

AN ETHNOARCHAEOLOGICAL ANALYSIS OF SMALL PREY BONE
ASSEMBLAGES PRODUCED BY FOREST FORAGERS OF THE
CENTRAL AFRICAN REPUBLIC

By

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To the Faculty of Washington State University:

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Abstract

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This dissertation is an ethnoarchaeological analysis of small prey (< 25 kg) bones produced by contemporary Bofi and Aka foragers of the Central African Republic. The interpretive benefits of understanding small prey use in prehistory are increasingly recognized, but specific data on processing and taphonomic patterning among small fauna are still relatively limited. This study contributes to the literature by descriptively detailing the taphonomic characteristics of culturally-produced damage (burning, cut marks, chop marks, and fracture patterns) for all prey species identified in the assemblage. It then explores these bone collections in a global context, comparing them to a range of other ethnographic, experimental, and archaeological studies, with an emphasis on the role of prey size in determining taphonomic damage patterns. Results suggest that the behavioral interpretation of small fauna requires a thorough re-evaluation of assumptions, primarily because conventional wisdom and theoretical expectations have so often been developed from studies of larger animals.

In addition to description and comparison, this study examines the ways that taphonomic expectations derived from foraging theory and tested on large prey apply to analyses of smaller fauna. Foragers, past and present, have had to make decisions about how to best extract energy from their environment, and from acquired resources. Among animal prey, contextual specifics such as carcass size and anatomy, prey availability, butchery technology, and cooking methods all impact the processing strategies employed by particular butchers. One compelling prediction of foraging theory is that butchers and consumers alter their investment in extracting resources (e.g., meat, marrow, and grease) from animal carcasses in relation to their abundance; as the availability of high-ranking prey species decreases, acquired carcasses of these species are expected to be processed more intensively. Ethnoarchaeological data from forest forager-produced bone assemblages are used here to evaluate commonly proposed zooarchaeological measures of processing intensity and their applicability to small prey. Results indicate that bone fragmentation has greater potential than cut or chop marks to link processing decisions and resulting taphonomic patterning in this context.

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Dedication

“When we recognize our place in an immensity of light-years and in the passage of ages, when we grasp the intricacy, beauty, and subtlety of life, then that soaring feeling, that sense of elation and humility combined, is surely spiritual”

Sagan 1995:29

Dedicated to Carl Sagan (1934-1996)

Who first opened my eyes to the wonders of the Cosmos

and our extraordinary species *Homo sapiens*.

1. ETHNOARCHAEOLOGY AND THE BEHAVIORAL ECOLOGY OF SMALL PREY USE

Introduction

“In approaching the study of modern and prehistoric hunter-gatherers from an explicitly evolutionary theoretical framework, we will continually add to our knowledge and understanding of the development and diversity of humanity. And that, after all, is the reason we do anthropology.”

Kelly 1995:344

This dissertation is an ethnoarchaeological case study of small mammal hunting and processing by contemporary forest foragers of the Central African Republic. It focuses on three major goals: 1) To document and describe the taphonomic characteristics of bones from a known cultural context, and from a generally understudied size class of mammalian prey. 2) To compare these descriptive data to other faunal studies, with an emphasis on the role that prey size and other contextual factors play in determining taphonomic patterning. 3) To go beyond description and comparison and explore how taphonomic expectations derived from foraging theory and tested on larger prey apply to analyses of small fauna. The primary theoretical issue I investigate is the relationship between resource intensification and small prey processing intensity – and, most importantly, ways that zooarchaeologists can evaluate small prey processing intensity in archaeofaunal assemblages.

This chapter introduces ethnoarchaeology as a research strategy and covers the history and uses of general theory in ethnoarchaeological research. Next, I discuss human behavioral ecology, resource depression, resource intensification, and foraging models used to identify these processes archaeologically and that will be applied in the analyses of subsequent chapters. The chapter concludes with a discussion of the archaeology and taphonomy of small fauna.

Ethnoarchaeology

“It is perhaps time for the archeologist to take to the field of living communities with his own theoretical orientation and gather the necessary information in his own way.”

Kleindienst and Watson 1956:76-77

Analogy

“The most widely used of the tools of archaeological interpretation is analogy” (Ascher 1961:317). Analogy is a form of reasoning that attempts to make inferences about an unknown subject based on shared similarities with a known source, or analog (Lyman and O’Brien 2001). The philosophical logic of analogy existed long before anthropology, or the development of ethnoarchaeology (Charlton 1981; Orme 1974, 1981; Wylie 1985). Kelley and Hanen (1988) explore the use of scientific methodology in archaeology, beginning with the difference between deductive and inductive inference. David and Kramer illustrate deduction with the following logical formulation: “All birds have wings. Aristotle is a bird. *Therefore*, Aristotle has wings” (2001:44). In cases of deductive inference, if the premises are correctly deduced, then the truth of the conclusion is certain.

Inductive inferences lack the conclusiveness of deductive ones, and analogy is a form of induction, which David and Kramer present as: “All birds have wings. All birds have feet. Birds fly. Sophocles has wings and feet, and can fly. *Therefore*, Sophocles is a bird” (2001:44). But Sophocles might not be a bird. In other words, a particular subject (Sophocles) may share multiple characteristics with an analog (bird), yet, in actuality, be an insect or some other flying animal with wings and feet. Thus, conclusions based on inductive, analogical reasoning are never guaranteed (Wylie 1985), and this is a common critique of the use of analogy in archaeological inference (discussed in detail below).

Analogy is defined as: “Inference that if two or more things agree with one another in some respects they will probably agree in others” (Merriam-Webster Dictionary). David and Kramer (2001) explain that analogies proceed by enumerating similarities between a known source and unknown subject. Although a “perfect analogy,” or exact correspondence between source and subject, is impossible (Fischer 1970:247; Wylie 1982:393), a greater number of shared attributes increases our confidence that source and subject also share an underlying relationship. If an underlying relationship, or causal mechanism, can be discerned, this understanding can be used to explain *both similarities and differences* between source and subject. That is, the presence or absence of an attribute in one side of the analogy, but not the other, can be explained. As a result, many scholars (e.g., David and Kramer 2001; Hodder 1982; Kent 1987; Wylie 1985) argue that relational analogies are much stronger and allow greater interpretive power.

Ethnographic Analogy and Ethnoarchaeology

Ethnoarchaeology is rooted in the specific type of analogy called ethnographic analogy: the premise that the material expressions of culture, and behavior, of ethnographically-documented peoples can provide insights applicable to prehistory. Ethnographic analogy utilizes the ethnographic record as a source, or analog, for making inferences about the unknown subject of past human behavior. In fact, David and Kramer argue that, “Ethnoarchaeology developed in order to provide better ethnographic analogies to assist in the interpretation of archaeological data” (2001:43).

The term “ethno-archaeologist” was first used by Fewkes (1900) to, in a very general sense, refer to an archaeologist who applies knowledge of the present to the past.

Fewkes' (1900:579) concern was that archaeologists should understand the present life of an ethnographic group in preparation for studying that particular group's prehistoric ancestors. Thus, Fewkes' philosophy was consistent with the direct historical approach commonly employed in the late Nineteenth and first half of the Twentieth Centuries. The direct historical approach sought to identify direct historical links between historically-documented cultures and archaeological cultures (Trigger 1989). If a relationship could be established, then it was believed that "ethnographic descendant cultures could be used as analogs of prehistoric ancestral cultures" (Lyman and O'Brien 2001:303). Willey (1953) refers to such studies as specific historical analogies because they rely on a direct evolutionary connection between specific cultures. Gould (1974) refers to the same type of analogy as "continuous," because there is historic continuity between subject and source.

Kleindienst and Watson's (1956) call for "action archaeology," in which they advocated that archaeologists work with living communities to inventory artifact types, record relationships between social status and material objects, and observe how plant and animal remains enter the archaeological record, is frequently cited as the true beginning of ethnoarchaeology. Most relevant to the present study, they suggested that "butchering techniques would be analyzed as to the resulting condition of the bones..." (1956:77). Kleindienst and Watson's action archaeology differs from Fewkes' (1900) conception of ethno-archaeology, because it raises the possibility of making comparisons between evolutionarily-unrelated past and present cultures; a form of analogy Willey (1953) refers to as general comparative analogy. Gould (1974) describes such analogies as "discontinuous." Kleindienst and Watson suggest:

Comparison of the results of several such studies involving the same type of community in different parts of the world, or different types of communities... Cross-cultural archeological inventories of the type described would furnish new perspectives for inferring the fundamental determinants shaping cultural manifestations (1956:78).

Clearly, they envisioned a more ambitious discipline than the specific historical analogy pursued by Fewkes (1900) a half century earlier.

In one early study, Thompson describes his analysis of modern Yucatecan Maya pottery making as “an exercise in the archaeology of ethnographic materials for the purpose of examining the nature of archaeological inference” (1958:9), and he asserts that archaeological inference is impossible without recourse to analogy. Thompson (1958:6) argues that specific historical analogies produce richer and more convincing interpretations, but that they are impractical because cultural continuity from prehistory to the ethnographic present is lacking in most locations. Further, he doubts the feasibility of obtaining data to be used for specific historical analogies in all parts of the world. Thompson concludes that “growing emphasis, therefore, must be placed on more carefully documented general comparative data” (1958:150).

When Kleindienst and Watson (1956) and Thompson (1958) argued for expanding the boundaries of action archaeology to include a comparative approach, they were not suggesting that all source analogs are equally valid. This point is reiterated by Ascher (1961) in his overview of the use of analogy in archaeological interpretation, and he emphasizes the need for boundary conditions when selecting suitable analogs. He uses the term “new analogy” to distinguish general comparative analogy from the “folk-culture approach” of the Old World and “direct historical approach” of the New World (1961:319). After reviewing several archaeological studies, Ascher concludes: “In summary, then, the canon is: seek analogies in cultures which manipulate similar

environments in similar ways” (1961:319). Ascher’s (1961) work was an early consideration of issues that remain of concern today: the extent to which ethnographic groups are appropriate analogs for prehistoric groups, and the role of environment in ethnographic analogy.

Despite major differences between the goals and scope of Fewkes’ (1900) research and that conducted in the latter half of the Twentieth Century, his term “ethnoarchaeology” gained general acceptance, eventually becoming more widely used than the alternatives action archaeology (Kleindienst and Watson 1956) or “living archaeology” (Gould 1980), among others. Stiles (also see Kent 1987:35) views Gould’s (1980) living archaeology as a kind of archaeological ethnography, and he seeks to expand the term ethnoarchaeology “to encompass all the theoretical and methodological aspects of comparing ethnographic and archaeological data, and in particular the use of the ethnographic analogy” (1977:88). He argues that the strongest analogies are those that consider cultural, ecological, geographical, and temporal similarities between contemporary and prehistoric hunter-gatherers. Stiles (1977) proposes that ethnographic data from field studies, written sources, and museums should be used to create hypotheses and models to be compared to archaeological data. Together, the collection of archaeologically-relevant ethnographic data and the development of hypotheses and models to guide ethnographic analogy, form the anthropological subdiscipline of ethnoarchaeology (Stiles 1977:97). David and Kramer employ a similarly inclusive definition of ethnoarchaeology: “research that includes an ethnographic component and is carried out with the analogical needs of the archaeologist in mind” (2001:11), and their definition is followed throughout this dissertation.

Table 1.1. Gould (1978a) and Watson (1979b) describe ethnoarchaeology.

Reference	
Gould 1978a:10	“Ethnoarchaeology...is an empirical approach designed to discover the totality of variables that determine human behavior in particular situations and to posit general principles that will show how these variables consistently interact.”
Watson 1979b:277	“The theoretical basis for ethnoarchaeology is the use of analogies derived from present observations to aid interpretation of past events and processes.”

Both Gould (1978a) and Watson (1979b) describe ethnoarchaeology as an approach that transcends direct historical analogies, and one that seeks an understanding of general principles and processes (Table 1.1), but they disagree about the meaning and use of analogy in ethnoarchaeological research. Gould (1978b, 1980; also see Kent 1987:39) is a proponent of the argument that ethnoarchaeology must go beyond analogy and, in at least one instance (Gould and Watson 1982), he presents a case *against* analogy in ethnoarchaeology. Based on a dictionary definition of analogy similar to the one provided above (i.e., the inference that resemblances between source and subject imply further similarity), Gould (Gould and Watson 1982:372-376) identifies three general objections to analogies.

Gould’s first objection is that analogical inference may commit the *fallacy of affirming the consequent*. For example, a logical formulation of this fallacy is: *If* tool type X was used for scraping animal hides prehistorically, *then* it will be used for scraping hides in a modern context. Tool type X *is* used for scraping hides in a modern context, *therefore* it was used for the same purpose prehistorically. Gould (1978b:254, 1980:30) argues that simple ethnographic analogies of this type are inherently self-limiting because they are only capable of identifying archaeological materials and/or

behaviors that have a historic or ethnographic counterpart, and cannot know what is not represented. Kleindienst and Watson noted this limitation years earlier: “When evidence is encountered which has no known analogs, it is incapable of interpretation” (1956:75; also see Freeman, Jr. 1968:262). Watson (1979a:1; 1979b:287) shares Gould’s concern when she warns against assuming that ethnographically known lifeways represent the complete range of human behaviors and imposing these explanations on archaeological remains without adequate testing. Simms elaborates on this same theme when he observes that prehistoric systems may not be represented by modern analogs and may, in fact, be “previously unknown, unimagined, and even ‘counter-intuitive’ (intuition being a culture-bound concept)” (1992:191).

Gould’s second objection to analogy is: “*No amount or number of resemblances can confirm a single case*” (Gould and Watson 1982:374). He states that we cannot assume underlying principles based on shared resemblances between subject and source. That is, ethnoarchaeologists have no way of knowing with certainty whether resemblances represent relational analogies. Gould writes: “Arguments by analogy, in other words, beg the question of what it is that structures the resemblances one is attempting to explain” (Gould and Watson 1982:373). From his perspective, without the application of some uniformitarian principle, resemblances are only “interesting coincidences” (Gould and Watson 1982:374). Gould concludes that ethnographic analogy is valid, but limited because it can never effectively rule out competing hypotheses.

Gould’s third objection to analogy is that resemblances between subject and source, alone, cannot account for variability. In a re-statement of his first criticism,

Gould (Gould and Watson 1982:375; also see Wobst 1978) argues that ethnographic analogies are self-fulfilling and that we must employ some sort of framework to explain the variability that occurs. For example, he suggests that analyses based on the discernment of uniformitarian processes (e.g., studies of human ecology) are a better framework for explaining why ethnographic and archaeological patterns conform to or diverge from expectations than simply “collecting and adding up resemblances” (Gould and Watson 1982:375). Gould (1980) refers to his approach as “argument from anomaly” to contrast it with argument from analogy, and he concludes that ethnoarchaeology must include “a willingness to recognize the importance of anomalies and to use such anomalies as a primary tool for discovering behavioral relationships that may have no counterpart in any contemporary or known historic human societies” (1980:xii). In summary, Gould (1980:x) is against the use of simple analogies based on ethnographic observations to explain archaeological findings.

Watson (Gould and Watson 1982:363) provides a counterargument in support of the use of analogy in ethnoarchaeology, based on the premise that analogical reasoning is the conceptual basis of all archaeological interpretation. Watson explains that all historical sciences, including archaeology, begin with the operating assumption that the past is knowable, although it is not directly observable. Her overall argument centers on the assertion that “we can achieve knowledge of the real past by applying empirically-based techniques within a general framework of argument by ethnographic analogy” (Gould and Watson 1982:359). Like Thompson (1958), Watson argues that direct (specific) historical analogies are stronger than general comparative analogies, but that ethnoarchaeologists must approach all ethnographic analogies as testable models or

hypotheses, rather than confirmed interpretations. Thus, she views the simple analogies derided by Gould (1978b, 1980) as only the beginning of a systematic process of hypothesis-testing, in which the relationships proposed by these analogies must be compared against the empirical reality of the archaeological record (Gould and Watson 1982:363; Watson 1979a:3, 1979b:278, 1980:56; also see Binford 1967). Watson refers to the entire process as “argument by analogy” (Gould and Watson 1982:360).

Unlike Gould (1980), Kent (1987) does not claim to be against analogy, but she does support a very limited role for ethnographic analogy in ethnoarchaeology. She is primarily concerned that analogy not be viewed as equivalent to, or the main function of, ethnoarchaeology. To stress this point, she states: “Ethnoarchaeology is *Not* Analogy or It Is Nothing” (1987:39). Kent (1987:42) views ethnographic analogy as a starting point for the particular identification of cultural materials and functional interpretations, but argues that it cannot provide abstract explanations or understandings, such as economic and technological organization. This is very much in line with Watson’s (1979a) understanding of ethnographic analogy as a method of generating hypotheses, not conclusions.

Wylie (1982) points out that the differences between Watson’s argument *for* analogy and Gould’s argument *against* analogy are almost entirely dependent on how each defines analogy. Gould proceeds from a narrow dictionary definition of analogy, which presents analogy as a cataloging of apparent similarities or “resemblances” between archaeological subjects and ethnographic analogues (Gould 1980:29; Gould and Watson 1982:371). Gould disagrees with Watson’s “expanding the concept of analogy to mean ‘hypothesis-to-be-tested’” (Gould and Watson 1982:376). Watson (Gould and

Watson 1982) supports her broader view of analogy by citing its usage in logic, philosophy, and general archaeological literature.

Wylie (1985:80) reiterates that all analogical inferences are ampliative, which means that they are ultimately inductive and, by definition, liable to be in error. Therefore, deductive certainty is unattainable in archaeological inference. Fischer refers to expectations of exact correspondence between subject and source as the “fallacy of perfect analogy” (1970:247). In reference to this fallacy, Simms comments, “analogy extracted from a dynamic world carries problems and...the key is not to be found in the location of the Perfect Analogy” (1992:194).

Wylie (1982:394; 1985:97) suggests that analogies cannot be judged as valid or invalid; they must be evaluated along a continuum from “weak” to “strong.” Weak analogies are those that consider only similarities, but not differences, and/or those that assume that partial similarity between subject and source implies similarity in all respects. She argues that Gould’s (Gould and Watson 1982) criticisms of analogy are directed only at this weak form. In contrast, Watson’s (Gould and Watson 1982) positive appraisal of analogy is based on a continuum of analogy that includes strong analogies. Strong analogies are those that 1) consider both similarities and differences between subject and source to more accurately gauge the *extent* of similarity and 2) those in which the similarities in the premise are a relevant basis for inferring further similarities in the conclusion (Wylie 1982:394). Thus, Watson and Gould (Gould and Watson 1982) agree in their rejection of weak analogies, and most of their differences in approach are terminological (Wylie 1982:396). Wylie (1982:400) concludes her commentary by

arguing that ethnoarchaeologists cannot replace analogy, but should extend and refine the idea of analogy, and work to improve the relative credibility of analogical argument.

Limitations of Ethnographic Analogy

Ethnoarchaeology is inextricably linked to ethnographic analogy, and strong analogies (as described above) remain the basis of ethnoarchaeological research, but the refinement of analogical reasoning continues. Most discussions of ethnographic analogy distinguish between source- and subject-side aspects of these analogies (e.g., David and Kramer 2001; Stahl 1993a; Wylie 1985, 1988, 1989). Stahl writes: “Source-side issues concern how we select and establish the relevance of particular analogues (including actualistic and ethnoarchaeological research). Subject-side concerns focus on how we apply analogical models to archaeological contexts” (1993a:235-236). In this section, I briefly review some additional limitations of the archaeological application of ethnographic analogy in terms of source and subject.

Source-Side Issues

A fundamental source-side issue is the degree to which modern human foragers are appropriate analogs of prehistoric ones. Common criticisms of the use of ethnographic analogy include the concern that archaeologists view modern foragers as static and underestimate the role of history and change in recent forager societies (MacEachern 1996; Stahl 1993a; Wilmsen 1989; Wobst 1978), or that the use of modern technology or relationships with farmers and nation-states makes them inappropriate analogues of past groups without these traits (Kent 1992; Layton 2001; Schrire 1980, 1984; Stiles 2001).

Archaeologists often envy the range and specificity of data available to cultural anthropologists working among living communities, but Gould suggests that archaeology must be more than “an imperfect anthropology of the past” (1980:250). In other words, ethnoarchaeology should be more than a futile attempt to construct prehistoric ethnographies from the archaeological record (in contrast, Heider 1967:62 suggests that archaeologists *should* view themselves as prehistoric ethnographers). Even if that were possible, Wobst (1978) identifies imperfections and limitations of the ethnographic record, especially as applied to archaeological interpretation. For example, he notes that ethnographers cannot observe private behaviors, behavior may be distorted by the presence of observers, and ethnographers are limited in the amount of time and space they can cover (Wobst 1978:303). Wobst is one of many scholars (Gould 1978b, 1980; O’Connell 1995; Simms 1992; Watson 1979b) to acknowledge that the full spectrum of materials and behaviors responsible for the creation of the archaeological record are likely not represented in the ethnographic record. As a result, he argues that archaeologists that utilize ethnographic analogy are biased towards interpretations based on ethnographically-documented behaviors.

Despite Lee’s (1979) insistence that modern hunter-gatherers should not be viewed as “living fossils,” Kelly suggests that, “some anthropologists persist in viewing living foragers as our Paleolithic ancestors, although they would admit that the window through which we view them is foggy and cracked” (1995:334). When using modern foragers as ethnographic analogues, we cannot underestimate the contextual differences between source and subject. To do so would be to engage in the type of weak analogy that Wylie (1982) describes. Some have questioned whether “hunter-gatherer” is a

meaningful category (Burch 1998; Panter-Brick et al. 2001), and have cautioned that, by lumping a diversity of past and present lifeways into this category, we risk assuming more general similarities than are warranted by the evidence (Kelly 1995; Stiles 2001). Kelly challenges ethnoarchaeologists to remember that “*hunter-gatherer* is a category we impose on human diversity – it is not itself a causal variable” (1995:3).

Headland and Reid (1989) review what they see as an anthropological tendency to perpetuate the idea that contemporary hunter-gatherers were isolated from their neighbors, untainted by “modernity” and the outside world until relatively recently. They cite Wolf (1982:18), who refers to this as the “mythology of the pristine primitive,” and the appeal of this mythology to archaeologists seeking to understand prehistoric behavior is obvious. However, Headland and Reid provide extensive evidence that this “isolate model” is inaccurate and counter it with their own “interdependent model,” in which most foragers have “typically been in more or less continuous interaction with neighboring groups, often including state societies, for thousands of years” (1989:44). As a result, much debate has centered on the impact that forager interactions with non-foragers have on our interpretations.

A well-known example is the so-called Kalahari or Revisionist Debate (Brooks 2002; Kent 1992, 2002; Kusimba 2005; Layton 2001; Lewin 1988; Shott 1992; Stiles 1992). Kusimba (2005:338) states that the classic ethnographies of Central African forest foragers (e.g., Turnbull 1965) emphasize their relationships with food producers, while the southern African ethnographies (e.g., Lee 1979) deemphasize these relationships. As a result, the San were viewed as the prototypical pristine primitives and an idealized contemporary model of simple foragers, in effect, making them “*the* hunter-gatherer

society” (Lewin 1988:1146). Kent (1992:45) labels this initial perception of San autonomy the “traditionalist” viewpoint.

In the 1980’s, “revisionist” research began to systematically deconstruct this depiction (Kent 1992:46). Schrire (1980) and Wilmsen (1989) present the complex political and economic history of the San. Far from being an untouched remnant of a Stone Age foraging lifeway, San subsistence is extremely variable throughout history and includes much contact and interaction with outsiders. For example, historical documents indicate periods of San subservience to farmers and herders, entrepreneurial commercial hunting and trading, and cattle ownership (Schrire 1980; Wilmsen 1989). Interactions between San-speaking hunters and herders may be as old as 1200 years in some parts of the Kalahari (Kusimba 2005; Solway and Lee 1990; Wilmsen and Denbow 1990). Solway and Lee (1990) counter that, although some San groups have contact with, and are even dependent on, Bantu-speaking neighbors, others are relatively autonomous. These groups were less impacted by historical trade and colonialism (Lee and Guenther 1991).

Schrire (1980) asserts that questions of prehistoric human behavior should not be addressed with modern San. She writes: “Were the San no longer portrayed as a unique example of an evolutionary stage in human development, they would emerge as an African people whose roots, history, and destiny are bound up with those of other Africans” (1980:28). While acknowledging the complex histories and interactions of different San groups, Solway and Lee (1990:109) argue that revisionist perspective should not be viewed as universal, and contact between San- and Bantu-speakers does not necessarily imply dependence, abandonment of foraging, or subservience. Kent (1992)

suggests that, since virtually all modern foragers engage in some non-foraging activities, the question of whether San are “genuine or spurious hunter-gatherers” (as Solway and Lee 1990 phrase it) is unimportant. The more relevant question is “whether we can still learn about foraging behaviour by studying such people” (Kent 1992:52). The answer is most often yes, provided we have a clear understanding of the role of history, change, and interaction in specific contemporary foraging societies.

Stiles proposes a method for classifying foragers based on their level of interrelatedness with agricultural neighbors, and his contextual classification stages are: 0) Precontact, 1) Contact, 2) Sporadic exchange, 3) Accommodation, 4) Acculturation, and 5) Assimilation/Annihilation (2001:44-47). These stages account for progressively greater interaction between hunter-gatherer groups and farming populations. In pre-agricultural times, all foragers were Stage 0, and Stiles (2001:55) questions the use of modern Stage 1-5 foragers as models for these people. To reiterate, Wylie (1982, 1985) argues that analogical sources are better judged along a weak-to-strong continuum than as valid or invalid. Although Stiles frequently discusses the “validity” of analogues, his main argument is that ethnographic analogies are stronger when the contextual stage of the source is relatively close to the stage of the archaeological subject (2001:57). Stiles (2001:57) concludes that researchers must be honest about the contextual situation of hunter-gatherer groups they work with and provide detailed descriptions of their interactions with agriculturalists. Layton (2001:315) concurs that this context must be understood to assess the significance of foraging behaviors.

Most of the anthropological literature discussed above focuses on the effect of farmers on foraging lifeways, but we cannot assume that hunter-gatherers are “people

without history” (MacEachern 1996:246; Stahl 1993a:241; Wolf 1982:4), or that the only relevant developments in these societies are imposed by external forces (Layton 2001:294). According to Layton, “Even when unaffected by contact with outsiders, recent hunter-gatherers have an extensive history of change” (2001:295). This is particularly important to remember in light of Wobst’s (1978) criticism that ethnographic studies cannot record the totality of modern cultures in a relatively short, and spatially-limited, study period. In this sense, Wobst (1978:307) argues that archaeologists are the only anthropologists with access to behavioral variability in all of its dimensions. These criticisms are legitimate, and must be acknowledged when making comparisons between past and present peoples, but they are not sufficient cause to abandon ethnographic analogy. O’Connell et al. conclude: “If modern hunters are not the source [of archaeologically testable expectations], what is?...The question is not whether to use information from the modern world, but how to use it best” (1988:150). This question is the topic of the following sections.

Subject-Side Issues

Subject-side issues concern the application of ethnographically-derived information to archaeological questions. A common subject-side concern is that ethnographic observations are *instructive* when applied to archaeological interpretations, but not *constructive* (Gifford 1978; O’Connell 1995; Simms 1992). Ethnoarchaeological research draws attention to our incomplete knowledge of archaeological processes, mistaken assumptions, and the contextual variability of archaeological patterning. As a result, contributions that focus on these limitations have collectively become known as “cautionary tales,” a term first used in the context of archaeology by Heider (1967).

Based on his ethnographic research among the Dugum Dani of highland New Guinea, Heider (1967) highlights aspects of tool manufacture and use, settlement patterns, art, and trade relations with neighbors that would be unidentifiable or misleading to archaeologists using traditional interpretative methods. As with most cautionary tales in ensuing years, Heider's message to archaeologists is "Don't simplify" (1967:63).

Gifford's (1978) work among Dassanetch pastoralists serves as a cautionary tale to archaeologists by illustrating the many ways that natural processes, in conjunction with cultural activities, affect Dassanetch site formation. In this case, ethnographic observations were effectively used to demonstrate that not all archaeological patterning is attributable to human behavior. However, Gifford (1978:100) argues that ethnoarchaeological research should do more than provide cautionary notes to archaeologists, and must develop testable propositions about natural and cultural processes in the creation of the archaeological record. So, rather than just warning of the difficulty of distinguishing natural and cultural processes, Gifford (1978) presents several expectations of what patterning should look like in different contexts, to be tested against archaeological data. Thus, her study is a constructive application of ethnographic research to archaeological investigation.

In praise of ethnoarchaeological research like that conducted by Gifford (1978), Simms (1992:188) proposes that ethnoarchaeology has to go beyond stating and re-stating what archaeologists are doing wrong, and offer applicable solutions to these issues for use in actual archaeological contexts, or risk being nothing more than an "obnoxious spectator". The continuous collection of ethnographic data without reference to practical archaeological applications, would make ethnoarchaeology a "trivial pursuit" (Simms

1992:189). Comparably, O'Connell (1995:208) and Schiffer (1978:242) comment that cautionary tales document interpretive problems, but often don't provide any methodological insights for resolving them.

What began as a necessary, but humbling, self-evaluation of methodology has become, in the eyes of some, a constant and unwelcome reminder of the limitations of archaeological reconstruction. David and Kramer note that, despite being frequently discussed dismissively, cautionary tales “alert archaeologists to the existence of a variety of models, and invite them to sharpen their analytical tools and develop new ones” (2001:16). Thus, archaeology benefits from cautionary tales but, as with analogy in general, there is a weak-to-strong continuum of cautionary research. Strong ethnographically-based evaluations of archaeological methods are those that instructively identify problems of interpretation *and* constructively provide potential solutions to those problems.

Another subject-side concern is whether analogical models can ever be applied to the archaeological record in ways that transcend “just-so stories.” In the social and biological sciences, just-so stories are an expression of the *ad hoc* fallacy (see Gould and Lewontin 1979 for a broad discussion). *Ad hoc* is defined as: “For the particular case at hand without consideration of wider application” (Merriam-Webster Dictionary). The term “just-so story” is pejoratively applied to explanations that fit the data, but are unverifiable and not generally applicable. The relationship between known effect and presumed cause is “just-so.” These explanations are subject to the same criticisms outlined in Gould's (Gould and Watson 1982:374) second objection to analogy; a just-so story may explain the available evidence, but cannot falsify competing explanations.

Thus, archaeological interpretations based on ethnographic analogy may explain *how* archaeological patterns came to be, but they do not explain *why* humans in both contexts engaged in analogous behavior, or *why* particular just-so stories are more probable than any other. Bettinger and Richerson argue that just-so stories serve a purpose, and are not inherently objectionable, but become so when:

they are merely asserted as true rather than set forth as evolutionary hypotheses with potentially rich and testable implications...The job is to follow simple rules provided by theory in generating a just-so story that matches the data more closely than the just-so stories generated in other ways, and more closely than the last try (1996:225).

Some have argued that source- and subject-side limitations of ethnographic analogy are best addressed by the consistent application of theoretically-grounded models of human behavior to ethnoarchaeological research (Gould 1980; O'Connell 1995; Simms 1992; see Cunningham 2003 and David and Kramer 2001 for counterarguments). The following section reviews the history of general theory in ethnoarchaeology.

General Theory in Ethnoarchaeology

The history of theory in ethnoarchaeology follows the trajectory of developments in general theory in archaeology as a whole during the latter half of the Twentieth and into the Twenty-first Centuries. In terms of broad theoretical trends, this can be described as: processualism, postprocessualism, and approaches that attempt to combine the best attributes of both.

Processual Ethnoarchaeology

The development and expansion of ethnoarchaeology parallels the rise of processualism, beginning with the New Archaeology of the 1960's (Binford 1962; Binford and Binford 1968; Clarke 1968). Processualism distinguished itself from the earlier culture historical approaches with the optimistic appraisal that archaeology could

transcend the description of artifacts and actually reconstruct past human behavior. Processualists argued that this could be achieved by applying the scientific methods and philosophy of the natural sciences to the archaeological record, particularly those ecological and economic aspects of human behavior that are most amenable to scientific testing. Broadly speaking, processual research seeks explanations of the human past using controlled variables, quantitative methods, hypothesis testing and, ultimately, aims to generate cross-cultural generalizations about behavior.

Wider acceptance of processualism among archaeologists, particularly the increasing value placed on middle-range research, spurred massive growth in ethnoarchaeology. David and Kramer (2001:19), for instance, document a tenfold increase in annual ethnoarchaeological publications for the period beginning in 1968. Binford is identified as spear-heading the development of middle-range theory to determine “a) how we get from contemporary facts to statements about the past, and b) how we convert the observationally static facts of the archaeological record to statements of dynamics” (1977:6). Thus, a fundamental challenge addressed by ethnoarchaeology is linking the dynamic behaviors of contemporary peoples to the static material products created by those behaviors. The goal of processual ethnoarchaeological research is to use contemporary human societies as laboratories for the generation of hypotheses to be tested against the archaeological record. Ethnoarchaeological research guided by this basic approach has been conducted in a range of environmental and geographical contexts (Binford 1978, 1980, 1981; Gould 1971, 1980; Watson 1979a; Yellen 1977a). These early and influential examples of processual ethnoarchaeological research are discussed below.

In Gould's (1971) ethnoarchaeological study of Australian Western Desert Aborigines, he cites the "culture process" approach's rigorous questioning of ethnographic analogy as an improvement over earlier culture historical approaches. From his perspective, interpreting archaeological data through the lens of contemporary experience is "scientifically dangerous" (1971:143) because this may lead archaeologists to ignore alternative interpretations, particularly those not represented in ethnographic contexts.

Gould (1971:175) identifies three levels at which ethnographic knowledge can be applied to archaeological research: the practical level, the level of specific interpretation, and the level of general interpretation. At the practical level, Aboriginal informants helped him locate sites and presented extensive cultural information about the uses of those sites. At the level of specific interpretation, Gould (1971:161) uses modern observations of stone tool use to interpret the function of prehistoric tools recovered from Puntutjarpa Rockshelter. Further, he statistically correlates the angle of working edge on cutting tools to their observed functions, thus providing quantitative measurements applicable to the interpretation of archaeological materials. Measurements of living surfaces from Puntutjarpa Rockshelter were comparable to measurements of modern living surfaces, but the area of modern summer and winter camps was not sufficiently different to make seasonal distinctions among prehistoric sites (Gould 1971:166). These examples demonstrate the potential of applying ethnographically-derived quantitative data to specific archaeological interpretations. At the level of general interpretation, Gould uses archaeological and ethnographic data to test and refine the hypothesis of an Australian desert culture that demonstrates relative technological continuity for at least

10,000 years. Gould (1971:175) praises the analytical methods of processualism, but argues that interpretations are most reliable when there is a direct historical connection between the ethnographic and prehistoric cultures studied.

