Box and whisker plots for puncture, pit and notch damage on all bones in the SEM sample. Scale is in millimeters. The code "- FC" refers to those bones that do not exhibit visible evidence of field cleaning. The code "+ FC" refers to those bones that do exhibit visible evidence of field cleaning.

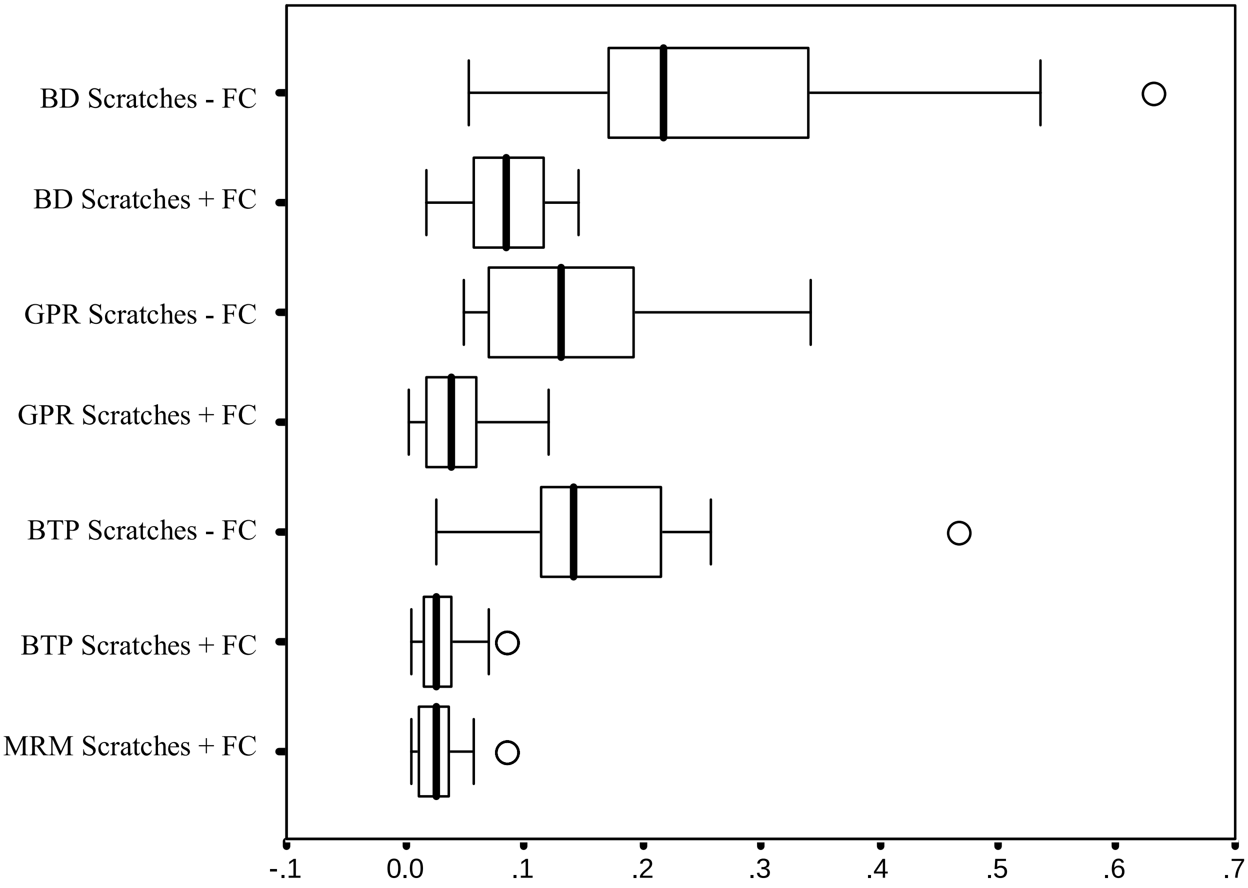

Figure 5.9: Box and whisker plots for tooth scratches on all bones in the SEM sample. Scale is in millimeters. The code "- FC" refers to those bones that do not exhibit visible evidence of field cleaning. The code "+ FC" refers to those bones that do exhibit visible evidence of field cleaning.

Whether this is due to a lack of actual tooth scratches on the bones, or the tooth scratches being hidden among the marks left by FC is unclear. Excepting those scratches that are associated with FC, the mean tooth scratch centers at approximately one-twentieth of a millimeter in width while the overall range on these small prey animals does not exceed three-quarters of a millimeter. There is more overall variation in tooth scratching between those marks that are and are not visibly associated with FC. Cleaning techniques in the field appear to have had a greater influence on tooth scratches (via duplication and possible obscuring) than on tooth pits, punctures and notches. In an effort to remain conservative during identification, I attributed many of the smaller scratches to FC. This effectively removes a portion of the variation. However, those scratches are imperceptible without the aid of magnification and their removal from the population of mastication-damaged bones is not likely to impact the overall macroscopic identification of mastication damage in a zooarchaeological assemblage.

SEM Sample Conclusions

This data indicates that tooth punctures, pits and notches are relatively consistent in size and shape (variation of the mean is less than one millimeter) on small-prey mammals and may not have been heavily impacted by field cleaning. The scratches are more variable between species than are the pits, however, they are also consistently smaller than a millimeter in width and appear to be strongly influenced by field cleaning only on a microscopic level. Further, macroscopic analysis indicates that crenulated and fractured edges are two common damage types on small sized prey utilized for human consumption. Microscopic tooth pits, punctures, notches and scratches in association with those damaged edges further support initial identifications of mastication damage. While the association of pits and scratches with consumption damaged edges is not a unique characteristic of mastication damage for humans, the overall patterning of tooth marks across the skeleton and their placement on individual elements may be. The following section draws upon the entire mastication damaged portion of the Bofi faunal collection to describe the tooth mark distribution with regards to element selection and overall damage patterning.

Preferential Element Consumption Patterns

This section of the chapter utilizes the entire portion of the Bofi faunal assemblage that has been altered by mastication in an effort to identify skeletal elements that are more frequently damaged by teeth. The actual number of identified specimen (NISP) counts of damaged bones in the Bofi forager collection per species as well as their associated Z-scores is shown in Table 5.10. The Z-scores are used to distinguish those bone elements that are more frequently damaged from those that receive little to no mastication damage.

The most heavily damaged skeletal elements of the BD are: 1) rib and rib portions, 2) thoracic vertebrate, 3) cervical vertebrate, 4) innominates, and 5) humeri. The most consistently damaged of all these elements are the ribs, which have counts well beyond multiple standard deviations. Although the vertebrate and innominate have counts that are also above average, they are well within one standard deviation, while the humeri are representative of an average frequency of consumption damage. Among all of the BD bones, the majority of consumption damage (in NISP values) occurs on the axial portion of the skeleton (12 elements, $n = 204$) and not on the appendicular elements (8 elements, $n = 49$). The number of consumption damaged appendicular elements is significantly lower than would be expected when compared against the undamaged axial and appendicular elements, but the relationship is not very strong (d.f. = 1, $\chi^2 = 12.62$, $p \leq .001$, $ø^2 = .01$).

Table 5.10: Raw NISP counts of tooth damaged bones by species with associated Z-scores.

Element	Duiker		w/o Ribs	Rat		Porcupine		Mouse		Totals
Atlas	1	-0.52	-0.98	-	-	1	-0.97	-	-	2
Axis	4	-0.39	-0.55	-	-	-	-	-	-	4
Astragalus	-	-	-	-	-	1	-0.97	-	-	1
Calcaneus	-	-	-	-	-	-	-	-	-	-
Carpal	-	-	-	-	-	-	-	-	-	-
Caudal Vert.	9	-0.16	0.16	15	1.50	3	-0.50	-	-	27
Cervical Vert.	18	0.24	1.43	1	-1.33	-	-	-	-	19
Cranium	-	-	-	-	-	-	-	-	-	-
Femur	7	-0.25	-0.13	13	1.09	4	-0.26	12	2.24	36
Fibula	-	-	-	1	-1.33	2	-0.73	-	-	3
Humerus	13	0.02	0.72	10	0.49	5	-0.03	2	-0.36	30
Innominate	15	0.11	1.01	11	0.69	12	1.61	2	-0.36	40
Lumbar Vert.	10	-0.12	0.30	17	1.90	5	-0.03	2	-0.36	34
Mandible	4	-0.39	-0.55	4	-0.73	-	-	1	-0.62	9
Metacarpal	1	-0.52	-0.98	-	-	-	-	-	-	1
Metatarsal	-	-	-	1	-1.33	-	-	-	-	1
Metapodial	-	-	-	-	-	-	-	-	-	-
NVC	2	-0.48	-0.84	-	-	-	-	-	-	2
Radius	3	-0.43	-0.69	5	-0.52	2	-0.73	-	-	10
Rib	103	4.04	-	11	0.69	15	2.31	-	-	129
Sacral Vert.	-	-	-	4	-0.73	-	-	-	-	4
Sacrum	7	-0.25	-0.13	4	-0.73	1	-0.97	1	-0.62	13
Scapula	10	-0.12	0.30	9	0.28	9	0.91	-	-	28
Sternum	3	-0.43	-0.69	-	-	-	-	-	-	3
Tarsal	-	-	-	-	-	-	-	-	-	-
Thoracic Vert.	29	0.73	2.99	8	0.08	9	0.91	-	-	46
Tibia	7	-0.25	-0.13	5	-0.52	3	-0.50	1	-0.62	16
Ulna	6	-0.30	-0.27	10	0.49	5	-0.03	-	-	21
Vertebrate	1	-0.52	-0.98	-	-	-	-	6	0.68	7
Teeth	-	-	-	-	-	-	-	-	-	-
NID/Frag	1	-0.52	-0.98	-	-	-	-	-	-	-
	254			129		77		27		486
mean	12.65		7.89	7.59		5.13		3.38		
Std	22.35		7.05	4.95		4.27		3.85		

However, since the high rib count overwhelms the average and hence the Z-score, I calculated a second column of Z-scores for the BD excluding the ribs (Table 5.10). The results show that the caudal vertebrate, lumbar vertebrate, and scapula shift into the above average category. This arrangement is similar to the patterning seen for the GPR and MRM skeletons (see Table 5.10 and the following discussion), where axial skeletal elements of the BD (11 elements, n = 101) are slightly more damaged than are the appendicular elements (8 elements, n = 49), but the difference is not significant (d.f. = 1, $\chi^2 = .02$, $p \leq .20$). Therefore, excepting the ribs, the BD is damaged by mastication relatively evenly with regards to the axial and appendicular elements

The heavy mastication damage focused on the ribs is likely to be indicative of both a cultural butchery practice and the structure of the ribs. It is likely that the ribs enjoy a high amount of mastication damage since the teeth are the most energy efficient tools for the removal of muscle and intercostal tissues from small animal ribs. With small ribs, it is easy to simply pull the entire rib between upper and lower teeth to effectively remove the muscle and intercostal tissue. Future butchery experiments focusing on small mammals will indicate whether or not the size of the rib sections makes butchery practices with tools excessively tedious for little or no extra return. Further, the physical structure of ribs (a thin cortical bone layer with underlying layers of cancellous bone) tends to promote the retention of tooth pits and scratches.

The GPR remains present a slightly different case. According to Table 5.10, the most frequently damaged GPR elements include: 1) lumbar vertebrate, 2) caudal vertebrate, 2) femurs, 3) innominates and ribs, 4) humeri and ulnas, 5) scapulas, and 6) thoracic vertebrate. Whereas the ribs are the most frequently damaged element in the BD assemblage, there is no single element that stands out in the collection of GPR bones. The three most often damaged bones include the lumbar vertebrate, caudal vertebrate and femurs. All three are outside of one standard deviation, yet remain within two standard deviations of the mean. Axial elements (9 elements, n = 75) are slightly more damaged by mastication than are appendicular elements (8 elements, n = 54), but this may well be a product of the small samples and is not significant (d.f. = 1, $\chi^2 = .26$, $p \leq 1.0$). This suggests that during consumption of pouched rat remains, moderate consumption damage occurs evenly across the entire skeleton.

Table 5.10 indicates that four BTP elements display above average tooth damage. As with the BD, the ribs are the most frequently damaged elements and are outside of two standard deviations. Although BTP innominates display considerable mastication damage, the frequency of damage remains within the bounds of two standard deviations. The scapula and thoracic vertebrate are only slightly within the bounds of one standard deviation. The differential distribution of axial (7 elements, n = 46) and appendicular (8 elements, n = 31) elements is not significant (d.f. = 1, $\chi^2 = 3.8$, $p \leq .10$). The damaged BTP elements are patterned like those of the BD and the GPR such that most elements of the skeleton, excluding the cervical vertebrae and mandibles, exhibit evidence of mastication.

Although the BTP skeleton does not exhibit the same degree of mastication damage as does the BD or the GPR, it displays much more mastication damage than does the assemblage of MRM remains. Table 5.10, indicates that the MRM femur is the most frequently damaged element (outside of two standard deviations) and that the vertebrate column is also above average (but within a single standard deviation). Although the strength of associations may be called into question with such a small sample, the distribution of mastication damage between the axial (5 elements, n = 12) and appendicular (3 elements, n = 15) elements is not significant (d.f. = 1, $\chi^2 = 1.3$, $p \leq 1.0$).

Many MRM elements survived cooking and consumption, yet relatively few of them exhibit evidence of mastication (see Appendix C). The survival rate of MRM elements is likely to be a size related issue dependent upon the maximum tooth mark size that an individual bone can imprint before undergoing structural failure. Only microtine skeletal elements with relatively large areas of cancellous tissue (innominate, femoral head, vertebral bodies, etc.) are big enough to retain tooth impressions. Hence, if MRM bones were damaged during mastication, they probably underwent complete structural failure and are unlikely to have survived and hence the collection consists mostly of non-tooth marked elements. Future research focused on other butchery practices (e.g., cutmarks) will clarify the capacity of microtine fauna to imprint human activities.

An inter-species comparison of mastication damaged bones in the Bofi faunal assemblage, indicates that three elements are consistently ranked above average with regards to consumption patterning: 1) rib or rib portions, 2) thoracic vertebrae, and 3) innominates. If the ribs are removed from the BD analysis, then the scapula is ranked above average with regards to mastication damage. Mastication damage in the Bofi forager faunal assemblage tends to be directed in raw NISP counts towards the axial elements, but the distribution of these numbers is not significant and the above average NISP counts may be a product of high axial element counts per skeleton. Since, teeth are possibly the most efficient tools for muscle removal from small animal ribs, the same may hold true for the rest of the axial skeleton. It is likely more difficult to separate muscles along the spine of a small animal (< 5 kg) with a knife at the numerous attachment points than it is to simply chew on/around the bone, particularly after the element is cooked. A high degree of mastication damage on axial elements is reported in other ethnographic contexts (Oliver 1993). Given his small sample, “Almost 79% of the size I bones broken during consumption (N = 56; 54 ribs and 2 metapodials) were broken by Hadza gnawing" (Oliver 1993:212). An increase in the sample size of this assemblage may help further any future indication of skeletal selection during consumption.

If the high Z-scores are a product of high axial element numbers per skeleton, then except for the BD ribs, the four species used in this research are damaged roughly evenly across the skeleton from the cranium down to the caudal vertebrate and metatarsals. It is interesting to note that only one astragalus (from a BTP) exhibits evidence of tooth damage in the entire collection (see Table 5.10). Tarsals and carpals have minimal amounts of muscle tissue as their movement is controlled by tendons and ligaments connected to muscles in the upper limb. Any nutrients encased in these elements are more likely to be removed during the cooking process than during consumption. A similar pattern of mastication damage on tarsals and carpals is also seen among other carnivores (Marean *et al.* 1992).

These data show that the appearance of mastication damage is distributed relatively evenly across the skeletons of small prey mammals in the Bofi forager assemblage. However, this data also suggests that mastication damage is focused on axial elements when based on raw NISP counts. If butchering of small mammal axial elements is more time intensive than for appendicular elements, then a focus of mastication damage on axial elements is suggestive of a relationship between the size of the animal and the effective ease with which tools help or hinder the removal of muscle tissue (see also O'Connell *et al.* 1988).

Table 5.10 is designed to show which skeletal elements are damaged by teeth, and not the intensity or location of mastication damage on those elements. Both the intensity and location of mastication damage are important as they relate to the overall amount and impact of mastication damage in an assemblage. As an example, *hyenids* will consume entire elements of a variety of prey size-classes, *canids* will often consume the softer ends, but rarely consume entire elements (Haynes 1983a). Hence, the overall impact of mastication damage in an assemblage may be indicative of a range of predator behaviors and if distinct enough, perhaps of a specific predator (Dominguez-Rodrigo and Piqueras 2003; Selvaggio and Wilder 2001). The following sections outline the location and intensity of mastication damage on specific elements in the Bofi faunal assemblage.

Specific Placement of Tooth Marks on Long Bones

Humans will often use tools to break the shaft of long bones from large prey animals to reach the marrow (Noe-Nygaard 1977; Oliver 1993; Todd and Rapson 1988). When dealing with small prey animals, some human foragers (such as the Aché) will generally choose to break off the ends of the smaller long bones, whether by tooth or tool, to gain access to marrow (Jones 1984; Weisler and Gargett 1993).

This section describes the location of mastication damage created by the Bofi foragers on long bones. I follow the method used by Bunn (2001) who distinguishes three portions or units of long bones (proximal, midshaft, and distal). His three analytical units correspond well to different density zones of long bones, where the proximal and distal areas of thin cortical bone are backed by a cancellous matrix and are distinguished from the midshaft and its relatively thick cortical bone and bone marrow cavity. I utilize the same three analytical units (proximal, shaft and distal) in this thesis, which are shown as femoral divisions in Figure 5.10. The proximal epiphysis and proximal shaft are combined to form the proximal unit whose boundary extends to a line placed perpendicular to the long axis of the element and which passes through the inferior portion of the gluteal tuberosity. The midshaft portion begins at the boundary with the proximal portion and extends to the most proximal portion of the lateral point of attachment for the gastrocnemius muscle. The distal portion borders with the midshaft portion and includes the entire distal epiphysis.

Figures 5.11, 5.12, 5.13, and 5.14 present bar graphs showing the actual presence/absence count distribution of macroscopic mastication damage on long bone element portions in the Bofi forager faunal assemblage. These graphs indicate that mastication damage is located on the epiphyseal ends of long bones in the Bofi assemblage. Rarely do the foragers leave tooth marks on the shafts of these elements. There are three potential reasons for consumption behavior that focuses on the less dense ends of long bones. Since consumption damage is the result of behavior directed at recovering nutritional material, the Bofi foragers may be attempting to consume either: 1) the cancellous bone and the grease it contains, 2) the muscles and attached tendons, or 3) as a point of access to marrow cavity.

Differences between those three choices should be possible by qualifying/quantifying visible amounts of bone consumption. If one or both of the epiphyseal ends are completely removed and a bone cylinder remains, then the bone was likely utilized for its marrow content (as per Jones 1984). If considerable portions of the epiphyseal ends are removed but the marrow cavity is still intact and inaccessible, then it is likely that the bone matrix and its grease content was the object of the consumption behavior. However, if only a minimal amount of bone is removed at points of muscle attachments then the adhering tissues are likely to be the focus of mastication.