Based on his fieldwork among the Dobe !Kung, Yellen (1977a) proposes four ways that ethnographic data may be applied to archaeology: the spoiler, buckshot, laboratory and general model approaches. He views the spoiler approach (cautionary tales) as a negative, but unavoidable and sometimes valuable, byproduct of ethnoarchaeological research. Like Heider (1967), Yellen (1977a:133) highlights the dangers of oversimplification. In this case, his data indicate that site type or consistent activity areas within Dobe !Kung sites would be extremely difficult to reconstruct archaeologically. Yellen's (1977a) buckshot approach refers to the ethnographic generation of specific, but scientifically inconclusive, analogies (just-so stories). These are suggestive, but unprovable explanations to archaeological questions that arise from ethnographic observations (1977a:134). He describes such observations as hit-or-miss speculations and suggests that they are problematic only when presented as fact (1977a:7).

Yellen (1977a:132) explains that the majority of his research employs the laboratory approach, in which the analyst makes observations and determines which techniques provide the best route between causes (behaviors) and effects (material consequences). Using this laboratory approach, he conducts spatial analyses ranging from broad !Kung settlement patterns to detailed within-camp patterning. Yellen (1977a:134) states that the most important contribution of this work is his quantitative analysis of household measurements that produced predictive equations for group size

and occupation length – equations that can be productively applied to archaeological data. The construction of general models from ethnographic data is an extension of this laboratory approach. General models are broadly applicable and include general analogies, deductive hypotheses, and law-like generalizations (Yellen 1977a:6). Yellen exemplifies the processual position that such models are best framed as testable hypotheses. He argues that models should be evaluated based on their ability to encompass existing facts, their predictive value, and their potential as frameworks for future research (1977a:47). Thus, Yellen compares two models of hunter-gatherer spatial organization developed among the !Kung, evaluates them according to these criteria, and suggests in which contexts each would be most useful to archaeologists (1977a:49).

Binford's (1978) research among the Nunamiut Eskimo is one of the most widely known and most influential processual ethnoarchaeological studies. He begins his work by distinguishing processualism from earlier culture history approaches. According to Binford (1978:3-4), compiling artifact and trait lists for specific cultures is analogous to trying to understand a functioning automobile by enumerating all of its parts. He supports, instead, a systematic, processual approach that identifies basic functional components (e.g., parts common to many types of automobile) and seeks to understand how these components interact and respond to different conditions. Applying this analogy to human societies, Binford suggests that much variability in the archaeological record that is attributed to different systems (i.e., distinct cultures) may be better understood as "*differing states of a single system*. We might also imagine that systems differing in overall organization could well share very similar strategies of adaptation" (1978:4).

Thus, Binford reiterates the generalizing goals and adaptational emphasis of processual archaeology. However, he argues that his research among the Nunamiut is not direct hypothesis-testing. Citing Kuhn (1964), Binford proposes that archaeology is in a crisis period – a period when there is no general agreement among practitioners of a science about how to attribute meaning to observed patterning or even on the overall aims of that science (1978:5). At such times, he argues, seeking additional archaeological facts, without any new insights or agreement as to their interpretation, is insufficient. It is necessary to seek relevant experiences in the world, and Binford's work with the Nunamiut is based on the premise that: "By documenting the relationship between the dynamics of a living system and the static archaeological remains deriving from that system I hoped to be able to improve or offer more reliable conventions for giving meaning to archaeological facts" (1978:451).

Binford (1978:451) limits his analysis to the Nunamiut use of caribou and sheep not because he has a particular interest in fauna or Arctic hunters, but because the relationship between the two provides a window into adaptive strategies and economic decision-making that is relevant to a wide range of human groups, past and present. Consistent with the processual emphasis on ecology and quantification, Binford (1978:74) measures the amount of meat, marrow, and grease associated with particular caribou and sheep body parts. He then applies these data to the construction of a general utility index (GUI) and modified general utility index (MGUI), which serve as quantitative scales of the food utility represented by different body parts. These indices are then used to evaluate how food utility affects Nunamiut strategies for carcass butchery, storage, and transport, and how strategies vary with season, location, and other

contextual factors. Binford (1978:496) suggests that the research tactics he employed among the Nunamiut result in a method for interpreting the behavioral and strategic meaning of archaeological faunal assemblages. Further, he argues that his analysis demonstrates how previously used interpretive methods were inadequate or inaccurate. Despite increasing recognition of the true complexity, and limitations, of applying utility indices in zooarchaeology (see Lupo 2006a for a recent overview), Binford's (1978) work remains a pillar of processual ethnoarchaeological literature.

Along with Binford, Watson is one of the archaeologists most often associated with processualism (see Watson et al. 1984), and a proponent of processually-based ethnoarchaeology. Watson's (1979a) archaeological ethnography of Laki farmers in Western Iran documents their material culture, manufacturing techniques, and subsistence patterns. She emphasizes these material and economic aspects of life as the most relevant to archaeologists, and presents extensive data as source material for the generation of hypotheses to be tested by archaeologists working in geographically similar situations (1979a:300). Thus, Watson seeks "to make a contribution to our knowledge of behavioral correlates for material culture" (1979a:8), and she suggests that behavioral-material linkages are possible even for relatively complex traits. For example, matrilineal residence, religious belief systems, and a cultural emphasis on private property all may have discernible material expressions (Watson 1979a:8). Watson's (1979a) study specifically focuses on the relationship between each village's social and economic patterns (behavioral correlates) and its spatial organization and house contents (material culture). She uses her resulting data to identify archaeologically-useful relationships between these variables and develops uniformitarian principles with broader

applicability. Watson (1979a:300) concludes that her Iranian data could aid the construction of explanatory models capable of addressing large-scale processes, such as the origins of food production in the Near East.

The ethnoarchaeological research outlined above illustrates how, by utilizing methods and terminology based in the natural sciences, processualism expands on the pre-existing methodological framework of science, and benefits from the interpretive power that this provides. Despite the successful application of processual research strategies, the objectives, methods, and basic assumptions of processualism increasingly became the subject of postprocessual critiques in the 1980's and 1990's.

Postprocessual Ethnoarchaeology

Postprocessualism, as applied to archaeological studies, is one facet of a larger body of theoretical viewpoints within the social sciences (Preucel 1995). The name "postprocessual" is an umbrella term to link archaeological theory with postmodernism and to suggest that it goes beyond processualism (Hodder 1985, 1986a). Fagan describes postprocessualism as "a convenient term that embraces an enormous range of different, and often transitory, theoretical approaches, as eclectic as those who propose them" (2006:83). These include contextualism (Hodder 1986a, 1987), later refined to interpretive archaeology (Hodder 1991; Preucel and Hodder 1996), critical archaeology (Shanks and Tilley 1987, 1989, 1992), and its specific aspects neo-Marxism (Leone 1982) and gender archaeology (Conkey and Gero 1991; Conkey and Spector 1984), among others. These influential works accuse processual archaeologists of minimizing or ignoring individual human agency that varies with gender, ethnicity, and many situationally-dependent social factors. From this perspective, processualism is viewed as

overly deterministic, functionalist, and not as objective as its scientific appearance suggests.

Postprocessualists view questions of human behavior from a perspective more closely associated with the social sciences or humanities than with the natural sciences favored by processualism. As the names of Hodder's (1982, 1986a, 1991) approaches imply, postprocessualists are generally more interested in context-specific principles, symbols, and interpretations than with cross-cultural processes. From this view, scientific explanations may be constructed, but they fall short of complete understanding, which can only be approached with reference to investigative bias, human agency, and specific historical contexts. Archaeologically, postprocessual critiques have attempted to limit the degree to which archaeologists inject their own biases into archaeological reconstructions, in essence "creating" a past that might never have existed (Tilley 1990:338).

David and Kramer (2001:54) note that ethnoarchaeology has been less influenced by postprocessualism than has archaeology as a whole. Postprocessual approaches to ethnoarchaeological research are so variable, in terms of theoretical emphasis and subject matter, that it is nearly impossible to briefly characterize postprocessual ethnoarchaeology beyond a shared emphasis on "exploring the symbolic dimensions of material culture" (David and Kramer 2001:54). Cunningham (2003:396) describes a postprocessual shift away from use of the term "ethnoarchaeology," which is too closely associated with the processual "core universals" of ecological, adaptive, and evolutionary processes. Alternatively, "material culture studies" (e.g., Conkey 1989; Hodder 1986b; Miller 1983, 1985) explore "how people construct their material worlds...Rather than an

adaptive response, culture and material culture are understood in relation to meaning” (Cunningham 2003:398). Thus, material culture studies are more in line with the postprocessual core universals of cultural and historical processes (Cunningham 2003:396). Shanks and Tilley praise the premise of material culture studies, but insist that:

The aim of a science of material culture, a science of the archaeological record, is a mistaken one, a futile search for scientific objectivity. As we hope to show, there can be no *objective* link between patterning perceived in material culture and processes which produced that patterning (1992:14).

Hodder’s (1982) *Symbols in Action* is an early and influential study of material culture. Hodder (1982:1) observes that archaeological cultures (geographically-bounded areas with recurring artifact types) do not always represent ethnic units. He questions the processual and behavioral explanation that shared material culture reflects high social interaction, and suggests that this hypothesis must be tested in ethnographic contexts. Concerning variability in material culture, Hodder asks, “Is the functional, adaptive viewpoint sufficient or are norms and beliefs perhaps also relevant?” (1982:11). In order to explore the nature of material culture in living contexts, Hodder (1982) conducted ethnoarchaeological research among pastoralists in the Baringo region of north central Kenya, Dorobo hunter-gatherers and Samburu pastoralists of the Leroghi Plateau, Kenya, Lozi farmers of Zambia, and Nuba farmers of Sudan.

Hodder’s (1982:155-161) description of domestic animal butchery and bone refuse clearly distinguishes his work from Binford’s (1978, 1981) processual approach to faunal analysis and its emphasis on the development of general utility indices. He writes:

The Nuba also know a lot about animal anatomy and the meat value of different parts of carcasses. But it would be insufficient to describe the Nuba use of animal resources in maximising and functional terms. The mundane practices of cutting up, eating and discarding animal products are enmeshed in a frame of meaning (1982:191).

Hodder (1982:160) argues that the difficulty of reconstructing these frames of meaning from archaeological evidence is not a result of limited data, but because relevant models have not been constructed. Without such models, based on context-specific principles, archaeologists' economic interpretations will be incomplete (Hodder 1982:161).

Hodder's (1982:211) analyses of pottery and metal production, decoration, and distribution lead him to conclude that material culture is not an adaptive response, or a passive reflection of economic aspects of life, but is "meaningfully constituted" in a ideological context. He describes contextual archaeology as an approach in which "emphasis is placed on the particular way that general symbolic and structural principles are assembled into coherent sets and integrated into social and ecological strategies" (1982:217). In contrast to the generalizing goals of processualism, Hodder (1982:228) acknowledges that his contextual approach is necessarily particularistic because the conceptual frameworks in which individuals behave and construct meaning are unique to each spatial and historical context. Thus, he argues that we can never predict consistent relationships between material culture and social behavior, only interpret the past based on our knowledge of contemporary symbolism and ideologies, since different meanings can be associated with material symbols in different contexts (1982:217).

Miller (1985) takes the same postprocessual material culture approach in his study of ceramic manufacture in Dangwara, India. Suggesting that most studies of artifact variability and categorization are dominated by technological and functional factors, Miller instead seeks to understand objects "in terms of the social relations which constitute their context" (1985:12). He proposes that understanding the processes which influence material variability can help us understand social variability. Miller writes:

“Pots are not ‘facts’ with unproblematic, measurable variability explicable in terms of general laws. Pottery is a ‘construct’; a part of the creation of a cultural environment...” (1985:13). In other words, ceramics are not just functional objects, but material manifestations of the social order. For example, in Dangwara, the specific, and highly variable characteristics of ceramic vessels are a means of distinguishing different castes and subcastes; as lower castes mimic the ceramic designs of higher castes, higher caste individuals demand new innovations in design to reinforce their distinct status. Yet when questioned about these “meanings,” informants denied them, and discussed pottery in trivial, practical, and functional terms (Miller 1985:192). Thus, material studies can supplement other ethnographic techniques. Miller (1985:203) argues that the dynamic nature of objects in the construction of culture is lost when, because artifacts are static, we assign them to categories of fixed meaning. Miller explains that his work is not intended to be an extended cautionary tale for archaeologists. In fact, he suggests that the wealth of information sources available to ethnographers (e.g., informant interviews) has led them to underestimate the potential of material culture studies to understanding past *and* present societies (Miller 1985:198).

David et al. (1988) conduct a similar material culture study of ceramics among Mafa and Bulahay horticulturalists of northern Cameroon, based on the simple question “Why are pots decorated?” They test the hypothesis that “pots are people,” or that pottery decoration and personal adornment are both cultural transforms that can be meaningfully compared to one another (David et al. 1988:365). Clearly, this prediction departs from the economic, adaptive, and ecological emphasis of processual hypothesis-testing. But from the postprocessual perspective, such questions are at least as relevant,

and answerable with archaeological data, as the behavioral-material correlates commonly pursued in processual ethnoarchaeology. David et al. show that Mafa and Bulahay pottery decoration is analogous to personal adornment, that similar decorative motifs are also seen in iron artifacts and village architecture, and that, together, these serve to symbolically express cosmological order, social order, and group identity. Thus, Mafa and Bulahay potters do not decorate ceramics as an arbitrary afterthought to practical concerns, or as “art for art’s sake,” but for complex social and symbolic functions (David et al. 1988:379). As a coincidental result of the symbolic roles of pot decoration in this living context, David et al. argue that “the structured system of ceramic types are likely to offer not only good but the best evidence of ‘ethnicity’ generally preserved in the archaeological record” (1988:378), a result of interest to all archaeologists regardless of theoretical orientation.

Despite the possibilities of postprocessual research illustrated by the selected studies above, postprocessualism has not replaced processualism, and there is substantial criticism of the application of postprocessual theory to archaeology (e.g., Binford 1987; Bintliff 1993; Watson and Fotiadis 1990; R. Watson 1990). In a review of postprocessual ethnoarchaeology, Stark (1993) accuses this approach of lacking adequate empiricism and methodological rigor, and of minimizing the value of cross-cultural comparisons. In response to postprocessual critiques of scientific objectivity, Stark argues, “If all observation is subjective...one must conclude that the symbolic system of meaning in an ongoing cultural system can never be understood” (1993:97). She further questions how competing ethnoarchaeological explanations can be evaluated without comparing them on empirical grounds. As with just-so stories, it is challenging to verify or generalize

beyond specific postprocessual interpretations (1993:97). Material culture studies provide cautionary tales by demonstrating the complex symbolic meanings of material objects in living societies, but Stark states that “Translating symbolic analyses from contemporary to prehistoric contexts is fraught with difficulty...” (1993:98). In summary, material culture studies face many of the same limitations as processual ethnoarchaeology. David and Kramer (2001:61) argue that cohabitation, if not synthesis, between processual and postprocessual ethnoarchaeologies is possible, and the following section explores this possibility.

Processual-Plus, Processual Pluralism, or a General Theory of Behavior?

The relationship between processualism and postprocessualism is sometimes caricatured as a struggle between a rigidly scientific philosophy and one that is unscientific, but this view is overly simplistic (see Cunningham 2003; VanPool and VanPool 1999). Postprocessualism has encouraged greater self-awareness and objectivity among processualists and helped limit simplified application of natural science methodology to the complexities of human behavior (David and Kramer 2001). Conversely, processualism has encouraged optimism about the degree to which the past can be known, and has effectively applied the proven methodology of science to questions of human prehistory (Redman 1991). Redman proposes that scientific archaeologists can devote more energy to understanding contextual relationships without engaging in “uncontrolled storytelling” (1991:301). Although many American archaeologists are “generally processual” or have “postprocessual leanings,” Hegmon (2003:216) argues that theoretical allegiance is not a defining issue. She suggests that postprocessual emphases of agency, gender, and meaning have been gradually

incorporated into the processual mainstream, creating a category best described as “processual-plus.” This compromise effectively combines processual objectives and methods with a greater awareness of postprocessual critiques. Relating this pragmatic approach to the application of general theory in ethnoarchaeology, David and Kramer write: “While we must strive towards in-depth understanding of particular examples of human cultural diversity, this need not conflict with ultimate comparative and generalizing goals” (2001:61).

In light of the diversity of goals, applications, and results discussed above, debate has centered on whether or not ethnoarchaeology would benefit from unification under a single body of general theory (Cunningham 2003; David and Kramer 2001; O’Connell 1995; Simms 1992). Simms (1992) suggests behavioral ecology as one general theory capable of guiding ethnoarchaeology beyond the criticisms of “obnoxious spectator” or “trivial pursuit,” and argues for an integration of middle-range and general theory, since general theory can profitably direct the development of middle-range questions. Comparably, O’Connell (1995) argues that ethnoarchaeology excels at middle-range research; specifically, documenting variable relationships between behavior and artifacts, but, without reference to a unified theoretical framework, it cannot explain or predict this variability. Along with others, he advocates the application of neo-Darwinian behavioral ecology to ethnoarchaeological studies, allowing them to test coherent, theoretically-derived predictions and generate more robust interpretations (Kelly 1995; O’Connell 1995; Simms 1992).

Others recognize the uses of general theory in ethnoarchaeology, but question the idea that it should be unified under a *single* high-level theory (Cunningham 2003; David

and Kramer 2001). David and Kramer characterize ethnoarchaeology as primarily a research strategy and suggest that “it may well be that different kinds of behavior are best explained by different theories” (2001:41), and they propose that scholars need only be explicit about what general theory is being employed in their research and why.

Cunningham (2003) argues that “processual pluralism” in ethnoarchaeology is preferable to unification within a theoretical framework, whether that framework is material culture studies, human behavioral ecology, or any other paradigm. He (2003:405) states that ethnoarchaeology should maintain its diverse middle-range focus and work with, rather than against, its diversity.

The methods and theoretical orientation of this dissertation have been shaped by many of the ethnoarchaeological contributions discussed above. While supporting the position of processual pluralism outlined by David and Kramer (2001) and Cunningham (2003), I agree with Simms (1992) and O’Connell (1995) that middle-range research is most effective when guided by general theory, and the theory most appropriate for the ecological and adaptive subsistence questions explored in this dissertation is human behavioral ecology. The strengths and weaknesses of this approach are discussed in the following section.

Human Behavioral Ecology

“In the contemporary ambience of anthropology, even cautious partisans of scientific knowledge aid themselves and the discipline by an occasional and reflective defense of its possibilities.”

Winterhalder and Smith 2000:65

Biological organisms are subject to, and shaped by, evolutionary processes. Evolutionary ecology makes interpretive use of this knowledge and is defined by Winterhalder and Smith as “the application of natural selection theory to the study of adaptation and biological design in an ecological setting” (1992:5). Hegmon (2003)

identifies evolutionary ecology, along with behavioral archaeology and Darwinian archaeology, as one of three clear-cut theoretical perspectives distinct from her “processual-plus” grouping, because of its explicit and consistent utilization of evolutionary theory. Human behavioral ecology (HBE) is simply the application of evolutionary ecology to human behavior (Bird and O’Connell 2006; Cronk 1991; Borgerhoff Mulder 1991; Shennan 2002; Simms 1987; Winterhalder and Smith 2000).

Although HBE has its roots in ecological studies of animal foraging behavior and reproduction (see Parker 2006 for a recent overview) and, particularly, cultural ecology (e.g., Steward 1955), it shares an emphasis on scientific methodology with processualism. Winterhalder and Smith (1992:11) describe evolutionary ecology’s use of the hypothetico-deductive method to address behavioral questions. According to this method, “The generation of theory or hypotheses is followed by processes of evaluation. Hypotheses are tested by experiment and observation and gain our respect by outliving the twin assaults of logic and evidence” (Winterhalder and Smith 1992:12). Archaeologically, HBE was first applied to subsistence questions, and this remains a primary focus, but Bird and O’Connell (2006:144) review a breadth of archaeological applications: resource transport, technological changes, material correlates of social status, social organization, development of social hierarchies, and the evolution of human life history.

HBE compensates for many of the limitations of ethnographic analogy and ethnoarchaeology discussed above. The greatest strength of evolutionary ecology is its applicability across cultures, environments, temporal periods, and even species. Gould asks, “What is it that holds true for past and present-day human behavior?” (Gould and

Watson 1982:365). HBE theory posits that the underlying relationship, or causal mechanism, necessary for the development of strong, relational ethnographic analogies is natural selection. HBE begins with the premise that humans, as biological organisms with a history of natural selection, tend to behave in ways that directly or indirectly maximize reproductive fitness. From this foundation, behavioral ecologists formulate testable hypotheses related to subsistence, reproduction, and a range of related economic and behavioral questions. The ways that context-specific case studies conform to or diverge from theoretically-derived expectations can be equally informative. Thus, HBE-derived analogies meet the criteria for strong analogies outlined by Wylie (1982, 1985). Further, HBE is flexible enough to adapt to the reality that modern foragers are not perfectly analogous to prehistoric ones, as noted by Stiles (2001). Blurton Jones et al. argue that “influences of neighbors and the global economy can easily be incorporated within the behavioral ecology approach. Neighbors modify the costs and benefits of alternative courses of action just as do flora, fauna, climate, geomorphology, and friends and relatives” (1996:184). Most importantly, HBE as applied to ethnoarchaeology transcends the description of behavior (i.e., cautionary tales and just-so stories) and seeks explanations of behavioral variability and its material consequences; explanations that may then be constructively applied to archaeological interpretation.

An important limitation of HBE, regardless of the context of its application, is that it cannot be universally applied to all anthropological questions. The foundation of HBE is the argument that humans will adjust behavior to maximize reproductive fitness and, from this basis, it is possible to develop expectations about many aspects of decision-making and behavioral variability. However, Bamforth (2002:438) cautions that

the frequently-employed theoretical linkage between Darwinian fitness and subsistence optimization (discussed in models below) is indirect and assumed. In addition, beyond economic choices, a vast number of decisions seem to have little direct connection to fitness; some may require the construction of more elaborate models, others may defy explanation within the realm of HBE. For example, the detailed symbolic and contextual understandings sought by Hodder (1982) are unlikely to be accessed via the hypothetico-deductive methods of HBE. Practitioners of HBE tend to be optimistic that models can be refined to explain a broader range of complex behaviors (e.g., Bird and O’Connell 2006:171; Simms 1992:192), while critics suggest that this approach is inherently limited to a narrow range of economically-oriented research (e.g., David and Kramer 2001:42; Schiffer 1999:167).

A primary focus of this dissertation is an assessment of taphonomic measures of resource depression and resource intensification in forager-produced faunal assemblages. The following sections review resource depression and intensification and HBE-derived models of human foraging that have been applied to the identification of these processes in the archaeological record. These foraging models set the stage for an optimality-based model of small prey processing intensity tested in Chapter 7.

Models of Optimal Foraging

“Foraging models are based on the premise that natural selection will favor organisms that obtain their food efficiently.”

Jones 1984:53

In developing models of forager subsistence, HBE makes frequent use of optimization analyses, to the extent that Bird and O’Connell (2006:144) accuse critics of viewing HBE and optimal foraging theory (OFT) as synonymous. Maynard Smith (1978) applied the concept of optimization to broad evolutionary ecology studies and, in

subsequent years, OFT (sometimes abbreviated as “foraging theory”) has been used to categorize a series of related subsistence models, all linked by their emphasis on optimality (see Bettinger 1991; Bird and O’Connell 2006; Foley 1985; Kaplan and Hill 1992; Lupo 2007; Smith 1983, 1987; Winterhalder 1981a for anthropological overviews of OFT, and Stephens and Krebs 1986; Sih and Christensen 2001 for general discussion). Optimal foraging models share four structural elements: they begin with a *goal* (sometimes referred to as an actor), they establish a *currency* with which to measure the degree of an organism’s success in attaining that goal, they include a set of *constraints* (any factors which serve to limit an organism’s choices), and they include a set of available *options* the organism may pursue to fulfill the goal. The underlying assumption of these models is that there is a relationship between reproductive fitness and foraging efficiency, and that this relationship shapes how organisms fulfill a goal.

In studies among human foragers, resource maximization or resource efficiency is usually the designated goal. Foragers are expected to procure the “optimal diet” from the range of available options. The optimality or efficiency of resources can be evaluated simply as the ratio of energy expended to energy acquired (using kilocalories as a currency) for a given resource. Constraints may be anything from extrinsic factors, such as the environmental scarcity of a favored resource, to intrinsic factors, such as a cultural food taboo prohibiting the consumption of a particular species. Options are the subsistence strategies available within the context being studied. This basic structure of *goal*, *currency*, *constraints*, and *options* has been greatly refined and elaborated upon in the related models discussed below: the prey choice model, patch choice model, and patch-derived marginal value theorem. Each emphasizes somewhat different variables,

but all proceed from the optimization framework outlined above. The theoretical basis, benefits and drawbacks, and anthropological applications of these models are introduced here, and explored further in the analyses Chapter 7.

The Prey Choice Model

Following Bird and O'Connell (2006:147), *prey choice model* is used here to refer to the “encounter-contingent prey choice model” developed by Emlen (1966) and sometimes referred to as the “diet breadth,” “basic prey,” or “optimal diet” model. As with most HBE-employed models, the prey choice model was first developed and tested by ecologists among non-human species (Emlen 1966, 1973; MacArthur and Pianka 1966; Maynard Smith 1974; Pulliam 1974; Schoener 1971; Stephens and Krebs 1986). Emlen (1966:611) states that the efficient exploitation of available food is vital to all animals, the value of food to an animal is determined by its caloric yield per unit of time, and that natural selection will favor individuals with feeding preferences that maximize efficiency. Based on these premises, Emlen (1966) devised a mathematical model of the role of time and energy in food preference. This model, now widely-known as “the prey choice model” defines the *search* and *handling* costs associated with specific resources and predicts whether an optimal predator will handle a particular resource when encountered or continue searching for a potentially more efficient resource. Search cost is the pre-encounter effort required to locate a resource. Handling costs include all energy expended during the post-encounter pursuit, capture, and processing of a resource. In order to gauge the relative value of resources, they are ranked in descending order of caloric efficiency (i.e., the ratio of energy acquired to energy expended).

Emlen's (1966) model posits that efficiency is maximized "when the post-encounter profitability of a selected item is equal to or greater than the expected overall foraging return rate, including search" (Bird and O'Connell 2006:147). The major predictions of the prey choice model are that the highest-ranked resource will always be taken on encounter, and progressively less-efficient resources will be incorporated into the diet in descending rank order "until the on-encounter return from the next lowest-ranked type falls below the expected return from searching for and handling all resources of higher rank" (Bird and O'Connell 2006:147). In other words, according to the prey choice model, an optimal predator will choose to take resources upon encounter until the benefit of doing so is outweighed by the perceived benefit of a continued search for higher-ranking items. Thus, resources are predicted to be included in the optimal diet not based on their own abundance or encounter rate, but as a function of the availability of higher-ranked resources. Consequently, diet breadth is expected to increase as encounters with high-ranking resources decrease, and this is why Emlen's model is often referred to as the "diet breadth model" (e.g., Kelly 1995). Emlen notes that, in reality, no animal has perfect judgment, but suggests "actual feeding behavior can be expected to approach this near optimal pattern...and, thus, the model can be used as a departure point from which to make testable predictions" (1966:613).

The prey choice model has since been used to explore human foraging behavior in a geographically diverse range of ethnographic settings (Hames and Vickers 1982; Hawkes et al. 1982; Hill and Hawkes 1983; Hill et al. 1987; O'Connell and Hawkes 1981, 1984; Smith 1991; Winterhalder 1981b). Kaplan and Hill (1992:173) discuss Winterhalder's (1981b) work among contemporary Cree foragers of Ontario, Canada as a

qualitative test of the prey choice model's diet breadth prediction. Winterhalder (1981b) compares the range of resources taken by early historic period Cree traveling by foot or paddled canoe to modern Cree who employ motorized transport. He writes: "The optimal diet breadth model produces the hypothesis that an increase in the efficiency of searching should result in a constriction of diet breadth. Snowmobiles and outboard motors provide that increase" (1981b:87). Thus, he expects contemporary Cree hunters to utilize a narrower range of prey. Winterhalder's (1981b:89) expectation is supported by observations of modern Cree hunters who consistently bypass historically-taken "low-priority species," usually small prey, such as beaver (*Castor canadensis*), in favor of continued search for larger moose (*Alces alces*).

Hames and Vickers (1982) provide an additional test of a qualitative prediction of the prey choice model; specifically, the expectation that diet breadth will increase as the density of high-ranked prey decreases. Their research among Siona-Secoya, Ye'kwana, and Yanomamö Amazonian societies shows that hunters do not kill prey species in direct proportion to their environmental abundance. Rather, there are selective factors, in addition to prey population densities that influence which species are taken (Hames and Vickers 1982:362). Hames and Vickers (1982:363) rank animal prey based on their dressed weight, with internal organs removed, but skin and bones intact. They acknowledge that "under ideal conditions one would use efficiency rank-order rather than weight rank-order" (1982:364; the validity of using animal size as a proxy measure of prey rank in archaeological contexts is discussed further below). To gauge the effects of hunting pressure and prey depletion on diet breadth, Hames and Vickers (1982) compare hunting behavior in the vicinity of older, intensively-occupied (and, they assume, more

depleted) settlements and new or distant (presumably less depleted) settlements. Their results indicate that hunters take a broader range of large and small game in areas of high hunting pressure, but in areas of low hunting pressure, small game are often ignored. In each recorded instance, the ratio of large to small prey decreased with increased hunting pressure (1982:373). Although Hames and Vickers' work represents a very general, qualitative test featuring a number of assumed relationships, it does support the prey choice model expectation that diet breadth will increase as encounters with high-ranking prey decrease.

In a preliminary quantitative test of the prey choice model, O'Connell and Hawkes (1981:99; also see O'Connell and Hawkes 1984) criticize the idea that human foragers, in contrast to other foraging species, take plant and animal resources in proportion to their environmental abundance, except when cultural factors, such as specific preferences or prohibitions, intervene. They use ethnographic subsistence data from modern Alyawara of Australia to test the hypothesis that "since seeds are expensive to take relative to their nutritional value, they should be used only when the returns from other resources are very low, regardless of their own absolute abundance" (1981:99). O'Connell and Hawkes (1981:109-110) estimate ranks for ten food items, then compare these against actual Alyawara foraging in two contexts: resource-abundant sandhill patches and resource-poor mulga woodland. As predicted by the prey choice model, in the sandhill patches, only the three highest-ranking resources were taken. Many species of seeds, despite being the most abundant resources, were ignored. However, seeds were also ignored in the mulga woodland, a context in which, based on energetic efficiency, they *should* be taken by an optimal forager. O'Connell and Hawkes (1981:110) suggest

that their combined results from both locations better fit the expectations of the model when the costs of manufacturing and maintaining seed processing gear are included with handling costs.

Ethnographic research among Aché foragers of eastern Paraguay (Hawkes et al. 1982; Hill and Hawkes 1983; Hill et al. 1987) examines whether each resource utilized by the Aché increases overall return rates, as predicted by the prey choice model. Kaplan and Hill (1992:174) explain that the first published results of this research (Hawkes et al. 1982), based on four months of field observations, are consistent with the model's quantitative predictions; Aché foragers only took resources for which the post-encounter return rates were greater than the average foraging return rate. Ethnographically, resource rankings in prey choice studies may include all *possible* resources, but more often are limited to all resources that ethnographers observe being used, or are identified as food resources by a particular foraging group. In this case, resource abundance was measured based on observed encounter rates, not census data of all available plant and animal species (Hawkes et al. 1982:388).

Later research (Hill and Hawkes 1983; Hill et al. 1987) examines Aché decision-making in finer detail by sub-dividing data by gender and specific subsistence activities. Evaluated separately, male hunting behavior is consistent with the prey choice model; the nine animal prey hunted by Aché men increased their overall hunting return rate (Kaplan and Hill 1992:175). Hill and Hawkes (1983) also document differences in prey choice resulting from different hunting methods. Analyses indicate that small birds and monkeys fall above the "efficiency threshold" (based on average hunting return rate) for bow hunters, but below this threshold for hunters using shotguns. In fact, Aché men

hunting with bows pursued these prey, while shotgun hunters almost always ignored them (Hill and Hawkes 1983:170).

In addition, Hill et al. (1987) demonstrate variation in foraging decisions based on the seasonal condition of specific prey. Armadillos (*Dasyus novemcintus*) may be encountered above ground or in subterranean burrows. Aché informants stated that it is not worthwhile to dig armadillos from their burrows in the early wet season because “they are not yet fat enough” (Hill et al. 1987:26). Data reveal that the mean weight of an adult armadillo increases by 20% from the beginning to the end of the wet season, and during the early wet season, armadillos fall below overall mean foraging returns (Hill et al. 1987:26). Kaplan and Hill write: “By ignoring armadillos in burrows when they are lean and pursuing them when they are fat, Aché men appear to have been maximizing their average hunting return rate” (1992:175-176).

Each of the above results matches the quantitative predictions of the prey choice model. However, Kaplan and Hill (1992) also report ways that the behavior of both Aché men and women deviates from expectations derived from the model. Men maximized caloric efficiency per unit time for animal prey, but not total caloric production, because they frequently ignored plant foods that would have increased average foraging return rates (Kaplan and Hill 1992:176). Conversely, Aché women focused on plant resources at the expense of more energetically-efficient animal prey (Hurtado et al. 1985). Overall, these Aché data illustrate the general accuracy of the prey choice model in predicting resource usage, but also the complexity of interrelated variables that influence prey choice in an actual ethnographic context.

Smith (1991:205-207) elaborates on some of the simplifying assumptions of the prey choice model, and ways that the model can be adapted to more accurately reflect human foraging. First, prey items are usually individual animals, but in some cases may be collective groupings. For example, a dip net full of smelt is better viewed as a prey item than each individual fish (Smith 1991:205; the archaeological implications of mass collecting are discussed in detail below). It is convenient to consider plant and animal species as distinct prey types, but intraspecies variability (e.g., the age and sex of animals or ripe vs. unripe fruit) may be relevant. Prey ranks may shift over time. For example, Aché armadillos vary meaningfully by season (Hill et al. 1987). A minor assumption of the model is that foragers immediately and accurately identify prey items upon encounter (Smith 1991:206; Stephens and Krebs 1986). Further, it is assumed that search and handling time are mutually exclusive. In reality, particularly among human foragers, it is conceivable that resources will be encountered in the process of searching for other resources, shifting the dynamics of the pursuit (Hill et al. 1987:17-18; Smith 1991:206). Finally, the prey choice model assumes a “fine-grained” encounter with prey types; It assumes that all prey are sought simultaneously, are distributed in a random sequence, and are encountered individually (e.g., finding an individual animal does not increase the odds of finding additional animals of the same type). Smith (1991:206-207) argues that very few, if any, hunter-gatherers search for and encounter the complete range of resources in their diet in such a simple manner, and the prey choice model must be selectively and judiciously applied, as he does by quantifying prey choice *within* specific hunt types as “patches.” Such assumptions limit the applicability of the model (Smith

1991:206), and ultimately prompted the development of related models, such as the patch choice model discussed below.

Before moving into quantitative assessments of prey choice, Smith (1991:209-213) explores whether long-term patterns of Inujuamiut prey choice are consistent with the qualitative expectations of the prey choice model. He observes that several environmentally-abundant plant and animal species are virtually never exploited by modern Inujuamiut foragers. Acknowledging that their avoidance may be attributable to “symbolic constructs defining what is edible or acceptable” (1991:210), Smith instead predicts that these ignored resources will be low-ranking when evaluated. Surprisingly, walrus (*Odobenus rosmarus*) and harp seal (*Pagophilus groenlandicus*), relatively large and seemingly “high-ranking” sea mammals are on Smith’s list of rarely or never taken species (1991:210). Smith notes that walrus were heavily hunted in the past, but no longer are, raising the question of why they dropped out of the diet. Inujuamiut informants explained that traveling to islands where walruses are available requires expensive diesel-powered boats, when walruses concentrate in these locations in the fall, water travel is dangerous and time-consuming, and historically, walrus meat was primarily fed to sled dogs, which are no longer used. Most of these explanations can be viewed as expressions of increased search costs, although the context-specific influence of feeding sled dogs would be difficult to predict with a general model (Smith 1991:211). Smith (1991:212) has no quantitative data on harp seal exploitation, but informants suggest that seals are too fast (high pursuit cost) and they will often ignore them when encountered for this reason.

Other resources commonly used by Inujjamiut in the past, but not the present, include mussels, sea urchins, seaweed, and berries. Smith (1991:212) documents that the mollusks are energetically inefficient, but cautions that people will eat them occasionally as a traditional delicacy. Again, this specific preference would likely be beyond the reach of generalized optimality models. However, Smith (1991:212) also notes that shellfish are much more likely to be pursued when weather prevents more efficient subsistence activities. Seaweed and berries have been supplanted by imported fruits and vegetables, effectively altering traditional Inujjamiut resource rankings. Seagulls and lemmings are both calorically inefficient and “undesirable.” Smith argues that “the common sense account – ‘Why waste time on lemmings when better game is afoot?’ – only replicates optimal foraging logic at a more intuitive and imprecise level” (1991:213). Most long-term changes in Inujjamiut diet are consistent with the qualitative predictions of the prey choice model.

Smith acknowledges that a true ethnographic test of the prey choice model requires detailed quantitative data on encounter rates and search and handling times. Arguing that these variables can shift over relatively short time periods, Smith (1991:214-227) examines short-term Inujjamiut prey choice sub-divided by specific types of hunts, with hunt type defined based on season, technology employed, and target prey. Since each hunt type (or “patch”) has a fine-grained encounter pattern, Smith (1991:207) argues that application of the prey choice model is appropriate. Within each hunt type, Smith tests the prediction that “foragers take only prey types that have a handling efficiency greater than the mean return for all higher ranked types” (1991:214). With seven different hunt types: summer canoe hunts, fall canoe hunts, canoe ptarmigan

hunts, winter caribou hunts, spring goose hunts, jig/goose hunts, and lake ice jig hunts, Smith effectively provides seven distinct tests of his hypothesis. Within these tests, the prey choice model accurately predicted diet breadth for four of the seven hunt types and 19 of 23 prey types. But this summary is misleading since Smith reports that the cases in which apparently sub-optimal prey were included in the diet can be explained by the unique circumstances of each hunt type. Such contextual specificity cannot be accounted for by general models, but Smith (1991:236-237) argues that only one hunt type is a possible falsification of the hypothesis – and in this case, evidence indicates that a more representative sample of jig/goose hunts would support the prey choice model. Considering these results, and the necessity of special explanations for specific circumstances, Smith concedes that the model is not infallible, but, “Given the present evidence, the fine-grained model would seem to be the best tool for explaining hunter-gatherer prey choice yet devised” (1991:237).

The Patch Choice Model and Marginal Value Theorem

The patch choice model shares many basic attributes with the prey choice model, but it attempts to correct for the prey model’s “fine-grained encounter” expectation (MacArthur and Pianka 1966; Stephens and Krebs 1986). Kelly (1995:90) notes two potentially problematic assumptions with this expectation: 1) it assumes that resources are uniformly or homogeneously distributed across the landscape and encountered in proportion to their abundance, and 2) it assumes that foragers search randomly. Lupo (2007:149) reiterates that ethnographically-documented foragers often violate the fine-grained assumption by exploiting specific microhabitats for particular resources, often selecting participants and appropriate technologies in anticipation of encountering those

resources. The patch choice model accounts for the fact that “if environments are sufficiently patchy, foragers may alter their return rate by spending more time searching specific portions of a habitat” (Kaplan and Hill 1992:178). MacArthur and Pianka (1966), emphasizing these factors, developed an ecological model in which optimal predators encounter resources in patches or clumps. This model predicts that patches are exploited in decreasing order of the expected search and handling return rates of resources within them. Importantly, travel time to a given patch is evaluated as a search cost, which leads to the prediction that a nearby relatively low-ranked patch may be exploited before a more distant higher-ranked one. However, as with the prey choice model, the patch choice model assumes that resource patches are encountered sequentially and randomly in proportion to their environmental frequency, that foragers do not return to patches until those patches return to full pre-encounter profitability (complete patch rejuvenation), and that travel time between patches is non-productive (Kelly 1995:90-91).

Smith (1991:250) distinguishes between patch *choice* and patch *use* and states that the MacArthur and Pianka (1966) model addresses only patch choice because it predicts which resource patches will or will not be utilized, but does not discuss resource depletion within those patches. Referring to MacArthur and Pianka’s (1966) work, Charnov and Orions write: “What is left out of this model is any method of deciding how much time to spend in any patch” (1973:72). Smith (1991:251) argues that, since the model makes no predictions about patch use, the most reasonable assumption is that resources in a patch are harvested at a constant rate until the patch is completely depleted. But, presumably, foragers also make choices that maximize their *within-patch* return rate

once a patch is chosen. To account for this limitation of the patch choice model, Charnov (1976) formally introduced the marginal value theorem. He observes that “The predator must make decisions as to which patch types it will visit and when it will leave the patch it is presently in” (1976:129). Charnov’s marginal value theorem directly addresses the question of patch use by predicting that foragers will leave a patch when its resource return rate drops below the average for the environment as a whole. In other words, it predicts that foragers will abandon a resource patch at a point of diminishing returns that may occur before the patch is entirely depleted.

Kelly (1995) suggests that there are no true ethnographic tests of the patch choice model because human foragers choose where to forage in advance, rather than encountering patches in a random sequence, as depicted in the model. However, anthropological studies (e.g., O’Connell and Hawkes 1984; Smith 1991) have addressed the patch choice model’s qualitative prediction that “foragers should choose the highest-return-rate patches given their environmental knowledge” (Kelly 1995:92). Kelly (1995:94) also states that the marginal value theorem cannot be fully tested in ethnographic contexts, since the data required are too complex (i.e., return rates for all potential patches and mean travel time between patches) and the theorem’s assumption that travel time is non-productive is frequently contradicted by human foragers. Nevertheless, the logic of the marginal value theorem has been used to investigate patch use among hunter-gatherers (e.g., Hawkes et al. 1982; Hill et al. 1987; Smith 1991; Winterhalder 1981b).

Winterhalder’s (1981b) research among contemporary Cree foragers investigates aspects of the patch choice model and marginal value theorem. Winterhalder’s data

contradict the patch choice assumption that travel between patches is non-productive. Viewing patches in the literal sense, as spatially-bounded resource habitats, Winterhalder notes that prey species move from patch to patch and “in these instances the Cree forager, rather than seeking to locate the animal within a patch, searches instead for tracks located between patches” (1981b:90). His observations of Cree hunting indicate that the abundance of game in a particular forest patch is an imperfect predictor of patch choice, since Cree take note of specific contextual factors not accounted for by the model. For example, Cree hunters avoid forest with thick vegetation for fear of making noise and scaring away prey (Winterhalder 1981b:90). However, Cree foraging behavior does provide qualitative support for the marginal value theorem, since foragers leave patches before they are completely depleted of the resources being sought (Winterhalder 1981b:91).

Hawkes et al. (1982) apply the patch choice model and marginal value theorem to understanding why Aché foragers consistently stop hunting upon encounter of oranges and honey, but ignore palm trees in favor of continued search. To answer this question, Hawkes et al. (1982) evaluate individual resources as patches. For example, palm trees may be envisioned as resource patches that include palm hearts, fiber, and fruit. They write: “If game animals are conceptualized as a patch, optimal foragers will exploit that patch in preference to patches with lower average returns and leave it for patches with higher average returns” (1982:392). Based on this logic, the game animal patch represents an average return rate of 1115 calories per hunter-hour, and hunters should bypass resources with lower average returns in favor of continued hunting, but “abandon the hunting patch” upon encounter of resources with higher average returns. In reality,

oranges have extremely low search and handling times, producing an average return rate of 4438 Cal/hr., so an optimal forager *should* leave the hunting patch for the orange patch. Similarly, honey results in an average return rate of 3231 Cal/hr., and is predicted to be chosen over continued hunting. However, the resources of the palm patch (hearts, fiber, and fruit) require greater search and handling time, resulting in a rate of 810 Cal/hr. Thus, the marginal value theorem accurately predicts Aché patch use when resources are evaluated as patches (Hawkes et al. 1982:392-394). In this case, Kelly (1995:96) notes that the marginal value theorem is used to predict patch abandonment by balancing one resource against another, rather than against the average for the environment as originally defined by Charnov (1976).

O'Connell and Hawkes (1984) use the prey choice model to examine why Alyawara women choose to collect the breadth of resources that they do, and the patch choice model to determine why men hunt in some areas while ignoring equally-accessible locations. Since Alyawara choice of hunting locations and return rates vary depending on mode of transportation (on foot vs. motorized vehicle), they evaluate each type of hunt separately. O'Connell and Hawkes (1984:520) calculate return rate as kilograms procured per hour of search and pursuit, and conclude that the patch choices of pedestrian hunters are consistent with the goal of maximizing their rate of energy capture. This holds true for most of their study period, but data from the summer season are insufficient to make any conclusions about pedestrian patch choice. Among motor vehicle hunts, the most frequently-visited hunting location produced a significantly higher average return rate than 11 locations that were visited less frequently, although data were limited for some of these patches (O'Connell and Hawkes 1984:523). Overall, the results of

O'Connell and Hawkes' (1984) Alyawara research meet the patch-choice expectation that foragers will choose the highest-return-rate patch available.

Smith (1991) applies the patch choice model and marginal value theorem to Inujjamiut time allocation at three levels: 1) marine and terrestrial habitats, 2) sea-ice, saltwater, freshwater, and terrestrial patches, and 3) the hunt types introduced in the prey choice section. Each level of analysis is informative about Inujjamiut subsistence decisions, demonstrating the flexibility of the model. He shows that Inujjamiut foragers tend to choose habitats and patches that maximize return rate at a particular time of year, and that this pattern holds if data are grouped by month or season (1991:259-269). Similar to Hawkes et al.'s (1982) use of individual resources as patches, Smith argues that "in a somewhat broader meaning, patch and patch type need not refer to spatially bounded areas, but could be any well-defined entities with characteristic return functions" (1991:249). He suggests that Inujjamiut time allocation is best understood when distinct hunt types, rather than habitats or literal resource patches (saltwater, freshwater, etc.) are viewed as patches. When data are grouped by season, Inujjamiut hunters choose the hunt type with the highest return rate, as predicted by the patch choice model (Smith 1991:269).

Sosis (2002) shares Kelly's (1995) concern about the lack of ethnographic data for a thorough test of the patch choice model. Citing previous studies of patch choice (e.g., Beckerman 1983; O'Connell and Hawkes 1984; Smith 1991), he questions why human foragers in these case studies do not exclusively exploit the patch with the highest mean profitability. In other words, once the highest-return-rate patch among available options is identified, and assuming it is not depleted, why do foragers exploit additional

patches? Kaplan and Hill observe “Foragers sometimes appear to be scheduling short-term patch use in relation to changing return rates, but often there is little information to assess this possibility” (1992:184). Sosis (2002:583) suggests that daily fluctuations in environmental conditions may alter the mean return rates of patches, and that this daily variation is not captured by sample averages over longer periods of time. To correct for this, Sosis (2002:587) collected complete and continuous data on all fishing activities of Micronesian Ifaluk fishers over a 75-day period. His data demonstrate that Ifaluk fishing is a probabilistic subsistence activity with high variance in daily success, and fishers attempt to choose the “best patch” in response to a wide range of ever-changing environmental cues such as wind patterns, tide strength, bird behavior, and the success of the previous day’s catch (Sosis 2002:596).

Sosis (2002) illustrates the complexity and short-term flexibility of human subsistence decisions, and the difficulty of consistently predicting this behavior with simple foraging models. In addition, ethnographic research has shown that foraging choices may be influenced by the age and sex of individual foragers (Bird and Bliege Bird 2000; Hawkes et al. 1995; Hurtado et al. 1985; Jochim 1988; Lupo and Schmitt 2002, 2005) and non-consumptive benefits such as social or political advantage or mating opportunities (Bliege Bird and Smith 2005; Hawkes 1990, 1991; Hawkes et al. 1991; Lupo and Schmitt 2004; Smith 2004; Smith and Bliege Bird 2000; Sosis 2000; Wiessner 2002). Each of these factors complicates the prediction of human prey and patch choice, even in contemporary settings. The following section reviews the application of these models to the archaeological record.

Foraging Theory and the Archaeological Record

The greatest strength of HBE, and its emphasis on the causal role of natural selection in shaping human behavior, is that evolutionary models of foraging are applicable to present *and* past humans. But, as evidenced by the challenges of testing these models among living foragers, it is clear that archaeological data are not sufficiently detailed for direct quantitative tests of prehistoric prey or patch choice. Foragers' estimates of search and handling costs vary in response to a number of specific localized variables, and individual foraging goals, which may change on a day-to-day basis. Thus, the biased sample of material remains, and coarse temporal resolution of the archaeological record generally do not reflect such short-term subsistence decisions. Nonetheless, the logic of foraging models, employed in analyses of resource depression and intensification, can be used to identify and explain broad spatial and temporal trends in prehistoric resource use.

Resource Depression

“A common but not universal consequence of the foraging activities of a predator is a lowering of capture rates with prey in its immediate vicinity...we term this phenomenon ‘depression’...”
Charnov et al. 1976:247

Foraging theory explores the ways that an optimal forager behaves in a dynamic context of options and constraints. Resource depression is an example of how the pursuit of short-term efficiency can, over time, lead to long-term constraints, and ultimately behavioral changes and the development of new options. As such, it is a fascinating phenomenon capable of shedding light on foraging adaptations. Charnov et al. (1976:247) elaborated on resource depression and its ecological consequences because, at the time of their writing, depression was widely recognized in ecological field studies, but rarely included in formal ecological theory. They define different types of resource

depression and stress that predators need not actually harvest prey species for depression to occur; the mere presence of a predator species could affect prey behavior (behavioral depression) and alteration of prey microhabitats (microhabitat depression) could force prey to leave. Both may be sufficient to decrease encounter rates between predator and prey. Thus, the process of depression may be evaluated with reference to any predator-prey relationship, one significant difference being that humans alter environments more extensively than other species. Charnov et al. (1976:247) refer to depression resulting directly from predation as “exploitation depression,” a process that reduces prey *abundance*. Alternatively, prey *availability* may decrease without significant declines in overall prey numbers.

Archaeological applications usually characterize resource depression using a variation of “declines in the capture rates of prey that result from the activities of foragers” (Broughton et al. 2007:374). Most (e.g., Broughton 1994b; Nagaoka 2002a) explicitly state that forager “activities” are not limited to hunting. For example, Butler collectively categorizes exploitation depression, behavioral depression, and microhabitat depression as “human-caused resource depression” (2001:96). To these, Betts and Friesen add two non-human causes: “*Ecological depression* is related to changing environmental conditions, which ultimately result in increased prey mortality...[and] *territoriality* of competing predators can negatively affect encounter rates, effectively resulting in a resource depression” (2006:74). Although both processes can decrease prey availability, they are not consequences of foraging activity and, arguably, do not meet the traditional definition of resource depression. Byers and Broughton (2004)

suggest the alternate term “anthropogenic depressions” to distinguish human-caused depressions from environmentally-caused depressions.

In recent years the concept of resource depression has been widely explored in archaeological contexts (Betts and Friesen 2006; Broughton 1999, 2002; Broughton and Bayham 2003; Broughton et al. 2007; Butler 2000, 2001; Byers and Broughton 2004; Cannon 2000, 2003; Hildebrandt and McGuire 2002, 2003; Lyman 2003; Nagaoka 2002a, 2002b; Ugan 2005). However, identifying resource depression, anthropogenic or otherwise, in the archaeological record requires different methods than those employed by ecologists, since we cannot directly observe prehistoric prey capture rates. Using reasoning extrapolated from foraging theory, this is often achieved by seeking evidence of the *effects* of resource depression, as reflected by intensification and zooarchaeological evidence.

Resource Intensification

“Other things being equal, a rise in population density should result in two simultaneous processes – intensification of existing strategies and diversification into new strategies.”

Earle 1980:20

Foraging theory has increasingly been applied to identifying depression-related declines in foraging efficiency and associated resource intensification (Lupo 2007:160). Boserup (1965) is credited with introducing the concept of resource intensification to studies of human subsistence and, specifically, relating agricultural change to population pressure. She (1965:12) explains the classical economic view that there are two ways to increase agricultural output: by expanding into new fields or cultivating existing fields more intensively. Although this basic formulation has been applied to archaeological interpretations (see Earle 1980 quote above), Boserup sees it as too simple for explaining agricultural change. She argues that, in terms of land use intensification, farmers may

increase the total energetic output of a parcel of land, but at the cost of disproportionately higher energy expenditure, resulting in a short-term net energy loss (measured as reduced output per man-hour; Boserup 1965:43). But Boserup (1965:118) concludes that sustained agricultural intensification can eventually lead to *both* increased production and increased efficiency (greater output per man-hour) in the long term. This conclusion sets Boserup's idea of intensification apart from its use in HBE-informed archaeological studies.

Beyond agricultural studies, evidence of prehistoric resource intensification among hunter-gatherers has been sought in a variety of archaeological settings (Beaton 1991; Betts and Friesen 2004; Broughton 1994a, 1994b, 1997, 1999; Butler and Campbell 2004; Dean 2007; Janetski 1997; Milner et al. 2007; Nagaoka 2006). Boserup's (1965) definition of intensification is frequently cited, but her long-term expectation of increased production *and* increased efficiency is usually unstated in archaeological applications (but see Butler and Campbell 2004:336). For example, Broughton defines resource intensification as "a process by which the total productivity per areal unit of land is increased at the expense of an overall decrease in foraging efficiency" (1994a:501). In this usage there is no expectation that resource intensification will ultimately lead to greater efficiency. As used in most archaeological applications, resource intensification is an attempt to extract more energy from a suite of resources or patch of land with a consequential decline in energetic efficiency, and the framework of foraging theory, paired with zooarchaeological data, can be utilized to explain changes in the efficiency of resource use through time.

The Zooarchaeology of Resource Depression and Intensification

The occurrence of prehistoric resource depression and intensification have been supported by multiple lines of zooarchaeological evidence including changes in the taxonomic composition of faunal assemblages, prey mortality profiles, skeletal part profiles, and taphonomic damage to bones (Lupo 2007). Many archaeological studies (e.g., Broughton 1999; Butler 2001; Janetski 1997; Nagaoka 2002a, 2002b) rely on the logic of the prey choice model to examine and interpret efficiency, but, as opposed to ethnographic studies, doing so requires determining prey ranks for species without observing the actual search and handling costs associated with them. Broughton (1994a:502) suggests that when return rates cannot be directly measured, prey size is the most common and straightforward proxy measure of prey rank. This generalized relationship between prey size and energetic efficiency is supported by ethnographic (Hawkes et al. 1982; Winterhalder 1981b) and experimental studies (Simms 1987), but there are notable exceptions. For example, researchers have long recognized that mass collecting may alter the traditional rule that singly acquired larger-sized prey are more efficient and thus higher-ranked than smaller-sized prey (Grayson and Cannon 1999; Jones 2006; Lupo and Schmitt 2002; Madsen and Kirkman 1988; Madsen and Schmitt 1998; Ugan 2005). On the opposite end of the size spectrum, the handling costs of extremely large animals, such as whales, may negatively impact their rank (Byers and Ugan 2005; Jones 2004), making them less efficient than smaller prey with lower handling costs. Further, Stiner and colleagues (Stiner 2001; Stiner and Munro 2002; Stiner et al. 1999, 2000) demonstrate that ranking prey by size alone can obscure significant trends in resource use, since similarly-sized prey may have very different

acquisition costs. For small prey, characteristics such as “catchability” as determined by prey speed and predator avoidance mechanisms, and prey population resilience may be equally relevant (Stiner et al. 2000:56; also see Bird et al. 2009). Stiner et al. (2000) document a shift from slow and sessile species such as tortoises and shellfish in the Middle Paleolithic to quicker birds and hares in the Upper Paleolithic of the Mediterranean Basin – a subsistence transition that would not have been discernible with rankings based solely on prey size. Finally, ranking prey by size can be difficult for species with great intraspecies size variation, such as highly sexually dimorphic pinnipeds (Lyman 2003).

Among the central tenets of the prey choice model is the expectation that foragers respond to declines in the abundance of highly-efficient resources by expanding the diet to include a broader range of less-efficient resources. As discussed previously, Hames and Vickers (1982) report a link between increased diet breadth/inclusion of smaller less-efficient prey and hunting pressure/prey depletion among modern Amazonian foragers. Thus, diet expansion may be viewed as a sign of resource depression and intensification. Archaeologically, trends in diet breadth are most often identified by quantifying taxonomic diversity within a faunal assemblage and making comparisons to assemblages from other temporal or spatial contexts. For example, Broughton (1994a) documents a decline in high-ranking large terrestrial vertebrates and a simultaneous increase in various lower-ranking freshwater fishes in late Holocene faunal assemblages from California’s Sacramento Valley. He attributes this shift to exploitation depression of high-ranking fauna and subsequent intensification, or more intensive use of available animal prey.

Variation in the taxonomic composition of zooarchaeological assemblages is commonly measured with abundance indices and taxonomic diversity as indicated by richness and evenness (Lupo 2007). Abundance indices are expressed as a ratio of representative large to small prey, and are a simple way of expressing patterns in prey size. For example, the artiodactyl index, which divides the number of artiodactyl specimens by the number of artiodactyl specimens plus the number of lagomorph specimens, is a well-known example used to gauge the degree to which zooarchaeological assemblages are dominated by large deer in comparison to smaller rabbits (e.g., Muir and Driver 2002; Potter 1995; Szuter and Bayham 1995). Similarly, Butler (2000) utilizes a fish index to calculate the ratio of large to small fishes as one way of exploring prehistoric resource depression along the Columbia River of Pacific Northwest North America. The generality of abundance indices allows bone specimens not identified to species (i.e., those classified only as “artiodactyl” and “lagomorph”) to be included in analyses.

Taxonomic richness and evenness are more specific measures (see Lyman 2008:172-213 for a recent summary). Richness is quantified as NTAXA (or Σ TAXA), the number of taxa (species or broader grouping) represented in an assemblage. One drawback of this measure is that richness is heavily influenced by sample size, and it is important to determine if variation in richness reflects meaningful differences in diet breadth or just varying sample sizes (Grayson 1984). Evenness indicates how evenly specimens are distributed among taxonomic categories, and there are multiple methods for quantifying evenness (Jones 2004). Richness and evenness are often examined together since richness alone may exaggerate the “diversity” of an assemblage in which

many taxa are represented by relatively few specimens (Grayson 1984; Schmitt and Lupo 1995).

Abundance indices, richness, and evenness are used in zooarchaeological analyses to approximate diet breadth. But, just as prey size is not perfectly equivalent to prey rank, zooarchaeological abundance indices and taxonomic diversity are not perfect measures of diet breadth. Analyses of taxonomic diversity typically focus on faunal remains and do not evaluate archaeological evidence of plant resources, creating an incomplete picture of prehistoric diet breadth. Also, each measure proceeds from the assumption that archaeological abundances of different taxa reflect their encounter rates in a living environment, but decades of research demonstrate that assemblages may be shaped by preservational bias, taphonomic history, sample size, data recovery methods, quantification methods, and space and time compression (Lupo 2007:157). Thus, despite being a valuable line of evidence, it cannot be assumed that faunal remains provide a flawless picture of prehistoric encounter rates. Further, patterning in abundance indices and diversity measures used to infer intensification (i.e., declines in large prey combined with an increase in smaller prey), do not unequivocally demonstrate exploitation depression (Lupo 2007:161), because the relative abundance of small prey may increase without substantial changes in the encounter rates of larger prey (Butler and Campbell 2004:338; Grayson and Cannon 1999:148).

Prey mortality profiles are another line of evidence used to identify resource depression and intensification, although the meaning attributed to patterning in age profiles varies considerably between different prey types (Lupo 2007:162). Broughton (2002:64) notes that increased harvesting pressure can decrease the mean and maximum

age of animals represented in archaeofaunal assemblages, since sustained preferential harvesting of larger and older individuals can deplete them, skewing the population toward smaller, less-energetically-efficient individuals. Among species that grow throughout their lifespan, this may be evident as a trend of decreasing size (Lupo 2007:162), which may be shown with bone measurements (e.g., Broughton 1997, 2002; Stiner et al. 2000). However, among some species, depression can have the opposite effect, leading to an increase in the mean age of harvested prey (Broughton 2002:64). Broughton (2002:65) explains that intensified use of prey with high-density, seasonal breeding colonies, such as pinnipeds and waterbirds, can lead to colony abandonment and the loss of both high-return patches and a major source of sub-adult animals. In addition, Broughton (2002:65) suggests that among spatially-segregated ungulates (divided into male groups and female-young groups), and assuming that females with attendant young are more sensitive to predation risk, increased predator density should decrease the relative abundance of female and sub-adult individuals. Both patterns reflect intensification-related increases in the mean age of exploited animals. Broughton argues that, although declines in mean age are “the default prediction of resource depression” (2002:64), variation in the behavior and spatial distribution of specific prey species must be considered as part of the interpretation of prey mortality profiles.

Skeletal part profiles are an additional avenue of archaeological investigation used to complement the taxonomic and age/sex composition of faunal assemblages. Just as assemblage diversity and prey mortality profiles can indicate declines in efficiency, the logic of central place foraging theory predicts that resource depression and intensification affect prey transport decisions, and may alter body part representation in

zooarchaeological assemblages (Lupo 2007:163). The central place foraging model, first presented by Orians and Pearson (1979), models foraging decisions with an emphasis on travel time to and from a specific point. As opposed to the prey and patch choice models, resources or patches of resources are ranked according to the ratio of energy acquired to travel *and* handling times (Bettinger 1991:96). Central place foraging models depict foraging trips with both a starting point and destination, and have been employed to explore the relationship between transport decisions and field processing of plant and animal resources in experimental (modeled by Metcalfe and Barlow 1992; Barlow and Metcalfe 1996), ethnographic (Bird and Bliege Bird 1997; Lupo 2006a; Thomas 2002), and archaeological contexts (Bettinger et al. 1997; Bird et al. 2002; Cannon 2003; Zeanah 2000). Lupo (2007:163-164) explains that in depressed environments foragers begin to exploit resource patches that are farther from their residential base (“extending into new fields” as Boserup 1965:12 phrased it). With increasing travel distances, hunters are expected to show greater selectivity in the body parts of large game they choose to transport back to their residential location. As a result, resource depression and intensification may be marked by fewer, but more high-utility, skeletal parts at residential camps (Broughton 1999; Cannon 2003; Nagaoka 2005; Speth and Scott 1989). A significant limitation of this approach, and one especially relevant to the present analysis of Central African prey, is that smaller animals may be transported whole, providing no evidence of selective transport.

Taphonomic damage, in the form of cut mark frequencies and bone fragmentation patterns, has been proposed as another index of intensification (Broughton 1999; Gould 1996; Munro and Bar-Oz 2005; Nagaoka 2005; Potter 1995; Quirt-Booth and Cruz-Uribe

1997). A subsidiary expectation, derived from combined elements of the patch choice model and marginal value theorem, is that human foragers respond to declines in higher-ranking prey by processing and consuming acquired resources more intensively. This expectation is based on the rationale that prey processing can be conceptualized as time spent in a patch, and optimal foragers should spend more time in a patch when high-ranking patches are rare in the environment (Burger et al. 2005; Fancher et al. 2003; Nagaoka 2006). Whether increased processing intensity is taphonomically discernible, and what specific patterns may result is a question that remains to be fully explored.

Binford (1988) suggests that cut mark frequencies are a function of a butcher's investment in meat and tissue removal, and that greater butchering intensity should produce more cut marks. Broughton (1999) reports an increase in cut mark frequency on large artiodactyl bones recovered from archaeological strata associated with other zooarchaeological evidence of resource intensification. However, others have cautioned that a consistent relationship between processing intensity, tool strokes, and cut mark frequency cannot be assumed without a more comprehensive understanding of these variables (Egeland 2003; Lyman 1992, 1995, 2005). Binford (1978) also proposed that marrow processing of low-utility skeletal elements is a sign of resource intensification, since the effort required to remove the small amount of marrow from these elements is only justified in times of resource stress. Taphonomic evidence of marrow processing has been used to examine spatial and temporal variability in prey processing intensity with informative results (Broughton 1999; Grayson and Delpeche 2003; Munro 2004; Nagaoka 2005; Quirt-Booth and Cruz-Urbe 1997). In addition, patterns of bone fragmentation indicating grease extraction may reflect intensification since this process

requires a great investment of processing time with relatively little caloric reward (Church and Lyman 2003; Lupo and Schmitt 1997).

Resource depression and intensification are issues with broad ecological and anthropological relevance, but zooarchaeologists are particularly interested in the ways that we may identify subsistence shifts and the specifics of carcass utilization from faunal remains. Consequently, later chapters examine in depth: the optimality of small prey use in ethnographically observed Central African contexts, the application of foraging models to resource depression and intensification in these contexts, and taphonomic evidence of processing intensity among ethnoarchaeological collections of small fauna.

Small Fauna in Archaeology and Taphonomy

“The role of small game is often neglected in models of human hunting, yet these prey species supply much of the meat consumed by some hunting societies, particularly in tropical regions.”

Hudson 1991:106

“researchers should pay more attention to this generally ignored class of faunal remains. Small mammal fauna of sub-Saharan Africa is both abundant and diverse...”

Yellen 1991b:152

This dissertation is primarily an analysis of the taphonomic characteristics of small-sized prey, but prey size classifications vary geographically depending on the range of animals represented (e.g., Brain 1981; Bunn 1982; Klein 1989; Potts 1988; Thomas 1969). Depending on context, there is substantial variation in the application of relative size descriptors, such as “small,” “medium,” and “large” prey, making general comparisons based on these qualitative terms difficult. The present study focuses on Central African prey previously divided into small (< 10 kg), medium (10-25 kg), and large (> 25 kg) size categories, based on live weight (Lupo and Schmitt 2005; Schmitt and Lupo 2008). Compared to general classification schemes that include much larger prey, even the largest Central African prey are relatively small (very few prey species

exceed 25 kg, and most weigh less than 10 kg). Many analyses designate small mammals as those weighing less than approximately 20-25 kg (Jones 1984; Landt 2007; Lupo and Schmitt 2002; Nicholson 2005; Yellen 1991a), and for the purposes of this discussion, “small” refers to prey with live weights below this range, unless otherwise specified. This threshold has practical and interpretive relevance, since Yellen (1991a:6) defines small prey, in his case those weighing less than 21 kg, as those that can be comfortably carried by a single adult.

Small Mammals in Archaeology

The last 25 years have seen progress in small mammal taphonomy and an ever-increasing appreciation of the importance of small prey in prehistoric human subsistence, but there is much that remains to be clearly understood. Jones (1984:88) comments that, despite the presence of small animals in archaeological contexts and their documentation as food resources in ethnographic settings, the specifics of small animal acquisition, treatment, and disposal have received little archaeological attention. The archaeological emphasis on larger prey has been attributed to a number of theoretical and methodological biases (Jones 1984; Stahl 1982; Yellen 1991a). Jones refers to this as “the big bone bias” (1993:105). Yellen writes: “It is surprising and perhaps best explained by our own cultural preconceptions, that small mammals have received such short shrift in the paleoanthropological literature” (1991a:1). In the context of early hominids, Yellen (1991a:1-2) suggests that the desire to understand the behavioral capacity of extinct hominids has contributed to the research emphasis on large mammal hunting, which is presumed to require more technological skill and social coordination than small mammal procurement. However, in other contexts, archaeological

explorations of technologically- and socially-sophisticated cooperative small prey hunting provide compelling insights into the subsistence behavior of modern humans (e.g., Driver 1990; Lupo and Schmitt 2002; Shaffer and Gardner 1995; Stiner et al. 2000). Another cultural preconception, formalized in the optimal foraging models described above, is the idea that large, high-ranking prey are usually more efficient to procure and process, and are assumed to be fundamentally more important to hunter-gatherer subsistence.

The bias that small mammals are dietarily insignificant is particularly strong against the very small rodents and insectivores (ranging from 4-354 g live weight; Alden et al. 1998) discussed by Stahl (1982; also see Stahl 1996). Yet Stahl highlights several attributes of these mammals that make them beneficial to humans: they have small home ranges (and tend to be attracted to human settlements; Linares 1976), high reproduction rates, low acquisition and processing costs, and a relatively high edible meat to live weight ratio (1982:823). Unfortunately, in some cases, processing costs are so low because small rodents can be consumed whole, leaving no zooarchaeological trace (Stahl 1982:826). The possibility of complete consumption of bone by non-human carnivores (e.g., Hudson 1990, 1993), and the resulting potential for under-representation of small prey, is another problem inherent in taphonomic studies of small fauna. Jones states: “In general, small animal bones are less likely to survive ravaging by animals, water, and physical and chemical weathering than are those of larger animals” (1984:108).

Even when the remains of small rodents and insectivores survive to enter the archaeological record, Stahl (1982:826) argues that traditional techniques of recovery and interpretation are biased against them. Shaffer (1992a; Shaffer and Sanchez 1994)

demonstrates that $\frac{1}{8}$ "-mesh screens are substantially more effective than $\frac{1}{4}$ " screens in the recovery of bones from small mammals similar in size (18-340 g) to those investigated by Stahl. Thus, excavations employing $\frac{1}{4}$ " screens inadequately recover these bones and their value to environmental and dietary reconstruction is diminished (Shaffer and Sanchez 1994:528). The work of Shaffer and Sanchez (1994) highlights the dual use of small animal bones, even those from archaeological contexts, as sources of behavioral, but more often, environmental data. Small rodents are abundant and particularly susceptible to subtle variation in climate and vegetation, making them excellent paleoenvironmental indicators (e.g., Avery 1982; Grayson 1993, 1998, 2000; Schmitt 2004; Schmitt et al. 2002). As valuable as small animals are for ecological studies, Jones (1984:88) is concerned that their relegation to this "secondary position" in archaeological interpretation diverts attention from their analysis as food resources. In fact, most taphonomic analyses of small mammals have focused on the many ways these bones are modified by non-cultural processes.