In Table 5.11, the marrow bearing long bones of small prey (<5 kg) are typically the femur, humerus and tibia, while the non-marrow bearing long bones are usually the ulna, radius, and fibula (after Jones 1984). However, the BD is slightly different from the other 3 species used here. For the BD the radius, metacarpals and metatarsals are included as marrow

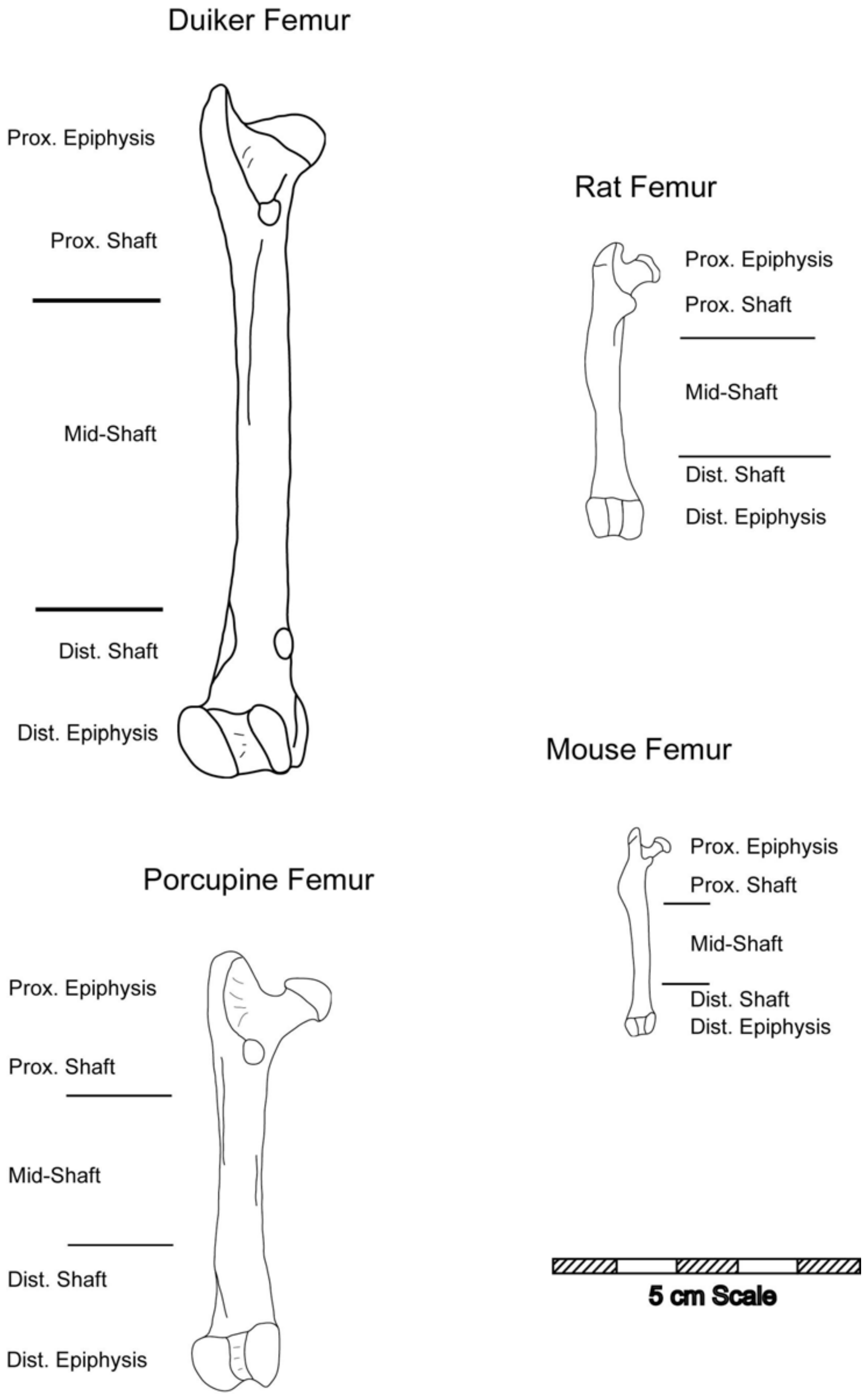

Figure 5.10: Femur Outlines as Examples of Longbone Divisions

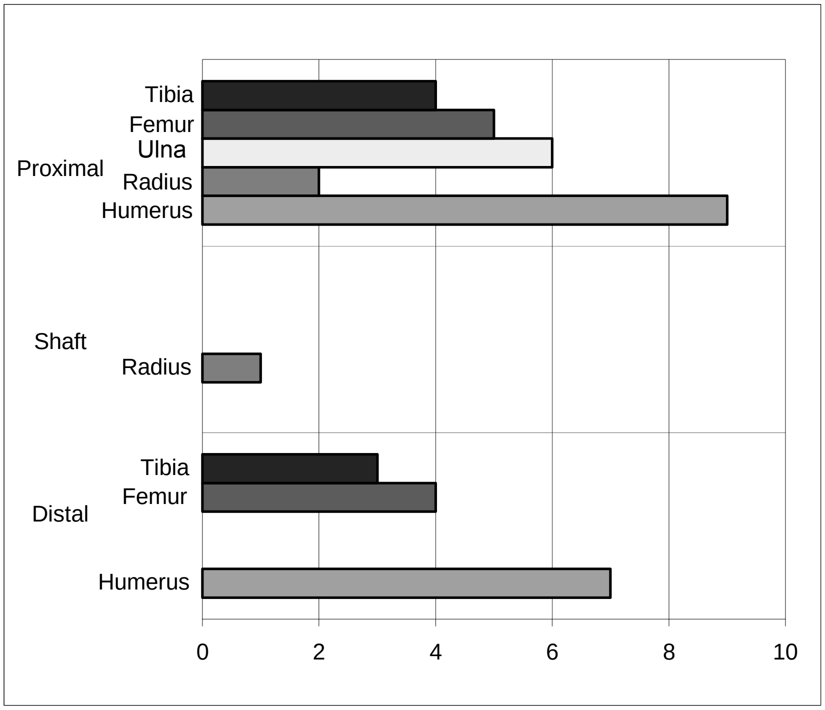

Figure 5.11: Presence/Absence location of mastication damage per BD long bone. X-axis represents the number of bones with tooth damage for each portion.

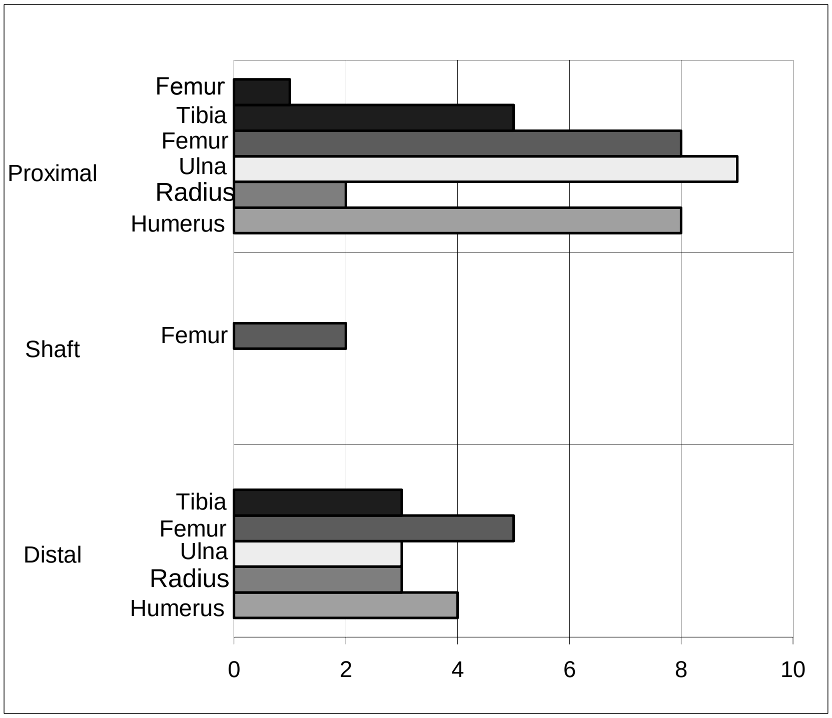

Figure 5.12: Presence/Absence location of mastication damage per GPR long bone. X-axis represents the number of bones with tooth damage for each portion.

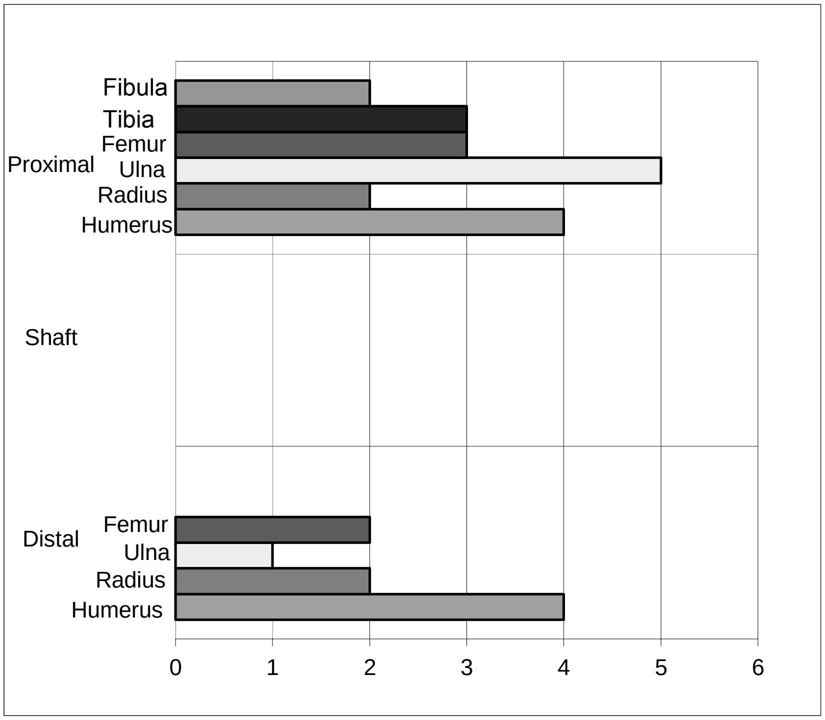

Figure 5.13: Presence/Absence location of mastication damage per BTP long bone. X-axis represents the number of bones with tooth damage for each portion.

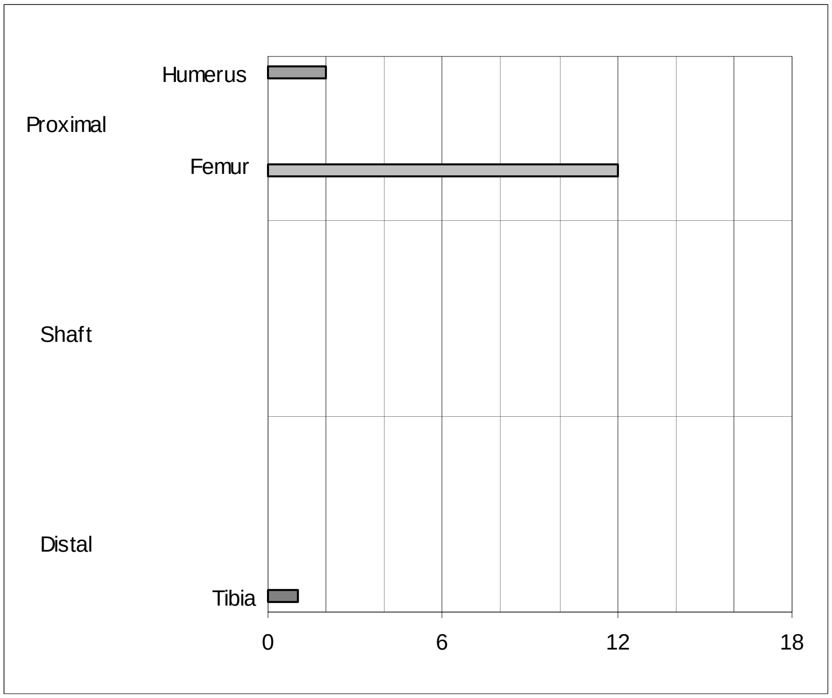

Figure 5.12: Presence/Absence location of mastication damage per MRM long bone. X-axis represents the number of bones with tooth damage for each portion.

bearing long bones. The total number of long bones in the mastication damaged Bofi faunal assemblage is designated ‘N’. ‘Complete’ refers to those bone elements that display mastication damage on the epiphyseal ends yet retain enough of the bone surface to identify articulation surfaces and attachment landmarks. Those bones identified as ‘shaft’ have lost the entire epiphysis during consumption (i.e., no observable articulation surfaces), yet leave enough cancellous matrix to seal the marrow cavity. Bones identified by ‘Mid-Break’ are breached midshaft with access to the marrow cavity. The ‘Mid-Break’ bones may exhibit damage from consumption behavior on either the softer ends and/or on the shaft. Bones identified as ‘Cylinder,’ exhibit no cancellous bone matrix and the marrow cavity is open on both ends.

Of the thirty-one marrow-bearing BD long bones in the Bofi faunal assemblage that display mastication damage, only 6% are true cylinders with the marrow cavity opened on both ends. Another 6% have had both epiphyses removed; yet enough cancellous matrix remains to prevent marrow removal. Fifty-eight percent are broken mid-shaft and 29% are mostly intact. Damage on the nine complete BD bones focuses on the heads, trochanters, tuberosities (both medial and lateral) and condyles, which are not completely removed. Of the marrow-bearing GPR long bones none are true cylinders, 11% had both ends removed yet retained some cancellous matrix, 28% were broken mid-shaft and the remaining 61% had unbreached marrow cavities. All eight of the intact GPR femurs were gnawed on the head, neck and greater trochanter, without removing the entire epiphysis. Of the marrow-bearing BTP long bones that exhibit mastication damage, there are no bone cylinders, 36% are broken mid-diaphysis and the remaining 64% have intact marrow cavities. Of those intact BTP bones, all of the mastication damage was localized on greater trochanters, tuberosities, condyles, and epicondyles where the ends are still intact. Of the fifteen mastication-damaged long bones in the MRM portion of the

Bofi faunal assemblage, there were no bone cylinders, one tibia was broken mid-shaft and the remaining 93% had unbreached marrow cavities. All of the twelve MRM femurs with intact marrow cavities only displayed mastication damage on the greater trochanter, the rest of the proximal end being left intact. Both of the MRM humeri with intact marrow cavities exhibited consumption damage only on the proximal ends, which are still largely intact.

Table 5.11: Completeness of Long Bone Elements. N = total number of bones.

Marrow Bearing Long Bones	N	Complete	Shaft	Mid-Break	Cylinder
BD	31	9	2	18	2
GPR	28	17	3	8	-
BTP	14	9	-	5	-
MRM	15	14	-	1	-
Total	88	49	5	32	2

Non-Marrow Bearing Long Bones	N	Complete	Shaft	Mid-Break	Cylinder
BD	6	2	-	4	-
GPR	16	9	1	6	-
BTP	9	8	-	1	-
MRM	-	-	-	-	-
Total	31	19	1	11	0

Using the data in Table 5.11, it is possible to return to the three distinctions drawn earlier regarding consumption choices. Access to marrow was attained in thirty-four of the eighty-eight (39%) marrow-bearing mastication damaged long bones. This compares favorably to the eleven (35%) mid-shaft broken non-marrow bearing long bones that were broken during consumption events. Fifty-four (61%) of the marrow bearing long bones were not breached for marrow access and exhibited localized tooth damage at points of muscle attachment on the proximal and distal ends. Twenty (65%) of the non-marrow-bearing long bones also exhibited localized damage on the softer cancellous ends.

Although it is unlikely that the accessed marrow was unutilized, the relatively low percentage of marrow bearing long bones exhibiting access to the marrow cavity and the similar percentage of non-marrow bearing long bones broken mid-shaft suggests that access to marrow was not the driving force in mastication damage. This may be expected since the Bofi generally boil the meat before consumption and in doing so remove some of the grease content. The lack of gnawing for marrow access is further emphasized by the relatively high percentage of long bones that exhibit mastication damage on epiphyseal ends (61%) without gaining access to the marrow cavity.

Six of the one hundred nineteen bones (5%) exhibit mastication damage on the softer cancellous ends, which results in the removal of the entire epiphyseal portion. In contrast, sixty-eight bones (57%) are mostly complete and display localized mastication damage on specific facets of the proximal and distal ends (i.e., condyles, trochanters, tuberosities, etc.). The relatively high percentage of nearly complete bones with minimal mastication damage (e.g., twelve mouse femurs with tooth damage only on the greater trochanters) is suggestive of incidental bone damage that results from mastication behavior focused on attached tissues.

Intra-Assemblage Settlement Pattern Comparisons

Until this point, the Bofi forager faunal assemblage has been treated as a single collection. However, the forager assemblage is from two distinctly different settlement sites, the semi-permanent camp near Grima and the remote forest camp. This section compares the frequencies of mastication damage between those two settlement camps as well as between species within those sites.

Table 5.12 shows the relative proportion of mastication damaged bones for each settlement type and for each animal species. The frequency of mastication damage is significantly distributed between Grima and the remote camps (d.f. = 1, $\chi^2 = 4.68$, $p \leq .05$). The calculation of individual chi values for each cell in the matrix indicates that the frequency of mastication damage in Grima is greater than would be expected, whereas the frequency of tooth marks in the remote camps is less than would be expected. In other words, animal remains in Grima are more frequently damaged during consumption than are prey animals in the remote camps. Breaking these figures down by species indicates that the difference between Grima and the remote camps with respect to distributed proportions of mastication damaged and undamaged remains of both duiker (d.f. = 1, $\chi^2 = 8.72$, $p \leq .01$, V = .007) and pouched rats (d.f. = 1, $\chi^2 = 13.65$, $p \leq .001$, V = .02) are highly significant, though neither of these results are very strong. The chi-square results for the above calculations are most strongly influenced by a greater than expected number of BD mastication damaged bones in Grima and a lower than expected number of GPR damaged bones in the remote camps. The differential distribution of tooth mark frequencies between Grima and the remote camps for BTP remains is not significant (d.f. = 1, $\chi^2 = 0.68$, $p \leq 1$). MRM remains are only found in the Grima assemblage.

Table 5.12: Proportions of mastication damaged bones in the Bofi assemblage.
Adapted in part from Jones 1984:27, Table 1

Agent	Assemblage Location (Number of Assemblages)	Population #	Gnawed #	% Range of Tooth-Marked Bones		
Bofi forager	All Combined	2322	487	12.0%	-	34.8%
Bofi forager	Remote Camps (4 species)	1302	252	13.0%	-	28.6%
Bofi forager	Grima (4 species)	1020	235	12.0%	-	34.8%
Bofi forager	Blue Duiker (2)	1170	254	19.2%	-	26.8%
Bofi forager	Giant Pouched Rat (2)	668	129	13.0%	-	24.4%
Bofi forager	Brush Tailed Porcupine (2)	259	77	28.6%	-	34.8%
Bofi forager	Murid Rats & Mice (1)	225	27			12.0%

In general, Table 5.12 indicates that the Bofi foragers damaged roughly 20-25% of all animal subsistence remains with their teeth. Further, consumption of MRM remains, combined with a relatively high mastication damage frequency in Grima of BD and GPR remains may suggest that the foragers are concerned with removing more nutrition from animal remains in Grima then they are from prey in the remote camps. The increase in mastication damage among 3 out of the 4 animal species consumed in Grima and utilized in this analysis may be an indicator of lean daily protein intake. Although I would not suggest that one could differentiate hunting camps from village sites based on the frequency of tooth marked remains, the notion that localized over-hunting and/or the selling of animals in a meat-trade can be seen in the relative amount of difference between bones with and without mastication damage in Grima and the remote camps is certainly intriguing and worthy of future research.

Conclusions

This chapter has focused on description and analysis of the Bofi forager faunal assemblage. The first and second portions described macro- and microscopic features of the SEM sampled portion of the assemblage. The third part drew upon the entire assemblage to discuss differential consumption patterns among skeletal elements and overall bone damage amount. The final portion of this section drew comparisons between Grima and the remote camp with regards to mastication damage frequencies of animal species.

Returning to previous discussions, it was noted in Chapter 4 that field cleaning with steel wool both removes and modifies external cortical bone layers. While all of the bones in the Bofi assemblage were cleaned in the field and the full impact of this practice on the Bofi forager faunal assemblage cannot be fully known, the previous discussion in this chapter suggests that tooth marks are not modified significantly enough to alter macroscopic identification of human mastication events. To better understand the impact of steel wool in the Bofi assemblage, future research that provides tighter controls on bone cleaning practices will help in clarifying the impact and signature of human mastication events.

Since descriptions of tooth marks in the Bofi forager faunal assemblage accounted for a portion of the discussion in this chapter, I believe it is appropriate to briefly discuss the issue of forager tooth modification. The argument could be made that the modification of the upper incisors will have enough impact on the morphology and frequency of gnaw-marks in the faunal assemblage to disadvantage this collection with regards to future comparisons among other human populations. I believe this is an inappropriate argument for a number of reasons. First, field observations indicate that when humans chew on bone (whether to gnaw on the bone itself, or in the process of removing tough adhering tissue), it is the premolars and molars that are most often used (see also Haynes 1981 for carnivore example), since the first molar is the point of peak masticatory muscle force for humans (Keiser 1999). Second, incisors end up broken and missing in every human society. A single missing or broken incisor in effect creates two neighboring corners that can act as a modified tooth with regards to ones ability to modify a bone's surface. Further, until there is another collection of this nature, there will remain no way in which to fully understand the taphonomic impact of this specific cultural tooth modification practice among the Bofi foragers. Even when such a comparative collection does exist, the Bofi collection, along with listings of the prolific orthodontic and dental surgery practices, will prove to be useful in speaking to the amount of variability inherent in human dentition.