Non-Culturally Accumulated and Modified Small Mammal Bones

The historical reticence to viewing small animal bones as food refuse stems, at least partially, from the difficulty of disentangling subsistence-related small mammal remains from natural deaths and assemblages accumulated by non-human predators (Jones 1984:89). Stahl (1982:826) observes that the presence of small mammals in archaeological contexts is often attributed to "accidental inclusion," leading them to be overshadowed by larger mammals of more straightforward cultural origin. Shaffer (1992b:683) adds that, unless they are found in human coprolites or exhibit unequivocal evidence of human modification (both unlikely), the bones of burrowing rodents

especially are classified as intrusive. But there is good reason to question taphonomic history because small mammal bones are particularly subject to accumulation and introduction to archaeological contexts by the activities of rodents, mammalian carnivores, and raptors (Lyman 1994:193-216). Further, Jones (1984) notes a lack of established criteria for distinguishing between cultural and non-cultural small animal bone, but in the years since his dissertation, this situation has been improved by numerous studies clarifying the taphonomic characteristics of small mammal assemblages produced by non-human agents (Andrews 1990; Andrews and Evans 1983; Cruz-Uribe and Klein 1998; Fernández-Jalvo and Andrews 1992; Fernández-Jalvo et al. 1998; Hockett 1989, 1991, 1994, 1995, 1996, 1999; Kusmer 1990; Schmitt 1995; Schmitt and Juell 1994; Shaffer 1992b).

Rodent bones frequently enter archaeological deposits via natural death, but rodents can also be active agents of bone transport and accumulation. For example, an experiment conducted by Hoffman and Hays (1987) in a cave inhabited by eastern wood rats (*Neotoma floridana*) indicates that this species is capable of moving small bones (0.3 – 100 g) up to 5 m across the cave floor and 1-2 m vertically. Both have obvious implications for spatial and temporal interpretations, but Hoffman and Hays' (1987) experiment is mainly a cautionary tale, providing no means of identifying wood rat transport. Hockett (1989) provides maximum dimensions (54.5 g, 1.1 cm wide, and 29.5 cm long) of bones that may be transported by bushy-tailed wood rats (*Neotoma cinerea*), and suggests that the possibility of wood rat transport can be eliminated for bone fragments that exceed one of these measurements. Lyman (1994) argues that wood rat

distribution of small bones should be considered in contexts where wood rat nests or bones are present, or there is evidence of rodent gnawing on bones.

Southern African crested porcupines (*Hystrix africaeaustralis*) and common porcupines (*Erethizon dorsatum*) of North America both accumulate and extensively gnaw on mammal bones (Brain 1980, 1981; Dixon 1984), but Andrews reports that “Since the main function of bone collecting by porcupines seems to keep their incisors in good condition rather than as food, it does not seem likely that small mammal [< 5 kg] bone could serve any useful purpose from the porcupine’s point of view” (1990:7). It is possible that porcupines could transport the bones of small prey (> 5 kg, < 25 kg), but Brain’s (1981) study indicates that they prefer the bones of larger taxa.

Andrews and Evans (1983) provide a wealth of descriptive data on small mammal bones recovered from the scats of three families of mammalian carnivores: canids (fox and coyote species), mustelids (weasel, marten, and polecat), and viverrids (mongoose and genet). They define small mammals as those weighing less than 5 kg, and further subdivide these into class a (0-100 g), class b (100-1000 g), and class c (1-5 kg; 1983:292). Andrews and Evans note that the repeated use of latrine areas by carnivores can produce concentrations of small mammal bone, but that the taphonomic characteristics of these specimens differs from those produced by owls or humans (1983:289). Patterning in prey size (classes a-c), skeletal element representation, extent of bone breakage, digestive corrosion, and tooth marks varies in recognizable ways between the scats of different carnivores, allowing Andrews and Evans (1983) to establish criteria for distinguishing these agents in fossil assemblages. For example,

Andrews and Evans (1983) and Fernández-Jalvo et al. (1998) apply these criteria to the interpretation of small mammal bones from Pleistocene deposits at Olduvai Gorge.

In another study of small mammal accumulation by mammalian carnivores, Schmitt and Juell (1994) provide a detailed taphonomic analysis of coyote (*Canis latrans*) scatological fauna from the Great Basin. These scats contain a range of prey sizes (Classes I-IV, after Thomas 1969), but are dominated by Class III leporid bones (Schmitt and Juell 1994:251). Schmitt and Juell (1994; also see Hockett 1999) describe patterns of breakage, and corrosive pitting, polishing, and staining of these bones on an element-by-element basis. This source of diagnostic data can be used to distinguish small mammal bones accumulated by coyotes from those of other predator species, including humans.

The collection and deposition of small mammal bones by birds, particularly owls (Andrews 1990; Dodson and Wexlar 1979; Kusmer 1990), eagles (Cruz-Uribe and Klein 1998; Hockett 1996; Schmitt 1995) and other raptors (Hockett 1991, 1995; Hoffman 1988; Mayhew 1977), has been more extensively investigated and documented than other non-human agents. Owls regurgitate pellets of undigested material at least twice a day (Kusmer 1990:629) and, over the course of time, can contribute substantial numbers of small mammal bones to caves and rockshelters where they often roost (Lyman 1994:198), as well as to open-air sites (Hockett 1995:223). Andrews (1990:5) notes that owls usually swallow small rodents whole, and bone breakage in owl assemblages is usually less than that of other predators. Another result of owls' consumption of whole rodent carcasses is that most skeletal elements of these prey are represented in owl assemblages (Dodson and Wexlar 1979; Kusmer 1990). Since owl pellets are

regurgitated food remains, and do not pass completely through the digestive tract, the bones they contain are generally less corroded than carnivore scatological remains (Andrews 1990; Hockett 1991; Kusmer 1990).

Both owls and other raptorial species consume larger prey such as lagomorphs (e.g., Hockett 1994; Schmitt 1995) and hyraxes (*Procavia capensis*; Cruz-Uribe and Klein 1998), but because these animals cannot be swallowed whole, they must be torn apart with beaks and talons, producing much more bone breakage, and loss of skeletal elements (Andrews 1990:4). Hockett (1991) specifically distinguishes between taphonomic patterning on leporid bones deposited in archaeological contexts by humans and those recovered from raptor pellets and nests. His results suggest that raptors create more cottontail (*Sylvilagus* sp.) than jackrabbit (*Lepus* sp.) diaphysis cylinders, bones with diagnostic beak and talon punctures and shearing damage, and high frequencies of juvenile and forelimb specimens. In contrast, human-produced assemblages are characterized by more jackrabbit diaphysis cylinders (also see Hockett and Haws 2002), occasional cut-marked bones, burned bone fragments, and higher frequencies of adult specimens (Hockett 1991:667). Hockett's (1991, 1994, 1995) analyses of lagomorph remains differ from most small mammal taphonomic studies by exploring human-produced patterning in addition to damage caused by other predators.

Culturally Processed Small Mammal Bones

One result of non-cultural taphonomic studies, and the comparative data they have generated, is that the examination of archaeological small prey as food resources is more productive. Rather than considering the bones of small fauna intrusive or non-cultural by default, analysts now have the tools to evaluate the impact of various non-human

predators on small mammal assemblages. But Schmitt et al. (2001) caution that, because far more time has been spent examining assemblages produced by non-human predators, inferences about culturally-produced small mammal bones are largely based on indirect processes of elimination. In other words, we have gradually expanded our knowledge of what human-produced assemblages *do not* look like, but Jones' statement that "archaeologists do not know what to expect in culturally produced small animal faunal assemblages" (1984:88) still applies. This is particularly true regarding the specific relationships between human small mammal processing and taphonomic damage patterns, a problem made more challenging by the fact that small mammals appear to rarely be damaged in obviously cultural ways (Landt 2007).

Resource intensification can result in greater dietary expansion, a dietary significance of smaller prey (or different types of small prey: e.g., Stiner and Munro 2002; Stiner et al. 2000), and more intensive processing of acquired prey; yet data on small mammal processing are relatively rare (but see Domínguez-Rodrigo and Barba 2005; Hockett and Bicho 2000; Hockett and Haws 2002; Jones 1983, 1984; Nicholson 2005; Speth 2000; Tamplin et al. 1983; Yellen 1991a, 1991b). As a result, we have few methods for knowing how humans process small fauna. By extension, methods of recognizing processing intensity among animals of this size have not been established, leaving zooarchaeologists little choice but to refer to larger prey as imperfect sources of small prey processing expectations.

Approaching the study of small fauna, especially when one has a background in large mammal taphonomy, requires an extensive re-evaluation of assumptions. Much of the conventional wisdom of zooarchaeology is derived from large mammals, yet studies

have demonstrated that applying the logic of large mammal processing to smaller prey is misleading at best (Andrews 1995; Tamplin et al. 1983; Wlodarski 1982). When examining small mammals, we immediately lose some of the traditional tools of zooarchaeological analysis. Skeletal part profiles and utility indices – in fact transport studies in general – have limited usefulness when dealing with small fauna. The most obvious reason for this is the fact that complete small mammal carcasses can be, and in many ethnographic cases are, transported whole (e.g., Hill and Hawkes 1983; Lee 1979; Turnbull 1965; Yellen 1991a). Even if some level of field butchery does occur, minimal bone is discarded at the site of the kill as the weight of these bones does not preclude carrying by humans (Lupo and Schmitt 2005:344).

Countless studies have confirmed that small mammals are hunted using different technologies and different techniques than larger prey (see Kelly 1995 for an overview). The fact that small mammals are processed in fundamentally different ways than large mammals, while recognized by most, has received less analytical attention (Jones 1984; Yellen 1991a). Given our incomplete knowledge of small mammal butchery, and limited data, we cannot assume that large mammal studies are directly applicable in all cases, and that the only meaningful difference in how carcasses of different sizes are processed is scalar. Additional theoretically-guided case studies of small prey utilization are necessary to understand the range of processing strategies that exist. This dissertation, based on ethnoarchaeological data collected in the Central African Republic, is one contribution.

Conclusion

This dissertation is an ethnoarchaeological case study of small mammal processing by Central African forest foragers and its zooarchaeological consequences in forager-produced faunal assemblages. It explores questions derived from human behavioral ecology, tests them against data collected in this specific context, and discusses broader implications for the interpretation of small animal bones in the archaeological record. Each chapter represents a contribution toward these goals.

Given the importance of examining human behavior in well-understood spatial and temporal contexts, Chapter 2 introduces Washington State University's Central African ethnoarchaeological research project and provides a detailed description of the study area's environmental history, modern ecology, and the prehistory of rain forest hunting and gathering as revealed by previous archaeological research in Central Africa.

Chapter 3 introduces the Bofi and Aka, contemporary forest foragers of the Central African Republic, with an emphasis on their subsistence pursuits and economic relations with neighboring horticultural villagers, and the treatment of animal prey from capture to consumption.

Chapter 4 discusses research methods, from the collection of the Central African small mammal assemblage bones in the field to their zooarchaeological and taphonomic analysis in the laboratory.

The benefits of understanding small prey use in prehistory are increasingly recognized, but specific data on small prey processing and taphonomic patterning are limited (with exceptions previously noted). Chapter 5 contributes to the literature by describing the taphonomic characteristics of culturally-produced damage (burning, cut

marks, chop marks, and fracture patterns) for all prey species contained in the assemblage.

Chapter 6 explores the Central African collections in a global context, comparing them to a range of other ethnographic, experimental, and archaeological studies, with an emphasis on the role of prey size in determining taphonomic damage patterns.

Chapter 7 draws on the foraging models introduced in the first chapter to compare evidence of resource depression and intensification between two contemporary Central African villages. The aspects of these models most relevant to analyses of prey processing intensity are reviewed and applied to the investigation of two basic questions: 1) How are processing behaviors recorded on the bones of small prey? 2) How can zooarchaeologists quantify variation in small prey processing intensity? The remainder of the chapter discusses the relationship between resource intensification, processing intensity, tool marks, and bone fragmentation patterns in these ethnoarchaeological faunal assemblages.

The eighth chapter summarizes the preceding chapters. Collectively, the analyses of these chapters demonstrate that prey processing decisions are strongly influenced by archaeologically-identifiable variables such as ecological context, technology, cooking methods, prey anatomy, and prey size. Well-balanced zooarchaeological interpretations must account for the interplay between these variables. Chapter 8 also presents final conclusions and suggestions for future research in taphonomic studies of small prey. Most importantly, the behavioral interpretation of small fauna requires a fundamental re-evaluation of assumptions, because conventional wisdom and theoretical expectations are so often developed from studies of larger animals.

2. ENVIRONMENT AND PREHISTORY OF THE STUDY AREA

Introduction

Archaeological analyses seek to document and explain human behavior in well-understood spatial and temporal contexts. This chapter sets the stage for the analyses of subsequent chapters by introducing the project and study area. I then review the regional environmental setting, late Quaternary development of rain forest and savanna ecosystems, prehistory of rain forest occupation, and recent history of Central African forest foragers.

Washington State University Ethnoarchaeological Project in the Central African Republic

The Washington State University ethnoarchaeological project in the Central African Republic was initiated by Karen D. Lupo and Dave N. Schmitt in 1999. Research was conducted among foragers and farmers in the villages of Grima and Ndele, both located in the 10,000 km² Ngotto Forest (Brugiere and Sakom 2001) of the Lobaye region of the southwestern Central African Republic (Figure 2.1). Within the Forest is the 3250 km² Ngotto Forest Reserve, which lies between the Lobaye and Mbaere Rivers, and is jointly managed by Ecosystèmes Forestiers d’Afrique Centrale (ECOFAC) and logging companies (Schmitt and Lupo 2008). To the south, the 872 km² wedge-shaped integral reserve area between the Mbaere and Bodingue Rivers has been proposed as a national park for the conservation of biodiversity (Brugiere et al. 2005; Chatelain and Brugiere 1999).

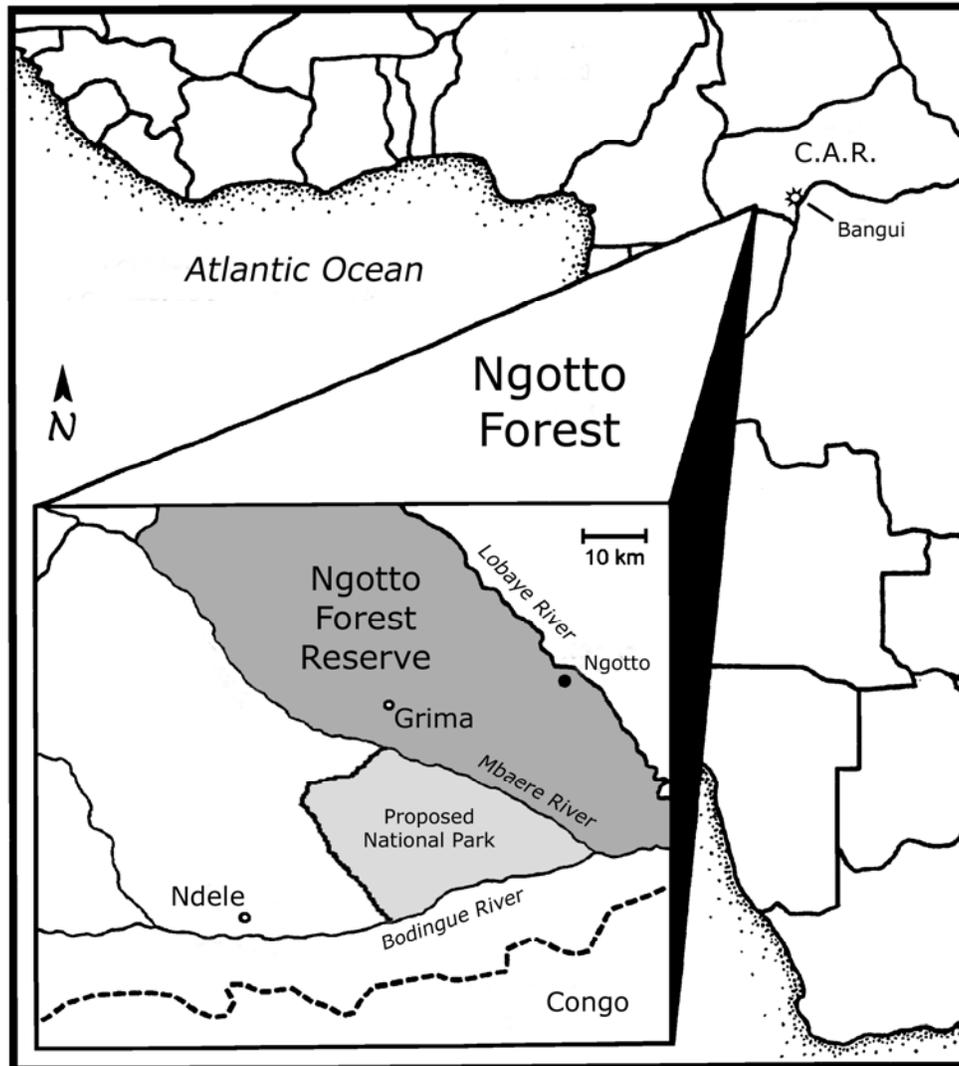


Figure 2.1. Map of study area showing Ngotto Forest and villages of Grima and Ndele, Central African Republic (adapted from Schmitt and Lupo 2008).

The Ngotto Forest is home to three closely-related forager groups: The Bofi, Aka, and Bolemba (Bahuchet 1990a; Hewlett 1996b; Hudson 1990; Kitanishi 1998; Lupo and Schmitt 2004; Noss 1995). Project members worked among Bofi and Aka foragers (detailed in Chapter 3), but not Bolemba, whom Hewlett (1996b:1) describes as a linguistically-distinct, relatively small group living around the village of Bogbaya. In the past, these groups were collectively referred to as “pygmies.” Noting the derogatory

nature of “pygmy,” Hewlett (1996a) suggests the alternate term “forest forager,” which is used throughout the present work.



Figure 2.2. Forager family and household in Ndele, Central African Republic.

The broad goals of the WSU ethnoarchaeological project are to investigate cooperative small mammal hunting, butchery, and consumption, meat sharing, forager-farmer interaction and socioeconomic status, and the material consequences of these behaviors as reflected in zooarchaeological and taphonomic patterning in collected bone assemblages. Several of these research objectives have been pursued in previous project-related publications (Landt 2004, 2007; Lupo in press; Lupo and Schmitt 2002, 2004, 2005; Schmitt and Lupo 2008) and presentations at professional meetings (Fancher 2005, 2006a, 2006b; Fancher et al. 2003; Lupo 2006b; Schmitt et al. 2001).

Rain Forest Ecology

“Conrad’s ‘green hell’ is better characterized as a ‘biodiversity paradise’ whose host of habitats is grossly oversimplified on a general map...Underestimating the forest’s diversity and overestimating its isolation leads to a flawed understanding of the interaction between forest dwellers and their habitats.”

de Maret 2005:421

This section introduces the ecology of the Central African rain forest and summarizes the late Quaternary environmental record of the region. The term “tropical rain forest” encompasses a diversity of forest types spanning the equatorial regions of the globe, and many scholars (e.g., Colinvaux and Bush 1991; de Maret 2005; Vansina 1990) caution against minimizing the regional variability and complex histories of specific forests. The southwestern Central African Republic (CAR) study area is located on the northern edge of the Guineo-Congolian forest, near its border with the Guinea-Congolia/Sudania regional transition zone (Boulvert 1986; White 1983:38; Figure 2.3). The core of this forest is geographically described as the Congo Basin, a broad, but relatively shallow (250-480 meters above sea level) depression in a plateau (Grainger 1996) and the presence of Congo River tributaries, notably the Oubangui River which forms part of CAR’s southern border.

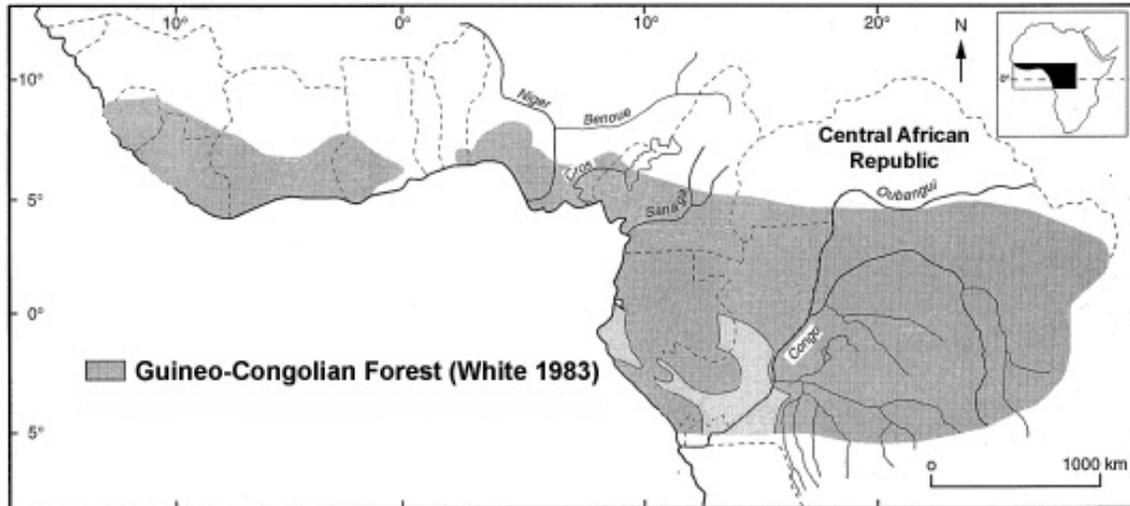


Figure 2.3. Geographic extent of the Guineo-Congolian Forest.

Modern Environment

The Guineo-Congolian Rain Forest

The Guineo-Congolian rain forest currently has the greatest diversity of plant species on the African continent, although it contains fewer species and is generally more arid than comparable rain forests in South America and Southeast Asia and this makes it anomalous. The Guineo-Congolian forest receives an average of between 1600 and 2000 mm of annual rainfall (White 1983:72). In the northern hemisphere portion of the forest, which encompasses our study area, most of this rain comes from the Atlantic during summer months and average temperatures are conducive to rain forest growth, oscillating between 23°C and 27°C (Vansina 1990:38). White classifies the southwestern CAR vegetation zone as “drier Guineo-Congolian rain forest” (1983:74-75). This zone is characterized as “drier” because it receives less precipitation (1200-1600 mm annually) than the Guineo-Congolian average, but is nevertheless a rain forest because it is marked by high relative humidity during the dry season (White 1983:76).

Table 2.1. Common tree species of the drier Guineo-Congolian rain forest (White 1983:79).

<i>Azelia africana</i>	<i>Khaya grandifoliola</i> ^b
<i>Aningeria altissima</i>	<i>Mansonia altissima</i>
<i>Aningeria robusta</i>	<i>Morus mesozygia</i>
<i>Aubrevillea kerstingii</i>	<i>Nesogordonia papaverifera</i> ^a
<i>Canarium schweinfurthii</i>	<i>Piptadeniastrum africanum</i>
<i>Celtis mildbraedii</i>	<i>Pterygota macrocarpa</i> ^a
<i>Celtis zenkeri</i>	<i>Ricinodendron heudelotti</i>
<i>Chlorophora excelsa</i>	<i>Sterculia oblonga</i> ^a
<i>Chrysophyllum perpulchrum</i> ^c	<i>Sterculia rhinopetala</i> ^a
<i>Cola gigantea</i> ^a	<i>Terminalia superba</i>
<i>Hildegardia barteri</i> ^a	<i>Trilepisium madagascariense</i>
<i>Holoptelea grandis</i>	<i>Triplochiton scleroxylon</i> ^a

^aMember of family Sterculiaceae, ^bMeliaceae, and ^cSapotaceae.

Table 2.1 lists commonly-occurring tree species for the drier Guineo-Congolian rain forest as a whole. Many scholars (e.g., Bahuchet 1978, 1988, 1992a; Grainger 1996; White 1983) stress the heterogeneity of Congo Basin rain forests, frequently referring to them as mosaics or juxtapositions of microenvironments largely determined by the life-cycles of canopy trees. As trees fall, they create gaps in the forest canopy, which, in turn, allow new species to spring up in the undergrowth. This process drives the rapidly-shifting, patchy spatial patterning of the forest (Bahuchet 1992; Bahuchet and Guillaume 1982; Hallé et al. 1978; Hladik 1982, 1990; Oldeman 1974). White (1983:76) adds that drier Guineo-Congolian forest is classified as deciduous or semi-deciduous, but is essentially evergreen since various species only briefly lose their leaves at different times during the dry season. As a result, this semi-deciduous forest is sometimes referred to as “drier peripheral semi-evergreen rain forest” (White 2001:15). Individual trees of the

same species may also lose their leaves at different times and most trees are never completely bare.

Table 2.2. Principal grass species of the secondary grassland (White 1983:85).

<i>Andropogon gayanus</i>	<i>Imperata cylindrical</i>
<i>Andropogon schirensis</i>	<i>Loudetia arundinacea</i>
<i>Andropogon tectorum</i>	<i>Loudetia phragmitoides</i>
<i>Brachiaria brizantha</i>	<i>Loudetia simplex</i>
<i>Ctenium newtonii</i>	<i>Monocymbium ceresiiforme</i>
<i>Hyparrhenia diplandra</i>	<i>Panicum phragmitoides</i>
<i>Hyparrhenia familiaris</i>	<i>Pennisetum purpureum</i>
<i>Hyparrhenia nyassae</i>	<i>Pennisetum unisetum</i>
<i>Hyparrhenia rufa</i>	<i>Schizachyrium sanguineum</i>
<i>Hyparrhenia subplumosa</i>	

Areas at the northern and southern peripheries of the Guineo-Congolian region, such as southwestern CAR, are drier, more likely to be affected by cultivation and fire, and are more likely to be intermixed with secondary grassland (White 1983:84). Table 2.2 lists grass species that occur frequently in these transitional rain forest/savanna zones. Savanna ecosystems, and especially forest-savanna mosaics, are characterized by the co-dominance of trees and grasses, and the amount of canopy tree cover is a major determinant of ecosystem properties (Sankaran et al. 2005). In these settings, grasses and trees compete for soil nutrients and water, with the proportion of tree to grass cover varying according to precipitation levels and soil moisture. Sankaran et al. (2005:486) consider arid or semi-arid savannas, with an average of less than 650 mm mean annual precipitation, stable systems, in which rainfall is insufficient to allow closed rain forest to dominate. Savannas with greater than 650 mm mean annual precipitation, including those in southwestern CAR, are unstable, and rainfall is sufficient for canopy closure, but

open grasslands may be sustained by fires, herbivores, or human activity (Sankaran et al. 2005). In fact, maintenance of savanna boundaries using controlled burning has been documented in many ethnographic contexts (Cosgrove et al. 2007; Hill and Baird 2003).

Dry savannas are those with average rainfall of less than 1000 mm per year or easily draining soils. In contrast, wet savannas receive more than 1000 mm rainfall per year, or are located on poorly draining soils (Barham and Mitchell 2008:147). Another definition states that dry savannas have 5-7 dry months annually, whereas wet savannas have only 3-5 dry months (Encyclopedia Britannica). Based on these distinctions, the savanna patches within our study area are classified as wet savanna. The food resources of forest and savanna zones utilized by modern forest foragers are discussed in the following chapter.

Environmental Variation Within the Ngotto Forest: Grima and Ndele

The Central African villages of Grima and Ndele are relatively close together (~40 km apart) within the Ngotto Forest and greater Guineo-Congolian forest, but there are some environmental and contextual differences between these two study locations relevant to the analyses of later chapters. The Ngotto Forest receives approximately 1600 mm of rain annually, mostly during the March-October rainy season (Brugiere et al. 2005:507), and the entire area covered by the forest is classified as semi-deciduous forest (Boulvert 1986). A recent ECOFAC-sponsored study identified a total of 315 tree species within the boundaries of the Ngotto Forest (Yongo 2003). Lejoly (1995) states that the Ngotto Forest has less representation of the tree family Sterculiaceae and more of Meliaceae and Sapotaceae (Table 2.1) than other forests of CAR. See Réjou-Méchain et

al. (2008:Appendix 1) for a comprehensive list of southwestern CAR tree species and relative abundances based on logging company inventories.

According to Goudie (1996), southern CAR is located at the transition of two climatic regions. The northern periphery of the study area near Grima is “tropical wet climate with short dry spells” characterized by 3-5 dry months, a greater range of temperatures than fully wet forests, and high precipitation and temperatures. Hewlett (1996b:2) describes Grima as a mixed forest-wet savanna ecological setting. To the south, nearer Ndele, is “tropical wet climate” which features some rain in all months and high temperatures year-round (Goudie 1996:37). White (1983) defines vegetation zones that approximately correspond to the climatic zones of Goudie (1996). The village of Grima is located near the boundary separating White’s “Mosaic of Guineo-Congolian rain forest and secondary grassland” and “drier Guineo-Congolian rain forest” vegetation zones, and the village of Ndele is more fully within the “drier Guineo-Congolian rain forest” (1983:74-75), or “the grand forest” as Hewlett (1996b:4) describes it.

Brugiere and Sakom (2001:251) note that the Mbaéré and Bodingué are the two major rivers of the Ngotto Forest. These rivers are bordered by large strips of forest that flood seasonally, inundating land up to 5 km from the riverbanks between mid-July and mid-January (Brugiere et al. 2005:507). Hicks et al. (2005:225) report that swamp forest is limited to within 1-2 km of the banks of the Mbaere River near Grima. Grima and Ndele are both situated along these seasonal flood zones, but Grima is located approximately 9-10 km from the Mbaere River, whereas Ndele is less than 2 km from the Bodingué River, (Figure 2.1). Thus, the people of Ndele have easier access to riverine resources, such as large fish, than those of Grima (Schmitt and Lupo 2008:318).

Despite its close proximity to the Bodingue River, Ndele is much more remote from major population centers and commercial markets than Grima, creating differences between the subsistence practices in each village. Grima is within 25 km of Ngotto and is located on a well-traveled road connecting the larger towns of the area. In contrast, Ndele is 53 km from the nearest large market and linked only by a narrow footpath (Schmitt and Lupo 2008:318). Plant and animal resources exploited by forest foragers are detailed in the next chapter, but duikers (*Cephalophus* sp.) are briefly mentioned here to distinguish between Grima and Ndele. Specific data on animal prey densities in the vicinities of Grima and Ndele are unavailable, but studies by Noss (1995, 1998a, b, 2000, 2001) in the Bayanga region of CAR (southwest of our study area) are informative. Blue duikers (*Cephalophus monticola*) are the primary game species hunted by Bofi and Aka, and Noss (2000:298) demonstrates a substantial increase in population densities for this species with increasing distance from the large village of Mossapoula. Further, hunters in the villages of Bayanga and Mossapoula state that they have had to travel farther from their villages in recent years as prey are depleted (Noss 2000:300). Noss (2001:330) reports that growing populations and more permanent settlements have made hunting of blue duiker and Bay duiker (*Cephalophus dorsalis*) unsustainable in the vicinity of Mossapoula and Bayanga. Schmitt and Lupo report that foragers in both Grima and Ndele provide meat for commercial bush-meat markets, but that the practice is more common in Ndele “because animal prey are more abundant around this more remote setting” (2008:318). Bahuchet and Guillaume also comment that the Ndele region “is still rich in game” (1982:206), which has important implications for the comparative prey choice and processing intensity analyses of this dissertation.

Paleoenvironment

“The rainforest is far from being a stable ecosystem. It reached its present geographical distribution, morphology, structure, and species composition only in the late Holocene.”

Mercader 2002:117

Contemporary African forest foragers are inextricably linked to the rain forest environment which they inhabit. This section reviews the complex history of this ecological setting and its impact on human life and subsistence through time. The dynamic nature of the modern forest extends deep into the past, as scores of paleoenvironmental studies have explored sub-regional and temporal variability of climate and vegetation in equatorial African rain forests throughout the late Quaternary, with particular focus on Holocene trends. Few studies have yet been conducted in our study area, and most are from West and West-Central Africa. These studies are largely based on palynological data (e.g., Brncic et al. 2007; Elenga et al. 1994; Elenga et al. 1996; Lezine et al. 2005; Maley 1991; Maley and Brenac 1998; Ngomanda et al. 2005; Reynaud-Farrera 1996; Sowunmi 1991; Vincens et al. 1998; Vincens et al. 1999), but also include diatom (Nguetsop et al. 2004, Verschuren et al. 2000), phytolith (Alexandre et al. 1997; Mercader et al. 2000a; Runge 1999), mineralogical (Wirmann et al. 2001), geomorphological (Thomas and Thorp 1992), and carbon isotope analysis (Runge 2002). Collectively, these studies have shed light on the late Quaternary environment of African rain forests and savannas.

Within the Congo Basin (and adjoining regions of equatorial Africa), the last 70,000 years are the most climatically well-understood and are characterized by dramatic cycles of rain forest and savanna expansion and contraction (Schwartz and Lanfranchi 1991). Citing Hopkins (1992), Runge writes: “Forest-savanna boundaries in Africa are mainly determined by a gradual climatic shift from humid forest to drier woodland and

savanna environments” (2002:68). Thus the following discussion subdivides the late Quaternary into periods based on frequencies of plant communities (as determined by pollen and phytolith analyses) and inferred climatic conditions, with an emphasis on humidity and precipitation.

Pleistocene: The Maluekian Phase (70-40,000 B.P.)

The late Pleistocene Maluekian dry phase is viewed as a time of general aridity and savanna expansion (Bahuchet 1993:50; Schwartz and Lanfranchi 1991:42; Maley 1993:44; Oslisly 2001:104). This dry phase was one of many during the Pleistocene in equatorial Africa. Recognition of these Pleistocene droughts spurred the development of the refuge hypothesis, the idea that aridity fragmented the rain forest into isolated patches, or refuges that preserved rain forest biodiversity during dry spells (Hamilton 1972). Mercader (2003a:7) argues that rain forest fragmentation during glacial phases of the Quaternary is well-supported, but that the refuge hypothesis has led scholars to exaggerate the extent of deforestation during these periods and its prohibitive influence on human occupation of forested environments (archaeological evidence for the antiquity of rain forest occupation is discussed later in this chapter).

Pleistocene: The Ndjilian Phase (40-30,000 B.P.)