Macroscopic intra-assemblage patterning indicates that small sized prey receive damage from human consumption relatively evenly across the skeletal remains although the axial elements may receive more focus. Further, mastication damage on the ends of long bones is not likely to be focused on attaining access to grease or marrow from within the bone. The focus of mastication damage on long bones in the Bofi assemblage appears to emphasize the removal of attached tissues as evidenced by the high percentage of mastication damage on points of muscle attachment in concert with the minimal destruction of the bone. Interestingly, emphasis on removing muscle tissue appears to occur more regularly in Grima than in the remote camp.

The next chapter will place these results in a larger research context. Emphasis will be given to inter-assemblage variation with other reports of carnivore and omnivore bone consumption behavior. By understanding distinctions between this ethnoarchaeological faunal assemblage and faunal assemblages impacted by a variety of other predators, it will be possible to understand the way in which human consumption patterns may be archaeologically visible.

Chapter 6: Inter-Assemblage Comparisons

"If the student should ask me how the paleontologist tells the difference between hyaena and human teeth-marks on a bone, and particularly a bone that has been rotting in a cave since the everlasting hills were builded, I should answer that I don't know."

(1871 comment from Mark Twain in White 1992:25)

"That was then, this is now."

(Monkees 1995 [1986])

This chapter is designed to place this thesis in a broader research context by drawing comparisons to other published assemblages of carnivore and omnivore consumption patterning. The first section compares the macro- and microscopic results from the CHCI assemblage to other reports where the emphasis is on avian fauna consumption. The next section compares the amount and range of Bofi forager mastication damage with a macro- and microscopic perspective. Specifically, the macroscopic comparison emphasizes the amount of overall mastication damage frequencies between carnivore and omnivore assemblages. Microscopic comparisons provide focus on damage left by multiple predator types. I then conclude with a brief look at topics of future research.

CHCI Assemblage in a Broader Context

The research of Weisler and Gargett (1993) has implications for human tooth marks on avian fauna, while Pickering and Wallis' (1997) and Plummer and Stanford's (2000) research is of importance for chimpanzee tooth marks on mammalian bone. Pickering and Wallis (1997) describe chimpanzee tooth marks from a zoo setting (hereafter referred to as ZOO assemblage), and Plummer and Stanford (2000) discuss a bone assemblage created by wild chimpanzees in Gombe National Park, Tanzania (see discussions in earlier chapters for details of those articles).

Since these are the only published reports that have specific relevance to descriptions of hominoid teeth on avian bone, comparisons are necessarily limited in scope. There are statistical and physical/histological problems associated with the comparison of my small sample on turkey (*Meleagris gallopavo*) with three other relatively small independent samples on varied populations of differing genera of prey. Weisler and Gargett (1993) used the bones of Lesser Golden Plover (*Pluvalis dominica*), Bulwer's Petrel (*Bulweria bulwerii*), and Quail (*Phasianidae*), Pickering and Wallis (1997) used the bones of Cow (*Bos* sp.), Deer (*Odocoileus virginianus*) and Goat (*Capra hircus*), and Plummer and Stanford (2000) used the bones of red colobus monkey (*Colobus badius*).

Weisler and Gargett's (1993) study shows that humans can consume the cancellous epiphyseal ends of bird long bones with little trouble and that the consumption process produces crushed, irregular edges. This definition is identical to that used by Pickering and Wallis (1997) to describe the edges of cattle, deer and goat ribs chewed by chimpanzees. Weisler and Gargett (1993) show that epiphyseal ends were completely removed on one or both ends of long bones, making the marrow cavity accessible in 30% of their archaeological collection. Notably less damage to limb bones occurs in CHCI 2001 than in Weisler and Gargett's (1993) study where all of the long bones are complete (no marrow cavity access) with only minimal damage to the softer bone ends. Unlike Weisler and Gargett's (1993) assemblage, none of the epiphyseal ends in CHCI 2001 are fully removed. However, the mastication damage in CHCI 2002 is greater than the damage reported by Weisler and Gargett (1993) for human gnawed bird bones. Fracturing is heavy in the CHCI 2002 assemblage and only 3 (21%) of the limb bones have intact ends; 2 fibula which do not have marrow and a tibiotarsus, which is broken midshaft. While overall morphology and skeletal selection were reported for Weisler and Gargett (1993) they did not perform microscopic analysis. Thus, there are no measurements to compare to the CHCI samples.

Pickering and Wallis's (1997) study of captive chimpanzee gnawed bones includes tooth mark measurements for four (4) tooth punctures and two (2) tooth notches. Given the small sample, the lack of measured pits for Pickering and Wallis's ZOO sample and the lack of punctures in the CHCI sample, considerable overlap exists in their respective ranges (Figure 6.1). While there is little overlap between the CHCI pits (mean = 2.33 mm) and the ZOO punctures (mean = 5.91 mm), the CHCI notches (mean = 4.55 mm) and ZOO notches (mean = 5.28 mm) provide a large overlap for all categories. The slightly overall larger size ranges for the ZOO samples is partially a product of differential research focus where low magnification was used on the ZOO collection and high magnification was used to examine the CHCI sample, thus increasing the likelihood of locating microscopic features.

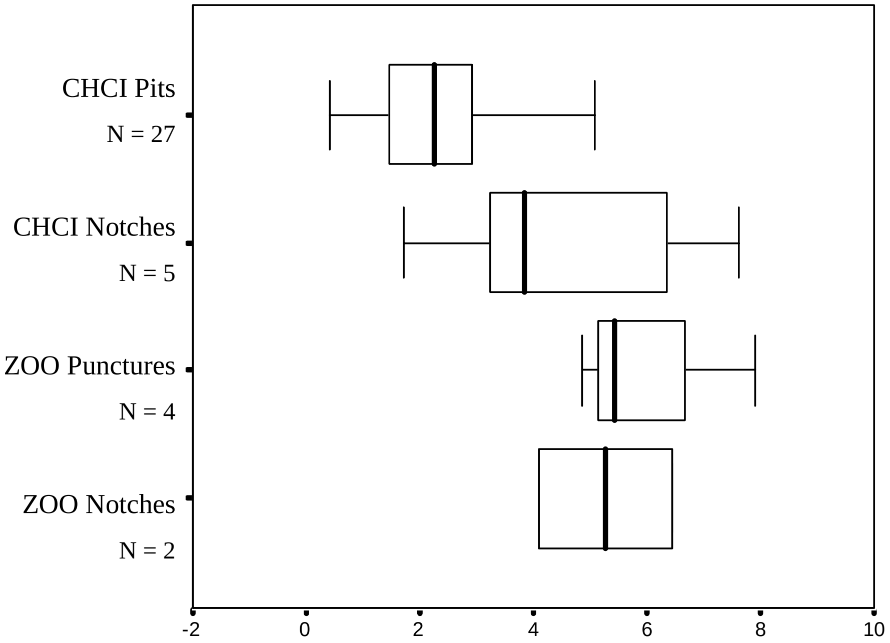

Figure 6.1: Comparison of chimpanzee tooth pits, notches, and puncturing on avian (CHCI sample) and mammalian (zoo sample) subsistence remains. Means are marked with a black line. Scale is in millimeters

Since both tooth punctures and notches can be defined as an extension of perpendicular force that results in either complete structural collapse of a bone element (notches) or localized crushing (punctures), the consistency in upper size range is considerable. This overlap is even greater in that the marks are on distinctly different skeletal elements. The lack of punctures in the CHCI sample is likely due to the relatively fragile nature of turkey limb bones as compared to artiodactyl ribs. Pickering and Wallis (1997) argue that the broad bunodont teeth of hominoids are likely to leave larger on average marks than the narrower carnassials of most carnivores. While the consistency in size range between these two samples should not be taken as a method for identifying chimpanzee mastication damage (see also Shipman 1983; Haynes 1983), the upper boundary of the tooth marks on different species and different skeletal elements may certainly indicate a body size-range for the responsible actor (Dominguez-Rodrigo and Piqueras 2003). Dominguez-Rodrigo and Piqueras (2003:1386) recently noted that tooth pits, "between 4-6 mm are mostly made by middle-sized and large-sized carnivores except felids other than lions. The mean percentage of tooth marks this size belongs to baboons, dogs and bears."

Pickering and Wallis (1997) provide a mean and overall range for one hundred (100) tooth scratches. Although tooth scratches are not as reliable as pits for identifying predator-size class, since they are the result of a tooth being pulled across the bone and are not directly related to tooth size (Dominguez-Rodrigo and Piqueras 2003), tooth scratch measurements may clarify the overall amount of bone gnawing and are used here as another basis for distinguishing assemblages. A comparison of tooth scratch measurements (Figure 6.2) shows that the marks in the CHCI assemblages are smaller on average than those in the ZOO assemblage (CHCI = 0.42

mm and Zoo = 1.3 mm). This distinction is likely the result of differential destruction based on bone structure. The ZOO measurements were taken from the relatively robust cow, deer and goat ribs. Seventy percent of the measurements in the CHCI assemblage were taken on avian long bone shaft fragments. Large quadruped ribs are composed mostly of cancellous bone and are more likely to retain the impression of large scratch marks without undergoing structural failure than are the cortical walls of avian long bones.

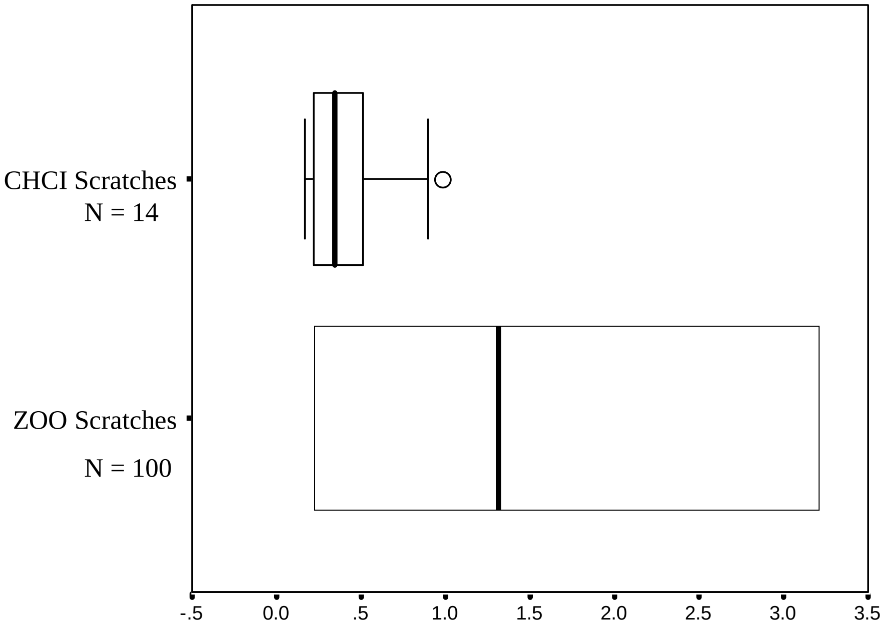

Figure 6.2: Comparison of chimpanzee tooth scratching on mammal (Zoo sample) and avian (CHCI sample) subsistence remains. Means are marked with black lines. Scale is in millimeters

Plummer and Stanford's (2003) study indicates that wild chimpanzees rarely prey upon animals that weigh over 10 kg (adult male red colobus monkeys). Pickering and Wallis' (197) use of large-prey (cow, deer and goat) remains is likely inappropriate for identifying chimpanzee behavior and mastication damage in archaeological assemblages, although it is useful in understanding the potential range of variation in chimpanzee mastication. Plummer and Stanford

(2003) only discuss macroscopic damage types and provide only one measurement, a tooth puncture with a maximum diameter of 10.6 mm, which was measured after refitting fractured cranial elements. Such large tooth punctures are unlikely to occur across the rest of a red colobus skeleton, tooth mark size being limited by the size of the skeletal elements. Average tooth mark sizes over 6 mm in diameter would place the chimpanzee in a predator size-class with lions and hyaenas (Dominguez-Rodrigo and Piqueras 2003) which is surprising given the consumption behavior of those two large animals.

Both Pickering and Wallis (1997) and Plummer and Stanford (2000) provide percentages for types of damage on long bones and ribs. Table 6.1 provides a comparison of damage types found in the CHCI assemblages and two other relatively small chimpanzee tooth marked assemblages. The higher average percentages of 'crenulation' and 'punctures' in the Gombe and ZOO assemblages is likely due to the inclusion of ribs, whereas the CHCI assemblage only consists of limb elements. This also accounts for the higher percentage of 'step fractures' in the CHCI assemblage. The low 'pit' percentage in the Gombe assemblage is a product of not including the cranial elements, which were noted as exhibiting pits. Table 6.1 indicates that the structure and density of bone is important in understanding the amount and type of mastication damage (see also Selvaggio and Wilder 2001).

The CHCI assemblages have interesting implications for the study of early hominoid behavior. First, the CHCI assemblages point to the large amount of variability in tooth mark sizes created by hominoids. Since chimpanzees (CHCI 2001 and 2002; Pickering and Wallis 1997; Plummer and Stanford 2001) and humans (Weisler and Gargett 1993) both leave visible consumption patterns, one could expect that the earliest hominoids left similar patterns as well. Comparisons between the CHCI and ZOO assemblages indicate that tooth pits may be more consistent in size and hence more reliable than scratches in actor body-size estimates (see also Dominguez-Rodrigo and Piqueras 2003; Selvaggio 1994). Due to the nature of the CHCI assemblages and the methodologies described in Chapter 4, this collection of avian remains does not allow for modeling of hominoid tooth mark patterning across skeletal remains. However, this assemblage does indicate that the mechanical properties of bone must be taken into consideration when trying to understand the impressions of various taphonomic events.

Table 6.1: Percentages of damaged long bones and ribs in three chimpanzee tooth marked assemblages.

Chimpanzee Group	Type of Bone Damage Crenulation/ Crushed Edges	Step Fractures	Pits	Scores	Notches	Punctures
CHCI (n = 31)	32.3	41.9	87.1	41.9	16.1	0.0
Gombe (n = 10)	60.0	40.0	0.0	30.0	10.0	30.0
ZOO						
SRA (n = 1)	0.0	0.0	100.0	100.0	0.0	0.0
SRB (n = 20)	59.1	36.4	72.7	68.2	18.2	9.1
SRC (n = 10)	70.0	20.0	80.0	80.0	20.0	10.0
TU (n = 31)	20.5	7.7	33.3	38.5	7.7	10.3

After Pickering & Wallis (1997), Table 2 and Plummer & Stanford (2000), Table 5

Bofi Faunal Assemblage in a Broader Context

In this section I focus on placing the Bofi faunal assemblage into a broader research context by comparing human mastication damage to tooth marks created by other nonhuman bone consumers. The first portion will focus on macroscopic distinctions with an emphasis on frequency of tooth marking. In the second part I compare the microscopic pits and scratches created by the Bofi to carnivore-ravaged assemblages.

Since this is the first study that provides an in-depth study of human tooth mark damage morphology on small mammal remains (see Weisler & Gargett 1993 for avian comparison), comparisons must be made to dissimilar collections. I am unable to find published reports of either small predator tooth mark size and/or small prey remains left by mammalian predators, except as anecdotal and scatological notes regarding nearly complete consumption of small mammals by most mammalian predators. Hence, I compare data from Bofi small mammal consumption to published data on carnivore modification of large mammal remians. One inherent difficulty of such comparisons is the size difference of the prey animals (e.g., cattle (*Bos Taurus,* Haynes 1983; Pickering & Wallis 1997), sheep (*Ovis aries,* Elkin and Mondini 2001), and goat (*Capra hircus,* Pickering & Wallis 1997)) and the relative strength and robusticity of their different bones. It may be important to distinguish the strength of the bone as it relates to the size of the predator and the bones ability to imprint tooth marks. On the upside, the comparison of differing prey size categories allows for the possibility of an entirely new range of questions that may provide interesting insight into the subsistence patterns of human and non-human carnivores.

Tooth Mark Frequencies

Table 6.1 shows the relative proportions of tooth marked bones from the Bofi faunal assemblage in relation to reported numbers of gnawed bovid/artiodactyl bones in assemblages created by from hyaena, leopards and wolves (Blumenschine 1988; Brain 1981; Jones 1984; Haynes 1980; Shipman 1981). As expected, hyaena faunal assemblages are distinctly more heavily tooth marked than are any of the other assemblages. The frequency of tooth marked bones in the Bofi assemblage is comparable to faunal assemblages from wolf kill sites and leopard dens, *if* all of the prey animals in table 6.1 were ranked in comparable size/weight groups. However, the prey animals are distinctly *not* ranked in comparable size groups.

Table 6.2: Proportions of mastication damaged bones from multiple assemblages.
Sources include Blumenschine (1988), Brain (1981), Jones (1984), Haynes (1980), and Shipman (1981).

Agent	Prey Weight-Class	Assemblage Location (Number of Assemblages)	Population #	Gnawed #	% Range of Tooth-Marked Bones
Hyaena	5 – 500 kg	kill site (9)	231	189	66.7% - 100.0%
Hyaena	5 – 500 kg	dens (2)	737	349	40.8% - 50.4%
Wolf	5 – 500 kg	kill site	-	-	5.0% - 17.0%
Leopard	5 – 250 kg	breeding lairs/caves (4)	765	79	2.1% - 28.4%
Bofi forager	< 5 kg	All Combined	2322	487	12.0% - 34.8%
Bofi forager	< 5 kg	Grima (4 species)	1020	235	12.0% - 34.8%
Bofi forager	< 5 kg	Remote Camps (4 species)	1302	252	13.0% - 28.6%
Bofi forager	< 5 kg	Blue Duiker (2)	1170	254	19.2% - 26.8%
Bofi forager	< 3 kg	Brush Tailed Porcupine (2)	259	77	28.6% - 34.8%
Bofi forager	< 3 kg	Giant Pouched Rat (2)	668	129	13.0% - 24.4%
Bofi forager	< 1 kg	Murid Rats & Mice (1)	225	27	12.0%

Macroscopically there are few reports that focus on features of carnivore tooth mark patterning on small mammalian fauna (Andrews 1990; Andrews and Evans 1983; Fernandez-Jalvo and Andrews 1992). Most published reports indicate that a large range of predators (*canids, felids, mustelids, vivverrids*) consume entire carcasses of mammals that weigh less than 5 kg (Andrews 1990; Hernandez *et al.* 2002; Kruuk 1972; Schmitt and Juell 1994). Predators generally deposit the skeletal remains of small mammals in den assemblages as fecal remains (Binford 1981; Brain 1981; Jones 1984; Kruuk 1972; Richardson 1980; Yellen 1991). Fecal remains are uniquely identifiable in zooarchaeological assemblages as they exhibit etching that results from digestive acids (Andrews and Evans 1983; Hockett 1996; Payne 1985; Schmitt and

Juell 1994; Sutcliffe 1970; Tappen and Wrangham 2000). Therefore, it would be surprising to find a proportion of tooth damaged small mammal bones like that seen for the Bofi (roughly 20-25%) in association with large predators that are not etched by digestive acids and highly fragmented.

Comparison of Tooth Mark Sizes

It is commonly accepted that the size of tooth marks does not indicate a specific predator although it may well indicate a size class of consumer (Elkin and Mondini 2001; Dominguez-Rodrigo and Piqueras 2003; Lyman 1994). In their study, Dominguez-Rodrigo and Piqueras (2003) indicated that the mean size of tooth pits on epiphyses and diaphyses are useful in distinguishing size classes of carnivores. They measured the length of pits left by a variety of carnivores on the epiphyses and diaphyses of bovid and equid bones. The only exception within the measurements of the large prey remains was on an indeterminate small-sized animal fed upon by the jackals. There is a general consensus among recent carnivore studies that tooth scratches are less likely to indicate even a general carnivore size-class let alone specific carnivore activity since scratches are made by a tooth being dragged across a bones surface and is not therefore a tooth impression (Dominguez-Rodrigo and Piqueras 2003, Selvaggio 1994, and Selvaggio and Wilder 2001). In this section I will focus on comparing tooth pits and punctures to other published reports of carnivore tooth marks sizes.

A comparison of the size ranges (MLDs) of tooth pits and punctures between Bofi foragers on a variety of species, human and fox (Elkin and Mondini 2001) and a number of large to small carnivore epiphyseal pit marks (Dominguez-Rodrigo and Piqueras 2003; Selvaggio and Wilder 2001) is provided in Figure 6.3 and 6.4. The ranges of variations given in Figure 6.3 are representative of one standard deviation for all species except for the fox and human tooth marks

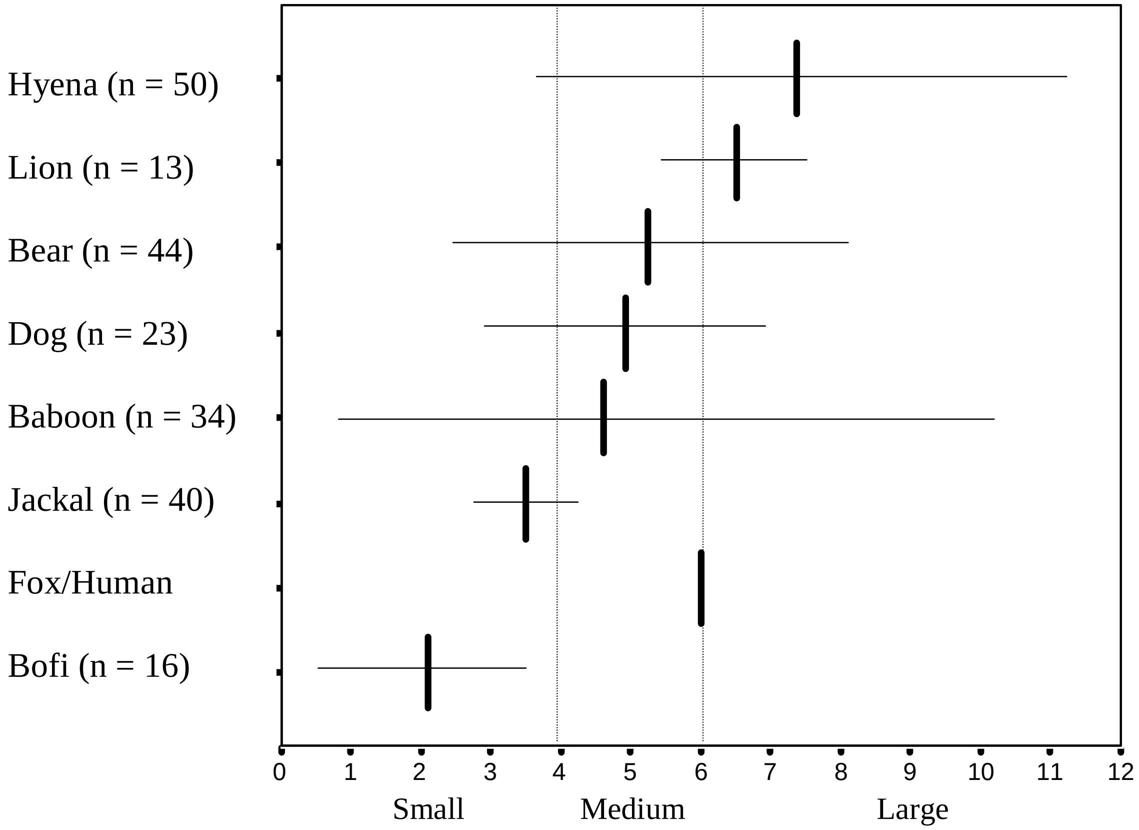

Figure 6.3: Mean tooth pit length on epiphyseal bone ends with one S.D. for a variety of carnivorous species where n = the number of measured marks. Bofi mean and S.D. are only for tooth punctures. Categories on the x-axis represent categories distinguished by Dominguez-Rodrigo and Piqueras (2003) for predator size classes.

as Elkin and Mondini (2001) only noted that the largest tooth puncture in their assemblage was 6 mm wide and that the average tooth pit varied between 1.5 and 3 mm. Further, they did not distinguish if a fox or a human left the relatively large puncture. Based on the size of Elkin and Mondini's (2001) tooth puncture and comparisons with the Bofi assemblage, I would suggest that a fox rather than a human likely produced the mark. Although overlap exists for most of the carnivores in Figures 6.3 and 6.4, especially given the single standard deviation, what stands out is the consistently small size of the Bofi tooth marks. One of the most notable problems with these predator size-class categories, and one that did not go unnoticed by the original authors is that a, “general phenomenon of convergence makes it almost impossible to isolate a determined carnivore species ” and that, “tooth marks alone cannot confidently be used to identify specific carnivore taxa in bone assemblages” (Dominguez-Rodrigo and Paqueras 2003:1387).

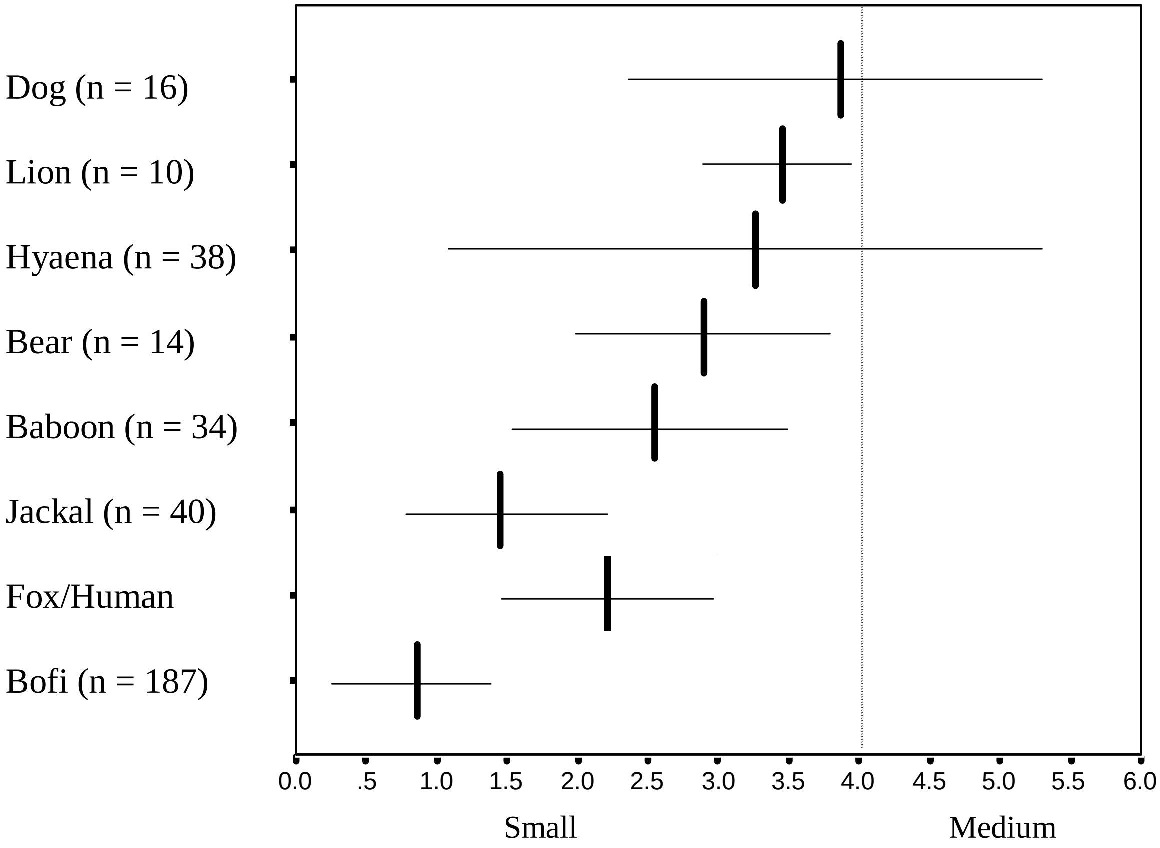

Figure 6.4: Mean tooth pit length on bone diaphyses one S.D. for a variety of carnivorous species where n = the number of measured marks. Bofi mean and S.D. are for all tooth pits. Categories on the x-axis represent categories distinguished by Dominguez-Rodrigo and Piqueras (2003) for predator size classes.

Figures 6.3 and 6.4 are useful comparisons because they include the most current information on a range of carnivore tooth modifications for a variety of carnivore size classes (jackals to bears). However, the usefulness of the comparison is also limited as the tooth marks from most of the carnivores were made on medium to large bovids and equids, which are definitely not in the same size-class as the prey utilized by the Bofi. The only animal that left mastication damage on an indeterminate small-sized prey from the above comparison is the jackal. And, while the Bofi assemblage may be consistently smaller than many of the other carnivores in Figures 6.3 and 6.4 there is considerable overlap in a single standard deviation with tooth marks left by jackals on small-sized prey. Further, all of the carnivores (except for lion's tooth punctures and Elkin and Mondini's (2001) single maximum puncture size) leave tooth pits and punctures that are under 4 mm in width (i.e., small-sized predators). This is an important point since tooth mark size is limited on small prey by the size of the skeletal element. This suggests that not only are human tooth marks likely to be confused with those of small canids on a morphological basis alone, but that the size of the mastication damaged prey is an important variable that needs to be controlled in future research.

Conclusions

While both the frequencies and tooth mark size ranges indicate that it is unlikely hyaena consumption of large prey bones will be confused with human induced mastication damage, there is a distinct lack of applicable data with regards to large and small predator consumption of small mammals. Figures 6.3 and 6.4 suggest that the range of variation in tooth mark size is in part controlled by 1) the maximum size of the predators tooth and 2) the structural composition and overall size of the damaged skeletal element (e.g., cancelleous ribs or cortical long bone of bovids versus rodents). If the maximum size of any given tooth mark is partly controlled by the structure and size of the bone (i.e. small bones can not imprint large tooth marks without undergoing complete structural failure and not providing a record of the tooth size), then the comparison of large carnivore tooth marks on large prey is inappropriate with regards to predator tooth mark size on small prey remains.

Given that tooth mark sizes are limited by the size of the skeletal elements for small animals, then the overlapping size of small tooth marks from multiple predators indicates that humans and carnivores are likely to leave identical micro-morphological marks on small prey remains. This is not surprising as one might expect the interaction of enamel with bone to perpetuate a similar reaction given the size and strength of both the bone and the actor. Given that tooth imprints are limited by the maximum size of the bone and tooth, and that the micro-morphology is the same, tooth mark size and microscopic morphology of individual marks on small mammal remains should not be used alone as indicator of predator species (as per Dominguez-Rodrigo 2003; Shipman 1983).

This does not mean that the carnivore or omnivore responsible for damage cannot be determined. It is important that the identification of bones damaged during consumption events also include information regarding the overall amount of bone destruction (e.g., mostly complete versus highly fragmented), the frequency of mastication across the collection (e.g., 25% or 100%) and the skeletal patterning of that gnawing (e.g., evenly across the skeleton or focused on specific elements) as indicators of which predator is likely to have left evidence of their consumption activity. Most importantly, when mastication damaged small prey bones are uncovered archaeologically, it must not be assumed that the predator leaving tooth marks was not human.

Chapter 7: Discussion & Conclusions

"The existence of man in previous ages is supported by two classes of evidence: first, the finding of human remains, and, second, the recognition of human products."

(Baker 1898:357)

I have argued that the identification of human mastication damage within the bounds of a specific ethnographic collection fills a void in taphonomic research. Bones from human consumption activities provide a means for identifying their subsistence remains in archaeological collections. The previous chapters have identified human tooth marks on small mammals with regards to morphology, frequency, and amount of element consumption. What remains to be seen is how the identification of human mastication damage in zooarchaeological assemblages can further archaeological research beyond merely adding to a cumbersome list of identifiable taphonomic processes. This chapter focuses on two main questions. First, can human tooth marks and tooth mark patterning be used as indicators of human subsistence activities that are distinguishable from other carnivore and omnivore mastication events? Second, in what way is this research useful when dealing with the archaeological record?

Synthesis of the Bofi Forager Faunal Assemblage

The samples analyzed in this thesis are useful in examining the morphological indication of human and chimpanzee subsistence activities and the way those faunal remains may or may not differ from the mastication damage created by other carnivores and omnivores. This research indicates that the micro-morphological damage produced by human mastication on the surface of small mammal bone elements (i.e. size and shape of individual tooth marks) is characteristically identical to damage produced by other carnivores. This appears to be a product of the nature of the interacting components and was foreshadowed by Binford (1981) and White

(1992:155) who noted that, "It is evident from simple mechanical considerations that substantial overlap between human and carnivore chewing damage on bones will be shown by future research in this area.” In other words, there are a limited number of ways in which tooth enamel, regardless of size, can interact with bone matrices. Thus, as seen via the Bofi forager faunal collection, consumption of small animal remains bones by carnivores and hominoids is likely to produce the same micro-morphological archaeological signature, although the patterning of that damage is likely to be different. It may be better understood by noting that a carnivore (be it hyaena or weasel) in the throes of sensitivity while consuming a small animal can produce the same damage on mouse bones that we see in the Bofi forager faunal collection. The fact that *hyaenids, felids, canids, mustelids,* and other carnivores have not been noted as producing this type of damage and will instead generally consume the entire carcass of small mammals (Andrews 1990; Andrews and Nesbit Evans 1983; Casteel 1971; Hudson 1990; Lyon 1970; Payne 1985; Willey and Snyder 1989) is an interesting point worthy of future research.

While microscopic characteristics cannot be used to identify human mastication damage, the results of analysis presented in this thesis indicate that the Bofi forager consumption patterns may be differentiated from other carnivore ravaged assemblages on a macroscopic level. Bofi consumption damage focuses on soft tissue instead of within bone nutrients (i.e., grease, marrow). Thus, the frequency and intensity (as presented in Chapter 6) of tooth marking in relation to the size of the skeletal element and the overall patterning throughout the assemblage may well prove to be a distinctive human consumption signature in zooarchaeological studies of small mammals. In other words, a collection of small animal remains that exhibit minimal bone consumption, which is evidenced relatively evenly amongst skeletal elements and lacks evidence of digestive etching (i.e., was not fully consumed), may be indicative of human mastication.

The Bofi forager faunal assemblage stands alone as an example of human tooth marked small mammal remains. However, assuming that future research supports the conclusions presented herein, then hominids are distinctive from other carnivores in that they will generally not consume entire bone portions or skeletal elements of small animals. I am not suggesting that humans *cannot* consume entire bones without the aid of tools, rather that modern humans *do not* masticate entire bones of large or small animals as a matter of practice.

Archaeological Implications

It is entirely possible that human mastication can be archaeologically identified in collections of small mammal remains based on observed tooth mark damage frequencies with minimal amounts of bone consumption. Until recently, most mastication damage in faunal assemblages has been attributed solely to carnivores. In fact, only three researchers have previously suggested that perhaps human mastication is archaeologically visible (Elkin and Mondini 2001; Weisler and Gargett 1993; White 1992). Perhaps an archaeological example may best be presented by an excerpt from White (1992:334) who, when referring to 23 cottontail femora from Mancos 5MTUMR-2346, noted that:

> “Two had their ends completely chewed off, one was burned only, and one lacked part of the condylar region but showed no other damage. The remaining distal femora were either completely intact and undamaged (n=8) or displayed shallow punctures, often with loss of some of the condylar area (n=11) … The finding that 47.8 percent of the lagomorph femora showed such punctures establishes a provocative pattern. It is possible to infer, on the basis of observed canid bone-chewing behavior, that canid chewing is unlikely to have been responsible for the observed pattern on the rabbit femora. This is because any canid chewing on the small, fragile lagomorph femur would

> have been likely to destroy the entire distal end of this bone, often with the carnivore subsequently ingesting the fragments."

Based on descriptive similarities with the Bofi forager assemblage it seems reasonable that the damage observed on the cottontail femora from Mancos is the result of human mastication events.

Any such conclusions should be tentative until further research, especially among smaller carnivores (e.g., foxes, weasels, etc.), corroborates that bone damage on or near points of soft tissue attachment with minimal mastication focused on utilizing within bone nutrients on small animal bones is a human consumption trait. However, if such is the case, then similar mastication patterns in faunal assemblages from archaeological sites may be used to indicate a human presence; a presence not otherwise exhibited.

Support for this hypothesis may best be found in areas well known for superior small mammal preservation, such as caves and rockshelters in the American Southwest and Great Basin or shell middens along coastal sites (Fancher 2001; Grayson 1991; Hockett and Bicho 2000; Nicholson 1998). Ethnographic data suggests that humans in these same areas subsisted on small fauna, such as rabbits and rodents (Fancher 2001; Quirt-Booth and Cruz-Uribe 1997; Schaffer and Gardner 1995). I would suggest that future research continue by looking at the frequency and extent of mastication damage in archaeological assemblages.

Admittedly, the most difficult component of this suggestion is the difficulty of ruling out other carnivore mastication activities (i.e., scavenging of domestic and wild canids). Observed mastication damage is often attributed to carnivores on an ad hoc basis and any 'canid' modified bones are then removed from further discussion of human activity. In some cases that assumption is probably appropriate, but it should not be assumed without supporting evidence.

What my research suggests is that the initial identification of canid influence may be in error. Published reports indicate that domestic dogs do not typically consume, scavenge and deposit bones in the same location (Kent 1981). Further, canid scatological remains should appear readily distinct from any human deposited small mammal archaeological component (Andrews and Nesbit Evans 1983; Payne 1985; Schmitt and Juell 1994). If it is possible to distinguish between canid and hominid subsistence remains, then archaeologists can provide a clearer picture of historic and prehistoric peoples across the landscape and in doing so, archaeologists can better understand and ask questions relating to diet breadth models, optimal foraging patterns, ecological impacts, and relationships to mobility that might otherwise go undetected.

Implications of Mastication and Early Hominid Diets

This research has further implications beyond merely uncovering the acting agent of individual bone consumption. Understanding the role of humans with reference to small mammal subsistence may be especially important in discussion of early *Homo* sites in Africa. Although the "Hunter vs. Scavenger" debate continues to draw attention, it is theoretically expected that early hominids hunted small game well before they turned their attention to large game (Bartholomew and Birdsell 1953; Fernandez-Jalvo 1999; Jones 1984; Yellen 1991). If such is the case, then early hominid research would be greatly enhanced by the ability to focus attention into the far-reaching past beyond that currently available with reference only to the oldest stone tools, especially since the earliest African rabbits of the family Ochotonidae date back to the early Miocene in Namib and East Africa and the oldest African blue duiker (*Cephalophus caeruleus,* a synonym of *C. monticola*) has been found in Taung, South Africa and Olduvai dating to the Late Miocene (Maglio and Cooke 1978). Postcranial Leporidae (specifically *Alilepus*) has been uncovered in Kenya and bracketed by dates at 6.57-6.54 mya

(Winkler 2002). The not so subtle suggestion is that perhaps the earliest traces of hominoid ancestry can be uncovered at a depth of time impossible when relying on stone tool cut marks.

Concluding Remarks

An advantage to this thesis is its application of actualistic research. By observing the consumption behavior of modern peoples and then filtering those patterns towards the archaeological record it is possible to specify and test characteristics of zooarchaeological assemblages. In testing archaeological faunal assemblages it is entirely reasonable to suspect that the frequency and pattern of mastication damage in the Bofi assemblage will have no archaeological double. Especially since humans can consume entire bone portions from much larger animals (Brain 1981; Binford 1981) and the removal of canid modification in the Bofi forager collection may alter any archaeological frequencies of a similar nature. Since the ethnographic information among the Bofi foragers represents a single point along a continuum of human behavior, the idea that the exact numbers may not have exact archaeological correlatives is not worrisome. The point of this research is to point out trends in behavior that should be taken into account during archaeological reconstructions of past human actions.

Further tests of the hypothesis advanced here should include more actualistic and archaeological research. Actualistic research should emphasize the impact of small sized predators (i.e., foxes, weasels, etc.) on small fauna (i.e., rabbits, gophers, etc.) and their potential for patterning within zooarchaeological collections. Furthering ethnoarchaeological studies of small-game hunters and the role of small fauna among large-game hunters is equally important as this thesis represents only one usable data point. Butchering studies involving tools and small fauna will clarify the expediency and applicability of tool-use patterns in archaeological contexts.

As the only in-depth account of human mastication damage and its potential impact and implication in archaeological settings, this thesis should be used as a starting point where further questions concerning human subsistence activities can be addressed. The ability of humans to modify their subsistence patterns to meet a variety of environmental and social needs cannot be underestimated. Diet breadth and optimal foraging models would be much strengthened by considering the impact of humans in zooarchaeological assemblages with small fauna that may or may not have other obvious indicators of a human presence. Many questions regarding human subsistence strategies can only be answered by looking at ethnoarchaeological assemblages, experimental collections, or by turning to the archaeological record and taking human consumption into account.

“It is expected that the basic patterns of modification that an animal is mechanically capable of producing are not going to vary a great deal from one species to another. It is more likely that the magnitude of the capability, and the use of it, will vary among species."