The Ndjilian wet phase is characterized as a period of increased precipitation and forest expansion (Bahuchet 1993:50; Elenga et al. 1994:345; Maley 1993:44; Mercader and Martí 2003:80; Oslisly 2001:104; Schwartz and Lanfranchi 1991:43). Elenga et al. (1994) cite a lack of palynological data for this period in Congo, but, based on a series of geomorphological, pedological, and archaeological studies of macroflora (e.g., Dechamps et al. 1988a, b; Delibrias et al. 1983; De Ploey 1963, 1965; De Ploey and Van Moorsel

1963; Giresse et al. 1981; Lanfranchi 1979; Schwartz 1988), they concur that 40-30,000 B.P. was a humid period marked by forest development.

Pleistocene: The Leopoldvillian Phase (30-12,000 B.P.)

The range and specificity of available environmental data greatly increases for the dates covered by the Leopoldvillian phase, a relatively cold, arid period characterized by forest regression, extension of wooded savanna, and the formation of forest refuges and savanna corridors (Bahuchet 1993:50; Elenga et al. 1994:345; Maley 1993:44; Mercader and Martí 2003:80; Oslisly 2001:104; Schwartz and Lanfranchi 1991:44). Pollen data from Ghana indicate a consistent lack of rain forest, and the presence of montane vegetation, suggesting sparse clumps of trees for the complete span of 28-9000 B.P. (Maley 1991). The pollen record of Lake Barombi Mbo in West Cameroon reveals persistent rain forest all the way from 24,000 B.P. to the present, leading Maley (1991:86) to argue that this area represents a forest refuge during times of drought. But, elsewhere, there is evidence of climatic and vegetational variation within this long phase. Palynological studies from West-Central Africa (Lanfranchi and Schwartz 1990; Maley and Brenac 1987) and Congo (Elenga et al. 1994) suggest a humid interlude and high frequencies of arboreal pollen within the Leopoldvillian, occurring around 24,000 B.P. Pollen evidence from tropical East Africa also demonstrates a relative increase in humidity between 25-20,000 B.P. (Bonnefille and Riollet 1988; Vincens 1986, 1991a, b). However, pollen cores from the Southern Batéké Plateaus (mosaic of Guineo-Congolian lowland rain forest and secondary grassland: White 1983) of Congo show an increase in grass pollen and decrease in arboreal pollen between approximately 24-13,000 B.P.

The pollen record of Lake Barombi Mbo in western Cameroon reflects further variation, with the period between 28-20,000 B.P. being cool and relatively wet. Between 20-10,000 B.P. data show forest recession and an increase in open vegetation, but large patches of forest refuges persisted, a palynological interpretation supplemented by isotopic ($\delta^{13}\text{C}$) analyses (Maley and Brenac 1998). This 10,000 year period was not uniform, however, as pollen frequencies suggest a “brief” warming period associated with increased precipitation between 13-12,000 B.P. (Maley and Brenac 1998:182). Analyses of phytoliths recovered from archaeological sites in the Ituri Forest (between the Western Rift and Congo Basin) of the Democratic Republic of Congo (DRC) indicate an abundance of grass phytoliths between 19-10,000 ^{14}C years B.P., but also enough tree phytoliths to demonstrate that the landscape was forested during this period (Mercader et al. 2000a).

The pollen sequence established from Lake Mobutu Sese Seko in Uganda also reflects variation in climate and vegetation communities within the Leopoldvillian dry phase (Sowunmi 1991). Sowunmi divides the sequence into four zones, three of which date to the Leopoldvillian. Zone I (ca. 29,900-25,350 B.P.) suggests a cooler and drier climate than today, with sparse patches of forest surrounded by dry savanna. Sowunmi describes Zone II (ca. 25,350-14,700 B.P.) as a very arid period of open grassland, partially coincident with the last glacial maximum. Zone III (ca. 14,460-12,530 B.P.) indicates climate amelioration, and an increase in wetness and the re-appearance of low-altitude forest toward the end of this period (but still somewhat colder and drier than today; Sowunmi 1991:213).

The complexity and sub-regional variability of equatorial Africa's late Pleistocene paleoenvironmental record is apparent from these studies. Mercader concludes:

In sum, isolated records, by definition, do not represent regions of transcontinental size. Evidence from the lowland forest per se suggests that glacial forests were fragmented forests, but this is not to say that Central Africa was almost entirely deforested during the Pleistocene. It seems clear that any theory attempting to understand rainforest paleogeography needs to appreciate the huge size of the area under discussion, and the effects over time that geographical, ecological, and climatological variations have had in past climates and ecosystems (2003a:11).

The following section explores significant environmental changes near the end of the Pleistocene and throughout the Holocene of Central Africa.

Terminal Pleistocene/Holocene: The Kibanguian Phase (12,000 B.P.-Present)

Maley (1990) dates the origin of the essentially humid climate of modern African rain forests to approximately 12,000 B.P. (also see Thomas and Thorp 1992). Lanfranchi et al. (1998) observe that the Holocene is often generalized as a forest-dominated period following intervals of Pleistocene drought in Central Africa. But, as with the late Pleistocene, there is evidence of considerable variation in climate and vegetation communities within the Holocene. The date of 12,000 B.P. marks the beginning of the Kibanguian climatic phase, characterized by warming, increased humidity, and rain forest extension (Bahuchet 1993; Elenga et al. 1994; Oslisly 2001; Runge 2002; Schwartz and Lanfranchi 1991). Maley (1993:44) divides this phase into Kibanguian A (12-3500 B.P.) and Kibanguian B (3500-Present). These dates encompass what appear to be the two most significant major climatic changes during the Holocene in equatorial Africa: Increased humidity and precipitation at the Pleistocene to Holocene transition, spurring a shift to denser rain forest cover (Mercader et al. 2000a:111), and a dry period beginning around 3000-2500 B.P. (or perhaps somewhat earlier) responsible for the creation of

Central African savannas, including those on the Congo/CAR border (Lanfranchi et al. 1997:41).

Additional paleoecological studies from equatorial Africa further subdivide the Holocene to incorporate locally-identified climatic changes, but comparable patterns of wet and dry episodes consistently occur in most reported samples. Sowunmi's (1991) pollen sequence from Uganda demonstrates a dramatic reduction of grasses and expansion of low altitude forest near the end of the Pleistocene at 12,530 B.P., and this shift becomes more marked from about 9270 B.P. onward. In this context, data suggest a progressively warmer and wetter climate similar to the modern environment by approximately 2920 B.P. (Sowunmi 1991:214).

Elenga et al. (1994:352) document an increase in humidity and the development of rain forest at approximately 13,000 B.P. in southern Congo. Around 3000 B.P. pollen samples begin to reflect the climate and vegetation of the present-day Batéké Plateaus, with reduced humidity, local extension of grassland, and the spread of oil palm (*Elaies guineensis*), which Elenga et al. (1994:353) link to anthropogenic activities (archaeological evidence of oil palm arboriculture is discussed further below).

Noting that the Batéké Plateaus represent a savanna environment, and that the history of Congolese forests has been indirectly deduced from savanna data, Elenga et al. (1996) collected pollen samples from Lake Kitina, southern Congo, located in a mixed moist semi-evergreen rain forest (White 1983). This sequence indicates dense forest with a high representation of swamp taxa between 5400 B.P. (the beginning of the core sample) and 2500 B.P. They relate dry conditions and increased grass pollen at 2,500 B.P. to the drying recorded at other Congo locations at 3000 B.P. (e.g., Elenga et al.

1992; Schwartz 1992; Vincens et al. 1994), attributing the time lag to differing ecological sensitivity between sites (Elenga et al. 1996:404). For example, Lake Kitina appears to have remained somewhat forested despite decreased precipitation, whereas the vicinity of Lake Sinnda (Vincens et al. 1994, 1998, 1999), also in southern Congo, was completely deforested and converted to open vegetation around 3000 B.P. (Elenga et al. 1996).

Phytolith analyses indicate that the opening of dense forest and replacement by short grass savanna may have begun as early as 4000 B.P. at Lake Sinnda (Alexandre et al. 1997). Further, Elenga et al. (1996) report a significant increase in oil palm pollen from 2000 B.P. onward, and a return of relatively humid conditions at Lake Kitina around 490 B.P. Oil palm pollen first appears in Lake Sinnda samples around 1000 B.P. and expands after 600 B.P. (Vincens et al. 1998:43).

Brncic et al. (2007) combine pollen, microscopic charcoal, and geochemical analyses to explore environmental changes in the Goualougo area of northern Congo, a mixed moist semi-evergreen forest comparable to Lake Kitina. Their results suggest that the area remained forested throughout the last 3300 years and there is no evidence of savanna expansion during this period. However, changes in forest composition were documented and linked to both climatic and anthropogenic processes. Charcoal increases significantly during the last 1200 years, peaking at 600 B.P. (correlating to oil palm expansion at Lake Sinnda; Vincens et al. 1998). Brncic et al. write: "Prehistoric burning had a larger impact on species composition in the past than climate changes in the Goualougo study area. Such disturbances seemed to increase opportunities for light demanding tree taxa without resulting in degradation to a savannah landscape" (2007:240). Iron smelting has been proposed as a cultural process that could reduce

forest cover (Goucher 1981). A study of iron production in Burkina Faso (Martinelli 2004) demonstrates that maintaining sufficiently high temperatures for 4-5 days requires more than 900 kg of charcoal and, over time, such intensive use of forest trees could alter the landscape. Despite this possibility, geochemical analyses of metallurgical dust by Brncic et al. (2007:239) indicate no significant correlation between forest composition changes and metallurgy at Goulougo.

Maley and Brenac's (1998) palynological analysis from western Cameroon shows similar Holocene patterns, with evidence of increased wetness beginning at 10,400 B.P. and forest trees reaching their maximum extent between 9500-3000 B.P. Pollen samples from Ghana also indicate an abrupt increase in rain forest tree species around 9000 B.P. (Maley 1990:83). At approximately 2800 B.P. the pollen record of western Cameroon reflects a sharp increase in grass pollen, indicating a phase of vegetation opening and forest retreat (Maley and Brenac 1998:172). After 2000 B.P. data indicate an increase in trees and forest expansion, but not to the extent represented in the early and middle Holocene. Maley and Brenac (1998:157) interpret the climate of the past 2000 years in the vicinity of Lake Barombi Mbo as warm, relatively wet, and similar to the present-day climate.

Additional palynological data from Cameroon correspond to some of the climatic changes identified by Maley and Brenac (1998). Reynaud-Farrera et al. (1996) report a pollen sequence from Lake Ossa, located in the wet rain forest of southwest Cameroon, which includes the establishment of dry climatic conditions at approximately 2730 B.P. This date is comparable to others identified in West-Central Africa (e.g., Elenga et al. 1992, 1994; Maley 1992; Schwartz 1992; Vincens et al. 1994), and reinforced by

mineralogical analysis of Lake Ossa sediments (Wirrmann et al. 2001). However, Nguetsop et al. (2004) reinterpret previous Cameroon pollen data based on Lake Ossa diatom analysis, which suggests high precipitation during the “dry” period inferred by Maley and Brenac (1998) and Reynaud-Farrera et al. (1996). Nguetsop et al. (2004:602) offer the alternative explanation that the increase in *Alchornea* sp. pollen (usually associated with drier climate) may be the result of forest canopy openings created by large blowdowns, made possible by a combination of heavy storms and highly-saturated, unstable soils. Thus, palynological and diatom analyses produce very different interpretations of the vegetational change identified in Cameroon at approximately 2800 B.P. Ngomanda et al. (2005:1022) argue that the relationship between open vegetation occurring around 3000-2500 B.P. and decreasing humidity during the late Holocene is well-established in western equatorial Africa. As with Elenga et al. (1994, 1996) in Congo, Reynaud-Farrera et al. (1996:750) note an increase in oil palm pollen in southwest Cameroon at 2200 B.P., and this species reaches high percentages around 1600 B.P. Reynaud-Farrera et al. (1996:750) place the emergence of present-day vegetation communities around Lake Ossa at approximately 950 B.P.

Despite substantial sub-regional variability, broad patterns in the late Quaternary environment of Central Africa can be identified from the extensive paleoecological literature covering equatorial Africa. First, the final 60,000 years of the Pleistocene are marked by long, alternating periods of wetness and rain forest expansion and dry periods with savanna expansion and the formation of forest refuges. Mercader (2003a) concedes that the late Pleistocene rain forest habitats were heavily impacted by long periods of drought, but maintains that forested environments did not completely disappear during

such periods. The Holocene is marked by relatively sustained humidity and extensive rainforest expansion, but a wide range of data support the onset of a dry period beginning approximately 3000-2500 B.P., or perhaps earlier in Central Africa. This climatic drying shaped the landscape, creating the rain forest savanna mosaic that still persists in many sub-regions of equatorial Africa. The late Quaternary paleoenvironmental record of this region is one of dynamic change. Archaeological evidence of human interaction with, and adaptation to, this dynamic ecological setting is explored in the following section.

The Prehistory of Central Africa

“African prehistory is a puzzle on a grand scale, still only partly solved.”

Diamond 1997:377

To fully understand the context in which modern forest foragers acquire and process animal prey, it is necessary to review the prehistory of rain forest exploitation by foragers, as revealed by the available archaeological evidence. While archaeology and paleoanthropology have flourished in much of Sub-Saharan Africa, these fields have been relatively neglected in the rain-forested portions of the continent. Mercader (2002) writes that Sub-Saharan Africa is traditionally divided into two evolutionary domains: the West and Central African rain forest, and the woodlands and savannas of East and Southern Africa. Mercader (2002, 2003a) describes tropical rain forest archaeology as being in its infancy and attributes the general lack of archaeological research to logistical difficulties and political unrest, the stereotype of poor archaeological preservation, and the misconception that rain forests were uninhabited and/or anthropologically uninteresting in the distant past. The zooarchaeological record of Central Africa is particularly underexplored, a fact often blamed on poor preservation. The study of archaeological animal bones has received far less attention than stone and iron technology, ceramics, and

paleobotanical research. Phillipson (1993:38) comments on the almost complete lack of faunal remains from this region. Eggert adds “Nothing has been said about animal sources of food because at present we lack evidence about this in the equatorial area; that is mostly because faunal remains are so scantily preserved” (1993:325). Mercader (2003a:4-5) is more optimistic, noting that preservation of bone in the wet tropics is “not optimal,” but he presents several contexts in which it is possible. Mercader (2003a) cites research suggesting that surface bones in savanna environments actually weather faster than those in the rain forest (Peterhans et al. 1993; Tappen 1994), although burial in acidic forest soils negatively impacts bone preservation. The ubiquitous lack of hominid skeletal remains in this environment is also attributed to acidic soils (O’Toole 1986). Animal bones from the late Pleistocene and Holocene are usually recovered from caves and rock shelters, likely a result of preservational bias (Mercader et al. 2003).

In contrast, East and South Africa have received decades of intensive archaeological and paleoanthropological attention, including faunal studies, leading some to wonder if early rain forests lacked a human presence, or if they have merely been under-studied (de Maret 2005; Mercader 2002, 2003a, 2003b; Phillipson 1993; Roosevelt 2005). Eggert cautions that, in the absence of systematic archaeological studies in Central Africa, “this part of the continent was either left out altogether or the blanks filled in with broad strokes of the imagination” (1993:326).

Prior to developing alternative interpretations, Roosevelt outlines a conventional scenario of the role of rain forests in human evolution:

According to the theory, great apes persisted in the relict tropical forests, but no indigenous human species or cultures could emerge there because of the adverse conditions. The high heat and humidity imposed a heavy disease load, limiting population growth, physical vitality, and intellectual energy. Specialized big-game hunting was not viable in the forest, where plants and invertebrates dominate...The

closed vegetation was considered poor in grains and starchy roots for human subsistence staples... Without the hunting economy necessary for the development of our species and advanced early culture, the rain forests remained vacant until civilizations spread to the humid tropics from arid, cool zones, but even then, without intensive agriculture, large settlements and complex cultures could not be maintained... (2005:171).

There is limited archaeological evidence to counter the perception that African rain forests played an insignificant role in human evolution. A lack of archaeological research has contributed to the ambiguity of early rain forest occupation, with some arguing that *Homo erectus* avoided tropical forests (Bar-Yosef and Belfer-Cohen 2001), that anatomically modern *Homo sapiens* was the first hominid species to inhabit the forest (McBrearty and Brooks 2000), or that interior rain forests were first colonized by farming populations (Bailey et al. 1989). The latter proposition has been indirectly addressed by a range of ethnographic and ecological research collectively exploring the “wild yam question.”

Ethnographic Approaches to the Wild Yam Question

The issue of whether interior rain forest hunting and gathering is possible without access to domesticated foods is referred to as the “wild yam question” (Bahuchet et al. 1991; Headland 1987; Yasuoka 2006). Proponents of the “cultivated calories hypothesis” maintain that foraging in the world’s tropical rain forests would be exceedingly difficult, or even impossible, without agricultural supplementation (Bailey et al. 1989; Bailey and Headland 1991; Bailey and Peacock 1988; Gamble 1994; Hart and Hart 1986; Headland 1987, 1997; Headland and Bailey 1991). Ethnographic data in support of the “independent foraging hypothesis” have been collected to explore contexts in which contemporary rain forest hunting and gathering is possible, and to extrapolate prehistoric possibilities (e.g., Bahuchet et al. 1991; Brosius 1991; Dwyer and Minnegal 1991; Endicott and Bellwood 1991; Hill and Baird 2003; overview in Roosevelt 2005:181-184;

Stearman 1991; Yasuoka 2006). Both hypotheses are critically important to our understanding of rainforest prehistory and are briefly outlined here.

The Cultivated Calories Hypothesis

“The world of the forest is a closed, possessive world, hostile to those who do not understand it. At first sight you might think it hostile to all human beings...”

Turnbull 1961:13

“hunter-gatherers could never have lived in tropical rain forest without direct or indirect access to cultivated foods.”

Headland and Bailey 1991:116

Hart and Hart (1986) conducted a study among the Mbuti forest foragers of DRC. During their four-year study period, they observed the diminished importance of gathered plant foods relative to agricultural produce. Further, none of the plant foods gathered by the Mbuti was carbohydrate or oil-rich enough to replace agricultural sources. Speth and Spielmann (1983) suggest that hunter-gatherers experiencing a shortage of plant foods could compensate and meet their energy needs by targeting game species with high fat content, storing carbohydrate and fat-rich foods, or trading lean meat for other sources of fat and carbohydrates. Hart and Hart (1986) argue that the Mbuti practice the third option today and probably would have been unable to pursue the first or second strategies within a closed tropical forest in the past. They conclude that Mbuti nutritional needs could only have been met in the past by living near the savanna border (as opposed to the interior forest) or by living symbiotically with agriculturalists.

Following Hart and Hart (1986), Headland (1987) spurred much debate with his article titled “The Wild Yam Question: How Well Could Independent Hunter-Gatherers Live in a Tropical Rain Forest Ecosystem?” Bailey et al. (1989) followed this article with the provocatively titled “Hunting and Gathering in Tropical Rain Forest: Is It Possible?” Based on research among the Agta of eastern Luzon, Phillipines, Headland

(1987) argues that gathered starchy plant foods would not have been abundant enough from year to year for prehistoric foragers in the forests of eastern Luzon to supplement lean game animals. He suggests that, in order to survive in these rain forests, hunter-gatherers would have required at least periodic access to cultivated resources.

Bailey et al. (1989) review a vast amount of archaeological and ethnographic literature from around the globe and conclude that there is no unambiguous evidence of hunter-gatherers living in tropical rain forest independently of agriculture. They use this apparent lack of evidence to argue against what they see as a tendency to view foragers as “recently emerged from isolation” or developing in a “historical vacuum” (1989:73). Bailey et al. (1989) also discuss the potentially far-reaching implications that their work has for the geographical distribution of earlier hominids, if hominids were incapable of subsisting in rain forest environments (archaeological evidence relevant to hominid rain forest occupation is discussed further below).

The Possibility of Independent Foraging

“the Pygmies have been in the forest for many thousands of years. It is their world, and in return for their affection and trust it supplies them with all their needs.”

Turnbull 1961:14

“People can indeed survive in the rain forest, and there is no risk of shortage!”

Hladik and Hladik 1990:14

Brosius (1991), utilizing data from Borneo, challenges the cultivated calories hypothesis on several grounds. First, he argues that it is overly simplistic to equate environmental diversity with subsistence diversity. He writes, “In analyzing the subsistence base of tropical foraging populations, attention should be focused, not on the diversity of these environments, or on generalizations about spatial and temporal distribution of resources, but on the characteristics of particular resources themselves”

(1991:128). Brosius recognizes that a model as universal and generalized as the cultivated calories hypothesis will have trouble accounting for local variability.

Brosius' (1991) second critique is that Headland (1987) and Bailey et al. (1989) are vague and inconsistent in their definition of "pure foragers." The lack of evidence for pure foragers living in rain forest independently of agriculture is central to the cultivated calories hypothesis. Brosius suggests that it is critical that there be some agreement on the criteria of "pure foraging." Third, Brosius disagrees with a strict dichotomy between agriculture and foraging (also see Casey 2005). This too, he argues, must be clarified before substantive evaluation of the cultivated calories hypothesis can proceed. Brosius (1991) notes that the results of his test of this hypothesis among the Penan of Borneo will remain inconclusive until the parameters of the cultivated calories hypothesis are defined with greater precision.

Endicott and Bellwood (1991) conducted extensive field research among the Batek De' of the Malaysian Peninsula and agree with Brosius' (1991) criticism of the generality of the Headland (1987) and Bailey et al. (1989) models. They state, "The lesson is that humans adapt to the specific details of an environment, not the general features of a generalized model" (1991:181). Endicott and Bellwood's work in the Malaysian rain forest suggests to them that subsisting by hunting and gathering alone is possible, but that access to agricultural products does make life easier. They argue that the success of the Batek De' is not the result of a "secret ingredient" or single resource that makes such a lifeway possible. Rather the Batek De' succeed in the rainforest with small, mobile groups that gather a diversity of moderately abundant resources available in complementary seasons (1991:181; see Hill and Baird 2003). In this case study, the

Malaysian forest does impose constraints on hunting and gathering, but none that can't be overcome by the foragers' intimate knowledge of their environment.

Unlike Endicott and Bellwood's (1991) Dwyer and Minnegal's (1991) description of Kubo foraging in lowland Papua New Guinea is more reliant on a "secret ingredient" - sago palm (*Metroxylon* sp.). According to these authors, in addition to providing starchy sago palm flour, these trees, when felled, attract wild pigs, and can also be used to rear insect larvae. During Dwyer and Minnegal's fieldwork, the Kubo were well aware of these interrelationships and organized their subsistence system, hunting and gathering, around groves of sago palm. "It is argued that this system lacks necessary dependence upon the agricultural system with which it co-occurs and, in fact, can be connected with a system of carbohydrate procurement that is not agricultural" (Dwyer and Minnegal 1991:187). They conclude that the Kubo subsistence system provides a model of rain forest foraging in which agriculture, though potentially beneficial, is not necessary.

Bahuchet et al. (1991) construct a point-by-point critique of the cultivated calories hypothesis beginning with the sub-heading: "The Argument is Not Logically Compelling" (1991:216). They suggest that even if there are no contemporary examples of foragers living in the interior forest without access to agriculture, this does not prove that independent foraging has never occurred or that it is impossible.

Second, Bahuchet et al. propose that "Some Versions of the Hypothesis are Unfalsifiable" (1991:218). By this, they mean that some definitions of tropical rain forest can be so overly restrictive that any claim of independent foraging can be refuted as not occurring in "true rain forest." Therefore, certain versions of the cultivated calories hypothesis can never be falsified and are unscientific.

Third, “Archeology is Neutral on the Question” (1991:220). The rarity of archaeological evidence of pre-agricultural rain forest settlement has been perceived to support the Bailey et al. (1989) hypothesis. Bahuchet et al. (1991) maintain that archaeology offers little support for or against the cultivated calories hypothesis and is effectively neutral. As will be elaborated below, since 1991 archaeological evidence clarifying the nature of prehistoric rain forest subsistence has gradually emerged (Mercader 2003a). Much of this evidence highlights the ways that foragers in specific ecological contexts adapt to the constraints imposed by rain forest ecology prior to the introduction of domesticates, often assisted by climatic or technological changes (e.g., Cosgrove et al. 2007). In this sense, it can no longer be said that archaeology is neutral; archaeology is increasingly supportive of independent foraging in rain forest environments (Barham and Mitchell 2008).

Fourth, “The Cultivated Calories Hypothesis Lacks Ecological Supporting Data” (1991:221). Given the limits of contemporary data in allowing us to extrapolate into the past, Bahuchet et al. (1991) suggest that resolution to this question is largely dependent on ecological data. Unfortunately, the authors argue, the primary weakness of the cultivated calories hypothesis is its misuse of ecological data. According to Bahuchet et al. (1991), inferring plant availability from extent of use is not accurate; low use does not necessarily indicate low availability. They propose that “extent of use” actually underestimates the availability of plant resources in the Congo Basin since Central African foragers have neglected these wild resources with the greater availability of cultivated crops.

Bahuchet et al. (1991) go beyond criticism of the cultivated calories hypothesis and introduce their own alternative hypothesis. This alternative hypothesis is centered on two testable predictions. First, that contemporary wild foods are not exploited to the limits of their availability. These wild plants might constitute a larger portion of the diet if cultivated plants were not available. Second, given the proposed length of contact between farmers and foragers, certain wild plant foods may have been completely abandoned and knowledge of them lost. Species that were once consumed may no longer be classified as food plants. Bahuchet et al. (1991) proceed to test these predictions against data on wild yam availability in the Congo Basin and arrive at two general conclusions. First, wild yams occur in high enough densities that they *could* be exploited much more heavily by the Aka than they currently are. In fact, Yasuoka (2006; also see Sato 2001) documents a long-term foraging expedition (two and a half months during the dry season) by Baka foragers of the northwestern Congo Basin, during which they subsisted solely on wild foods, and particularly yams. Bahuchet et al.'s (1991) second conclusion is that several types of wild plants, particularly starchy tubers, were utilized in greater quantities in the past, with some of them dropping out of the modern diet entirely. Both conclusions indicate that a foraging life would have been feasible in the interior rain forest prior to the arrival of cultivators.

Stearman (1991), using ethnographic data obtained among the Yuqui of Bolivia, again challenges the generality of the cultivated calories hypothesis. She refers to the structural variation within and between rain forests and, as evidenced in the preceding section on rain forest ecology, states: "All tropical forests are not alike" (1991:257). In addition, Stearman (1991) questions the notion, proposed by Bailey et al. (1989) that

arriving agriculturalists paved the way for foragers in the rain forest. Alternatively, she argues that encroaching agriculturalists might actually have disturbed the environment in a way that *caused* the shift to agricultural dependence. Stearman (1991) concludes by suggesting that the Yuqui, with their knowledge of the environment, mobility, and use of “keystone resources” (critical resources that allow populations to survive periodic lean times; Stearman 1991:254) represent an example of non-agricultural foraging in tropical rain forest.

As argued by Headland (1987), access to carbohydrates is a critical limiting factor in rain forest occupation, however, foragers have devised methods of managing carbohydrate resources (Sponsel et al. 1996). Recent ethnographic research in northeastern Australia demonstrates how Kuku-Yalanji people use a dual strategy of fire management and procurement of rain forest seeds to obtain sufficient carbohydrates (Hill and Baird 2003). Kuku-Yalanji utilize controlled burning to maintain small clearings within the rain forest, in which high-carbohydrate *Cycas* sp. plants are allowed to grow. These are harvested during the, otherwise carbohydrate-lean, dry season. During the wet season, Kuku-Yalanji obtain ample carbohydrates from rain forest seeds (which require special processing techniques) and some wild yam species. This combination of fire management and seed processing provides year-round access to carbohydrates in a rain forest setting (Hill and Baird 2003:40).

Despite these compelling ecological and ethnographic analyses in support of the independent foraging hypothesis, questions of the antiquity of rain forest occupation and the role of cultivated calories are most directly addressed by archaeological research. Archaeological data capable of addressing complex issues of rain forest adaptation and

subsistence remain rare, but have increased in recent years (e.g., Casey 2005; Cornelissen 2002, 2003; Cosgrove et al. 2007; de Maret 2005; Lavachery 2001; Mercader 2003a, b).

The majority of archaeological evidence discussed below reinforces ethnographic interpretations by demonstrating forager occupation of the rain forests well prior to the arrival of farmers. The discussion proceeds chronologically, covering the prehistory of Central Africa from the Early Stone Age through the Iron Age, and into recorded history.

Early Stone Age

“The more forested regions of the Congo are perhaps less likely to yield Stone Age material belonging to the earlier cultures, as it seems likely that this region has been under dense forest throughout the Pleistocene period, and, on the whole, Stone Age man preferred more or less open country.”

Leakey 1970:132

The Paleolithic of Africa is traditionally divided into Early (or Old), Middle, and Late phases (Gotilogue 2000; Kusimba 2003; Mercader 2002). Mercader (2002) states that Miocene and Pliocene hominids would have had the capacity to exploit the Guineo-Congolian forest, but acknowledges that this cannot be evaluated without further research. Casey (2003:35) notes that Davies (1964) claimed to have found a complete sequence of African technological history, from Oldowan and Acheulean artifacts to the present, in tropical West Africa. But more recent evaluations (e.g., Nygaard and Talbot 1984; Swartz, Jr. 1972) have reclassified these assemblages and associated them with later time periods, leaving no good evidence of Oldowan tools in West Africa (Casey 2003:42). Whether Pleistocene *Homo erectus (ergaster)* could permanently settle the forest is another unanswered question, owing to a scarcity of Acheulean period sites in the Congo Basin and West Africa (Casey 2003:42; McBrearty and Brooks 2000:493; Mercader 2002:118). More importantly, few of the Acheulean artifact assemblages discovered in this region have come from a straightforward stratigraphic sequence. For

example, Bayle de Hermens (1975) reports five sites in the High Sangha of western CAR that included Acheulean bifaces, but these were unearthened during road construction and mining activities. Further, some of the Acheulean artifacts were recovered from the surface or suggest extensive rounding and redeposition, so the stratigraphic provenience of these assemblages and their “taphonomic integrity” is ambiguous (Eggert 1992; Mercader 2003a). Another source of ambiguity for the interpretation of both Early Stone Age (ESA; e.g., Cahen 1975; Clark 1969) and later industries (see Mercader et al. 2002:72 for a comprehensive list) in rain forest contexts is the occurrence of so-called “stone-lines.”

Stone-lines are geological features that are widespread in tropical and subtropical regions throughout the Quaternary record, and that are often associated with archaeological assemblages (Mercader et al. 2002). In the African tropics, stone-lines are described as layers of gravel above bedrock and capped by structureless clay or sand (Mercader et al. 2002:71). The formation of stone-lines has been attributed to multiple processes, such as terrace deposition (Cornelissen 1997), termite-created pedogenic mantles (Johnson 1990; McBrearty 1990), or geogenic deposition; consolidation of deposits caused by erosion and the lowering of the ground surface (Thomas 1994). Clearly, each of these processes affects the interpretation of cultural materials associated with stone-lines (Mercader 2003a:9). Mercader et al. (2002:94) argue that stone-lines cannot be used for paleoenvironmental reconstruction or relative dating purposes. Contrary to the prevailing view that stone-lines were formed during arid periods such as the last glacial maximum, they show that stone-line formation may be a discontinuous process operating over long periods of time, not limited to the last glacial maximum. On

the other hand, they argue that artifacts recovered from stone-lines are not necessarily behaviorally-meaningless, or fundamentally out of context; Some stone-lines maintain archaeological integrity, and do not contain “highly energetic and translocated archaeological records” (Mercader et al. 2002:92).



Figure 2.4. Robert L. Humphrey cartoon depicting “the forest barrier”^a

^aReprinted from Mercader 2003a, with permission from Rutgers University Press.

Considering the ambiguity of Central Africa’s ESA record and the challenges of modern rain forest subsistence discussed above, some scholars have reasonably suggested that *Homo erectus* lacked the behavioral flexibility required to forage in the Congo Basin (Barham 2000; McBrearty and Brooks 2000). The apparent pattern of Acheulean materials seemingly stopping at “the forest barrier” (Mercader 2003a:13; Figure 2.4) or

edge of the interior forest may indicate that *erectus* utilized the resources of the savanna-forest boundaries, but did not venture further. Another possibility is that low population densities of *Homo erectus*, compounded by poor preservation and insufficient archaeological research, left little evidence of their presence within the interior forest. Others have argued that constraints of the rain forest might even have played a role in the spread of *Homo erectus* beyond the African continent since, “Moving into new environments, especially away from the tropics to cooler, drier environments, reduces the danger of being exposed to zoonotic diseases” (Bar-Yosef and Belfer-Cohen 2001:22). Alternatively, based on evidence of *Homo erectus* in diverse ecological settings in other parts of the world and Acheulean artifacts in CAR and DRC (despite their contextual problems), Mercader (2003a:12) proposes that Pleistocene hominids had expanded beyond East and South Africa and into Central Africa well before 200,000 B.P. These are intriguing and plausible ideas, but only future archaeological research will definitively establish the presence or absence and extent of pre-*sapiens* hominids in Central Africa.

Middle Stone Age

Phillipson (1993) classifies the Middle and Late Stone Ages as “post-Acheulean,” commenting that these periods roughly correspond to the Middle Paleolithic and Upper Paleolithic/Epipaleolithic, respectively. The Middle Stone Age (MSA) spans the period between approximately 300,000 and 50,000 years B.P. (Kusimba 2003:121). The Sangoan and Lupemban technological complexes are associated with the Early to Middle Stone Age and are the first widespread archaeological manifestations of the African tropics (Clark 1970; Kusimba 2003; McBreartry 1988; Mercader 2002; Mercader and

Martí 2003). The Sangoan is named after a series of surface-collected artifacts first discovered near Sango Bay, Uganda (Wayland and Smith 1923), and is characterized by heavy-duty picks, small flake tools, Levallois cores, and the first bifacial points (Barham and Mitchell 2008:234). The first Lupemban tools were discovered near the Lupemba River of DRC (Breuil 1944). Lupemban assemblages are characterized by carefully crafted lanceolate points. Sangoan and Lupemban techno-complexes rarely include the bifacial hand axes and cleavers typical of the ESA, and the microliths of the Late Stone Age (Mercader and Martí 2003:64).

Sangoan artifacts and assemblages have been recovered from tropical forest archaeological sites in Cameroon (Mercader and Martí 1999a; Omi 1977), Congo (Lanfranchi 1990, 1996), Côte d'Ivoire (Lioubine and Guede 2000), and Gabon (Bayle des Hermens et al. 1987; Clist 1993, 1995; and Locko 1990). The distribution of Sangoan artifacts corresponds well with the present extent of the African equatorial rain forest, but they have also been found in arid East (Cornelissen 1995; McBrearty 1991) and North Africa (Van Peer et al. 2004). The apparent primitiveness of Sangoan tools, and a wide range of dates extending beyond 270,000 years B.P. (Barham 2000) has led some to argue that the Sangoan is an Acheulean-related tradition that preceded the MSA (McBrearty and Brooks 2000; Lioubine and Guede 2000; Tryon and McBrearty 2002). This distinction is particularly important because the beginning of the MSA may coincide with the appearance of *Homo sapiens* (Tryon and McBrearty 2002:211).

Other researchers (Barham 2000; Van Peer et al. 2003) view Sangoan artifacts as a MSA departure from earlier Acheulean technology. The chronology and cultural meaning of the Sangoan are still not entirely clear, because Sangoan assemblages from

reliable stratigraphic contexts are rare (McBrearty 1988:390; Mercader and Martí 2003:64). Based on an exceptional site in northern Sudan that documents the ESA-MSA transition in primary context and direct stratigraphic superposition, Van Peer et al. report: “In contrast to the Acheulean, the early MSA Sangoan levels show sophisticated behaviours involving considerable technological and symbolic investment” (2003:187). The site provides evidence of complex processing of plant foods; plant phytoliths and starch granules were retrieved from polished surfaces of cobbles, which Van Peer et al. relate to the processing of siliceous and starchy plant tissues, possibly grass seeds. There is also evidence of the symbolic use of colored pigments that begins in the Sangoan levels of the site (Van Peer et al. 2003:190-191). Thus, Van Peer et al. (2003) argue that the Sangoan complex reflects the MSA geographical dispersal of modern humans.

McBrearty and Brooks (2000) suggest that the Lupemban complex, which generally occurs more recently than the Sangoan and is characterized by more refined tools (particularly “beautifully made lanceolate points” 2000:494), is the first tradition representative of modern human behavior. Unfortunately, very few Lupemban artifacts have been recovered from sites in primary context (McBrearty and Brooks 2000:494). Further, associated faunal remains that might clarify the nature of Lupemban subsistence are lacking (Marean and Assefa 2005:110). Lupemban assemblages have been discovered at archaeological sites in the lowland rain forests of Gabon (Pommeret 1965, 1966) and Equatorial Guinea (Mercader and Martí 1999a, 2003). Further, Bayle de Hermens (1975) documents several Lupemban sites in regions of the Central African Republic that were recently covered by tropical forest (Mercader 2002:120). Given the geographical and temporal extent of Sangoan and Lupemban sites, Mercader (2002,

2003a; Mercader and Martí 1999a, 1999b, 2003) argues that Middle Pleistocene humans undoubtedly had the capacity to inhabit the rain forest.

Clark (1964, 1970) proposes that, not only could Middle Pleistocene humans live in the rain forest, the Sangoan and Lupemban industries are specific adaptations to life in the rain forest. Clark argues that the large, seemingly crude (particularly the Sangoan), implements of these complexes represent woodworking tools specially adapted for forest use, rather than “a falling-off in technical skills” (1970:112; also see Miller 1988).

However, there is little evidence to support this idea (Barham 2001; Marean and Assefa 2005; Mercader 2003a), since Sangoan artifacts have been found outside of forested environments (McBrearty and Brooks 2000:494) and Sangoan and Lupemban assemblages have “no strong ecological signature” (Mercader 2002:118). McBrearty notes that they could have been used for woodworking in forest contexts, but “They might as easily have been used for digging, or for any task requiring a pointed object which can be delivered with weight behind it” (1988:412). In fact, the only use-wear analysis of Sangoan tools to date (core-axes at Sai Island, Sudan) suggests that they were hafted, but used for digging (Rots and Van Peer 2006). Specifically, Rots and Van Peer conclude: “It is suggested that this use concerns subsurface exploitation of lithic raw material, plant foods, or perhaps iron oxides” (2006:369). Considering the ethnographically-demonstrated importance of roots and tubers to modern rain forest subsistence (i.e., the wild yam question), this proposed relationship between Sangoan technology and subsurface plant food exploitation is very intriguing. The possibility exists that MSA tools *do* represent an adaptation to forest life, but for the purpose of obtaining carbohydrate sources necessary for rain forest subsistence, rather than

woodworking. Use-wear analysis of Sangoan and Lupemban tools from tropical contexts could help establish their function(s) and, possibly, their widespread appearance in equatorial Africa during the MSA. Mercader (2003a:15) provides a more conventional interpretation, arguing that these MSA stone tools, which feature no clear sign of specific forest adaptation, show that sophisticated technologies are not necessary for the exploitation of forest resources.

Late Stone Age

Determining a straightforward date for the Middle-to-Late Stone Age (LSA) transition is problematic, since in some parts of Africa MSA and LSA technologies co-occur for the entire period between 50,000 B.P. and the end of the Pleistocene (Casey 2003; McBrearty and Brooks 2000; Mercader and Brooks 2001; Mercader and Martí 1999a). For example, stratified archaeological sequences in locations as widespread as Egypt, Tanzania, Botswana, Zimbabwe, and South Africa include strata containing both MSA and LSA elements situated above clearly MSA assemblages and below clearly LSA assemblages (McBrearty and Brooks 2000:490-491). Within West and Central Africa, excavations in Equatorial Guinea recovered MSA Lupemban assemblages that dated to greater than 30,000 B.P. (Mercader and Martí 1999a), while at nearby Shum Laka rock shelter of northwestern Cameroon Late Stone Age materials dated to the same time period (Lavachery et al. 1996).

Regardless of the start date of the LSA, archaeological materials dramatically increase during this period, and reflect a gradual reduction in tool size (Cornellisen 1997), exemplified by microliths. The earliest evidence of LSA microlithic technology in tropical Africa dates to approximately 40-30,000 B.P. (Ambrose 1998; Cornelissen 1996;

Lavachery et al. 1996; Mercader and Marti 2003). Casey (2003:48; also see McBrearty and Brooks 2000:490) observes that criteria used to define “microlithic industries,” considered diagnostic of LSA occupation, are inconsistent, and this adds to the difficulty of dating the MSA-LSA transition. Some use “microlith” to refer specifically to purposely-formed geometric microliths, although unmodified, retouched, and utilized flakes are also sometimes referred to as microliths (Casey 2003:48). For example, Cornelissen (2003:3) argues that the frequent use of quartz, with its unusual flaking properties, may account for the relatively nonstandardized nature of Shum Laka microliths, as compared to other African sites. The earliest microliths at Matupi Cave, DRC (dated to 40-30,000 B.P.) are described as technologically microlithic, despite a lack of geometrics (Van Noten 1977:39), leading McBrearty and Brooks (2000:490) to reinterpret them as late MSA artifacts. So-called “Mode 5” technologies, which include geometric microliths, are common in the mid-levels of Matupi Cave, dated to 21,000 B.P. (Mercader and Brooks 2001:213).

Mercader (2002:123) states that virtually all twelve countries of the African rain forest indicate dense LSA settlement, a departure from the scattered evidence of occupation from earlier periods. “The Later Stone Age was a crucial period in the development of tropical forest cultures, for it was then that the consolidation of skills obtained during previous phases was able to support the most extensive settlement of rainforests in pre-agricultural times...” (Mercader 2002:122). Mercader and Marti (2003:82) document over 30 radiocarbon-dated Central African LSA sites in diverse environmental contexts, including forests, savannas, mosaics, and coastal areas. Palynological data from three LSA rock shelter sites in the Ituri Forest of DRC show high

percentages of rain forest tree species in association with cultural remains dating to the last 18,000 years, definitively establishing rain forest occupation prior to farming (Mercader et al. 2000a). LSA lithic assemblages recovered from sites in forest and woodland-savanna areas of the Democratic Republic of Congo were very similar, leading Mercader and Brooks (2001:214) to argue that ecologically distinct or highly specialized technologies were not required for rain forest settlement during this period. Comparably, based on stone tool industries found in forest, woodland savanna, river and lake margins, and open landscapes with patchy forest, Cornelissen (2003:21) suggests that Central African foragers of the late Pleistocene had the capacity to exploit multiple environments using a single flexible technology based on quartz microliths.

Mercader concludes: “In short, the environmental and archeological evidence from Later Stone Age sites in Central Africa indicates that neither glacial nor interglacial forests were a cultural, economic, or physical barrier to African foraging groups of the late paleolithic period” (2002:123). In many parts of the world, the post-glacial period beginning approximately 10,000 years B.P. marks the end of the Pleistocene, the beginning of the Holocene, and is reflected by “broad-spectrum” shifts in resource use and technology that are viewed as setting the stage for the Neolithic Revolution. As opposed to Eurasia or the Americas, the Mesolithic (i.e., Epipaleolithic or Archaic) is not a clearly delineated period in Sub-Saharan Africa, where it is generally perceived as a continuation of the LSA (Bogucki 1999).

Origins of Food Production in Central Africa

Like the Mesolithic, the Neolithic is not as straightforward in Africa as it is in other regions. Vansina (1990) notes centuries of temporal overlap between

archaeological sites identified as LSA and those identified as Neolithic. Ground stone tools and pottery are often perceived as elements of a diagnostic “Neolithic package” that includes food production, but Casey (2005:234) argues that these have been found in contexts from the LSA (Clist 1986) to the Iron Age (Eggert 1993). Mercader et al. (2000c:164) relate the inception of ceramics to a farming migration into the Ituri Forest, but note that hunter-gatherers also produced, used, and discarded ceramics. Thus, there is nothing about these artifacts that necessarily indicates food production by the people who used them (for extensive analysis of ceramic chronologies see Eggert 1987, 1992, 1993, 2002). Casey (2005) also reports that ground stone and pottery have been discovered in several Central African sites, dating to as recently as 2400-2100 B.P., with no additional evidence of food production. As a result, she contends:

What is being missed in this rush to ‘neolithize’ the Holocene is the opportunity to investigate a lifeway in which the management of domesticated resources is only one of many options and does not inevitably, predictably, and irrevocably lead to a commitment to large-scale agriculture with everything that implies (2005:225).

Casey (2005:229) supports the concept of intensification as used by Stahl (1989, 1993b) to describe the Kintampo complex in central Ghana. The Kintampo was initially classified as Neolithic (Davies 1962), but fails to meet all of the criteria usually associated with the term. Along with others (Casey 2005; Klieman 2003), Stahl sees “ceramic Late Stone Age” as a more accurate description of archaeological patterning in Late Holocene West Africa. Comparably, Lavachery et al. (1996; Lavachery 2001) propose “Stone to Metal Age” be used, to avoid connotations of the Neolithic, until this time period is better understood. Stahl (1993b:272) uses the term intensification to describe a series of changes that mark the transition between the LSA and ceramic LSA: decreasing residential mobility, involvement in trade networks, accumulation of material

culture, greater investment in food processing (evidenced by ceramics and grinding stones), and major changes in subsistence that may include elements of food production. But, unlike “Neolithic,” intensification can incorporate a broader range of specific subsistence adaptations. Casey suggests “Intensification is a useful way to conceptualize the cultural forms that we see in the Mesolithic, Archaic, Epipaleolithic, and LSA because there is nothing inevitable about any outcome” (2005:229).

This flexible concept of subsistence intensification is equally applicable in Central Africa, since the origins of food production in this region are complex, particularly in the tropical rain forest and related ecosystems. Traditionally, the arrival of farming populations in the Congo Basin was firmly linked to the phenomenon of “Bantu expansion,” an explanation for the spread of numerous mid- to late-Holocene traits (de Maret 2005). Vansina (1990:49) characterizes the earliest Bantu speakers as “Neolithic” since they produced ceramic vessels and presumably had begun to farm, but did not yet work with iron, although the later development of iron technology would also be attributed to Bantu agriculturalists (Herbert 2005:977). Glottochronological analysis indicates that sometime around 5000 B.P. the Bantu language family, which is thought to have originated in the grassy highlands of the Nigeria-Cameroon border (Oslisly 2001:107), split into eastern and western sub-families, with western Bantu speakers ultimately occupying all of central Africa and eastern Bantu speakers moving farther eastward to savanna environments (Vansina 1990:49).

David (1980:620) suggests that the agricultural penetration of the northwestern Bantu zone, which Bahuchet and Guillaume (1982) describe as the Aka western equatorial fringe, may have occurred as early as 4400 B.P. However, the earliest

archaeological evidence of farming societies in Central Africa dates to only 3000-2500 B.P. (Mercader et al. 2000b:107). Others have suggested that the climatic drying phase that began at 3500 B.P. may have facilitated a rapid spread of Bantu speakers at this time (Oslisly 2001:102). Much of the evidence in support of Bantu expansion comes from linguistics, and recent archaeological evidence supports a more complex history, in which the origins of food production and ceramic and iron technology were not systematically linked in Central Africa (de Maret 2005:424). Although migrations of Bantu speakers are well-established, it is increasingly clear that they did not arrive in forest zones with an intact “Neolithic package,” as technological and subsistence innovations of the past 3000 years occur in different places, at different times, and in different combinations (Casey 2005:234).

Some scholars propose that western Bantu speakers initially expanded gradually, perhaps following river systems inland, into those portions of the forest zone that were most conducive to fishing and yam and palm growth (David 1980; Vansina 1990). David (1980:623) speculates that these original farming populations could have relied primarily on fish for protein, possibly supplemented by goats, and forest game provided by foragers. Whether western Bantu farmers entered rain forest areas already inhabited by foragers, or cleared paths for the initial occupation of forests by hunter-gatherers was a primary subject of debate, which Eggert refers to as “the pygmy problem” (1994-1995:333). However, ethnographic and archaeological data related to the wild yam question discussed above have effectively confirmed both the possibility and actual occurrence of pre-agricultural rain forest occupation by hunter-gatherers (Barham and Mitchell 2008:324). That farmers and foragers did not “arrive together” in the rain forest

as part of the Bantu expansion is further reinforced by mitochondrial DNA data, which indicate that the ancestors of the Bantu and Western Pygmies of Cameroon, Congo, and CAR diverged between 60-30,000 years B.P., suggesting a long period of geographic separation (Batini et al. 2007; Quintana-Murci et al. 2008; Verdu et al. 2009).

Eastern and Western Bantu languages provide intriguing clues to early food production. Terms related to the cultivation of cereal crops occur only in eastern Bantu, whereas most terms for tree and root crop cultivation are western Bantu (Vansina 1990:49). There is widespread archaeological evidence of oleaginous (oil-producing) oil palm (*Elaies guineensis*) and canarium nuts (*Canarium schweinfurthii*) and some propose that management of these trees, referred to as arboriculture, may have paved the way for additional cultivated crops (de Maret 1982; Shaw 1976). Both species represent valuable sources of vegetable fat that may be cultivated by farming populations, or minimally managed to supplement a rain forest hunting and gathering economy (Mercader 2003b). Thus, the presence of arboricultural resources in archaeological contexts may indicate a shift to farming, or intensification by hunter-gatherers with little alteration of foraging subsistence patterns (Casey 2005:235).

Elaies is generally assumed to have originated in West Africa (Eggert 1994-1995) and it requires openings in the forest canopy to survive (Mercader 2003b), while *Canarium* can thrive in closed forest or semi-open spaces (Laden 1992). The presence of *Elaies* pollen in forest archaeological sites may indicate that “arboriculturalists” cleared land or encouraged the growth of oil palms in open areas, and oil palm pollen does increase dramatically at about 3000 B.P. in pollen cores from forested areas of Congo (Elenga et al. 1994), Ghana (Sowunmi 1981, 1999) and Nigeria (Talbot et al. 1984).

However, Casey (2005:234) cautions that natural phenomena such as landslides and tree falls can also create suitable locations for oil palm growth (also see Nguetsop et al. 2004). Direct evidence of oil palm exploitation within the last 3000 years, in the form of *Elaeis* endocarps in cultural strata, date to 2280 B.P. at Lope 12 in Gabon (Oslisly and Peyrot 1988).

Importantly, oil palm and canarium nuts do not necessarily prove the presence of sedentary farming populations, since both species occur naturally in and around forest environments (i.e., they were not introduced by farmers), and both appear to have been utilized by foragers before the proposed arrival of the Bantu. *Elaeis* endocarps were recovered from a sequence of cultural strata dating between 6100 and 3495 B.P. at Kintampo 6 in Ghana (Stahl 1985). *Canarium* endocarps are often (e.g., Lavachery et al. 1996; Stahl 1985), but not always (e.g., Mercader 2003b) associated with ceramics, again demonstrating an inconsistent “Neolithic package.” In the Ituri Forest of DRC, *Canarium* endocarps have been recovered from archaeological contexts as old as 10,000 B.P. (Mercader 2003b). At Shum Laka Cave in western Cameroon, *Canarium* first appears 7000-6000 B.P. and is associated with stone axes (suggesting management of arboreal resources), but reaches its maximum abundance during the ceramic Late Stone Age and Iron Age (Lavachery 2001).

The current staple crop of manioc (*Manihot* sp.) was introduced to equatorial Africa from South America by Portuguese sailors in the Seventeenth Century (Jones 1959; Vansina 1979). Prior to this introduction, plantains (*Musa paradisiaca*) may have been propagated by forest farmers as a primary food source (Eggert 1993). How and when plantains, native to Southeast Asia, arrived in Africa is not firmly established, but

Simmonds (1966) argues that they were introduced to the East African coast between 2000-1500 B.P. and spread inland from there (also see Bahuchet 1990c; De Langhe 1995). *Musa* sp. phytoliths recovered from the first millennium BC site of Nkang, Southern Cameroon suggest that bananas or plantains may have arrived on the African continent much earlier (Mbida et al. 2000), although there is some controversy over this early date (Mbida et al. 2004; Vansina 2004). Lejju et al. (2006) report *Musa* sp. phytoliths from sediment cores at Munsa, Uganda that could be as old as the fourth millennium BC, but the authors admit that their ¹⁴C dates could be erroneous. Alternatively, *Musa* sp. phytoliths may not be as easily distinguishable from indigenous “false banana” (*Ensete* sp.) as analysts currently believe (Lejju et al. 2006; Vansina 2004).

Regardless of the ultimate antiquity of plantains in Africa, there appears to be a substantial period of pre-plantain agricultural time. Many have proposed that native yam species (*Dioscorea* sp.) would have been important crops before the arrival of plantains, with some arguing that their natural abundance could provide a wild source of carbohydrates capable of sustaining forest foragers without access to domesticated calories (Bahuchet et al. 1991; Hladik and Dounias 1993; Sato 2001; Yasuoka 2006). Unfortunately, plantains and yams are more difficult to detect archaeologically than oil palm endocarps or canarium nuts, so their role in prehistoric foraging and farming remains conjectural (David 1980; Eggert 1993, 1994-1995). However, continued investigation of paleobotanical evidence (e.g., phytoliths) has the potential to clarify this issue.

Iron Age

Designating a starting point for the Iron Age in Central Africa is problematic since, “the contemporaneity and partial areal coexistence of ‘neolithic’ and iron technology communities suggested by radiocarbon dates denies any straightforward explanation” (Eggert 1993:304). Schneider (1981) places the arrival of iron on the African continent at about 2500 B.P. in the Upper Nile area. But more recent data indicate the development of iron smelting in Central Africa as early as 3000-4000 B.P. (Bocoum 2004; Maes-Diop 2004). David (1980) argues that smelting and forging techniques probably spread from North Africa to West Africa and, ultimately, into the forests of Central Africa, although archaeological evidence for early use of iron in Central Africa is sparse (Phillipson 1993).

Eggert (1993) and Mercader et al. (2000b) note that the Congo Basin provides little direct evidence about the antiquity or development of iron metallurgy, but a general outline is possible. There is evidence of an “ancient Iron Age,” linked with the expansion of Bantu populations (Lanfranchi et al. 1998; Maes-Diop 2004). Small-scale iron use, in the form of iron slag dating to approximately 2300 B.P. in southeastern Cameroon demonstrates the early arrival of iron in Central Africa, although ground stone axes and hoes continued to be used at this site long after iron first appears (de Maret 1989). In Gabon, widespread metallurgy occurs between 2200 and 2100 B.P. (Clist 1990). Similarly, archaeological evidence of metallurgy from coastal and interior Congo dates to approximately 2000 B.P. (Denbow et al. 1988; Denbow 1990; Schwartz et al. 1990; Pincon 1990). Within southern CAR, the site of Batalimo, which dates to approximately 1600 B.P. (reported in de Maret 1985), contains ground stone tools similar to those

identified in Cameroon (de Maret 1989) but no evidence of iron even at this relatively late date (Bayle des Hermens 1975). However, iron metallurgy consistent with dates for the ancient Iron Age, is reported from the southwestern CAR site Bécaré II (Lanfranchi et al. 1998). Lanfranchi and colleagues also demonstrate “recent Iron Age” metallurgy at the sites Sabélé I and II dating between the Thirteenth and Fifteenth Centuries AD, and use this to argue for “a continuum of human occupation in these forest regions in the great African Forest belt” (1998:47).

Mercader et al. (2001) report a human skeleton recovered from an Ituri Forest rock shelter, which dates to ~810 B.P. and is associated with LSA quartz industries. Considering the rarity of ceramics at this site and a single iron specimen, the authors argue that these implements represent trade between foragers and farmers. Again, these findings suggest extensive temporal overlap between supposed “Stone” and “Iron” ages. Most importantly, the skeleton was found in direct context with floral and faunal remains indicative of hunting and gathering and arboriculture: *Canarium* and *Elaies* endocarps and the bones of brush-tailed porcupine (*Atherurus africanus*), duikers (*Cephalophus* sp.), primates, small bovids, and mollusk shells (*Achatina* and *Limicolaria*) (Mercader et al. 2001:26).

Matupi Cave in northeastern Democratic Republic of Congo is one of the rare sites in tropical Africa to yield faunal remains. Van Neer (1984, 1989) reports animal bones interpreted as food remains from Late Stone Age and Iron Age deposits. Late Stone Age strata were dominated by large bovids, suids, lagomorphs, porcupine (*Hystrix* sp.), dassies (*Procavia* sp.), and cane rat (*Thryonomys* sp.). The Iron Age strata reveal relatively more pygmy antelope (*Neotragus batesi*), blue duiker (*Cephalophus*

monticola), primates (*Cercopithecus* sp.), carnivores, brush-tailed porcupine (*Atherurus africanus*), and giant rat (*Cricetomys* sp.). Van Neer (1984, 1989) attributes this taxonomic variation to environmental change rather than shifts in prey selection by hunters. Paleoecological data indicate that, during the period represented by Late Stone Age levels, Matupi Cave was situated in a savanna environment. Eastward expansion of the rain forest during the period represented by Iron Age deposits likely resulted in the prevalence of rain forest taxa, species still common in the vicinity of the cave in modern times (Van Neer 1984:73). Kiantapo, a cave site from southeastern Democratic Republic of Congo, dates to only 200 years B.P. The cave currently exists in closed forest, and its faunal assemblage was dominated by closed forest species (Van Neer 1989:125).

Vansina (1990) characterizes the centuries following 1000 B.P. as a period of relative stability, with the end of large-scale migrations and equatorial African language groups approaching their present distributions. The limited archaeological evidence that exists does not conflict with this interpretation (Vansina 1990:68), but, as with most other questions about rain forest prehistory, more information is needed.

Recent History

“In many parts of Africa the last 1,000 years comprise a period for which archaeology, although still of considerable importance, is by no means our only source of information.”

Phillipson 1993:208

“In the history of the Central African Republic there is a tremendous gap between the events of the distant past, which can be traced in broad strokes using archaeological, geographical, and linguistic data, and events of the more recent past, which are documented by only a few written accounts and widely scattered traditions.”

O’Toole 1986:10

The prehistory of Central African forest foragers is traceable by ecological change and subsistence and technological adaptation. Unfortunately, the massive sociocultural changes that undoubtedly occurred during this long period prior to written records are

beyond the range of present archaeological evidence. Over many millennia, forest foragers adapted to life in the rain forest, and adapted to the arrival of people with very different subsistence strategies and, probably, very different lifeways in general. Despite consisting of a much shorter time span than prehistory, the recent history of Central Africa documents rapid acculturative change equally significant in shaping the lives and subsistence strategies of forest foragers.

Slavery

Kalck (1993) states that Central African history of the last 400 years is inseparable from the intercontinental slave trade. Tragically, O'Toole (1986) comments that the greatest wealth Central Africa contributed to the world was its human population. Central African people were likely captured and taken north along the Nile slave routes as long ago as 2000 B.P. and perhaps earlier, but the impact of the trans-Saharan slave trade intensified in the mid-Seventeenth Century A.D. During the same period, Central Africans were transported along rivers to the West African coast where they were forced into the Atlantic slave trade. By the Nineteenth Century slaves were also taken to the East African coast and the Indian Ocean (O'Toole 1986:15). Slave traders traveled the rivers of the southwestern CAR trading imported goods for people, sometimes raiding villages for unwary victims (O'Toole 1986). O'Toole (1986:15) suggests that these victims were often social outcasts, or "troublemakers" that their fellow villagers were willing to trade. Bouquiaux and Thomas (1980) report that inhabitants of the Lobaye River Basin describe fleeing slave raiders in the lower Oubangui region into the 19th Century. Thus, for at least the last 400 years, the population demographics of the region were impacted by the intercontinental slave trade. Kalck (1993) argues that the social

chaos and population movements spurred by the slave trade ultimately made it easier for France to take possession of Central Africa.

Trade

Forest foragers were not initially affected by intercontinental economics, since European trade with West African coastal groups began much earlier than trade with the landlocked interior. The Portuguese had begun trading along the coast of Central Africa by AD 1500, followed by the Dutch in 1594, and the British and French by the 1680's (Noss 1995; Vansina 1983, 1990). Bahuchet and Guillaume cite Dapper's (1686)

Description de l'Afrique as the first written account of European trade involving Aka foragers specifically: "He recounts that 'dwarves' living outside the forest brought 'elephant teeth' to the townspeople of the Lovango Kingdom; these ivory tusks were then sold to the Portuguese" (1982:198-199). Forest forager involvement in trade, via village intermediaries, continued to develop throughout the Eighteenth and Nineteenth Centuries. Before Europeans visited the interior in the 1890's, the Sangha and Oubangi Rivers, both of which extend into southwestern CAR, served as conduits of internal and external trade, expediting the transport of beads, cloth, dried fish, guns, powder, ivory, jewelry, manioc, palm nuts, rubber, and slaves (Harms 1981; Kalck 1993; Noss 1995; O'Toole 1986; Sautter 1966).

Archaeological evidence suggests that forest foragers hunted and gathered forest resources for subsistence purposes, long before the arrival of farmers, but in later prehistory entered into an exchange relationship with cultivators (Mercader 2003a). The dynamic of exchange between forest foragers and farmers, which had existed for an indeterminate period of time (conceivably hundreds or thousands of years), changed once

again when it became linked to external commercial markets. During the colonial period in Central Africa trade relationships were increasingly imposed on village farmers, who then imposed the production cycle on forest foragers. Aka foragers acquired ivory, palm nuts, and skins and traded these to farmers for broader distribution (Bahuchet and Guillaume 1982; Demesse 1957; Hewlett 1991; Noss 1995).

Bahuchet and Guillaume (1982) cite 1899-1910 as a period of high ivory production by the Aka, but as elephant populations decreased, wild rubber (a product of *Landolphia owariensis*) became a more important export between 1910-1940. The Compagnie Forestiere Sangha-Oubangui forced village men to collect rubber in the forest. Despite not directly harvesting rubber, foragers were increasingly relied on to produce meat for exhausted village workers (Bahuchet and Guillaume 1982). Noss (1995) reports that the European desire for fur coats and gloves in the 1920's further increased the value of blue duiker skins and created an external market for this forest product, which forest foragers were well-equipped to provide.

Twentieth Century Political History

Although the political history of the Twentieth Century shaped the present-day nation of CAR, the nation's forest foragers were only indirectly influenced by international power struggles. Heightened competition between the European colonial powers in the late Nineteenth and early Twentieth Centuries led to increased interest in African raw materials. Paralleling the thesis of Diamond's (1997) *Guns, Germs, and Steel*, Martin (1983) suggests that quinine and advanced weaponry allowed the Belgians, British, French, and Germans to successfully colonize tropical Africa. O'Toole writes: "The use of quinine to control malaria allowed Europeans to survive in the tropics.

Breech-loading and finally automatic rifles and rudimentary machine guns gave them the ‘tools of expansion’” (1986:21). Thus, this combination of malarial resistance and military strength made it easier for European colonizers to conquer the previously inaccessible interior of the continent. Great Britain and France initially showed little interest in present-day CAR, but the French eventually became more interested when they began to view this area as a strategic “back door” to Lake Chad and the Nile (O’Toole 1986).

In 1899, Bangui was founded as part of the French Congo colony (O’Toole 1986) and in 1910 Ubangi-Shari (currently CAR) joined Gabon and Moyen-Congo (currently Congo) to form the Afrique Equatoriale Française federation (Kalck 1993). Despite the end of formal slave raids, the colonial period in Central Africa was marked by continued dehumanization in the form of authoritarian, often brutal, control of local populations (O’Toole 1986). The logistical difficulties of managing such a large area and population (most of whom did not accept the authority of their foreign “governors”), prompted France to hand local government duties over to concessionary companies, which were allowed to exploit labor and resources in any manner they chose (Austen and Headrick 1983; Coquery-Vidrovitch 1972; O’Toole 1986).

In 1939, France declared war on Germany, thus entering the Second World War. This declaration had little immediate impact on the distant French colony of Ubangi-Shari, although the people of Ubangi-Shari would be affected. In 1940, the colonial administrator of Ubangi-Shari joined the Free French in opposing Germany. O’Toole (1986) writes that of the 3,000 African soldiers recruited to fight for the Free French in Syria and North Africa, 10% did not return. Despite the human cost, the war actually

benefited Ubangi-Shari economically, as roads, bridges, and ports were improved.

International demand for coffee, cotton, diamonds, and rubber also increased, effectively forcing a continuation of the concessionary system during the war years (O'Toole 1986).

The post-war latter half of the Twentieth Century was arguably as tragic as the years of slavery and colonialism. "During the fifteen years following the Second World War Ubangi-Shari, along with other French territories of black Africa, moved towards autonomy, and then towards independence" (Kalck 1993:xxviii). This was a politically turbulent period that would grow even more so after CAR achieved independence in 1960 (Austen and Headrick 1983). O'Toole (1986) argues that when Barthélemy Boganda was killed in an airplane accident in 1959, CAR lost its only plausible national leader. What followed, and continues to the present, was a continuous cycle of usually corrupt national leaders ousting one another via military coup. The tragedy of this cycle is best personified by Jean-Bedel Bokassa, who declared himself Emperor and brought economic ruin to the Central African "Empire" in 1976 (Titley 1997). Bokassa's excesses and brutality would ultimately lead to his replacement and the return of the republic, but the democratic basis and legitimacy of Central African leadership has been questionable in subsequent years (Kalck 2005). CAR, particularly the capital city of Bangui, continues to suffer from interrelated effects of political instability, but these effects are less acute in the remote villages that are the focus of this study. The following chapter introduces the Bofi and Aka forest foragers, and their subsistence in the villages of Grima and Ndele, with an emphasis on the treatment of animal resources from capture to consumption and, ultimately, the introduction of bones into the zooarchaeological record.

3. FOREST FORAGERS IN THE SOUTHWESTERN

CENTRAL AFRICAN REPUBLIC

Contemporary African Forest Foragers

“Very little is known about the history of Aka or Bofi foragers. Extensive linguistic, ethnohistorical and archaeological data are desperately needed.”

Hewlett 1996b:6

Bofi and Aka foragers belong to the larger grouping referred to as Western Pygmies of Cameroon, Congo, Gabon, and CAR. This group is genetically, culturally, and linguistically distinct from the Eastern Pygmies of DRC (Bahuchet 1993; Cavalli-Sforza 1986; Hewlett 1996a; Murdock 1959). Yet undeniable similarities in physical characteristics, cultural practices, and even language between Eastern and Western groups, and the fact that they are collectively referred to as “pygmies,” raise questions about the evolutionary relationship between the two. Recent genetic studies have helped clarify the point at which they diverged (Batini et al. 2007; Destro-Bisol et al. 2004, 2006). The recent divergence hypothesis relates the genetic differences between groups to the Bantu expansion discussed in the previous chapter. According to this model, encroachment by Bantu-speaking people approximately 2000-3000 years ago divided a relatively contiguous forager population; Eastern Pygmies became isolated and retained “original” Pygmy characteristics, and Western Pygmies are the product of hybridization between Eastern Pygmy ancestors and recently-arrived Bantu farmers (Cavalli-Sforza 1986). One problem with this interpretation is that Bantu and Western Pygmies do not appear to be closely genetically related (Batini et al. 2007). An alternate hypothesis, referred to as pre-Bantu divergence, is supported by mitochondrial DNA evidence indicating that the Eastern-Western split occurred more than 18,000 years ago (Destro-Bisol et al. 2004, 2006). According to these data, Eastern and Western Pygmies were

genetically distinct populations prior to Bantu expansion, and Bantu farmers were not a causal factor in the formation of the Western group that includes present-day Bofi and Aka foragers.

Unfortunately, the major geographical division between East and West oversimplifies the considerable cultural and linguistic diversity within each grouping. Hewlett (1996a) compares and contrasts the Aka and Baka of the western Congo Basin with the Efe and Mbuti of the eastern Congo Basin. The Efe language belongs to a unique phylum distinct from the other three groups, the Baka speak an Oubangian language, and the Aka and Mbuti, despite great geographical separation, both speak Bantu languages (Hewlett 1996a:217-219). The Aka also share many similarities in subsistence practices and hunting technology with the eastern Mbuti that differ from both the western Baka and eastern Efe. Based on cultural characteristics of language, subsistence and settlement, kinship and marriage, and infancy and demography, Hewlett emphasizes the variability between individual forest forager groups and cautions against referring to “African ‘pygmy’ culture” (1996a:243-244). As a result, although the Bofi and Aka are both forest foragers of the western Congo Basin, they are treated as distinct ethnolinguistic groups here.

Anthropological research has been conducted among the Bofi (Fouts 2002, 2004, 2005, 2008; Fouts et al. 2001, 2005; Fouts and Lamb 2005; Hewlett 1996b; Landt 2007; Lupo and Schmitt 2002, 2004, 2005), but they have not been studied to the extent of better-known groups such as the Mbuti, Efe, or Aka. Hewlett (1996b) points out that, despite sometimes being lumped together with Aka foragers, the Bofi speak an Oubangian language (also see Fouts et al. 2005; Gordon 2005). Fouts (2002:44)

explains that sometime after 1870, Bofi-speaking farmers associated with Aka foragers and, for reasons that are unclear, these foragers chose to abandon the Aka language in favor of Bofi. Bofi foragers are sometimes referred to as “Babinga Bofi” to distinguish them from Bofi farmers (Hewlett 1996b). Ethnic, cultural, and material culture similarities between the Bofi and Aka may be explained by the recent origin of Bofi foragers and their ancestral relationship with the Aka (Fouts 2002; Hewlett 1996b).



Figure 3.1. Aka foragers in Ndele, Central African Republic.