Binford 1981:35-36

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Appendix A:

Mastication Damaged Bofi Forager Faunal Assemblage

Key to Coding Sheet of Bofi Forager Assemblage

ID	Unique Specimen Number
Location	Grima or Remote Camp
Common Name	Common Name of Animal
Portion	Assignment to Butchery Unit
Element	Specific Bone Element
SEM	Number of SEM Pictures
IA	Number of Image Analysis Pictures

Segment

CO	Complete Bone
~CO	Nearly Complete
Half	Unspecified Half
Missing DS	~ CO with Missing Distal End
Frag	Fragment, not otherwise specified
Prx w/Shaft	Proximal Articulation with Half of Shaft
Dist w/Shaft	Distal Articulation with Half of Shaft

Damage	Notes on Damage Type
Count	# of Elements
# Pics SEM	Number of SEM Photos Used

Crushed

1	Presence of Crushed Edges
-	Absence of Crushed Edges
#	Number of Crushed Edges

Proximal/Shaft/Distal/Other

1	Presence of Crushed Edges
-	Absence of Crushed Edges

Crenulated

1	Presence of Crenulated Edges
-	Absence of Crenulated Edges

Step Fracture

1	Presence of Step Fracture
-	Absence of Step Fracture

Shallow Pit

1	Presence of Pit
-	Absence of Pit
#	Number of Pits
Location	Notes on Location of Pit
Nearest Dmg	Notes on Location of Nearest Damage
MLD	Measured Maximum Linear Dimension in mm

Scoring

1	Presence of Tooth Scratches
-	Absence of Tooth Scratches
#	Number of Measured Tooth Scratches
Modified Ct.	Number of Tooth Scratches not Associated with Cleaning
Location	Notes on Location of Tooth Scratch
Nearest Dmg	Notes on Location of Nearest Damage
Width	Widest Measured Width of Scratch

Tooth Notches/Chipping Back

1	Presence of Tooth Scratches
-	Absence of Tooth Scratches
NB-ND	Measurements on Notch Breadth and Depth in mm
FsB-FsD	Measurements on Flake Scar Breadth and Depth in mm

ID #	Location	Common Name	Portion	Element	SEM	IA	Scouring	Crushed	Crenulated	Step Fracture	Shallow Pit	Scoring	#	Tooth Notches Chipping Back	Dimensions in mm			0
															NB-ND index	FsB FsD index	Y N	Pit #
2.2	Remote Camp	Duiker	Head	Axis	12	0	1	1	-	-	1	-	-	-	0	0	-	-
136.3	Remote Camp	Duiker	Head	Cerv. Vert.	13	0	1	1	-	-	1	1	3	-	0	0	1	1
157.4	Remote Camp	Duiker	Head	Mandible	10	6	1	1	-	-	-	1	5	-	0	0	-	-
29.01	Remote Camp	Duiker	Forelimb	Humerus	11	2	1	1	-		1	1	3	-	0	0	-	-
126.7	Remote Camp	Duiker	Forelimb	Humerus	4	1	-	1	-	-	1	1	1	-	0	0	-	-
126.8	Remote Camp	Duiker	Forelimb	Scapula	11	4	1	1	-	-	1	1	1	-	0	0	-	-
79.15	Remote Camp	Duiker	Hindlimb	Navic-Cuboid	15	0	-	-	-	-	1	1	1	-	0	0	-	-
188.09	Remote Camp	Duiker	Hindlimb	Femoral Distal Epiphysis	12	0	-	1	-	-	1	-	-	-	0	0	-	-
5.8	Remote Camp	Duiker	Back	Thoracic Vert.	7	3	-	1	-	-	1	-	-		0	0	-	-
18.5	Remote Camp	Duiker	Back	Innominate	24	5	1	1	-	-	1	1	7	-	0	0	-	-
19.15	Remote Camp	Duiker	Back	Thoracic Vert.	22	7	-	1	-	-	1	1	2	-	0	0	-	-
102.03	Remote Camp	Duiker	Back	Caudal Vert	7	2	-	1	-	-	-	-	-	-	0	0	-	-
146.08	Remote Camp	Duiker	Back	Thoracic Vert.	8	3	-	1	-	-	1	-	-	-	0	0	-	-
146.06	Remote Camp	Duiker	Back	Lumbar Vert	10	0	-	1	-	-	1	-	-	-	0	0	-	-
146.15	Remote Camp	Duiker	Back	Caudal Vert	8	0	1	1	-	-	-	1	1	-	0	0	-	-
185.7	Remote Camp	Duiker	Back	Thoracic Vert.	5	4	1	1	-	-	1	1	2	-	0	0	-	-
5.4	Remote Camp	Duiker	Chest	Rib	18	0	1	-	-	-	1	1	3	-	0	0	-	-
26.1	Remote Camp	Duiker	Chest	Rib	6	0	-	1	-	Midshaft(Prox)	1	1	1	-	0	0	-	-
26.9	Remote Camp	Duiker	Chest	Rib	8	0	1	1	-	Midshaft(Prox)	1	1	2	-	0	0	-	-
65.7	Remote Camp	Duiker	Chest	Rib	5	0	1	1	-		1	-	-	-	0	0	-	-
99.26	Remote Camp	Duiker	Chest	Rib	5	0	-	1	-	-	-	1	1	-	0	0	-	-
116.15	Remote Camp	Duiker	Chest	Rib	13	4	1	1	-	1	-	1	1	-	0	0	-	-
188.3	Remote Camp	Duiker	Chest	Rib	2	0	-	1	-	-	1	-	-	-	0	0	-	-
195.4	Remote Camp	Duiker	Chest	Rib	3	0	-	1	-	1	1	-	-	-	0	0	-	-
205.13	Remote Camp	Duiker	Chest	Rib	18	0	1	1	-	-	1	1	6	-	0	0	-	-
56.13	Remote Camp	Porcupine	Head	Axis	1	-	-	1	1	-	1	-	0	-	0	0	-	-
189.6	Remote Camp	Porcupine	Forelimb	Humerus	20	5	1	1	-	-	1	1	1	-	0	0	-	-
51.31	Remote Camp	Porcupine	Forelimb	Ulna	6	3	1	1	-	-	1	1	0	-	0	0	-	-
96.2	Remote Camp	Porcupine	Forelimb	Ulna	6	2	1	1	-	-	1	1	0	-	0	0	-	-
94.1	Remote Camp	Porcupine	Hindlimb	Tibia Epiphysis	3	1	1	1	-	-	1	1	0	-	0	0	-	-
189.1	Remote Camp	Porcupine	Hindlimb	Femur	12	2	1	1	-	-	1	1	1	-	0	0	-	-
146.2	Remote Camp	Porcupine	Thorax	Rib	12	-	1	1	-	-	1	1	1	1	.75 - .4285	-	-	-
67.10	Remote Camp	Porcupine	Thorax	Thoracic Vert.	5	2	-	1	-	-	1	1	1	1	3.67 - .85	4.47 - 1.13	-	-
146.7	Remote Camp	Porcupine	Thorax	Thoracic Vert.	6	1	-	1	-	-	-	1	0	-	0	0	-	-
100.2	Remote Camp	Porcupine	Thorax	Thoracic Vert	2	1	-	1	-	-	1	1	1		0	0	-	-
25.0	Remote Camp	Porcupine	Pelvis	Innominate	17	2	1	1	-	1	1	1	2	-	0	0	-	-
100.5	Remote Camp	Porcupine	Pelvis	Lumbar Vert	6	1	1	1	-	1	-	1	0	-	0	0	-	-
100.6	Remote Camp	Porcupine	Pelvis	Lumbar Vert	6	1	1	1	-	-	-	1	1	0	0	0	-	-
67.6	Remote Camp	Porcupine	Pelvis	Lumbar Vert	10	-	-	1	-	-	1	-	0	-	0	0	-	-
51.28	Remote Camp	Porcupine	Pelvis	Innominate	27	2	1	1	-	1	1	1	2	-	0	0	-	-
63.19	Remote Camp	F. Rat	Head	R. Mandible	22	-	1	1	1	-	1	1	7	-	-	-	-	-
10.12	Remote Camp	F. Rat	Forelimb	Radius	17	1	1	1	1	-	1	1	7	-	-	-	-	-
63.9	Remote Camp	F. Rat	Forelimb	Ulna	17	1	1	1	1	-	1	-	8	-	-	-	-	-
64.21	Remote Camp	F. Rat	Hindlimb	Metatarsal	6	1	1	1	-	1	1	-	0	1	1.285 - .6857	-	-	-
60.4	Remote Camp	F. Rat	Hindlimb	Femur	20	1	1	1	1	-	1	1	8	-	-	-	-	-
164	Remote Camp	F. Rat	Thorax	Rib (big)	14	3	-	-	-	-	1	1	1	-	-	-	-	-
164	Remote Camp	F. Rat	Thorax	Rib (little)	24	1	1	1	1	-	1	1	2	-	-	-	-	-
10.14	Remote Camp	F. Rat	Pelvis	Innominate	19	2	-	1	1	1	1	-	0	-	-	-	-	-
22.2	Grima	Duiker	Head	Axis	5	2	1	1	-	-	-	0	0	-	0	0	-	-
140.1	Grima	Duiker	Head	1st Cerv. Vert.	11	1	-	1	-	-	1	1	1	-	0	0	-	-
142.6	Grima	Duiker	Head	Thoracic Vert	11	3	-	1	-	-	1	-	-	-	0	0	1	2
149.7	Grima	Duiker	Head	Cerv. Vert.	4	3	-	1	-	-	1	1	1	-	0	0	-	-
149.9	Grima	Duiker	Head	Thoracic Vert	11	2	1	1	-	-	1	1	3	-	0	0	1	4
119.2	Grima	Duiker	Forelimb	Humerus	7	2	1	1	-	Midshaft Fracture	1	1	2	-	0	0	-	-
154.3L	Grima	Duiker	Forelimb	Scapula	4	1	1	1	1		-	1	1	-	0	0	-	-
160.11L	Grima	Duiker	Forelimb	Scapula	7	2	-	1	-	-	-	1	2	-	0	0	-	-
193.1R	Grima	Duiker	Forelimb	Ulna	8	3	-	1	-	Midshaft Fracture	1	-	-	-	0	0	1	1
44.0L	Grima	Duiker	Forelimb	Scapula	4	3	1	1	-	-	1	1	2	-	0	0	-	-
44.2L	Grima	Duiker	Forelimb	Humerus	4	2	1	1	1	-	1	1	2	-	0	0	-	-
11.1	Grima	Duiker	Hindlimb	Femur	7	2	1	1	-	Midshaft Fracture	1	1	1	-	0	0	-	-
44.1L	Grima	Duiker	Hindlimb	Tibia	11	5	1	1	-	Midshaft Fracture	1	1	2	-	0	0	4	1,2,3,4
111.1R	Grima	Duiker	Hindlimb	Tibia	21	2	1	1	1	Midshaft Fracture	1	1	4	-	0	0	-	-
42.2	Grima	Duiker	Back	Lumbar Vert.	9	1	1	1	Split Sagitally	-	-	-	-	-	0	0	-	-
42.5	Grima	Duiker	Back	Lumbar Vert	5	1	-	1	Split Sagitally	-	1	-	-	-	0	0	-	-
83.4	Grima	Duiker	Back	Sacrum	18	1	1	1	-	-	-	1	2	-	0	0	-	-
192	Grima	Duiker	Back	Thoracic Vert.	8	1	1	1	-	-	1	1	2	-	0	0	-	-
192.2	Grima	Duiker	Back	Thoracic Vert	2	2	-	1	Split Transversely behind spine	-	-	1	1	-	0	0	-	-
159.5L	Grima	Duiker	Back	Sacrum/Ilium	3	1	-	1	-	-	1	-	-	-	0	0	-	-
193.3R	Grima	Duiker	Back	Innominate	10	4	-	1	-	-	1	1	1	-	0	0	1	4
3.4	Grima	Duiker	Chest	Rib	23	2	1	1	-	1	1	1	1	-	0	0	-	-
3.5	Grima	Duiker	Chest	Rib	7	2	1	1	-	-	1	1	1	-	0	0	-	-
43.1	Grima	Duiker	Chest	Rib	14	4	1	1	-	-	1	1	1	-	0	0	-	-
43.4	Grima	Duiker	Chest	Rib	17	3	1	1	-	Angle Fracture	1	-	-	-	0	0	-	-
142	Grima	Duiker	Chest	Rib	8	3	1	1	-	1	1	-	-	-	0	0	-	-
150.2	Grima	Duiker	Chest	Rib	10	2	-	1	-	-	1	1	1	-	0	0	-	-
43.10L	Grima	Duiker	Chest	Rib	20	3	1	1	-	-	-	1	2	-	0	0	-	-
43.1L	Grima	Duiker	Chest	Rib	6	4	1	1	-	1	1	1	2	-	0	0	-	-
43.7L	Grima	Duiker	Chest	Rib	15	3	1	1	-	1	1	1	2	-	0	0	-	-
132.9	Grima	Porcupine	Forelimb	Ulna	11	-	1	1	-	-	1	-	0		-	-	-	-
132.8	Grima	Porcupine	Hindlimb	Fibula	10	-	1	1	-	-	1	1	2	1	5.15 - 0.98	6.71 - 1.57	-	-
139.13	Grima	Porcupine	Thorax	Rib	12	-	1	1	-	-	1	1	1	-	-	-	-	-
132.4	Grima	Porcupine	Thorax	Rib	8	-	1	-	1		0	1	0	1	.5835 - .3317	-	-	-
132.13	Grima	Porcupine	Pelvis	Caudal Vert.	17	-	1	1	-	-	1	1	1	1	2.035 - .60	2.571 - .8571	-	-
139.6	Grima	Porcupine	Pelvis	Innominate	26	-	1	-	-	-	1	-	0	-	0	0	1	-
203	Grima	Mouse	Head	Mandible	8	-	1	-	-	1	1	1	0	-	0	0	-	-
173.11	Grima	Mouse	Forelimb	Humerus	8	-	-	1	-	1	1	-	0	-	0	0	-	-
158.6	Grima	Mouse	Hindlimb	Femur	21	-	-	1	-	1	1	-	0	-	0	0	-	-
158.9	Grima	Mouse	Hindlimb	Femur	10	-	-	1	-	-	-	-	0	-	0	0	-	-
169	Grima	Mouse	Hindlimb	Femur	9	-	-	-	-	-	-	-	0	-	0	0	-	-
169.4	Grima	Mouse	Hindlimb	Femur	9	-	1	-	-	-	-	1	0	-	0	0	-	-
203.28	Grima	Mouse	Pelvis	Caudal Vert.	9	-	1	-	-	1	-	1	0	-	0	0	-	-
203.28	Grima	Mouse	Pelvis	Lumbar Vert	12	-	1	1	1	1	-	1	0	-	0	0	-	-
203.28	Grima	Mouse	Pelvis	Lumbar Vert	14	-	0	1	1	1	-	-	0	-	0	0	-	-
131.8	Grima	F. Rat	Head	Cerv. Vert	8	-	-	1	1	-	-	-	-	-	-	-	-	-
148.7	Grima	F. Rat	Head	Mandible	22	-	1	-	-	1	1	1	30	-	-	-	-	-
148.6	Grima	F. Rat	Forelimb	Scapula	13	-	1	1	1	-	1	1	5	-	-	-	-	-
141.8	Grima	F. Rat	Forelimb	Scapula	18	-	-	1	-	1	1	1	1	1	2.185 - 1.007	-	-	-
141	Grima	F. Rat	Forelimb	Ulna	15	-	1	-	-	1	1	1	4	-	-	-	-	-
196.03	Grima	F. Rat	Forelimb	Humerus	18	-	-	1	1		1	-	-	1	1.821 - .921	-	-	-
151.09	Grima	F. Rat	Hindlimb	Tib/Fib	10	-	-	1	1	1	1	-	-	2	1.21 - 1.21	.80 - 1.09	-	-
170.07	Grima	F. Rat	Hindlimb	Femur	15	-	1	1	1	-	1	-	-	-	-	-	-	-
187.04	Grima	F. Rat	Hindlimb	Femur	15	-	1	1	1	-	1	1	5	2	2.00 - 1.46	1.67 - 1.03	-	-
53.06	Grima	F. Rat	Thorax	Thoracic Vert	9	-	1	1	-	1	1	-	3	-	-	-	-	-
131.28	Grima	F. Rat	Thorax	Thoracic Vert	14	-	1	-	-	1	-	1	9	1	.482 - .203	-	-	-
148.1	Grima	F. Rat	Thorax	Rib	17	-	1	1	1		1	1	4		-		-	-
171.08	Grima	F. Rat	Thorax	Rib	12	-	-	1	1	-	1	-	-	-		-	-	-
53.24	Grima	F. Rat	Pelvis	Innominate	31	-	-	1	1	1	1	1	4	1	4.6 - 1.42	-	-	-
131.22	Grima	F. Rat	Pelvis	Lumbar Vert	17	-	-	1	-	1	1	-	-	-	-	-	-	-
152.01	Grima	F. Rat	Pelvis	Lumbar Vert	9	-	-	1	-	1	-	1	2	1	.714 - .342	-	-	-
170.01	Grima	F. Rat	Pelvis	Lumbar Vert	23	-	1	1	-	1	1	1	1	-	-	-	-	-
186.07	Grima	F. Rat	Pelvis	Innominate	38	-	1	1	1	1	1	1	10	-	-	-	-	-
Totals		111 bones			1313	144	69	99	23	28	87			15	0	0	10	12

ID	Location	Hunter	Consumer	Species	Element	Segment	Damage	Count
2.1	R.C.	Marie	Margerie	Duiker	Atlas	~CO	Gnawed	1
2.2	R.C.	Marie	Margerie	Duiker	Axis	~CO	Gnawed	1
3.1	Grima	Mary	Mary	Duiker	Humerus	~CO	Cut, Gnawed, Carbonized	1
3.2	Grima	Mary	Mary	Duiker	Radius/Ulna	PX w/shaft	Cut, Broken, Gnawed, Carbonized	2
3.3	Grima	Mary	Mary	Duiker	Rib	~CO	Gnawed	3
4.0	R.C.	Boyo	Elapha	Duiker	Femur	Shaft	Gnawed	1
4.1	R.C.	Boyo	Elapha	Porcupine	Innominate	Posterior	Chopped, Gnawed	1
4.2	R.C.	Boyo	Elapha	Porcupine	Femur	~CO	Gnawed, Carbonized	1
4.3	R.C.	Boyo	Elapha	Porcupine	Humerus	Px w/shaft	Gnawed, Fractured	1
4.4	R.C.	Boyo	Elapha	Porcupine	Scapula	Blade	Gnawed, Fractured	4
5.4	R.C.	Zonani	Touandike	Duiker	Rib	~CO	Gnawed	1
5.5	R.C.	Zonani	Touandike	Duiker	Cervical	~CO	Gnawed	2
5.8	R.C.	Zonani	Touandike	Duiker	Thoracic	~CO	Gnawed	1
6.3	R.C.	Zonani	NDoki	Duiker	Rib	~CO	Gnawed	1
6.4	R.C.	Zonani	NDoki	Duiker	Cervical	~CO	Gnawed	3
7.9	R.C.	Marie	Dangi	Duiker	Rib	~CO	Gnawed	1
8.0	Grima	NDoki	Kossombo	Duiker	Sacrum	Half	Chopped, Gnawed	1
8.3	Grima	NDoki	Kossombo	Duiker	Sacrum	Half	Chopped, Gnawed	1
9.24	R.C.	Boyo	Kala	Duiker	Humerus	Px epiphysis	Gnawed	1
9.25	R.C.	Boyo	Kala	Porcupine	Scapula	~CO	Cut, Fractured, Gnawed	1
10.11	R.C.	Ngapua	Ngapua	Rat	Ulna	Missing DS	Fractured, Gnawed?	1
10.12	R.C.	Ngapua	Ngapua	Rat	Radius	Missing DS	Fractured, Gnawed?	1
10.14	R.C.	Ngapua	Ngapua	Rat	Innominate	~CO	Gnawed	1
11.01	Grima	NBondo or Zonani	Twe-deke	Duiker	Femur	PX w/shaft	Chopped, Striae, Gnawed	1
12.01	R.C.	?	Bondo	Porcupine	Innominate	Acetabulum, Ilium, Pubis	Gnawed	1
12.09	R.C.	Zonani	Bondo	Duiker	Lumbar	Spine	Broken, gnawed	1
12.19	R.C.	Zonani	Bondo	Duiker	Caudal	~CO	Gnawed	4
13.08	Grima	Alphonse	Alphonse	Mouse	Femur	CO	Gnawed	2
18.05	R.C.	Marie	Semedi	Duiker	Innominate	~CO	Gnawed	1
18.09	R.C.	Marie	Semedi	Porcupine	Humerus	CO	Gnawed	1
19.03	R.C.	Boyo	Boyo	Duiker	Cervical/Thoracic	~CO	Chopped, Gnawed	2
19.09	R.C.	Boyo	Boyo	Duiker	Rib	~CO	Gnawed	1
19.11	R.C.	Boyo	Boyo	Duiker	Rib	Proximal	Gnawed	1
19.14	R.C.	Boyo	Boyo	Duiker	Thoracic	~CO	Gnawed	3