The history of literature documenting Aka foragers is longer and represented by a greater variety of research, much of it sociocultural (Bahuchet 1990a, 1993; Bahuchet and Guillaume 1982; Bentz 2001; Davies 1996; Hardin 2000; Hardin and Remis 2006; Hewlett 1989, 1991, 1992, 1996a, 2001; Hewlett and Cavalli-Sforza 1986; Hewlett et al.

1982; Hewlett et al. 1986; Hewlett et al. 2000a, 2000b; Hewlett 2004; Kisliuk 1998; Kretsinger 2002; Kretsinger and Hardin 2003; MacDonald and Hewlett 1999; Meehan 2005; Neuwelt-Truntzer 1981; Noss and Hewlett 2001; Shannon 1996) and/or with an ecological emphasis (e.g., Bahuchet 1988, 1990b, 1992a; Dounias 2001a; Kitanishi 1994, 1995, 1996, 1998, 2000; Noss 1995, 1997, 1998a, b, 2000, 2001). Additional Aka research has been medically or genetically-oriented (e.g., Cavalli-Sforza 1986; Hewlett and Walker 1991; Motte-Florac et al. 1993; Walker and Hewlett 1990). In recent years, the Aka have become the subject of ethnoarchaeological projects (Hudson 1990, 1991, 1993; Lupo and Schmitt 2005; Zietz 2002). In addition to the English-language literature, a substantial amount of Aka research has been published in French (e.g., Bahuchet 1978, 1979, 1985, 1992b; Bouquiaux 2006; Delobbeau 1989; Dounias 2001b; Guille-Escuret 1998; Motte 1982) and, to a lesser degree, Japanese (Takeuchi 1991, 1994, 1995a, 1995b, 2001).

Despite sharing common ancestry with the Bofi, Aka foragers are distinguished by their use of a Bantu language (Cloarec-Heiss and Thomas 1978; Duke 2001; Gordon 2005; Hewlett 1996b; Ruhlen 1987; Vansina 1986). Other differences between Bofi and Aka are illustrated by their perceptions of one another (Hewlett 1996b). The Bofi refer to the Aka using a derogatory term meaning “forest pygmy.” In contrast, the Bofi view themselves as “less wild” since they tend to live near the edge of the forest rather than the interior forest, and make greater use of the wet savanna ecological zone. They attribute greater supernatural powers to the Aka and see the forest life of the Aka as more difficult than their own (Hewlett 1996b). Conversely, the Aka describe Bofi as lacking knowledge of the forest, being less able to climb trees, and having fewer supernatural

powers. Hewlett (1996b) reports that Aka are more likely to plant crops in the deep forest, and Bofi rarely farm. The Bofi do not emphasize *tuma* (great hunters), *dzengi* (great forest spirit), or *kombeti* (clan leader), all significant features of Aka culture (Hewlett 1996b). These differences are outweighed by extensive subsistence, technological, and cultural similarities (e.g., both groups value patrilineal clan organization and recognize *ngangas*, or healers). Commonalities between Bofi and Aka subsistence and hunting technology are discussed in the following sections.

Economy and Subsistence

Flora

Very few domesticated plants utilized in modern Central Africa originated on the continent; most are exotic introductions. Manioc, plantains, taro (*Colocasia esculenta*), corn (*Zea mays*), peanut (*Arachis hypogea*), arrowroot (*Xanthosoma* sp.), chili pepper (*Capsicum* sp.), coconut (*Cocos nucifera*), mango (*Mangifera indica*), orange and lemon (*Citrus* sp.), breadfruit (*Artocarpus utilis*), avocado (*Persea americana*), and some varieties of yam are relatively recent arrivals (Bahuchet 1990c). The cultivation of manioc in Congo was observed as early as 1611, but this resource spread very slowly into interior forests (Bahuchet 1989). Because of the difficulty of processing and detoxifying manioc tubers, initially only the leaves were utilized as a food resource in forest zones. During the colonial period, foreign powers imposed manioc on the people of Central Africa, and it was quickly established as a staple food. Throughout the Twentieth Century, manioc and plantains were a primary source of carbohydrates for forest foragers and an impetus for trade with village farmers (Bahuchet 1990c).

Prior to the colonial period, plantains and native yam species likely served as staple foods for foragers and farmers. Evidence compiled to address of the “wild yam question” (e.g., Bahuchet et al. 1991; Hladik and Dounias 1993; Sato 2001; Yasuoka 2006) suggests that a native yam-based subsistence could have sustained foragers in the interior forest prior to the arrival of farmers and their crops. Nevertheless, in a contemporary context, cultivated calories are an integral part of life in the southwestern Central African Republic. Bahuchet (1990a) estimates that, based on weight, about 50% of the Lobaye Aka diet is composed of agricultural crops. Fouts (2002) writes that a large, but unspecified, proportion of carbohydrate calories consumed by Bofi foragers is acquired from neighboring farmers.

Domesticated plants are supplemented with a great variety of wild alternatives, desired by forager and farmer alike. According to Kitanishi (1995:83) and Sato (2001:126), the Aka of northeastern Congo and Baka of southern Cameroon recognize 10 types of edible wild yam (*Dioscorea* sp.). The number of distinct yam species is currently unresolved, but Hladik and Dounias (1993:164) estimate 15-17 species occur in the Central African forest. Density studies conducted by Sato (2001) indicate some differences in the abundance of particular yam species related to forest type. Densities of *Dioscorea smilacifolia* and *Dioscorea burkilliana* were somewhat higher in mosaic forest zones around sedentary villages than in remote forest. Baka eat both the tuber and sweet fruit of *Dioscoreophyllum cumminsii* (technically a “yam-like plant;” Yasuoka 2006:286), the most abundant species overall, and one that occurred in much higher densities in mosaic forest (Sato 2001:127). These results counter Hart and Hart’s

(1986:40) argument that yams *require* relatively open or disturbed environments, although these factors may play a role in the environmental density of particular species.

Further, in actuality, the forest forager use of wild yam species may fall somewhere between strictly defined foraging and cultivation. Dounias (2001a) documents Baka “paracultivation” of wild yams, in which foragers encourage the reproduction of naturally-occurring plants, so that their tubers can be repeatedly exploited. He prefers the term paracultivation, as opposed to “proto-cultivation” because Baka patterns of yam utilization are not viewed as an intermediary step on the way to full cultivation. Baka carefully excavate tubers, leaving the head of the tuber intact and backfill the yam pit with a mixture of earth and humus, which serves to fertilize plant growth and the less-dense matrix allows tubers to grow more efficiently (Dounias 2001a:144).

Bahuchet (1988:121) comments that the Aka state that yams are available between October to June, but he has observed them being dug up year-round. However, edible yams exploited by Baka foragers reach their maximum size between November and March, which may explain the Aka preference for harvesting them during the dry season (Yasuoka 2006:291). In contrast to many wild yam species, most wild yams of the western Congo Basin are not chemically defended (requiring extensive detoxification), but mechanically defended by deeply buried tubers or stout spines above the ground surface (Bahuchet et al. 1991:224; Hladik and Hladik 1990:15). As a result, these yams are easier to process for consumption (*Dioscorea semperflorens* can even be eaten raw; Sato 2001:126) and can be located by their above-ground stems. Upon detecting a yam stem, Aka of the Lobaye forest, CAR, northeastern Congo, and the Baka

dig yams with a stick or machete. A particular deep-growing yam species (*Dioscorea semperflorens*) requires the use of a specialized tool (Bahuchet 1990b; Kitanishi 1995). The Baka use another specifically adapted tool to excavate *Dioscorea praehensilis*, a species that develops in heavy clay-rich soils, but this species is rare in CAR (Dounias 2001a:145).

Honey is a prized and widely shared resource among the Bofi and Aka and one frequently sold or traded to villagers (Bahuchet 1985, 1988, 1990a, 1990b; Kitanishi 1995, 1996; Lupo and Schmitt 2004). The seasonal availability of honey is dependent on the blooming of flowering trees and the production of honey bees, the timing and quantity of which varies from year to year (Terashima 1998). For the Aka of the Lobaye region and Baka of Cameroon, the peak “honey season” usually begins after the first heavy rains in the month of June (Bahuchet 1992a), and this general time of year during the early wet season is a good time for honey collecting among the Efe (Bailey 1991; Terashima 1998) and Mbuti (Hart and Hart 1986; Ichikawa 1981) of the Ituri Forest as well. Terashima (1998) discusses the important role of honey in mediating interactions between the Efe foragers and Lese farmers of the Ituri Forest. Comparably, Ichikawa (1981) demonstrates that honey is ecologically and socially significant among the Mbuti. Similar to Baka wild yam paracultivation, Mbuti hunters may try to ensure the future availability of honey. Although termites and honey bees belong to different taxonomic orders, while gathering termites, Mbuti hunters allowed many termites to escape, explaining that they would later drop their large wings and become honey bees the following season (Ichikawa and Terashima 1996:277).

In forest forager cultures wild honey is definitively associated with the forest. In fact, the Bofi view of Aka life as more primitive or difficult than their own is partially based on the Aka's perceived greater reliance on wild tubers and honey (Hewlett 1996b). The cultural value of both forest resources to Efe foragers is evidenced by a celebratory ceremony: at 5 or 6 years of age, boys are given a miniature axe symbolizing honey collection, and girls are given a yam-digging stick (Terashima 1998:127). The Aka value the sweetness of honey and men capable of the difficult task of climbing 20-30 m to obtain it are particularly favored (Bahuchet 1990b); Ichikawa (1981:59) comments that there are very few trees that Mbuti cannot climb. In some cases, foragers expend great time and energy in chopping down a tree to acquire hives unattainable by climbing (Fouts 2002; Ichikawa 1981), but Kitanishi (1995:83) indicates that Aka in his study area more commonly chopped down trees to access honey. Most honey exploited by forest foragers is recovered from trees, but Hicks et al. (2005:232) observe that both chimpanzees and humans in the vicinity of Grima also harvest honey from subterranean stingless-bee nests.

Nuts gathered by the Aka include *Irvingia* sp., *Antrocaryon micraster*, and *Panda oleosa* (Bahuchet 1990b). The use of *Irvingia* sp. and *Panda oleosa* is also observed among Baka foragers (Hayashi 2008; Yasuoka 2006). Many species of the genus *Irvingia* produce edible nuts, but the fruit of *Irvingia gabonensis*, referred to as *payo*, are the most important. Payo nuts are a high-calorie and high-fat food (Kitanishi 1994:83), making them an important resource in the rain forest diet. Bahuchet (1988:128) writes that Aka families gather at the base of *Irvingia* trees during the early wet season and process large quantities of payo nuts, removing their broad, flat seeds from kernels that require an axe or machete to crack (Kitanishi 1994:83). Payo nuts have hard seed coats

and delayed germination, traits that allow !Kung hunter-gatherers to store and use the well-known mongongo nuts (*Ricinodendron rautanenii*) year-round (Hart and Hart 1986:42). However, Bahuchet (1988:130) notes that payo nuts will begin to decompose and germinate after a time if they are not dried. According to Kitanishi (1994:84; 2006:127), payo nuts are frequently collected by the Aka of northeastern Congo and Baka of southern Cameroon and traded to farmers, either raw or in the form of processed (dried, scorched, and pounded) cakes which preserve longer and are easier to transport than raw nuts. Similarly, Bahuchet (1985) reports that the Aka of southern CAR trade payo cakes with cultivators. Payo nuts are also gathered for consumption and trade by Aka of the Bayanga region (Noss 2001) and Bofi foragers of Grima (Fouts 2002).

Various mushrooms are collected by the Aka and Bofi (Bahuchet 1988; Fouts 2002; Hewlett 1996b; Noss 2001), as well as fruits, including *Anonidium mannii*, *Gambeya lacourtiana*, *Pancovia laurentii*, and *Synsepalum longecuneatum*. *Anonidium mannii* is relatively high in protein (12% of dry weight; Hladik and Hladik 1990:15), providing an additional source of vegetable protein. But Bahuchet (1990b) suggests that these fruits with edible pulp are especially appreciated by children, are eaten in the forest, and rarely returned to camp. These fruits are generally not available in large quantities because monkeys eat them in the trees and those that fall to the ground are consumed at night by foraging duikers (Bahuchet 1990b). Kitanishi (1995) reports that such fruits are collected in large quantities, particularly by tree-climbing young men, and returned to camp by the Aka of northeastern Congo.

The leaves of *Gnetum* sp., called *koko*, as well as honey and mushrooms, collected by foragers in the Ngotto Reserve are all marketable outside of the local region

(Hewlett 1996b). Thus, like so many forest products, koko leaves are collected by the Bofi and Aka for consumption and trade, and they are available year-round (Bahuchet 1988:124). Fouts (2002:46) notes that Bofi men and women of Grima collect koko leaves (also payo nuts, meat, and seasonal foods such as caterpillars, snails, and mushrooms) to trade with farmers for manioc. The consumption and trade of these leaves is also reported among the Aka of the Bayanga region (Noss 2001) and northeastern Congo (Kitanishi 1994, 1995) and Baka of Cameroon (Kitanishi 2006). Nutritionally, koko leaves are important because of their high protein content, about 30% of dry weight (Hladik and Hladik 1990:14). The tuberous roots of the koko plant may also be consumed, but are only eaten when yams or manioc are unavailable (Bahuchet 1990b:20).

Fauna

The ecological, biological, and behavioral characteristics of animal prey hunted by Bofi and Aka are discussed in detail in subsequent chapters, but the range of taxa used by both groups is introduced here. Most animal food resources utilized by forest foragers are actively hunted. However, some species are so slow-moving or stationary that they can be effectively gathered. Such prey are mainly invertebrates including caterpillars, snails, grubs, beetle larvae, termites, and various other insects, but also include vertebrates such as tortoises (*Kinixys* sp.) and pangolins (*Phataginus* sp.) (Bahuchet 1990b; Lupo and Schmitt 2002). The use of caterpillars is described here since these dietarily and culturally significant species are not covered in later zooarchaeological analyses.

The invertebrates most often procured by forest foragers, and one of the resources most often associated with the Aka, are caterpillars. Bahuchet (1992a:222) describes caterpillars, along with honey, as the only highly seasonal resources used by the Aka of the Lobaye region, and he classifies the period between mid-August and mid-September as caterpillar season. Little has been written about the specific Bofi use of caterpillar species, beyond the fact that many caterpillar species are procured between August and October by Bofi men and women of Grima (Fouts 2002:46; Fouts et al. 2001:33). A comparable season is cited for the Baka of eastern Cameroon (Bahuchet 1992a:244) and Aka of northeastern Congo (Kitanishi 1995:93). Kitanishi (1995) observed six species of caterpillar (larva of Lepidoptera) used by the Aka. These caterpillars fall from the tree canopy before metamorphosis into the chrysalis stage, and can be easily collected from the ground (Bahuchet 1990b:20; Kitanishi 1995:83). Bahuchet describes this metamorphic phase as “extremely brief but perfectly cyclical” (1988:122). Despite the annual regularity of caterpillar season, the *abundance* of caterpillars fluctuates from year to year (Bahuchet 1985; Hudson 1990) and by location. Hewlett (1991:26) links differences in seasonal mobility of Aka foragers in the villages of Bokoka and Ndele (discussed further below) to the presence of swamp forests around Ndele, which contain fewer caterpillar trees. Thus at the time of his study, Ndele did not have a caterpillar season comparable to other locations (Hewlett 1991:26).

Small animals (primarily mammals < 10 kg live weight) are the most commonly hunted prey among the Aka and Bofi and include blue duiker (*Cephalophus monticola*), giant pouched rat (*Cricetomys gambianus*), brush-tailed porcupine (*Atherurus africanus*), guenon monkeys (*Cercopithecus* sp.), civet (*Civettictis civetta*), mongoose (*Herpestes*

naso), rats and mice (Muridae), and small reptiles and birds. Medium prey (10-25 kg), such as bay (*Cephalophus dorsalis*) and Peters duikers (*Cephalophus callipygus*) are pursued by Bofi and Aka hunters, but are more frequently encountered in Ndele than Grima. Large prey (25 to >100 kg), such as yellow-backed duiker (*Cephalophus silvicultor*), red river hog (*Potamochoerus porcus*), giant hog (*Hylochoerus meinertzhageni*), sitatunga (*Tragelaphus spekei*), bongo (*Tragelaphus euryceros*), and forest buffalo (*Syncerus caffer*), occur in the Ngotto Forest, but are rarely encountered or killed (Lupo and Schmitt 2004, 2005).

Hewlett (1996a) includes ritual activities associated with elephant hunting among the criteria shared by most African forest foragers, except the Bofi. Aka foragers historically hunted elephants (*Loxodonta africana*), which are currently endangered in southwestern CAR and legally protected (Colyn 1994; Dethier and Ghiurghi 2000; Lupo and Schmitt 2005). The Aka recognize the position of *tuma* (great, or elephant, hunter), but the Bofi do not (Hewlett 1996b), probably indicating that the hunting of elephants is not culturally significant to the Bofi. The Baka of southeastern Cameroon use the term *tuma* to refer to experts in hunting large game such as gorillas (*Gorilla gorilla*) or elephants, and these individuals are highly respected (Hayashi 2008:78). Although we observed no elephant hunting during the course of this ethnoarchaeological project, we did locate the sites of previous elephant kills in the forest around Ndele, represented by scatters of elephant bones.

Interdependent Relationships with Farmers

“Indeed, it is not possible to consider pygmy culture and subsistence in isolation from the African farmers with whom they trade and live...Central African farmers and pygmies exist together, are interdependent, and should be considered as an integrated economic and social system.”

Bailey et al. 1992:204-205

Very few aspects of forest forager life have received as much scholarly attention as the interdependent relationship between Central African farmers and foragers. The previously discussed “cultivated calories hypothesis” (Bailey et al. 1989) is partially based on the recognition that all ethnographically known forest forager societies engage in the exchange of subsistence goods with farmers to varying degrees (i.e., none subsist by foraging alone). How far this pattern extends into the past and whether it demonstrates forager dependence on farmers or simply an efficient alternative to full-time foraging is at the heart of the debate. Documented relationships between foragers and farmers in Central Africa are perceived in ways ranging from mutually beneficial symbiosis to pervasive inequality and farmer dominance over forest foragers (Joiris 2003; Rupp 2003).

Among contemporary Central African societies, the exchange of material goods is the most visible expression of relationships between forest foragers and farmers and it has been extensively covered in the anthropological literature (e.g., Bahuchet and Guillaume 1982; Bailey and Peacock 1988; Hart 1979; Ichikawa 1986; Kitanishi 1994; Schebesta 1936; Terashima 1986, 1998; Wilkie and Curran 1993). Throughout recorded history, forest foragers have provided farmers with wild plant and animal resources procured in the forest. Foragers also represent an intermittently available labor pool for agricultural work in villages. In exchange for forest products and labor, village farmers provide foragers with domesticated plants (primarily manioc), iron tools, wages, clothes, alcohol, tobacco, etc. Villagers may acquire forest products for personal consumption or for commercial redistribution. Although markets for specific products have fluctuated since colonial days, the role of village intermediaries remains similar, and this is

especially evident in the modern bushmeat trade. Bushmeat is acquired for commercial networks by foragers and farmers using various technologies, discussed further below (Auzel and Wilkie 2000; Eves and Ruggiero 2000; Hart 2000; Ngongba-Ngouadakpa 2001; Noss 2000). Meat procured by foragers often passes through a village “middle man” before transport to larger markets, but is sometimes sold directly to traveling meat vendors (Hart 1978; Noss 1995).

On the surface, the relationship between farmers and forest foragers revolves around material exchange. However, most studies elaborate on multiple, interrelated dimensions of interaction. For example, Hewlett (1996b:5) distinguishes between traditional and independent forager-farmer relationships. Traditional relations include economic, religious, social, and symbolic dimensions. In such relationships, forager and farmer families may grow up together, share clan names, and attend each other’s marriages and funerals in addition to exchanging food and material goods. Independent foragers are those who have broken away from traditional systems because their village patron mistreated them, or in pursuit of other economic opportunities. Independent foragers still provide forest products to villagers, but the traditional social connections are absent. Some studies portray these relationships as unequal (Bahuchet and Guillaume 1982; Grinker 1990, 1994), while others emphasize the role of forager autonomy and choice in maintaining these interactions (Köhler and Lewis 2002; Turnbull 1965). Some scholars question the widespread interpretation of “forager” and “farmer/villager” as dichotomous categories, suggesting that this analytical framework is too inflexible, oversimplifying complex, variable relationships between individuals in specific contexts (Joiris 2003; Rupp 2003; Terashima 1998).

Stiles (2001) agrees that forager-farmer interdependence occurs in multiple forms and he proposes a method for classifying foragers based on their level of interrelatedness with agricultural neighbors. His contextual classification stages are: 0) Precontact, 1) Contact, 2) Sporadic exchange, 3) Accommodation, 4) Acculturation, and 5) Assimilation/Annihilation (2001:44-47). These stages account for progressively greater interaction between hunter-gatherer groups and farming populations, and Stiles (2001:46) cites the Aka as an example of Stage 4 foragers. Foragers in Stage 4 relationships with agriculturalists:

- become ideologically and socioeconomically structured in relation to farmers
- become low status relative to farmers
- often adopt the language and some cultural characteristics of farmers
- trade forest products with farmers as a principal occupation
- may work sporadically for farmers
- become more sedentary for at least part of the annual cycle

Each of these traits generally holds true for the Aka, but Bahuchet and Guillaume (1982) provide a more specific overview of Aka-farmer relations in the northwest Congo Basin. Considering the similarities between Bofi and Aka, much of the information is applicable to the Bofi and, in some cases, forest foragers in general (but see Hewlett 1996a). According to Bahuchet and Guillaume (1982), the Aka refer to their neighbors using the term *milo/bilo*, translated as “Tall Blacks.” The term has multiple connotations, including stranger, non-pygmy, villager, sedentary, master, and boss. Conversely, villagers associate the Aka with both savagery and salvation. The Aka are “of the forest” and represent an intermediate state between the human and animal worlds, yet these traits

guided the farmers “to a world which was previously alien and hostile to them, and provided them with necessary forest products (i.e., meat, gathered food, medicinal plants, etc.)” (Bahuchet and Guillaume 1982:193). To the Tall Blacks, the geographical separation of village (cultural space) and forest (natural space) expresses an inherent division of labor, and one which justifies the domination of the Aka. Despite the clearly subordinate position of the Aka, the Tall Blacks are impressed, and sometimes fearful, of the Aka association with and ability to manipulate the supernatural powers of the forest world. Further, the subjugation legitimized by Tall Black ideological representations is not manifested in all aspects of Aka-farmer relations, particularly subsistence exchanges (Bahuchet and Guillaume 1982:195). As noted previously, the Aka have control over the forest products they provide and can, in fact, opt out of traditional relations altogether if mistreated. Thus, as Turnbull (1965) documented among the Mbuti, the Aka are not powerless in their relationship with the village world.

Hewlett (1996b) states that foragers with traditional relations, as opposed to one-dimensional economic relations, with farmers predominate in the villages of Grima and Ndele. A comprehensive treatment specific to Bofi-farmer relations has not been written, but Fouts (2002) provides many insights. The foragers and farmers of Grima live in close proximity to one another, know the details of each other’s lives, and share spiritual rituals, but are not consistently friendly. Some Bofi foragers are comfortable entering the village and engaging in village life, while others only do so when necessary and in a cautious, reserved manner. Fouts (2002:56) documents physical and verbal conflicts between foragers and farmers, noting that after one conflict an entire forager clan exercised their independence and left Grima indefinitely. Alternatively, Bofi foragers

and farmers may file complaints with the village chief, although foragers rarely win such disputes.

The Grima villagers' perception of Bofi supernatural powers is comparable to that described among the Aka, with positive and negative consequences. Farmers respect the Bofi expertise in spiritual matters and may participate in forager funerals or seek the guidance of a Bofi healer (*nganga*). However, Bofi and Aka foragers are sometimes accused of turning themselves into animals in order to steal from farmers – an accusation that foragers are unable to disprove (Fouts 2002; Hewlett 1996b).

Economically, the pattern of forager-farmer exchange in Grima is comparable to the generalized description above. Bofi foragers provide villagers with forest products in exchange for cultivated crops and material goods. Lupo and Schmitt (2002:150) write that approximately 35% of meat acquired by the Bofi of Grima is traded to villagers. Interestingly, the demand for meat is so high that, to avoid competition with other buyers, farmers sometimes intercept foragers in the forest to purchase meat before it arrives back in Grima (Fouts 2002). Fouts (2002:58) also reports that farmers from larger villages such as Boda visit Bofi forager camps weekly to trade clothing, jewelry, money, and whiskey for koko leaves.

Mobility and Settlement Patterns

Contemporary forest forager mobility and settlement patterns are largely dictated by exchange with farmers and other village-based considerations, but this may be a relatively recent phenomenon. Wilkie and Curran (1993) document major historical changes in exchange between the Efe and Lese of northeastern DRC. As discussed in the previous chapter, archaeological evidence from tropical Africa is growing, but many

fundamental questions remain unanswered. Consequently, Wilkie and Curran (1993:394) can only speculate about what pre-horticultural Efe subsistence in the Ituri Forest would have been like. They suggest that small groups of Efe would have been highly mobile and foraged widely to exploit a broad range of seasonally-available resources. Exchange with Lese horticulturalists, and precisely when this began is unknown, would have created new options for the Efe and altered mobility (reduced nomadism) and resource use (new options for carbohydrates and fats; Wilkie and Curran 1993:399).

Belgian colonial policy between the 1920's and 1940's brought further changes to Efe mobility as relatively dispersed Lese farmers were encouraged to form centralized permanent villages along major roads. Increased population density around these roadside villages "reduced the area in which an Efe band could forage while still avoiding conflict with proximal groups...a reduction in foraging area or exclusive use of a foraging area likely would have resulted in increased hunting pressure within the area" (Wilkie and Curran 1993:405). A significant consequence of this long-term "tethering" to roadside villages is that, in recent years, Efe have begun to clear their own fields and plant their own crops (Wilkie and Curran 1993:409).

Aspects of these historical changes in Efe mobility and settlement are seen in other forest forager groups as well. Many have noted that the Cameroonian government implemented sedentarization and agriculturalization policies in the 1950's aimed at encouraging Baka foragers to settle alongside major roads (Althabe 1965; Hayashi 2008; Joiris 1998; Kitanishi 2006; Sato 1992; Yasuoka 2006) and many contemporary Baka cultivate plantains for their own use and even cacao as a cash crop (Hayashi 2000; Kitanishi 2003).

Comparably, colonial “taming policies” in 1930’s CAR encouraged Aka foragers to settle along roads, cultivate plant foods, and sell forest products at markets (Bahuchet and Guillaume 1982). Citing Demesse (1978), Bahuchet and Guillaume describe this process:

1. Nomadism decreases and the time spent in settled camps on the edge of the forest, close to villages, increases. Hunting and gathering are increasingly carried on from these bases, and no longer from temporary forest camps.
2. The territory of exploitation is more and more restricted. Great hunting expeditions are slowly replaced by shorter trips of limited distance.
3. There is a decrease in natural resources and lowered hunting efficiency occurs because of over-hunting in the most frequented areas (1982:207).

Thus, Bahuchet and Guillaume describe modern Aka as being tied to villages, but Hewlett (1996b) argues that Aka mobility is determined by availability of resources, and Western developments such as conservation projects, missions, forestry companies, and roads are all potential resources. In fact, the first people to move near new roads, which are perceived as resources, are often foragers (Hewlett 1996b:11). Hewlett (1996b:5) writes that some Aka plant their own crops in the context of large villages, but others, including those of Ndele, tend to establish farms independent of villages deep in the forest. During our study period some Aka planted crops of manioc near Ndele for domestic consumption and Aka women reported spending 3-4 days a week tending to these fields (Karen Lupo, personal communication 2009). In addition, most Aka of Mossapoula, CAR have their own manioc fields (Noss 1995:113). A minority of contemporary Bofi foragers of Grima also grow very small crops of manioc and maize (Fouts 2002:45).

From this brief history it can be seen that present patterns of forest forager mobility and settlement are likely not representative of pre-horticultural, or even pre-colonial patterns. Recently documented forest forager groups follow a seminomadic pattern of living near farming villages for part of the year and in remote forest camps for

the remainder (Hewlett 1996a). Within this general pattern, there is great variability in the number of months spent in forest camps, the distance of camps from villages, and subsistence and other context-specific considerations in group mobility.

Village Camps

Making population estimates of forest forager villages is difficult because group composition constantly changes (Bahuchet 1979). Bahuchet explains: “many Aka spend time in several different camps, although they consider themselves ‘members’ of the camp where they live most of the time and ‘visitors’ in the others” (1990a:29). At the time of our study, a population fluctuating between approximately 150 and 250 Bofi was distributed among several forager camps of Grima (Lupo and Schmitt 2002, 2004), each consisting of about 20-30 individuals socially organized by patrilineal clans (Fouts et al. 2001:33). Village camps include multiple house types, primarily small, circular thatched-roofed structures, although foragers in Grima and Ndele also sometimes live in rectangular houses with peaked roofs and mud-reinforced walls, more comparable to farmer houses (Figure 3.2). Fouts describes these camps:

the Grima forager village-camps are located very close to the village of Grima, with the distance from the center of the village to the center of the forager camps being approximately 50-60 yards. In actuality, the main forager camp is adjacent to the village, because several of the outlying village houses are directly adjacent to forager houses. This close proximity accentuates the social ties between the two groups, with individuals of both groups interacting on a daily basis (2002:56).

In contrast to Grima, Bofi foragers of the village of Poutem interact with Poutem farmers on a daily basis, but occupy a “village camp” approximately 1 km from the village. Despite this distance, Bofi distinguish between Poutem camps and the more remote forest camps discussed below (Fouts 2002:56).



Figure 3.2. Photo of Aka family in Ndele, CAR illustrating common house types.

Comparable to Poutem, Hudson (1990) documents 70 Aka village camps at a distance of 1-5 km from the villages of Bangandu and Kenga, southwestern CAR. Camp populations ranged from as few as seven to as many as 67 individuals (Hudson 1990:57). The Aka village camps of Ndele are more similar to the Bofi camps of Grima than those of Poutem in that they are located very close to the village. During our study period, Ndele was inhabited by approximately 250 foragers (Fancher et al. 2003). Lupo and Schmitt (2005) describe two representative Aka residential camps from Ndele. Camp Ndele 5 is occupied by an extended family of two grown men, five grown women, and three children, and includes four houses covering 100 m². Camp Ndele 7 is occupied by an extended family of three men, three women, and eight children, and includes four houses spread over 330 m² (Lupo and Schmitt 2005:345).

Bahuchet (1988, 1990a, 1992a) characterizes Lobaye Aka camps, regardless of proximity to farming villages, as the basic socioeconomic unit of Aka life. He describes a typical camp as consisting of fewer than 20-30 adults, living in 6-8 houses comprised of nuclear families, and in most cases, the majority of people living within the same camp are members of an extended family (1992a:219). The community nature of camps is reflected in their spatial patterning: “six to eight huts placed in a circle, delimiting a central area which, except when it rains, provides the stage for daily activities” (Bahuchet 1990a:29).

Kitanishi (1994, 1995, 1996, 1998) reports that Aka of northeastern Congo also maintain base camps near villages. He divides these village-associated camps into two types based on length of occupation: semi-sedentary and temporary, but refers to both as “village camps” and distinguishes these from forest camps deeper in the forest. Temporary camps are quickly built when Aka return from long periods in the forest, and used until semi-sedentary camps are established (Kitanishi 1995:78). The village of Linganga-Makaou, Congo includes nine (later increasing to 12; Kitanishi 1998) village camps (a total of 340-350 Aka), located behind farmers’ houses, near horticultural fields, or in the secondary forest within a 30-minute walk of the village (Kitanishi 1995:78). There is great variability in residential groups ranging from 3-20 families and 15-100 individuals who share kinship, and these residential groups correspond very closely to village camps (i.e., village camps are comprised almost entirely of related individuals; Kitanishi 1998:5).

Forest Camps

Another common feature of forest forager mobility is that a portion of each year is spent farther away from villages in remote forest camps. The proportion of the year spent in these camps, and their relative distance from base or village camps varies (Hewlett 1996a). The village of Grima is close enough to the forest that hunters can hunt in the forest during the day and return to village camps at night, so the Bofi of Grima spend much of the year in village camps (Fouts 2002:55). Lupo and Schmitt (2005:337) report that the Bofi spend as many as six months of the year in residential camps around Grima, and possibly longer for some segments of the population. The remainder of the year is spent in “a series of temporary hunting camps in the forest which are used for procuring products for trade and consumption” (Lupo and Schmitt 2002:150).

At the time of Fouts’ (2002) study, the Bofi of Grima spent only 2-3 months of the year in forest camps, usually timed during the wet season (June-October) to coincide with the availability of caterpillars and snails in the forest. The timing of forest camps may also depend on the scheduling of agricultural work in Grima, since foragers who stay in village camps during the dry season can combine work clearing farmers’ fields with short-distance hunting excursions from Grima. Bofi foragers usually build about 2-3 forest camps per wet season approximately 5-9 km from the village, and these small camps include only one or two families for a total of 15-20 individuals per camp (Fouts 2002:55). In contrast, Lupo and Schmitt (2005:345) report the exceptionally large Sungu temporary wet season camp in the vicinity of Grima that contained 30 residential structures, covered 3375 m², and was intermittently occupied by up to 60 people over a period of 3 ½ months. This camp was specifically used as a base of operations from

which to hand, snare spear, and trap hunt (Bofi and Aka hunting methods are elaborated on in the next section).

The Bofi foragers of Poutem also depart to forest camps during the wet season, but there are some notable differences between Grima and Poutem Bofi (Fouts 2002). Poutem Bofi spend more time in forest camps (3-4 months per year), build more camps per wet season (5-6), occupy somewhat larger camps (20-25 individuals), and these camps are generally farther from Poutem (8-12 km) than those of Grima (Fouts 2002:55). Poutem Bofi collect caterpillars from forest camps during the wet season and, when this season ends, stay in the forest to collect koko leaves before returning to Poutem to work on the coffee plantation of a wealthy clan chief in the early dry season (Fouts 2002:55). Fouts (2002) concludes that both Grima and Poutem Bofi foragers spend far less time in forest camps, which are located closer to villages, than is typical for the Aka (see Table 3.1 for comparison to other forest forager groups).

Table 3.1. Forest forager settlement^a.

Settlement	Aka ^b	Baka ^c	Bofi ^d	Efe ^e	Mbuti ^f
Distance to forest camps	15-40 km	4-20 km	5-12 km	4-5 km	5-15 km
Months per year in forest	7-8	4-5	2-6	5	8

^aAdapted from Hewlett 1996a:220, with addition of Bofi.

^bBahuchet 1985, 1988; Hewlett 1991, 1996a.

^cHayashi 2008; Vallois and Marquer 1976; Yasuoka 2006 (special *molongo* camp occurs 20-50 km from village).

^dFouts 2002; Lupo and Schmitt 2002, 2004.