ID	Location	Hunter	Consumer	Species	Element	Segment	Damage	Count
20.04	Grima	Kosona/Ngandi	Nbaka	Duiker	Rib	~CO	Gnawed	1
22.02	Grima	Dangi	Yvonne	Duiker	Axis	CO	Gnawed	1
25.00	R.C.	Samedi	Etien	Porcupine	Innominate	Ischium	Gnawed, Fractured	1
25.08	R.C.	Samedi	Etien	Porcupine	Rib	Px w/shaft	Fractured, Gnawed	1
25.11	R.C.	Samedi	Etien	Porcupine	Rib	Px w/shaft	Fractured, Gnawed	1
26.00	R.C.	Boyo	Gapua	Duiker	Sternum	segment	Gnawed	1
26.01	R.C.	Boyo	Gapua	Duiker	Rib	DS w/shaft	Fractured, Gnawed	2
26.03	R.C.	Boyo	Gapua	Duiker	Sternum	segment	Gnawed	1
26.04	R.C.	Boyo	Gapua	Duiker	Rib	DS w/shaft	Fractured, Gnawed	2
26.07	R.C.	Boyo	Gapua	Duiker	Sternum	segment	Gnawed	1
26.08	R.C.	Boyo	Gapua	Duiker	Rib	DS w/shaft	Fractured, Gnawed	2
27.06	R.C.	Dangi	Mondeli	Porcupine	Rib	DS w/shaft	Gnawed	1
28.03	R.C.	Boyo	Jean Claude	Duiker	Rib	Ds shafts	Gnawed, Fractured	3
28.07	R.C.	Boyo	Jean Claude	Duiker	Rib	Ds shafts	Gnawed, Fractured	2
29.01	R.C.	Mombedu	Mombedu	Duiker	Humerus	CO	Gnawed	1
29.02	R.C.	Mombedu	Mombedu	Duiker	Humerus	CO	Gnawed	1
29.08	R.C.	Mombedu	Mombedu	Duiker	Rib	Shaft	Gnawed	1
31.03	R.C.	Boyo	Kosona	Duiker	Rib	Midshaft	Carbonized, Cut, Fractured, Gnawed	5
33.00	R.C.	Margarie	NDoki	Duiker	Scapula	~CO	Cut, Gnawed	1
33.06	**R.C.**	**Margarie**	**NDoki**	**Duiker**	**Innominate**	**ilium**	**Cut, Gnawed, Fractured**	**1**
36.06	Grima	Gozie	Gozie	Rat	Femur	DS w/shaft	Gnawed	1
38.01	Grima	Bondo	Namkia	Duiker	Thoracic Vert.	Column	Chopped, Gnawed	2
38.12	Grima	Bondo	Namkia	Duiker	Rib	Shaft	Broken, gnawed	1
42.01	Grima	Baye	Gondoboko	Duiker	Ulna	Px	Broken, gnawed	1
42.02	Grima	Baye	Gondoboko	Duiker	Lumbar Vert.	Half	Chopped, Gnawed	1
42.04	Grima	Baye	Gondoboko	Duiker	Innominate	Acetabulum & Ischium	Chopped, Fractured, Gnawed	1
42.05	Grima	Baye	Gondoboko	Duiker	Lumbar Vert.	Half	Chopped, Gnawed	2
42.08	Grima	Baye	Gondoboko	Duiker	Rib	Shaft	Fractured, Gnawed	1
43.00	Grima	Alphonse	Kopayo	Duiker	Rib	Shaft	Chopped, Gnawed	1

ID	Location	Hunter	Consumer	Species	Element	Segment	Damage	Count
43.01	Grima	Alphonse	Kopayo	Duiker	Rib	PX w/shaft	Gnawed	2
43.02	Grima	Alphonse	Kopayo	Duiker	Rib	Shaft	Chopped, Gnawed	1
43.04	Grima	Alphonse	Kopayo	Duiker	Rib	Shaft	Chopped, Gnawed	1
43.06	Grima	Alphonse	Kopayo	Duiker	Rib	DS w/shaft	Chopped, Gnawed	1
43.07	Grima	Alphonse	Kopayo	Duiker	Rib	Px w/shaft	Gnawed	1
43.08	Grima	Alphonse	Kopayo	Duiker	Rib	Shaft	Chopped, Gnawed	1
43.10	Grima	Alphonse	Kopayo	Duiker	Rib	Px w/shaft	Gnawed	1
44.00	Grima	Baye	Baye	Duiker	Scapula	~CO	Gnawed	1
44.01	Grima	Baye	Baye	Duiker	Tibia	PX w/shaft	Chopped, Gnawed	1
44.02	Grima	Baye	Baye	Duiker	Humerus	DS w/shaft	Chopped, Gnawed	1
48.00	Grima	Zongabese's Dog	Mombedu	Duiker	Scapula	~CO	Gnawed	1
48.01	Grima	Zongabese's Dog	Mombedu	Duiker	Ulna	~CO	Gnawed	1
49.06	Grima	Seki	Biade'	Rat	Scapula	Blade	Gnawed, Fractured	1
50.02	R.C.	Ngandi & Mumbedu's Dog	NDoki	Duiker, Juvenile	Ulna	PX w/shaft	Chopped, Gnawed	1
51.00	R.C.	Elapha	Elapha	Porcupine	Scapula	~CO	Fractured, Gnawed	1
51.01	R.C.	Elapha	Elapha	Porcupine	Ulna	~CO	Gnawed	1
51.02	R.C.	Elapha	Elapha	Porcupine	Scapula	~CO	Fractured, Gnawed	1
51.04	R.C.	Elapha	Elapha	Porcupine	Rib	~CO	Gnawed	1
51.07	R.C.	Elapha	Elapha	Porcupine	Rib	~CO	Gnawed	2
51.09	R.C.	Elapha	Elapha	Porcupine	Rib	Px w/shaft	Gnawed	1
51.10	R.C.	Elapha	Elapha	Porcupine	Rib	~CO	Gnawed	1
51.21	R.C.	Elapha	Elapha	Porcupine	Humerus	DS w/shaft	Gnawed	1
51.25	R.C.	Elapha	Elapha	Porcupine	Scapula	~CO	Fractured, Gnawed	1
51.28	R.C.	Elapha	Elapha	Porcupine	Innominate	~CO	Gnawed	1
51.30	R.C.	Elapha	Elapha	Porcupine	Tibia	Px w/shaft	Gnawed, Fractured	1
51.31	R.C.	Elapha	Elapha	Porcupine	Ulna	~CO	Gnawed	1
53.00	Grima	Pillawine	Pillawine & Family	Rat	Thoracic Vert.	CO	Gnawed	6
53.06	Grima	Pillawine	Pillawine & Family	Rat	Lumbar Vert.	CO	Gnawed	1
53.07	Grima	Pillawine	Pillawine & Family	Rat	Sacrum	CO	Gnawed	2
53.12	Grima	Pillawine	Pillawine & Family	Rat	Lumbar Vert.	~CO	Gnawed	1
53.24	Grima	Pillawine	Pillawine & Family	Rat	Innominate	~CO	Gnawed	1
53.30	Grima	Pillawine	Pillawine & Family	Rat	Lumbar Vert.	~CO	Gnawed	1

ID	Location	Hunter	Consumer	Species	Element	Segment	Damage	Count
53.31	Grima	Pillawine	Pillawine & Family	Rat	Lumbar Vert.	~CO	Gnawed	1
53.32	Grima	Pillawine	Pillawine & Family	Rat	Sacrum	CO	Gnawed	1
53.?	Grima	Pillawine	Pillawine & Family	Rat	Caudal Vert.	CO	Gnawed	5
53.?	Grima	Pillawine	Pillawine & Family	Rat	Caudal Vert.	CO	Gnawed	5
55.05	R.C.	Margarie & Bookie	Ernest (MBelle)	Rat	Radius	~CO	Gnawed	1
56.14	R.C.	Zonani	Zonani	Porcupine	Atlas	~CO	Gnawed	1
60.04	R.C.	Mombedu	Mombedu	Rat	Femur	DS epiphysis	Gnawed	1
60.14	R.C.	Mombedu	Mombedu	Rat	Femur	~CO	Gnawed	1
60.15	R.C.	Mombedu	Mombedu	Rat	Femur	~CO	Gnawed	1
61.08	R.C.	NDombe	Lindegne	Rat	Tibia	Shaft	Gnawed	1
61.09	R.C.	NDombe	Lindegne	Rat	Innominate	ilium	Gnawed	1
62.00	R.C.	Mombedu	NGabi	Rat	Femur	DS half	Fractured, Gnawed	1
62.06	R.C.	Mombedu	NGabi	Rat	Rib	Px half	Gnawed	1
63.00	R.C.	Mombedu	NGabi	Duiker	Tibia	Px w/shaft	Fractured, Gnawed	1
63.03	R.C.	Margarie	Margarie	Rat	Ilium	CO	Gnawed	1
63.04	R.C.	Margarie	Margarie	Rat	Humerus	~CO	Gnawed	1
63.06	R.C.	Margarie	Margarie	Rat	Humerus	~CO	Gnawed	1
63.07	R.C.	Margarie	Margarie	Rat	Ulna	~CO	Gnawed	1
63.09	R.C.	Margarie	Margarie	Rat	Ulna	~CO	Gnawed	1
63.16	R.C.	Margarie	Margarie	Rat	Scapula	~CO	Gnawed	1
63.19	R.C.	Margarie	Margarie	Rat	Mandible	Alveo & dias	Gnawed	1
63.20	R.C.	Margarie	Margarie	Rat	Scapula	Middle	Gnawed	1
63.28	R.C.	Margarie	Margarie	Rat	Lumbar	~CO	Gnawed	1
63.30	R.C.	Margarie	Margarie	Rat	Lumbar	~CO	Gnawed	1
63.37 - 63.58	R.C.	Margarie	Margarie	Rat	Rib	~CO	Gnawed	3
64.10	R.C.	Margarie	Namkia	Rat	Femur	CO	Cut, Gnawed	1
64.21	R.C.	Margarie	Namkia	Rat	Metatarsal	~CO	Gnawed	1
64.38	R.C.	Margarie	Namkia	Rat	Sacral Vert.	~CO	Fractured, Gnawed	4
65.07	R.C.	Boyo	Boyo	Duiker	Rib	~CO	Broken, Gnawed	1
65.08	R.C.	Boyo	Boyo	Duiker	Rib	Shaft	Broken, Carbonized, Calcined, Gnawed	1
65.09	R.C.	Boyo	Boyo	Duiker	Rib	Shaft	Broken, Gnawed	1
65.11	R.C.	Boyo	Boyo	Duiker	Rib	PX	Cut, Gnawed	1
66.01	R.C.	NBondo	NBondo	Duiker	Innominate	ilium	Chopped, Gnawed	1
67.05	R.C.	Selaboli	Selaboli	Porcupine	Astragalus	CO	Cut, Gnawed	1
67.06	R.C.	Selaboli	Selaboli	Porcupine	Lumbar Vert.	~CO	Gnawed	1
67.10	R.C.	Selaboli	Selaboli	Porcupine	Thoracic	Body	Gnawed	1
67.11	R.C.	Selaboli	Selaboli	Porcupine	Thoracic	~CO	Fractured,	1

ID	Location	Hunter	Consumer	Species	Element	Segment	Damage	Count
							Gnawed	
68.03	R.C.	Zonani	Kombo	Duiker	NID Vert.	Frag	Chopped, Gnawed	1
68.04	R.C.	Zonani	Kombo	Duiker	Humerus	Proximal	Chopped, Gnawed	1
68.05	R.C.	Zonani	Kombo	Duiker	Thoracic	Right Half	Chopped, Fractured, Gnawed	1
68.08	R.C.	Zonani	Kombo	Duiker	Sacrum	Right Half	Chopped, Gnawed	1
68.09	R.C.	Zonani	Kombo	Duiker	Tibia	Shaft	Broken, Carbonized, Cut, Gnawed	1
68.15	R.C.	Zonani	Kombo	Duiker	Rib	~CO	Gnawed	1
68.17	R.C.	Zonani	Kombo	Duiker	Rib	~CO	Gnawed	2
72.01	R.C.	Dangi	Zoanefoyo	Porcupine	Innominate	Acetabulum & ilium	Chopped, Fractured/Gnawed	1
72.05	R.C.	Dangi	Zoanefoyo	Duiker	Rib	Shaft	Cut, Gnawed	1
72.07	R.C.	Dangi	Zoanefoyo	Duiker	Rib	Shaft	Carbonized, Fractured, Gnawed	1
73.02	R.C.	Marie	NGaba	Duiker	Mandible	~CO	Gnawed	1
73.07	R.C.	Marie	NGaba	Duiker	Rib	Px w/shaft	Gnawed	1
73.13	R.C.	Marie	NGaba	Duiker	Rib	~CO	Carbonized, Cut, Gnawed	1
74.01	Grima	Baye	Baye	Duiker	Rib	~CO	Fractured, Gnawed	1
74.05	Grima	Baye	Baye	Duiker	Rib	Shaft	Fractured, Gnawed	1
78.01	R.C.	Zonani	Kombo & Wanboli	Porcupine	Innominate	Acetabulum, Ilium	Cut, Chopped, Gnawed	1
78.04	R.C.	Zonani	Kombo & Wanboli	Porcupine	Humerus	~CO	Gnawed	1
79.01	R.C.	Lindengue	Tiba	Duiker	Tibia	PX	Broken, Carbonized, Gnawed	1
79.05	R.C.	Lindengue	Tiba	Duiker	Tibia	DS	Broken, Carbonized, Gnawed	1
79.10	R.C.	Lindengue	Tiba	Duiker	Rib	Shaft	Chopped, Fractured, Gnawed	1
79.12	R.C.	Lindengue	Tiba	Duiker	Rib	Shaft	Chopped, Fractured, Gnawed	1
79.13	R.C.	Lindengue	Tiba	Duiker	Rib	Shaft	Chopped, Fractured, Gnawed	1
79.15	R.C.	Lindengue	Tiba	Duiker	Navicular Cuboid	~CO	Gnawed?	1
81.14	R.C.	NBondo	Samedi	Duiker	Axis	CO	Gnawed	1
83.04	Grima	Alphonse ?	Ivonne	Duiker	Sacrum	Fragment	Gnawed	1

ID	Location	Hunter	Consumer	Species	Element	Segment	Damage	Count
83.07	Grima	Alphonse ?	Ivonne	Duiker	Innominate	~CO	Chopped, Gnawed	1
84.04	R.C.	Kosona Ngandi	Lopo	Porcupine	Innominate	~CO	Fractured, Gnawed	1
84.05	R.C.	Kosona Ngandi	Lopo	Porcupine	Sacrum	~CO	Fractured, Gnawed (1)	3
85.03	R.C.	Mombedu	Mombedu	Rat	Humerus	~CO	Gnawed	1
86.06	R.C.	NBondo	NBondo	Duiker	Cervical	~CO	Fractured, Gnawed	2
87.02	Grima	Alphonse	Namkia	Duiker	Femur	DS w/shaft	Carbonized, Chopped, Fractured, Gnawed	1
90.07	R.C.	NBondo	Culotie	Duiker	Rib	~CO	Chopped, Gnawed	1
91.00	R.C.	Kosona	Dangi	Duiker	Mandible	Alveo & dias	Gnawed	1
92.04	R.C.	Marie	Yala	Rat	Innominate	~CO	Gnawed	1
92.05	R.C.	Marie ?	Yala	Porcupine	Innominate	Ilium	Chopped, Fractured, Gnawed	1
94.00	R.C.	Elapha	Elapha	Porcupine	Femur	~CO	Gnawed	1
94.01	R.C.	Elapha	Elapha	Porcupine	Tibia	Epip-Medial Half	Gnawed	1
95.06	R.C.	Marie	Marie	Rat	Innominate	CO	Gnawed	1
96.02	R.C.	NBondo	Elapha	Porcupine	Ulna	~CO	Gnawed	1
96.03	R.C.	NBondo	Elapha	Porcupine	Radius	Px w/shaft	Gnawed	1
97.02	Grima	Zongabese	Angeline	Mouse	Innominate	~CO	Fractured, Gnawed	1
97.03	Grima	Zongabese	Angeline	Mouse	Innominate	CO	Gnawed	1
99.04	R.C.	Dangi	Fami	Duiker	Thoracic	Half	Chopped, Gnawed	1
99.06	R.C.	Dangi	Fami	Duiker	Rib	Mid-shaft	Cut, Gnawed	1
99.11	R.C.	Dangi	Fami	Duiker	Rib	Mid-shaft	Cut, Gnawed	1
99.12	R.C.	Dangi	Fami	Duiker	Thoracic	Half	Chopped, Gnawed	1
99.14	R.C.	Dangi	Fami	Duiker	Rib	~CO	Gnawed	1
99.22	R.C.	Dangi	Fami	Duiker	Rib	Px w/shaft	Calcined, Fractured, Gnawed	1
99.27	R.C.	Dangi	Fami	Duiker	Rib	Px w/shaft	Gnawed	1
100.01	R.C.	Tiba	Lindegne	Porcupine	Thoracic	Bodies	Fractured, Gnawed	2
100.03	R.C.	Tiba	Lindegne	Porcupine	Lumbar	~CO	Gnawed, Fractured	2
100.05	R.C.	Tiba	Lindegne	Porcupine	Lumbar	~CO	Gnawed, Fractured	2
102.02	R.C.	Zonani	Marie	Duiker	Caudal	~CO	Gnawed	4
104.00	R.C.	?	Touendeke	Porcupine	Ulna	~CO	Gnawed	1
105.01	R.C.	Marie	Marie	Duiker	Femur	~CO	Gnawed	1
107.03	Grima	Gapua	Gapua & Gozie	Duiker	Tibia	CO	Gnawed	1
107.07	Grima	Gapua	Gapua & Gozie	Duiker	Innominate	Ilium	Chopped, Gnawed	1

ID	Location	Hunter	Consumer	Species	Element	Segment	Damage	Count
108.01	R.C.	Mombedu	Yenga	Duiker	Rib	Px w/shaft	Chopped, Gnawed	2
111.00	Grima	Baye	Pillawine	Duiker	Scapula	Dorsal	Chopped, Gnawed	1
111.01	Grima	Baye	Pillawine	Duiker	Tibia	PX w/shaft	Fractured, Gnawed	1
111.02	Grima	Baye	Pillawine	Duiker	Innominate	Ilium	Chopped, Gnawed	1
111.05	Grima	Baye	Pillawine	Duiker	Thoracic Vert.	Dorsal Spine	Chopped, Gnawed	1
113.06	Grima	Marie	Margarie	Duiker	Humerus	PX	Chopped, Gnawed	1
114.08	R.C.	Mombedu	Tiba	Rat	Ulna	Px w/shaft	Gnawed, Fractured	1
115.04	R.C.	Kosona	Kosona	Duiker	Innominate	iliac crest	Chopped, Gnawed	1
115.08	R.C.	Kosona	Kosona	Duiker	Frag	Frag	Fractured, Gnawed	1
116.06	R.C.	Zonani	Boyo	Duiker	Rib	Px w/shaft	Gnawed	1
116.08	R.C.	Zonani	Boyo	Duiker	Thoracic Vert.	~CO	Gnawed	1
116.10	R.C.	Zonani	Boyo	Duiker	Thoracic	Body	Carbonized, Fractured, Gnawed	1
116.11	R.C.	Zonani	Boyo	Duiker	Rib	Px w/shaft	Gnawed	1
116.13	R.C.	Zonani	Boyo	Duiker	Rib	Shaft	Gnawed	1
117.01	Grima	Alphonse	NBoko	Duiker	Femur	PX	Chopped, Gnawed	1
117.05	Grima	Alphonse	NBoko	Duiker	Rib	~CO	Cut, Fractured, Gnawed	1
118.00	R.C.	Marie	Samedi	Porcupine	Caudal	~CO	Chopped, Gnawed	1
119.02	Grima	Etiem	Etiem	Duiker	Humerus	PX w/shaft	Fractured, Gnawed	1
119.04	Grima	Etiem	Etiem	Duiker	Rib	PX w/shaft	Gnawed	2
122.00	R.C.	Bondo	Combo	Duiker	Sacrum	~Half	Chopped, Cut, Gnawed	1
124.03	Grima	Dengbe	Alphonse	Rat	Innominate	ilium/ischium	Gnawed	1
126.02	R.C.	NBondo	NBondo	Duiker	Ulna	~CO	Gnawed	1
126.04	R.C.	NBondo	NBondo	Duiker	Rib	~CO	Gnawed	1
126.06	R.C.	NBondo	NBondo	Duiker	Metacarpal	Metaphysis	Gnawed	1
126.07	R.C.	NBondo	NBondo	Duiker	Humerus	~CO	Gnawed	1
126.08	R.C.	NBondo	NBondo	Duiker	Scapula	~CO	Gnawed	1
128.02	R.C.	Boyo	Pauline	Duiker	Navicular Cuboid	~CO	Gnawed	1
128.07	R.C.	Boyo	Pauline	Duiker	Innominate	Ischium	Carbonized, Fractured, Gnawed	1
128.08	R.C.	Boyo	Pauline	Duiker	Rib	Shaft	Gnawed, Fractured	1
131.03	Grima	Gozie	Gozie & Dumasie	Rat	Innominate	Half	Gnawed	1

ID	Location	Hunter	Consumer	Species	Element	Segment	Damage	Count
131.06	Grima	Gozie	Gozie & Dumasie	Rat	Lumbar Vert.	~CO	Fractured, Gnawed	1
131.07	Grima	Gozie	Gozie & Dumasie	Rat	Femur	~CO	Gnawed	1
131.08	Grima	Gozie	Gozie & Dumasie	Rat	Cervical Vert.	~CO	Gnawed	1
131.12	Grima	Gozie	Gozie & Dumasie	Rat	Lumbar Vert.	~CO	Cut, Gnawed	1
131.15	Grima	Gozie	Gozie & Dumasie	Rat	Thoracic Vert.	~CO	Gnawed	1
131.22	Grima	Gozie	Gozie & Dumasie	Rat	Lumbar Vert.	~CO	Gnawed	1
131.28	Grima	Gozie	Gozie & Dumasie	Rat	Thoracic Vert.	~CO	Fractured, Gnawed	1
131.30	Grima	Gozie	Gozie & Dumasie	Rat	Radius	~CO	Gnawed	1
132.00	Grima	Elapha	Elapha	Porcupine	Radius	CO	Gnawed	1
132.01	Grima	Elapha	Elapha	Porcupine	Innominate	Ilium, Sacrum	Chopped, Gnawed, Cut	1
132.04	Grima	Elapha	Elapha	Porcupine	Rib	~CO	Gnawed	1
132.06	Grima	Elapha	Elapha	Porcupine	Rib	DS w/shaft	Gnawed	1
132.08	Grima	Elapha	Elapha	Porcupine	Fibula	CO	Gnawed	1
132.09	Grima	Elapha	Elapha	Porcupine	Ulna	~CO	Gnawed	1
132.10	Grima	Elapha	Elapha	Porcupine	Innominate	Acetabulum, Pubis, Ischium	Chopped, Gnawed, Cut	1
132.11	Grima	Elapha	Elapha	Porcupine	Femur	~CO	Cut, Gnawed	1
132.12	Grima	Elapha	Elapha	Porcupine	Tibia	CO	Gnawed	1
132.13	Grima	Elapha	Elapha	Porcupine	Caudal Vert.	~CO	Gnawed	2
134.00	Grima	Gapua	Gapua	Duiker	Scapula	Blade	Chopped, Gnawed	1
134.04	Grima	Gapua	Gapua	Duiker	Rib	PX w/shaft	Gnawed	1
136.03	R.C.	Zonani	Ngaba	Duiker	Cervical	~CO	Gnawed	2
137.00	R.C.	Lopo	Etien	Rat	Scapula	~CO	Gnawed	1
137.02	R.C.	Etien	Etien	Duiker	Rib	DS w/shaft	Gnawed	1
138.00	Grima	Village Purchase	Zamba	Duiker	Rib	DS w/shaft	Chopped, Gnawed	2
139.07	Grima	Kosona	Kosona	Porcupine	Innominate	Ilium	Chopped, Gnawed	1
139.12	Grima	Kosona	Kosona	Porcupine	Rib	Px w/shaft	Gnawed	2
139.16	Grima	Kosona	Kosona	Porcupine	Rib	DS w/shaft	Gnawed	1
139.22	Grima	Kosona	Kosona	Porcupine	Fibula	CO	Gnawed	1
140.00	Grima	Zonnanee	Kosona	Duiker	Axis/Cervical	~CO	Gnawed	2
141.00	Grima	Dekor-Lopo	Wena	Duiker	Radius	CO	Gnawed	1
141	Grima	Dekor-Lopo	Wena	Rat	Ulna	~CO	Gnawed	1
141.02	Grima	Dekor-Lopo	Wena	Rat	Humerus	CO	Gnawed	1
141.03	Grima	Dekor-Lopo	Wena	Rat	Mandible	~CO	Gnawed	1
141.06	Grima	Dekor-Lopo	Wena	Duiker	Rib	Shaft	Chopped, Gnawed	1
141.07	Grima	Dekor-Lopo	Wena	Rat	Lumbar Vert.	~CO	Gnawed	1
141.08	Grima	Dekor-Lopo	Wena	Rat	Scapula	CO	Gnawed	1
141.10	Grima	Dekor-Lopo	Wena	Rat	Lumbar Vert.	~CO	Cut,	2

ID	Location	Hunter	Consumer	Species	Element	Segment	Damage	Count
							Fractured, Gnawed	
141.12	Grima	Dekor-Lopo	Wena	Duiker	Rib	Shaft	Fractured, Gnawed	1
141.17	Grima	Dekor-Lopo	Wena	Rat	Femur	~CO	Gnawed	1
142.00	Grima	Alphonse	Kapaye Debe	Duiker	Rib	~CO	Gnawed	1
142	Grima	Alphonse	Kapaye Debe	Rat	Humerus	~CO	Gnawed	1
142.05	Grima	Alphonse	Kapaye Debe	Duiker	Cervical/Thoracic	~CO	Cut, Gnawed	2
143.00	Grima	NBondo	GBoko	Duiker	Innominate	Ilium	Chopped, Gnawed, Striae	1
144.04	Grima	Alphonsa	Dakou	Rat	Mandible	~CO	Gnawed	1
145.10	Grima	Debe	Alphonse	Duiker	Humerus	Shaft	Broken, Gnawed	1
146.01	R.C.	Elapha	Wena	Porcupine	Rib	DS w/shaft	Gnawed	1
146.02	R.C.	Elapha	Wena	Porcupine	Rib	Shaft	Cut, Fractured, Gnawed	1
146.04	R.C.	Elapha	Wena	Porcupine	Thoracic	~CO	Gnawed	1
146.06	R.C.	?	Wena	Duiker	Lumbar	Half	Chopped, Gnawed	3
146.07	R.C.	Elapha	Wena	Porcupine	Thoracic	~CO	Gnawed	4
146.14	R.C.	?	Wena	Duiker	Sacrum	Half	Chopped, Gnawed	1
146.15	R.C.	?	Wena	Duiker	Caudal	~CO	Gnawed	1
148.01	Grima	Beye'	Godoboko	Rat	Rib	DS w/shaft	Gnawed	1
148.03	Grima	Beye'	Godoboko	Rat	Humerus	~CO	Gnawed	1
148.06	Grima	Beye'	Godoboko	Rat	Scapula	Posterior	Gnawed	1
148.07	Grima	Beye'	Godoboko	Rat	Mandible	Fragment	Gnawed, Fractured	1
149.02	Grima	Bundu or Zonanee	Boyo	Duiker	Rib	PX w/shaft	Broken, Gnawed	2
149.04	Grima	Bundu or Zonanee	Boyo	Duiker	Rib	Shaft	Chopped, Gnawed	1
149.06	Grima	Bundu or Zonanee	Boyo	Duiker	Rib	~CO	Gnawed	1
149.07	Grima	??	Boyo	Duiker	Cervical Vert.	~CO	Gnawed	2
149.08	Grima	??	Boyo	Duiker	Thoracic Vert.	~CO	Gnawed	2
150.02	Grima	Zamba	Zamba	Duiker	Rib	PX w/shaft	Gnawed	1
151.04	Grima	Alphonse	Alphonse	Duiker	Rib	Shaft	Chopped, Gnawed	1
151.08	Grima	??	Alphonse	Rat	Tib/Fib	DS w/shaft	Gnawed	1
152.01	Grima	Makondi & Dekou	Pillawine	Rat	Sacrum/Lumbar/Caudal	CO	Gnawed	7
152.09	Grima	Makondi & Dekou	Pillawine	Rat	Scapula	~CO	Gnawed	1
154.03	Grima	Kosona	Debe	Duiker	Scapula	~CO	Gnawed	1
155.01	Grima	Fami	Zamba	Duiker	Cervical	~CO	Fractured,	1

ID	Location	Hunter	Consumer	Species	Element	Segment	Damage	Count
					Vert.		Gnawed	
155.03	Grima	Fami	Zamba	Duiker	Humerus	~CO	Cut, Gnawed	1
156.05	Grima	Elapha	Debe	Duiker	Radius	PX w/shaft	Fractured, Gnawed	1
156.06	Grima	Elapha	Debe	Duiker	Femur	PX w/shaft	Cut, Fractured, Gnawed	1
156.10	Grima	Elapha	Debe	Duiker	Humerus	PX w/shaft	Fractured, Gnawed	1
156.11	Grima	Elapha	Debe	Duiker	Innominate	Anterior	Chopped, Fractured, Gnawed	1
157.04	R.C.	Marie	Mokoundi	Duiker	Mandible	~CO	Carbonized, Gnawed	1
158.06	Grima	NBoko	NBoko	Mouse	Femur	~CO	Broken, Gnawed	1
158.09	Grima	NBoko	NBoko	Mouse	Femur	~CO	Gnawed	2
158.14	Grima	Dangi	NBoko	Duiker	Thoracic Vert.	Half	Chopped, Gnawed	1
159.05	Grima	NDoki - Debe	NDoki - Debe	Duiker	Sacrum/Ilium	Fragment	Chopped, Gnawed	2
159.08	Grima	NDoki - Debe	NDoki - Debe	Duiker	Mandible	Fragment	Chopped, Gnawed	1
159.10	Grima	NDoki - Debe	NDoki - Debe	Duiker	Rib	PX w/shaft	Gnawed	1
160.09	Grima	??	Baye	Duiker	Humerus	Shaft	Gnawed	1
160.11	Grima	Boyo	Baye	Duiker	Scapula	~CO	Gnawed	1
161.04	Grima	Zonanee	Zonanee	Duiker	Rib	Shaft	Gnawed	1
161.05	Grima	Zonanee	Zonanee	Duiker	Rib	~CO	Chopped, Gnawed	1
161.06	Grima	??	Zonanee	Duiker	Cervical Vert.	~CO	Chopped, Cut, Gnawed	2
161.08	Grima	??	Zonanee	Duiker	Cervical Vert.	~CO	Gnawed	1
164.05	R.C.	Mombedu	Boyo	Rat	Rib	~CO	Gnawed	3
165.01	Grima	Debe	Magale	Duiker	Rib	~CO	Gnawed	1
166.02	R.C.	Gapua	Etien	Duiker	Thoracic	Half	Chopped, Fractured, Gnawed	1
166.10	R.C.	Gapua	Etien	Duiker	Rib	Shaft	Chopped, Gnawed	1
167.00	Grima	Pillawine	Baye	Rat	Rib	PX w/shaft	Fractured, Gnawed	1
168.04	R.C.	NBondo	Tuandeke	Duiker	Rib	Px w/shaft	Fractured, Gnawed	2
168.07	R.C.	NBondo	Tuandeke	Duiker	Rib	Px w/shaft	Fractured, Gnawed	1
168.08	R.C.	NBondo	Tuandeke	Duiker	Rib	~CO	Fractured, Gnawed	2
169.00	Grima	Gapua	Gapua	Mouse	Femur	CO	Gnawed	1
169.04	Grima	Gapua	Gapua	Mouse	Femur	CO	Gnawed	1
169.14	Grima	Gapua	Gapua	Mouse	Femur	CO	Gnawed	1
170.00	Grima	Dekou	Pillawine	Rat	Tibia	~CO	Gnawed	1

ID	Location	Hunter	Consumer	Species	Element	Segment	Damage	Count
170.07	Grima	Dekou	Pillawine	Rat	Femur	~CO	Gnawed	1
170.09	Grima	Dekou	Pillawine	Rat	Lumbar Vert.	CO	Gnawed	4
171.04	Grima	Marie	Marie	Rat	Ulna	CO	Gnawed	1
171.15	Grima	Marie	Marie	Rat	Rib	~CO	Gnawed	2
172	Grima	Pillawine	Pillawine	Mouse	Sacrum	~CO	Gnawed	1
172.01	Grima	Pillawine	Pillawine	Mouse	Femur	~CO	Gnawed	1
172.05	Grima	Pillawine	Pillawine	Mouse	Tibia	DS w/shaft	Gnawed, Pathology	1
173.01	Grima	Baka	Angeline	Mouse	Femur	CO	Gnawed	1
173.09	Grima	Baka	Angeline	Mouse	Humerus	~CO	Gnawed	2
178.06	Grima	Mombedu	Mombedu	Rat	Humerus	~CO	Gnawed	1
179.06	Grima	Mary	Mary	Duiker	Innominate	Ischium	Fractured, Gnawed	1
180	Grima	Pillawine	Pillawine	Rat	Scapula	~CO	Gnawed	1
183.07	R.C.	NBondo	Touandike	Duiker	Rib	~CO	Gnawed	1
185.06	R.C.	Zonanee	Wena & Munda	Duiker	Thoracic	~CO	Fractured, Gnawed	2
185.07	R.C.	Zonanee	Wena & Munda	Duiker	Thoracic	~CO	Chopped, Fractured, Gnawed	2
186	Grima	Dekou	Lopo	Rat	Ulna	~CO	Gnawed	1
186.00	Grima	Dekou	Lopo	Rat	Innominate	Posterior	Gnawed	1
186.04	Grima	Dekou	Lopo	Rat	Femur	~CO	Gnawed	1
186.08	Grima	Dekou	Lopo	Rat	Innominate	~CO	Gnawed	1
187	Grima	Mary's Mom	Yenga	Rat	Tibia	Shaft	Gnawed	1
187	Grima	Mary's Mom	Yenga	Rat	Ulna	Fragment	Gnawed	1
187	Grima	Mary's Mom	Yenga	Rat	Radius	~CO	Gnawed	1
187.01	Grima	Mary's Mom	Yenga	Rat	Humerus	CO	Gnawed	1
187.04	Grima	Mary's Mom	Yenga	Rat	Femur	Shaft	Gnawed	1
188.00	R.C.	Margarie	Zoana Foyo	Duiker	Thoracic	Half	Chopped, Gnawed	3
188.03	R.C.	Margarie	Zoana Foyo	Duiker	Rib	Px w/shaft	Chopped, Fractured, Gnawed	2
188.09	R.C.	Margarie	Zoana Foyo	Duiker	Femur	Distal epiphysis	Gnawed	1
189.01	R.C.	Tiba	Lindengue	Porcupine	Femur	Distal/Shaft	Broken, Gnawed	1
189.03	R.C.	Tiba	Lindengue	Porcupine	Innominate	Ischium	Broken, Gnawed	1
189.06	R.C.	Tiba	Lindengue	Porcupine	Humerus	~CO	Gnawed	1
190.05	R.C.	Marie	Etiem	Duiker	Rib	CO	Gnawed	1
190.08	R.C.	Marie	Etiem	Duiker	Rib	DS w/shaft	Gnawed	1
191.00	R.C.	?	Tiba	Porcupine	Scapula	~CO	Gnawed	1
191.02	R.C.	Zonani	Tiba	Duiker	Rib	Shaft	Gnawed	1
191.04	R.C.	Zonani	Tiba	Duiker	Innominate (left)	Pubis-symphysis	Chopped, Gnawed	1
191.05	R.C.	Zonani	Tiba	Duiker	Scapula	~CO	Gnawed	1
191.09	R.C.	Zonani	Tiba	Duiker	Lumbar	Half	Chopped, Gnawed	3
191.14	R.C.	Zonani	Tiba	Duiker	Thoracic	Half	Chopped, Gnawed	1

ID	Location	Hunter	Consumer	Species	Element	Segment	Damage	Count
192.00	Grima	Alphonse	Margarie	Duiker	Thoracic Vert.	~CO	Gnawed	2
192.02	Grima	Alphonse	Margarie	Duiker	Thoracic Vert.	Ventral	Fractured, Gnawed	1
193.00	Grima	Debe	NDoki	Duiker	Scapula	~CO	Gnawed	1
193.01	Grima	Debe	NDoki	Duiker	Ulna	PX w/shaft	Fractured, Gnawed	1
193.03	Grima	Debe	NDoki	Duiker	Innominate	Ilium	Chopped, Gnawed	1
194.04	R.C.	Elapha	ZuaneFoyo	Duiker	Rib	Px w/shaft	Gnawed	1
194.10	R.C.	Elapha	ZuaneFoyo	Duiker	Rib	Px w/shaft	Gnawed	1
195.02	R.C.	Marie	Marie	Duiker	Rib	Px w/shaft	Gnawed	1
196	Grima	??	Kosona	Rat	Ulna	~CO	Gnawed	1
196.02	Grima	??	Kosona	Rat	Scapula	~CO	Gnawed	1
196.03	Grima	??	Kosona	Rat	Humerus	PX w/shaft	Gnawed	1
199.06	Grima	Dangi	NDoki	Duiker	Rib	DS w/shaft	Gnawed	1
203	Grima	Namkia	Namkia	Mouse	Mandible	Fragment	Gnawed	1
203	Grima	Namkia	Namkia	Mouse	Lumbar Vert	~CO	Gnawed	2
203.01	Grima	Namkia	Namkia	Mouse	Femur	CO	Gnawed	1
203.28	Grima	Namkia	Namkia	Mouse	Vertebrae	Column	Gnawed	6
204.01	Grima	Gondoboko	Gondoboko	Mouse	Femur	CO	Gnawed	1
205.13	R.C.	Marie	NGaba	Duiker	Rib	~CO	Gnawed	1
206.01	Grima	Pillawine	Pillawine	Rat	Humerus	DS w/shaft	Gnawed	1
206.01	Grima	Pillawine	Pillawine	Rat	Femur	~CO	Gnawed	1
206.02	Grima	Pillawine	Pillawine	Rat	Ulna	PX w/shaft	Gnawed	1
206.03	Grima	Pillawine	Pillawine	Rat	Radius	PX w/shaft	Gnawed	1
206.07	Grima	Pillawine	Pillawine	Rat	Tibia	Shaft	Gnawed	1
	Grima	??	Alphonse	Rat	Femur	Shaft	Gnawed	1

Appendix B:

Turkey Assemblage from Chimpanzee Feeding Experiment

Key to Coding Sheet of Turkey Assemblage

ID #	Unique Specimen Number
Location	Location and Year of Collection
Species	Species of Animal

Portion

CO	Complete Bone
~CO	Nearly Complete
Frag	Fragment, not otherwise specified
Prx .5	Proximal Articulation with Half of Shaft
Dist .5	Distal Articulation with Half of Shaft

Element	Specific Bone Element
Side	Left (L) or Right (R)
# Pics SEM	Number of SEM Photos Used

Crushed

1	Presence of Crushed Edges
-	Absence of Crushed Edges
#	Number of Crushed Edges

Proximal/Shaft/Distal/Other

1	Presence of Crushed Edges
-	Absence of Crushed Edges

Crenulated

1	Presence of Crenulated Edges
-	Absence of Crenulated Edges

Step Fracture

1	Presence of Step Fracture
-	Absence of Step Fracture

Shallow Pit

1	Presence of Pit
-	Absence of Pit
#	Number of Pits
Location	Notes on Location of Pit
Nearest Dmg	Notes on Location of Nearest Damage
MLD	Measured Maximum Linear Dimension in mm

Scoring

1	Presence of Tooth Scratches
-	Absence of Tooth Scratches
#	Number of Measured Tooth Scratches
Modified Ct.	Number of Tooth Scratches not Associated with Cleaning
Location	Notes on Location of Tooth Scratch
Nearest Dmg	Notes on Location of Nearest Damage
Width	Widest Measured Width of Scratch

Tooth Notches/Chipping Back

1	Presence of Tooth Scratches
-	Absence of Tooth Scratches
NB-ND	Measurements on Notch Breadth and Depth in mm
FsB-FsD	Measurements on Flake Scar Breadth and Depth in mm

						# Pics	Macroscopic Damage Types												Dimensions in mm				Microscopic Tooth Impressions					Dimensions in mm			Tooth Notches/Chipping Back		
ID #	Location	Species	Portion	Element	Side	SEM	Crushed	#	Proximal	Shaft	Distal	Other	Crenulated	Step Fracture	Shallow Pit	#	Location	Nearest Dmg	MLD				Scoring	#	Modified Ct	Location	Nearest Dmg	Width			Notches	NB-ND Index	FsB-FsD Index
1.1	CHCI 2001	*M. gallopavo*	CO	Femur	L	1+	1	2	1	-	1	-	1	-	1	2	Prox	Crushing	3.800	3.240	-	-	1	1	1	Proximal	-	0.980	-	-	1	3.24 - 1.13	-
1.2	CHCI 2001	*M. gallopavo*	CO	Femur	R	1+	1	2	1	-	1	-	1	-	-	-	-	-	-	-	-	-	1	1	1	Proximal	-	0.900	-	-	1	3.85 - 2.12	-
1.3	CHCI 2001	*M. gallopavo*	–CO	Tibiotarsus	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.4	CHCI 2001	*M. gallopavo*	–CO	Tibiotarsus	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.5	CHCI 2001	*M. gallopavo*	Prx .5	Fibula	R	7	1	2	1	1	-	-	1	-	1	2	Shaft & Prox	Varied	2.545	0.403	-		1	2	2	External	Varied	0.171	0.457	-	-	-	-
1.6	CHCI 2001	*M. gallopavo*	CO	Fibula	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.7	CHCI 2001	*M. gallopavo*	CO	Humerus	R	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	6.34 - 1.28	9.73 - 2.23
1.8	CHCI 2001	*M. gallopavo*	~CO	Carpometacarpus	R	3	1	1	-	1	-	-	-	1	1	2	External	Varied	2.250	1.786	-	-	-	-	-	-	-	-	-	-	-	-	-
1.9	CHCI 2001	*M. gallopavo*	CO	Ulna	R	1	1	1	1	-	-	-	-	-	1	1	Prox	-	3.540	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.10	CHCI 2001	*M. gallopavo*	CO	Radius	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.11	CHCI 2001	*M. gallopavo*	CO	Digit II, Phalanx I	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.12	CHCI 2001	*M. gallopavo*	CO	Digit II, Phalanx II	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.13	CHCI 2001	*M. gallopavo*	CO	Pollex	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.14	CHCI 2001	*M. gallopavo*	CO	Symphysis 1.4	Prx	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.15	CHCI 2001	*M. gallopavo*	CO	Symphysis 1.3	Prx	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.16	CHCI 2001	*M. gallopavo*	CO	Scapolunar	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.17	CHCI 2001	*M. gallopavo*	CO	Patella	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.1	CHCI 2002	*M. gallopavo*	Dist .5	Tibiotarsus	R	1+	-	-	-	-	-	-	-	1	1	1	Midshaft	Fracture	1.150		-	-	-	-	-	-	-	-	-	-	-	-	-
2.2	CHCI 2002	*M. gallopavo*	CO	Fibula	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.3	CHCI 2002	*M. gallopavo*	Frag	Long Bone Frag	-	4	-	-	-	-	-	-	-	1	1	1	External	-	1.521	-	-	-	1	3	3	External	Varied	0.514	0.343	0.579	-	-	-
2.4	CHCI 2002	*M. gallopavo*	Frag	Long Bone Frag	-	6	-	-	-	-	-	-	-	1	1	2	External	Fracture	2.000	1.371	-	-	1	2	2	External	Fracture	0.214	0.193	-	-	-	-
2.5	CHCI 2002	*M. gallopavo*	Frag	Long Bone Frag	-	1	-	-	-	-	-	-	-	1	1	1	External	Fracture	2.293	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.6	CHCI 2002	*M. gallopavo*	Frag	Long Bone Frag	-	3	-	-	-	-	-	-	-	1	1	2	External	Fracture	1.821	2.514	-	-	-	-	-	-	-	-	-	-	-	-	-
2.7	CHCI 2002	*M. gallopavo*	Frag	Long Bone Frag	-	6	-	-	-	-	-	-	-	1	1	4	External	Fracture	2.314	1.429	1.371	1.143	1	3	3	External	Fracture	0.214	0.471	0.193	1	7.61 - 2.68	10.32 - 3.01
2.8	CHCI 2002	*M. gallopavo*	Frag	Frag	-	5	1	1	-	-	-	1	1	1	1	1	External	Fracture	2.743	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.9	CHCI 2002	*M. gallopavo*	Frag	Frag	-	5	1	1	-	-	-	1	1	1	1	4	External	Fracture	4.400	3.107	2.214	1.886	-	-	-	-	-	-	-	-	-	-	-
2.10	CHCI 2002	*M. gallopavo*	Frag	Long Bone Frag	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.11	CHCI 2002	*M. gallopavo*	Frag	Long Bone Frag	-	3	1	1	-	-	-	1	-	1	1	1	Internal	Fracture	5.078	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.12	CHCI 2002	*M. gallopavo*	Frag	Long Bone Frag	-	7	-	-	-	-	-	-	-	1	1	3	External	Fracture	3.429	2.571	1.105	-	-	-	-	-	-	-	-	-	-	-	-
2.13	CHCI 2002	*M. gallopavo*	Frag	Frag	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.14	CHCI 2002	*M. gallopavo*	Dist .5	Fibula	L	6	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	Midshaft	-	0.217	-	-	1	1.714 - 1.125	3.45 - 1.392
Totals	31 bones in Turkey Sample					57	10	13	5	3	2	3	5	13	14	27							7	13	13						5	0	0

Appendix C:

Rabbit Bones Used In Cleaning Experiment

Key to Coding Sheet of Rabbit Bones

ID #	Unique Specimen Number
Species	Species of Animal

Portion

CO	Complete Bone
~CO	Nearly Complete
Half	Unspecified Px or Dst Half
Frag	Fragment, not otherwise specified
Prx w/Shaft	Proximal Articulation with Unspecified Shaft Amount
Prx Half	Proximal Articulation with Half of Shaft
Dist Frag	Distal Articulation
Prx Frag	Proximal Articulation

Element	Specific Bone Element
Side	Left (L) or Right (R)
# Pics SEM	Number of SEM Photos Used

Scouring

1	Scrubbed with Steel Wool
-	Not Scrubbed

Scoring

1	Presence of Steel Wool Scratches
-	Absence of Steel Wool Scratches
#	Number of Measured Steel Wool Scratches
Width	Widest Measured Width of Scratch

Scrubbed	Notes on Intensity and Element Side of Steel Wool Scrubbing
Direction	Notes on Direction of Steel Wool Scrubbing
Wet/Dry	Notes on Whether Bone was Wet or Dry When Scrubbed

ID #	Species	Portion	Element	Side	# Pics SEM	Scouring	Scoring	#	Width							Scrubbed	Direction	Wet Dry	Comments
1.1	O. cuniculus	~CO	Rib	R	19	1	-	-	-	-	-	-	-	-	-	Ext Mod & Int Light	Bi	dry	Untouched during feeding Loss of superficial detail over most of rib, added damage on ext end (doesn't appear as mastication dmg) Goldcoated
1.2	O. cuniculus	~CO	Rib	R	11	1	1	2	0.02	0.04	-	-	-	-	-	Ext Mod & Int Light	Uni	dry	Untouched during feeding Loss of superficial detail over most of rib Goldcoated
1.3	O. cuniculus	~CO	Rib	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Untouched during feeding
1.4	O. cuniculus	Half	Rib	R	6	1	-	-	-	-	-	-	-	-	-	Ext Mod & Int Light	Multi	dry	Untouched during feeding Loss of superficial detail over most of the bone, including edge rounding
1.5	O. cuniculus	Half	Rib	R	8	1	-	-	-	-	-	-	-	-	-	Ext Light & Int Mod	Bi	dry	Untouched during feeding minimal loss of superficial details
1.6	O. cuniculus	~CO	Rib	R	9	1	1	12	0.02	0.02	0.06	0.03	0.05	0.02		Ext Light & Int Mod	Multi	dry	Untouched during feeding loss of superficial details considerable edge rounding & visible scoring **good pics**
1.7	O. cuniculus	~CO	Rib	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Untouched during feeding
1.8	O. cuniculus	~CO	Rib	R	8	1	-	-	-	-	-	-	-	-	-	Ext Light & Int Mod	Uni	dry	Untouched during feeding loss of considerable surface detail, produced considerable "crushing" dmg on end, **good pics**
1.9	O. cuniculus	~CO	Rib	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Untouched during feeding
1.10	O. cuniculus	~CO	Rib	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Untouched during feeding
1.11	O. cuniculus	~CO	Rib	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Untouched during feeding
1.12	O. cuniculus	~cc	Rib	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.13	O. cuniculus	Half	Rib	L	4	1	-	-	-	-	-	-	-	-	-	Ext Mod & Int Light	Multi	dry	Bitten Loss of superficial detail, and considerable edge rounding **good pics**
1.14	O. cuniculus	~CO	Rib	L	-	-	-	-	-	-	-	-	-	-	-		-	-	-
1.15	O. cuniculus	~CO	Rib	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.16	O. cuniculus	~CO	Rib	L	6	1	-	-	-	-	-	-	-	-	-	Ext Light & Int Mod	Bi	dry	Loss of superficial detail, Goldcoated
1.17	O. cuniculus	~CO	Rib	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.18	O. cuniculus	~CO	Rib	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.19	O. cuniculus	Half	Rib	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.20	O. cuniculus	~CO	Rib	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.21	O. cuniculus	~CO	Rib	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.22	O. cuniculus	~CO	Rib	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.23	O. cuniculus	~CO	Rib	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.24	O. cuniculus	~CO	Scapula	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.25	O. cuniculus	Frag	Scapula Frag	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.26	O. cuniculus	~CO	Scapula	L	6	1	1	4	0.01	0.03	0.02	0.03	-	-	-	Moderate	Uni	dry	Loss of superficial detail, added dmg on neck **good pics**
1.27	O. cuniculus	~CO	Humerus	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.28	O. cuniculus	~CO	Humerus	L	5	1	1	3	0.02	0.02	0.05	-	-	-	-	Moderate	Bi	dry	Loss of superficial detail, considerable scoring on head (see second pic of head); **good pics**
1.29	O. cuniculus	~CO	Ulna	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.30	O. cuniculus	Prx w/Shaft	Ulna	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Articulated w/1.32
1.31	O. cuniculus	Prx w/Shaft	Radius	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.32	O. cuniculus	Prx w/Shaft	Radius	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Articulated w/1.30
1.33	O. cuniculus	~CO	Clavicle	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.34	O. cuniculus	CO	Innominate	L	-	-	-	-	-	-	-	-	-	-	-	-	-		-
1.35	O. cuniculus	CO	Innominate	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.36	O. cuniculus	CO	Femur	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.37a	O. cuniculus	Half	Femur	R	12	1	1	6	0.03	0.03	0.02	0.02	0.03	0.04	-	Moderate	Multi	dry	Considerable loss of superficial detail with added scoring on head and shaft **Excellent Pics**
1.37b	O. cuniculus	Half	Femur	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.38	O. cuniculus	Prx Half	Tibula/Fibula	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.39	O. cuniculus	Prx Half	Tibula/Fibula	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.40	O. cuniculus	~CO	Art Sternum	\	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.41	O. cuniculus	CO	Zyphoid	\	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.42	O. cuniculus	Frag	Acromion Process	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.1	O. cuniculus	Dist Frag	Rib 1	R	-	-	-		-	-	-	-	-	-	-	-	-	-	-
2.2a	O. cuniculus	Dist Frag	Rib 2	R	-	-	-		-	-	-	-	-	-	-	-	-	-	-
2.2b	O. cuniculus	Prx. Frag	Rib 2	R	-	-	-		-	-	-	-	-	-	-	-	-	-	-
2.3	O. cuniculus	CO	Rib 3	R	-	-	-		-	-	-	-	-	-	-	-	-	-	-
2.4	O. cuniculus	CO	Rib 4	R	-	-	-		-	-	-	-	-	-	-	-	-	-	-
2.5	O. cuniculus	CO	Rib 5	R	-	-	-		-	-	-	-	-	-	-	-	-	-	-
2.6	O. cuniculus	CO	Rib 6	R	-	-	-		-	-	-	-	-	-	-	-	-	-	-
2.7	O. cuniculus	CO	Rib 7	R	-	-	-		-	-	-	-	-	-	-	-	-	-	-
2.8	O. cuniculus	CO	Rib 8	R	-	-	-		-	-	-	-	-	-	-	-	-	-	-
2.9	O. cuniculus	CO	Rib 9	R	-	-	-		-	-	-	-	-	-	-	-	-	-	-
2.10	O. cuniculus	CO	Rib 10	R	-	-	-		-	-	-	-	-	-	-	-	-	-	-
2.11	O. cuniculus	CO	Rib 11	R	-	-	-		-	-	-	-	-	-	-	-	-	-	-
2.12	O. cuniculus	~CO	Femur	R	-	-	-		-	-	-	-	-	-	-	-	-	-	-
2.13	O. cuniculus	CO	Distal Femoral Epiphysis	R		-	-		-	-	-	-	-	-	-	-	-	-	-
2.14	O. cuniculus	Prx w/Shaft	Tibia/Fibula	R	-	-	-		-	-	-	-	-	-	-	-	-	-	Charred Distal End
2.15	O. cuniculus	~CO	Scapula	R	-	-	-		-	-	-	-	-	-	-	-	-	-	-
2.16	O. cuniculus	~CO	Acromion Process	R	-	-	-		-	-	-	-	-	-	-	-	-	-	-
2.17	O. cuniculus	CO	Humerus	R	-	-	-		-	-	-	-	-	-	-	-	-	-	-
2.18	O. cuniculus	~CO	Ulna/Radius	R	-	-	-		-	-	-	-	-	-	-	-	-	-	Charred Distal End
2.19	O. cuniculus	CO	Sternum	\	-	-	-		-	-	-	-	-	-	-	-	-	-	4 articulated pieces including zyphoid
2.20	O. cuniculus	CO	Sternal Piece	\	-	-	-		-	-	-	-	-	-	-	-	-	-	-
2.21	O. cuniculus	CO	Clavicle	R	-	-	-		-	-	-	-	-	-	-	-	-	-	-
2.22	O. cuniculus	~CO	Rib	L	8	1	1	13	0.03	0.02	0.04	0.02	0.02	0.02		Moderate	-	Wet	High number of scoring, double check 2 pics
2.23	O. cuniculus	CO	Rib	L	-	1	-		-	-	-	-	-	-	-	-	-	Wet	-
2.24	O. cuniculus	CO	Rib	L	-	1	-		-	-	-	-	-	-	-	-	-	Wet	-
2.25	O. cuniculus	CO	Rib	L	-	1	-		-	-	-	-	-	-	-	-	-	Wet	-
2.26	O. cuniculus	CO	Rib	L	-	1	-		-	-	-	-	-	-	-	-	-	Wet	-
2.27	O. cuniculus	CO	Rib	L	-	1	-		-	-	-	-	-	-	-	-		Wet	-
2.28	O. cuniculus	CO	Rib	L	-	1	-		-	-	-	-	-	-	-	-	-	Wet	
2.29	O. cuniculus	CO	Rib	L	-	1	-		-	-	-	-	-	-	-	-	-	Wet	-
2.30	O. cuniculus	CO	Rib	L	-	1	-		-	-	-	-	-	-	-	-	-	Wet	-
2.31	O. cuniculus	CO	Rib	L	10	1	1	6	0.03	0.02	0.01	0.01	0.01	0.02	-	Moderate	-	Wet	Dmg'd edge with added scoring edge and shaft
2.32	O. cuniculus	~CO	Scapula	L	7	1	1	6	0.02	0.02	0.02	0.01	0.02	0.02	-	Moderate	-	Wet	Scoring on ext neck and head
2.33	O. cuniculus	Frag	Acromion Process	L	-	1	-	-	-	-	-	-	-	-	-	-	-	Wet	-
2.34	O. cuniculus	Frag	Acromion Process	L	-	1	-	-	-	-	-	-	-	-	-	-	-	Wet	-
2.35	O. cuniculus	CO	Humerus	L	5	1	1	4	0.03	0.02	0.01	0.02			-	Moderate	-	Wet	added scoring on head
2.36	O. cuniculus	CO	Sternum	L	-	1	-		-	-	-	-	-	-	-	-	-	Wet	-
2.37a	O. cuniculus	~CO	Radius	L	6	1	1	5	0.04	0.03	0.03	0.03	0.02	-	-	Moderate	-	Wet	midshaft scoring, **good pics**
2.37b	O. cuniculus	~CO	Ulna	L	5	1	1	3	0.06	0.03	0.05	-	-	-	-	Moderate	-	Wet	scoring on proximal end
2.38	O. cuniculus	CO	Femur	L	6	1	1	6	0.09	0.07	0.07	0.1	0.07	0.1	-	Heavy	-	Wet	much scoring on prox. shaft and head cutmarks **good pics**
2.39	O. cuniculus	~CO	Tibia/Fibula	L	9	1	1	7	0.05	0.05	0.05	0.03	0.1	0.04	0.06	Heavy	-	Wet	much scoring on shaft and head **excellent pics**
Totals bones in Rabbit sample					148	30	13	77											

Appendix D:

Forager Tooth Modifications

Name	Sex	Camp	Maxillary Incisors				Date
			Right 2	Right 1	Left 1	Left 2	
Kopayo	F	1	s	s	s	s	20-Nov-03
Palo	F	1	s	s	s	s	20-Nov-03
Yvonne	F	1	s	x	s	s	20-Nov-03
Fami	M	2	s	x	x	s	16-Nov-03
Kiloti	F	2	s	s	s	s	16-Nov-03
Zoannefoyo	F	2	s	s	s	s	16-Nov-03
Emolie	F	2	-	-	-	-	19-Nov-03
Kodinga	F	2	s	s	x	s	19-Nov-03
Kokbar	M	2	-	-	-	-	16-Nov-03
Embiekie	F	2	s	s	s	s	16-Nov-03
Nzalli	F	2	s	s	s	s	19-Nov-03
Nzelli	M	2	s	x	x	s	16-Nov-03
Yada	F	2	s	s	s	s	16-Nov-03
Biana	F	2	s	x	s	s	16-Nov-03
Mariera	F	2	s	s	s	s	16-Nov-03
Boyo	M	2	-	-	-	-	16-Nov-03
Kogia	F	2	-	-	-	-	16-Nov-03
Dangi	M	2	-	-	-	-	16-Nov-03
Mondeli	F	2	s	s	s	s	16-Nov-03
Samedi	M	2	s	s	s	s	16-Nov-03
Yada	F	2	s	s	s	s	19-Nov-03
Nzobo	M	2	-	x	-	-	19-Nov-03
Wife of Nzobo	F	2	p	p	s	s	16-Nov-03
Etien	M	2	s	s	p	-	16-Nov-03
Etonzi	F	2	x	x	x	x	16-Nov-03
Ngapua	M	2	s	s	s	s	16-Nov-03
Wife of Ngapua	F	2	s	x	s	s	16-Nov-03
Ngaba	M	2	x	x	x	s	16-Nov-03
Leti	F	2	s	s	s	s	19-Nov-03
Kristine	F	3	s	s	s	s	19-Nov-03
Twandeki	F	4	s	s	s	p	16-Nov-03
Bedingi	M	4	-	-	-	-	19-Nov-03
Zoane	F	4	s	s	s	s	16-Nov-03
Giles	M	4	s	s	s	s	19-Nov-03
Zonannee	M	4	s	s	s	s	16-Nov-03
Babunga	F	4	s	s	s	s	19-Nov-03
Salebali	M	5	s	s	s	s	16-Nov-03
Elapha	M	5	s	x	x	s	16-Nov-03
Yenga	F	5	s	s	s	s	20-Nov-03
Kosona	M	5	s	s	s	s	16-Nov-03
Baka	F	5	-	-	p	-	16-Nov-03
Benkase	F	5	s	s	s	s	16-Nov-03
Yada	F	5	-	-	-	-	16-Nov-03
Wapie	M	5	s	s	s	s	20-Nov-03
Beningi	F	5	s	s	x	s	16-Nov-03
Baye	M	5	s	s	s	s	16-Nov-03
Feti	F	5	s	s	s	s	16-Nov-03
Namkia	F	5	-	-	-	-	16-Nov-03
Zonday	M	5	s	s	s	s	16-Nov-03
Yenga	F	5	s	s	s	s	16-Nov-03
Boki	F	5	s	s	s	s	16-Nov-03
Margarie	M	5	s	x	x	s	16-Nov-03
Petite Margarie	M	5	-	-	-	-	16-Nov-03
Mary	M	5	-	-	-	-	19-Nov-03

Maxillary Incisor Codes

S = Shaped
P = Partially Shaped
X = Missing
- = Unshaped