^eBailey 1991; Peacock 1985; Bailey and Peacock 1988; Hill 1982; Harako 1976.

^fHarako 1976, 1981; Hart 1978; Hill 1982; Ichikawa 1978, 1986; Turnbull 1965.

More data are available on the Aka use of forest camps and, as a result, even greater diversity in the variables discussed among the Bofi is evident. Most documented

Aka groups spend more time in forest camps than do the Bofi, and this contributes to the Bofi perception of Aka as “forest pygmies.” However there is considerable variability in the number of months that specific groups spend in forest camps. Hewlett (1996b) reports that the Aka of Londo (also the Bofi of Mbakolo, both within the Ngotto Forest) live in permanent rectangular houses in the village and only spend 3-4 months in forest camps. These locations are aberrant since most Aka spend at least half of the year in the forest (Hewlett 1996b:6).

As with the Bofi of Grima, the Aka of Ndele spend variable lengths of time up to several months in forest camps, ranging from single-family camps to much larger aggregates (Lupo and Schmitt 2005). Hewlett (1991) compares the seasonal camp movements of Aka from Bokoka and those from Ndele, noting that they vary according to ecological and social factors. Both groups spend the months of March through June and July in forest camps because it is a good time to net hunt, trees start to flower (indicating abundant fruits, nuts, and honey), and termites are available. Conversely, since village crops are planted in April for harvest in July, there is less to be gained from villagers during the months of March-July (Hewlett 1991:26). Bokoka is closer to urban areas than Ndele and its coffee farmers are wealthier. As a result, Bokoka Aka are willing to leave forest camps, and forego the early dry season (December-January) net hunting period, in favor of harvesting coffee in the village. In contrast, Ndele coffee plantations are small, and because of the greater presence of swamp forest near Ndele there are fewer caterpillars during what is caterpillar season elsewhere, so Ndele Aka move into the village during the height (August-October) of the wet season (Hewlett

1991:25-26). These Bokoka and Ndele mobility data were collected in the 1980's, but demonstrate the social and ecological factors involved in Aka settlement patterns.

More recently, Lupo and Schmitt (2005) describe two representative forest camps from the vicinity of Ndele inhabited during the late dry-early wet season. Bodenge 1 is a temporary net-hunting camp occupied by a core group of nine related men, with visitors frequently coming and going, for 15 days. The 300 m² camp included one residential structure and three large ramadas used for eating and sleeping (Lupo and Schmitt 2005:344). Bodenge 2 comprises two camps separated by approximately 500 m that were simultaneously occupied by five related families for eight weeks in the late dry-early wet season. The camps included five residential structures and a 50 m² communal ramada (Lupo and Schmitt 2005:344).

During Bahuchet's (1985) research among Lobaye Aka, foragers spent between 7-8 months annually in forest camps located at distances of 15-40 km from farming villages. As with the Bofi, the mobility decisions of Aka are influenced by their involvement with village life. Although the dry season is generally perceived as better for net hunting in the forest (Hewlett 1996b; Hudson 1990; Lupo and Schmitt 2004), village patrons may compel foragers to stay nearby in the dry season to help harvest coffee (Hewlett 1996b) or assist with field clearing (Bahuchet 1992a). In some cases, Aka foragers alternate one year of collective net hunting in the forest and one year near a village for agricultural labor (Bahuchet 1988, 1992a; Bahuchet and Thomas 1985).

In the Bangandu/Kenga area, Hudson (1990:54) indicates that the dry season is when villagers seek Aka to clear new fields and to climb palm trees to collect nuts for oil. Hudson appropriately cautions that Aka mobility is not a simple annual round, since:

During any given time of year there is often more than one viable and attractive option. Some groups divide their time between options, pursuing alternative subsistence and settlement strategies sequentially. Others divide the group itself, different members pursuing alternative strategies simultaneously. This variability allows considerable flexibility in meeting both social and subsistence needs (1990:57).

Kitanishi (1994, 1995, 1996, 1998) documents similar variability among the Aka of Linganga-Makaou, noting that they spend anywhere from 4-8 months per year in the forest, and subsistence-related mobility “does not fall into a simple annual cycle, but fluctuates from year to year” (1995:73). He describes forest camps as those made “deep in the forest,” usually built near rivers for access to fresh water, as opposed to village camps which are within a 30-minute walk of the village (1995:78). During Kitanishi’s study period, Aka followed a complex pattern of village-forest mobility, with large residential groups (Kitanishi’s focal residential group consisted of 80 individuals) sometimes splitting up, then merging again after periods of separate work in forest and village. Forest camps are usually comprised of individual residential groups, ranging from 21-74 individuals, but occasionally multiple residential groups will camp together in the forest (Kitanishi 1998:7-9). Comparable to Bahuchet (1990a), Kitanishi (1998:8) illustrates a spatial arrangement of forest camps in which houses face each other in a circular arrangement around a central space.

The mobility and settlement of contemporary and recent Bofi and Aka foragers are heavily influenced by economic, logistical, and social concerns, primarily their relationship with farming populations. The economic aspect of these relationships centers on the procurement of forest products by foragers and the following section details the variety of hunting methods employed by the Bofi and Aka to acquire animal prey.

Hunting Methods and Technology

Forest foragers rely on a range of cooperative and individual hunting techniques, the use of which varies according to many interrelated variables, including: seasonal considerations, number of participants, targeted prey, method efficiency, proximity to farming populations, market involvement, and possibly the foraging goals of individual men, women, and children (Abruzzi 1979; Bailey and Aunger, Jr. 1989; Harako 1976; Hewlett 1996a; Ichikawa 1983; Lupo and Schmitt 2002, 2004; Milton 1985; Noss 1997; Terashima 1983; Turnbull 1965; Wilkie and Curran 1991).

Predominant forms of communal hunting among the Aka and Bofi are net hunts and spear hunts, both of which may occur simultaneously, given a sufficiently large hunting party. According to Aka foragers and Ngandu farmers, net hunting was originally a villager hunting technique that became more prevalent among foragers in response to increased demand for duiker skins in the early Twentieth Century. Prior to this, spear hunting was more common among the Aka (Hewlett 1991:16).

Among the Bofi of Grima, nets are produced from raw fiber collected in the forest and range from 60-80 cm in height and 28.0-65.5 m in length; Aka nets are made of the same material (Lupo and Schmitt 2002:153). Noss (2000:287) observed nets between 100-150 cm in height and between 5-40 m (18 m average) long among the Aka of the Bayanga region. Aka and Mbuti hunting nets are reported to be produced from *Manniophyton fulvum* bark fiber (Harako 1981:513; Noss and Hewlett 2001:1034; Tanno 1976:103). Tanno writes: “The net-hunters collect the young leafless branches of this vine, making long strings from the cambium of the branches peeled off the outer skin and weaving these strings into their nets” (1976:110). Mbuti nets are owned by the person

who wove them, usually a married male (Ichikawa 1983:58). However, in a study conducted by Noss and Hewlett (2001:1028) 26% of Aka nets were owned by women, and those who did not own nets often borrowed them from men. Net ownership is significant because the owner of a net owns any animals captured in it and is subject to culturally determined sharing rules, which are discussed below (Harako 1981; Lupo and Schmitt 2004; Noss and Hewlett 2001). In the event that a net is borrowed, “a captured animal is the property of the net owner, even if the owner is not hunting” (Noss 1997:74), although the net borrower is entitled to a portion of catches made with another person’s net (Bahuchet 1990a:33; Hudson 1990:104; Lupo and Schmitt 2005:340). There are many societal benefits to sharing hunting technology. For example, Bahuchet writes about the Aka:

An elder who can no longer go hunting will lend his weapon to a younger man. This procedure has two advantages: first it allows a younger person without his own weapon to provide meat for the group. Second, it allows an elder to participate in food-getting activities through an intermediary. By being the ‘acquirer’ of the animal killed, he presides over sharing and in this way enters into the exchange network. This is an elegant way of receiving help without losing dignity since, according to the rules, the old man does not have the right to eat the meat (1990a:41).

Tanno writes of another benefit demonstrated by the Mbuti: “On the day that a net-owner does not take part in the hunting, another man uses it, so that almost all of the nets in the hunting camp are used every day” (1976:113). Net hunting is widely characterized as a method that benefits from, and arguably requires, large groups (Harako 1981; Ichikawa 1983; Lupo and Schmitt 2002; Noss 2001; Tanno 1976; Terashima 1980, 1983).

Lupo and Schmitt (2004) describe Bofi net hunts consisting of up to 35 forager men, women, and children, most of whom may be active participants. The technique of Central African net hunting has been well-covered in previous literature (Harako 1976; Hart 1978; Noss 1997; Takeuchi 1995b; Tanno 1976; Turnbull 1965). Noss and Hewlett

provide a brief description of the method used by the Aka of the Central African Republic and northern Congo:

Hunters form a circle or semicircle with the nets, hanging the nets on small trees or vines, pegging the bottom of the net to the ground. Upon completing the circle or semicircle, the net carriers (usually male) begin searching the interior, beating leaves and shouting to drive animals from their hiding places. Often one or more men with spears also search the interior. The other participants (usually females) remain hidden near the nets to spot flushed animals, frighten them into the nets, and then seize them before they escape. Animals captured in nets are killed with machetes or logs lying nearby. The hunters quickly determine that no animals are inside the circle or that what is there has escaped or been captured. They then gather up the nets, move on to the next spot only a couple hundred meters away, and begin again (2001:1027).

In terms of prey species, net-hunting is technically a non-selective technique, although hunters avoid driving large prey into nets because they are more likely to damage the fiber (Hudson 1990; Putnam 1948). The small blue duiker is the species most commonly taken in nets. Noss (1997:75) suggests that prey larger than bay and Peters (medium) duikers can tear through or jump over nets to escape capture. Data presented by Lupo and Schmitt (2004:251) demonstrate that over 95% of animals caught in Bofi nets are blue duikers. Net hunting data from the Bayanga region show 75% blue duiker, with most of the remainder comprised of brush-tailed porcupine, bay and Peters duikers (Noss 1997:75). Net hunting is less commonly practiced in the wet season, since excessive moisture can damage nets and make them heavier to transport (Bahuchet 1988; Hudson 1990; Noss 1995). As a result, spear hunting takes on greater importance during the wet season. Bahuchet and Guillaume refer to duikers as “the net game par excellence” (1982:207), and Tanno suggests that “Mbuti net-hunters are essentially duiker-hunters” (1976:125).

Aka and Bofi spears are prepared by fitting an iron tip onto a shaft fashioned of wood. Small groups of male spear hunters generally target porcupines or larger prey that are not easily taken in nets, such as medium and large-sized duikers and river hogs (Lupo

and Schmitt 2002). A similar prey-size-based division of spear and net hunting is seen among the Mbuti of the Ituri Forest, although they appear to more frequently take medium and large duikers in nets (Harako 1981:511). Ichikawa (1983:65) suggests that Mbuti nets are capable of taking animal prey weighing up to 30 kg. Kitanishi (1995:81) reports that the Aka of northeastern Congo most often pursue bush pigs with spears, but that they occasionally hunt gorillas, and traditionally spear-hunted elephants “scores of years ago” (Kitanishi 1996:40). As with nets, the owner of the spear that first strikes an animal, even if that strike is not fatal, owns the animal (Bahuchet 1990a:31; Kitanishi 1998:10). Demonstrating the applicability of sharing rules to specific circumstances, Kitanishi (1996:41) notes that an animal struck by a spear *before* running into a net belongs to the owner of the spear.

Noss (2000:287) indicates that, as opposed to net hunting where major roles are performed by both sexes, only Aka men use spears. Kitanishi suggests that Aka men spear hunt during a time of year when this method is inefficient because it is a highly appreciated male activity (i.e., showing off), and hunting bush pigs with a spear is one requirement of being “an adult man” (1995:92). Spear hunting of large animals by the Mbuti is perceived as dangerous, requiring great skill and courage (Harako 1981; Tanno 1976). Comparably Lupo and Schmitt (2004) argue that nonconsumptive factors may influence the choice of small prey hunting technology among Bofi and Aka men since net hunting is higher-risk, but witnessed by many, whereas individual techniques are lower-risk, but occur in isolated locations and provide fewer opportunities to show off.

Individual (1-3 people) hunting techniques used by the Aka and Bofi include hand capture, trapping, and bow hunting (Bahuchet 1985; Kitanishi 1995; Lupo and Schmitt

2005). Lupo and Schmitt (2004) describe the technique of hand-capturing animals, using dogs and fire to flush small prey such as monitor lizards (*Varanus* sp.), pangolins, and tortoises from dense vegetation and giant pouched rats and Murid rodents from underground burrows (also see Bahuchet 1988:127). Among the Bofi of Grima, rat hunting is less effective during the wet season since wet soil allows rats to more easily dig escape tunnels (Lupo and Schmitt 2004). Kitanishi (1995:80) notes that the Aka of northeastern Congo sometimes capture pangolins or other small prey by hitting them with sticks or machetes.

Rats, porcupines, and rarely small duikers, are sometimes captured by foragers in wire snares or string traps (Bahuchet and de Garine 1990). Lupo and Schmitt (2005:338) explain that pole noose snares are commonly used by farmers in Grima and Ndele, but are increasingly used by foragers as well. Cables made of natural fibers and metal are both used even though the use of metal wire is illegal (Eves and Ruggerio 2000; Noss 1998b; Schmitt and Lupo 2008). Hudson writes: “In interviews, older Aka have suggested that the increasing use of wire traps has contributed to over-exploitation of the game” (1990:108). Rarely used small traps include a cone-shaped trap that targets Murid rats and mice and a fiber bag trap that targets brush-tailed porcupines and occasionally giant pouched rats (Lupo and Schmitt 2005:338).

Trapping is much more common among some forager groups such as the Aka of northeastern Congo (Kitanishi 1995, 1996, 1998) and Baka of southeastern Cameroon (Hayashi 2008; Yasuoka 2006). Hewlett (1996a:229) writes that the Baka spear hunt and use traps, but do not net hunt. Kitanishi (1995:81) indicates that the Aka are able to capture relatively large prey in spring traps, including yellow-backed duiker, Peters

duiker, bush pigs, and giant forest hogs. These traps are usually made with steel wire, but are still sometimes made with the fibers of *Raphia* sp. and *Maniophyton fulvum* (Kitanishi 1995:81). Peters and blue duikers are the main species captured by cable snares in the Bayanga region (Noss 1998b:394). Any animals captured in snares belong to the person who set the trap (Bahuchet 1992a:228; Kitanishi 1998:10).

Archery is the dominant hunting technology employed by the Efe of the Ituri Forest (Abruzzi 1979; Bailey and Auger, Jr. 1989; Milton 1985), but bow technology, whether straight or cross bows, is less often used by other forest foragers. Bahuchet (1990a) reports that Aka hunt monkeys, birds, and bats with crossbows (technology introduced by the Portuguese in the Fourteenth Century; Auzel and Wilkie 2000:417) and poisoned arrows, but among the Bofi, crossbows are only used to hunt monkeys (Fouts 2002). Bofi foragers use individual hunting methods year-round, but traps and crossbows are most frequently used in the wet season (Lupo and Schmitt 2002:151). The Aka of northeastern Congo hunt arboreal monkeys with crossbows and poisoned arrows but, because of the degree of skill involved, few hunters regularly used this method (Kitanishi 1995:82).

Prey Processing: From Capture to Bone Discard

Among the Bofi and Aka, prey are processed in the field prior to transport back to camp. Here I describe the field processing of prey commonly taken by the foragers of Grima and Ndele. The butchery sequence for medium duiker (bay and Peters duikers), blue duiker, monkey, porcupine, and giant pouched rat is comparable between villages, with variations noted below. Butchery is conducted with an iron knife and/or machete. If the animal was procured in a net, it is usually carried by a female relative of the hunter

until near the end of the hunt, at which point it is processed by a male relative (or female relative among the Aka) of the owner of the net in which it was captured. In some cases, if no one is nearby, hunters will occasionally butcher their own carcasses and prey captured using individual hunting methods may be processed immediately after capture, rather than at the end of the hunt. All descriptions of butchery units are based on field observations (Lupo unpublished field data).

There were only minor differences in the butchery sequence and resulting carcass portions for medium duiker species between Grima and Ndele. Table 3.2 lists stages of medium duiker butchery and potential taphonomic consequences of these processes to be further explored in Chapters 5-7.

Table 3.2. Medium duiker butchery sequence.

Butchery process	Taphonomic Damage
Ventral torso is cut to allow for evisceration	No bone damage
Lower internal organs (intestines and stomach) are separated from the upper organs	No bone damage
For all duiker species, if the animal is female, the fetus and udders are removed	No bone damage
In Grima, but not Ndele, skin is removed from entire carcass except metapodia, head, and tail	Various cut marks on ribs, vertebrae, and limbs. On long bones, usually in mid-shaft locations distinct from dismemberment locations near epiphyses
Sternum is removed	Chops along lateral edges of sternum or through sternum
Head and attached cervical vertebrae are cut and/or chopped off	Cuts and/or chops between occipital condyles and first thoracic vertebra

Remaining carcass is chopped sagittally and transversely, creating forequarter and hindquarter segments	Sagittally-oriented chops to all vertebrae and transverse chops to thoracic vertebrae
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When internal organs are removed from medium duikers, each half (lower and upper) represents a distinct portion and, in most cases, is immediately given from the butcher to the recipient. The intestines are usually, but not always, cleaned in the field and wrapped in leaf packages for transport. Table 3.2 describes the most frequent butchery divisions of medium duikers, but demand sharing (discussed in the following section) may necessitate the creation of additional carcass portions during primary field butchery. For example, the tail and partial sacrum of medium duikers is occasionally cut or chopped off, potentially causing cuts and/or chops to the pubis/sacrum and caudal vertebrae, in response to a specific request for this portion. In rare instances, the forelimbs may be separated from the forequarter portion, causing additional cuts to the scapulae and ribs. Further, particularly with relatively large game like medium duikers, people will ask for small pieces of meat during butchery or transport. The portions and resulting taphonomic damage are highly variable, but this practice increases the possibility of fillet marks, which otherwise rarely occur on duiker bones. Thus, standard field processing of medium duikers minimally creates 8-9 distinct divisions or portions: lower organs, upper organs, detached skin (Grima), sternum, head/neck, forequarters (2), and hindquarters (2).



Figure 3.3. Bofi foragers field butchering a medium duiker.

Blue duiker field processing reflects greater differences between Grima and Ndele (Table 3.3).

Table 3.3. Blue duiker butchery sequence.

Butchery process	Taphonomic Damage
Ventral torso is cut to allow for evisceration	No bone damage
Lower internal organs are separated from the upper organs	No bone damage
Fetus and udders are removed (if female)	No bone damage
In Grima, but not Ndele, skin is removed from carcass except metapodia, head, and tail	Various cut marks on ribs, vertebrae, and limbs. On long bones, usually in mid-shaft locations distinct from dismemberment locations near epiphyses

Sternum and attached distal ribs are cut/chopped from the rest of torso	Cuts and/or chops along lateral edges of sternum, through sternum, or through distal ribs
In Grima, but not Ndele, forelimbs are removed by cutting between scapula and ribs	Cuts on medial scapula and lateral/proximal ribs
Head and attached cervical vertebrae and first ribs are cut and/or chopped off	Cuts and/or chops between occipital condyles and first thoracic vertebra. Cuts and/or chops to first ribs
Remaining carcass is sagittally split by chopping through the length of the vertebral column	Sagittally-oriented chops to all vertebrae, mainly thoracic and lumbar vertebrae

When the blue duiker forelimb portion is removed (Grima), it may be immediately be given to another individual, but is more commonly reattached to the remainder of the carcass with wooden skewers expediently produced for the purpose. The hindlimb remains attached to the sagittally-split carcass. As with medium duikers, the tail and partial sacrum are rarely chopped off, if requested. There is notable variability in blue duiker field butchery divisions. The process in Ndele results in a minimum of six carcass portions: lower organs, upper organs, sternum/distal ribs, head/neck/first ribs, and half post-cranial carcass (2). Grima blue duiker butchery creates a minimum of nine portions: lower organs, upper organs, detached skin, sternum/distal ribs, forelimbs (2), head/neck/first ribs, half post-cranial carcass (2). The most marketable unit of those described above is the half carcass with the hindlimb, and in many cases the forelimb, attached. The remaining segments were rarely sold or traded to villagers. Hart (1978:325) suggests that among the Mbuti, the unsold (retained for consumption) head, neck, and internal organs are the most desirable pieces. Project members did not observe

duiker carcasses being smoke-preserved in the field, but this reportedly does occur at remote forest camps when foragers procure meat for commercial purchasers (Karen Lupo, personal communication 2009).

Guenon monkeys (*Cercopithecus* sp.) acquired by the foragers of Grima and Ndele were butchered in the same manner in both villages (Table 3.4).

Table 3.4. Guenon monkey butchery sequence.

Butchery Process	Taphonomic Damage
Carcass eviscerated. Upper and lower organs removed	No bone damage
Head cut/chopped off	Cuts and/or chops between occipital condyles and first thoracic vertebra
Tail cut/chopped off	Cuts and/or chops through caudal vertebrae
Remaining carcass sagittally chopped along vertebral column	Sagittally-oriented chops to all vertebrae, mainly thoracic and lumbar vertebrae

The monkey butchery sequence results in six divisions: lower organs, upper organs, head, tail, and half post-cranial carcass (2).

There was no difference in the processing of brush-tailed porcupines between villages (Table 3.5).

Table 3.5. Brush-tailed porcupine butchery sequence.

Butchery Process	Taphonomic Damage
Complete carcass singed over fire to preserve flesh	Possible burning to thinly-fleshed bone surfaces (e.g., head, paws, tail)
Carcass eviscerated. Upper and lower organs removed	No bone damage
Tail and back fat portion cut off	Cuts to lumbar, sacral, and caudal vertebrae

Brush-tailed porcupine carcasses were only divided into four portions: lower organs, upper organs, nearly-complete carcass with head attached, and tail and back fat. Hewlett (1996b:10) comments on the intense Aka desire for porcupine meat due to its taste and high fat content. The tail/back fat portion is particularly fatty.

Giant pouched rats were taken much more frequently in Grima than Ndele (See Chapters 4 and 7), and this species was field butchered into fewer portions in Ndele (Table 3.6).

Table 3.6. Giant pouched rat butchery sequence.

Butchery Process	Taphonomic Damage
In both villages, rat carcasses are field processed by roasting them over coals to singe off hair (see Figure 3.4)	Possible burning to thinly-fleshed bone surfaces (e.g., head, paws, tail)
In Grima, sternum and distal ribs removed	Cuts and/or chops to sternum and distal ribs
In Grima, upper and lower organs are removed	No bone damage
In Ndele, internal organs are removed as a single unit, not divided into upper and lower halves	No bone damage
In Grima, the tail is cut off	Cuts and/or chops to caudal vertebrae



Figure 3.4. Bofi foragers roasting a giant pouched rat.

Among the Bofi of Grima, giant pouched rats are often consumed in the field, which may necessitate the more extensive field processing of this species. Ndele foragers rarely eat pouched rats prior to transport and complete rat carcasses, including sternum and tail, remain intact. Ndele field butchery of giant pouched rats results in only two portions: internal organs and remaining carcass. In Grima, five portions are produced: sternum and distal ribs, lower organs, upper organs, tail, and remaining carcass. The subsequent sharing of the various prey divisions is discussed in the following section.

Meat Sharing

An understanding of meat sharing, directly observable in ethnographic contexts, contributes to zooarchaeological analysis because sharing behavior affects butchery processes and resulting taphonomic damage patterns. Bahuchet describes a three-phase

sharing pattern among the Aka, Baka and Gyeli of Cameroon, and Mbuti of eastern DRC: “(1) dividing up meat among hunters, (2) sharing of each hunter’s part among his kin, (3) distributing cooked food by every household” (1990a:27; also see Hudson 1990:113; Kitanishi 1998:10).

Comparably, among the Bofi of Grima, Lupo and Schmitt (2004:247) divide post-acquisition sharing into three levels. The first level entails the field distribution of meat portions introduced in the preceding section. The rules governing Bofi sharing are informal, complex, and highly variable, suggesting that these sharing rules are best viewed as selectively applied “loose guidelines” (Lupo and Schmitt 2004:247). During Bofi communal hunts, acquired prey usually belong to the owner of the net or spear that captures/kills the animal, which must also be shared with the individual who actually kills the animal (in some cases, the same person). As mentioned previously, field butchery is most often conducted by a male relative of the net/spear owner, and this same person is responsible for distributing meat to others during first level sharing. Hunters who capture prey using individual techniques may share these animals in any way they choose (Lupo and Schmitt 2004:247).

In contrast to the Bofi, Aka first-level sharing of communally hunted taxa is dictated by obligatory and strictly-enforced rules (Bahuchet 1990a; Kitanishi 1998). In studies of Mbuti hunters, this first level of sharing is referred to as “formal sharing” (Harako 1981; Ichikawa 1983). Among the Mbuti, prey ownership is determined by the weapon that kills or incapacitates the animal. If an animal is captured in a borrowed net, the borrower receives one leg and the net owner keeps the rest. Spears are rarely borrowed by Mbuti hunters, but when prey are killed by a borrowed spear, the borrower

is entitled to only a foreleg, with the spear owner retaining the remainder of the carcass. Another formal Mbuti sharing rule is that the person who builds the morning hunting fire prior to a net hunt gets the heads of all animals captured during the day (Harako 1981:535). When an animal is killed by an Aka spear, the head goes to the hunter whose spear struck first. Portions may be given by the “acquirer” (spear owner) to other hunters based on their perceived contribution (e.g., hunters who effectively encircled the animal, struck second, helped carry meat, etc.; Bahuchet 1990a:32). Net-captured blue duikers belong to the net-owner, with the head being given to the person who first seizes the duiker in the net (Bahuchet 1990a; Hudson 1990). Hudson comments that “for individually caught animals, such rules are irrelevant” (1990:103). Acquired plants and invertebrates are not distributed as a part of this first phase of sharing, but may be shared at the second and third levels (Bahuchet 1990a).

Second-level sharing occurs when meat units acquired in the forest are further subdivided and redistributed upon returning to camp. In Grima, portions of prey killed on communal hunts may be reserved for specific relatives, but this varies from hunter to hunter (e.g., a hunter paying bride-service must give a portion to his in-laws; Lupo and Schmitt 2004:247). Bahuchet writes that both communally acquired prey and those taken using individual methods (trap and crossbow) are subject to second-level sharing with a long list of family members, mainly elders (Bahuchet 1990a:33). However, this level of sharing is generally less strictly regulated than first level sharing among the Mbuti and Aka and is referred to as “informal sharing” (Harako 1981; Ichikawa 1983; Kitanishi 1996). Among the Mbuti, the primary owners of carcasses redistribute them after transportation to the base camp until everyone has received a share. Harako suggests that

“There are no prescribed rules for redistribution, and the Mbuti frequently remark that this depends on a person’s generosity” (1981:536).

Kitanishi (1998:12) observes that, at this stage, meat is sometimes cut into smaller pieces for redistribution, which could lead to increased taphonomic damage to bones as meat is more widely shared. During Kitanishi’s (1998) study, second level distribution was influenced by Aka camp size, with meat being more widely shared in smaller (average 16-21 individuals) camps. In larger camps (average 59 individuals), it was impossible for the *konja* (owner) of meat to share with all adult women, so the *konja* had to choose whom to share with. Kitanishi’s data suggest that kinship did not affect sharing; *konjas* made a conscious effort to distribute evenly and not disproportionately share meat with any “specific persons, families, kinship group or neighboring persons in the second distribution” (1998:15).

Additional, third-level, sharing may occur when individuals join families at their fires for meal time, a practice referred to as “meal sharing” (Bahuchet 1990a; Kitanishi 1998). During meal sharing, meat and vegetable stews are shared with multiple households. “The *konja* of stew is the person who contributed animal food, more highly appreciated than plant food by the Aka in principle. However, the person who leads the sharing is not the *konja* of meal but the cook” (Kitanishi 1998:17). As a result, women have considerable control over the final stage of meat distribution just prior to consumption. Bahuchet (1990a:36) states that cooks decide both whether or not they have enough food to distribute beyond their own household and with whom to share.

Kitanishi (1998:17) reports that the cook gathers plates, pot lids, or large Marantaceae leaves from households she intends to share with and enlists children from

those households to return stew to their families. Women who receive food then share it with their unmarried children. Men generally eat separately at a hut called *mbanjo* and receive many plates of food from husbands or sons of the cooks, but men may occasionally eat with their wives and children. After stew is distributed, cooks usually eat any remaining in the pot with their own children. Interestingly, women eat very little of their own stew and up to 75% of stew they consume is cooked by other women. As with second level distribution, camp size was a constraining factor on the number of distributed portions during meal sharing among the Aka of northeastern Congo (Kitanishi 1998:17-22). Noss and Hewlett (2001:1028) indicate that Aka cooks share more widely than Mbuti cooks who share with men in a central hut (comparable to the Aka *mbanjo*) and generally only a few other women.

Cooking Methods and Consumption

The activities of cooking and consumption further alter the characteristics of animal bones. Whether animal segments are boiled or roasted can have a significant impact on rates of burned specimens, and studies have demonstrated that cut, chop, and fracture patterning may also vary with cooking method (Gifford-Gonzalez 1989, 1993; Jones 1983, 1993; Kent 1993; Lupo 1993; Speth 2000; Yellen 1977b). Thus, an understanding of how Bofi and Aka foragers cook food has important ramifications for the taphonomic analyses of later chapters. As mentioned above, the Bofi and Aka most often prepare meat by boiling it in pots with koko leaves or other vegetables (Figure 3.5), and less frequently roast meat over an open fire (Schmitt et al. 2001; de Garine and Bahuchet 1990). However, there are exceptions for particular prey and body parts, including tortoises, which are roasted in the shell. The heads of all prey are commonly

roasted and portions of meat from particularly large prey may be roasted as well. Hudson (1990:117) observed Aka adults give low meat value parts, such as tails and lower limbs from the metapodia down, to children to grill over fires as a snack. Brush-tailed porcupines, giant pouched rats, and sometimes monkeys are singed with fire prior to being stewed. Bones are chopped or hand fractured in order to “pot-size” them before boiling, a process that Hudson (1990:116) considers the guiding principle of the final stage of butchery. Boiling facilitates the exploitation of bone marrow and grease (Hudson 1990:117). This preparation method greatly impacts the ways that consumers extract nutritional value from the meat, marrow, and grease associated with a bone portion, a topic returned to in Chapters 6 and 7.

Ethnoarchaeological studies among the Aché of eastern Paraguay record the use of both fire-roasting and boiling to cook meat; Aché boil small prey (< 10 kg) and roast larger animals (20-35 kg) on wooden racks, with the exception that small prey taken in large quantities may be roasted for preservation. Large carcasses are roasted until blackened to preserve the meat for 4-5 days (Jones 1984:96; Nicholson 2005:109). Nicholson (2005:109) notes that the Aché prefer the taste of roasted meat, but boiling is faster and captures bone grease in the broth. Among modern !Kung, “Meat may be either boiled or roasted, and the former method is preferred because it softens the food more effectively and yields a gravy as well” (Yellen 1977b:291). Similar to African forest foragers, Aché singe the hair off of all prey, regardless of size, prior to boiling or roasting, and those carcasses that are boiled must be subdivided into pot-sized pieces (Nicholson 2005:24).

The final process that may damage bones prior to discard occurs during consumption, often without the benefit of tools. Ethnographic research indicates that humans can modify the surface of a bone by relying on their teeth and hands to dismember and consume carcasses (Binford 1978, 1981; Brain 1981; Elkin and Mondini 2001; Gifford-Gonzalez 1989; Jones 1983; Oliver 1993; Weisler and Gargett 1993; White 1955; Yellen 1991b).



Figure 3.5. Bofi woman boiling meat in Grima (photo by K. Lupo).

Yellen explains that “!Kung eat with their hands and use their teeth to pick meat from bones. Just how much meat they leave behind depends not only on the consumer’s

degree of effort and desire but also on the conformation, the nooks and crannies of an element, and the points and extent of muscle attachment” (1991b:174). Landt (2004, 2007) has shown that Bofi foragers leave identifiable tooth marks on small mammal bone. Such marks may be created incidentally while chewing meat, muscle attachments, and connective tissues adhering to bone or intentionally in an attempt to access embedded bone grease.

Bone Discard

Once consumers have fully exploited a particular bone portion, it may be discarded in one of many ways. Lupo and Schmitt (2005:344) write that at long-term Bofi and Aka habitation sites bone middens accumulate next to or behind most residential structures since these are routinely swept and cleaned. In small camps, the sweeping arcs in front of houses overlap and the central areas of camp remain free of bone, with the exception of small bones that may be missed by brooms. The majority of bones become concentrated behind houses, eventually forming a ring around the periphery of the site (Hudson 1990:119). Efe trash heaps of bone fragments and plant remains also accumulate along the perimeter of camps behind or beside huts, or sometimes in the center of camp, often forming around the base of a tree (Fisher, Jr. 1987:119).

At temporary forest camps, the amount of organic refuse generally does not warrant sweeping (Hudson 1990:119), and bones are more likely to be discarded into the surrounding vegetation, but middens may accumulate if forest camps are occupied for more than a few weeks (Lupo and Schmitt 2005:344). Jones (1983:176; 1984:96) reports that Aché hunting camps in eastern Paraguay are occupied for such a short time that little effort is made to clean up bone refuse, which is usually just dropped at the site of

consumption near the campfire. The same pattern is documented at !Kung camps, where meat is cooked and consumed in a family context and bones are discarded in the vicinity of individual family hearths. When sites are occupied for a long time, ashes are scooped out of the hearths and dumped outside of camp, but this cleaning does not affect the area around hearths where bones are left (Yellen 1991b:177).

Hudson notes that during her field study the Aka usually discarded bone where their meals were eaten, inside houses or outside near fire hearths. Bones were usually tossed on the ground, to waiting dogs or, sometimes, directly into fire hearths (1990:118). Each of these disposal methods has implications for the archaeological preservation and interpretation of forest forager food remains. Hudson suggests that Aka dogs are not intentionally fed meat, but are allowed to scavenge discarded bones. As a result, she writes: “dogs are kept lean and hungry and have a considerable destructive effect on the bone...Bone that is picked up by the dogs is generally either consumed on the spot, if the fragment is small, or taken to the privacy of the midden behind the nearest hut for more leisurely gnawing” (1990:119-120).

Many ethnographic studies (e.g., Bartram et al. 1991; Hudson 1990, 1993; Kent 1981, 1993) have illustrated how domestic dogs can spatially displace, fragment, or completely consume faunal remains. Thus, dogs are a non-cultural agent capable of creating easily-misinterpreted patterning in archaeological faunal assemblages. Comparable to Hudson’s (1990) research with Aka foragers, Kent (1993:348) observed Basarwa hunters of Botswana dispose of bone refuse in hot fire ashes. Bones that have residual flesh adhering to them may be discarded in fire to reduce their attractiveness to scavengers (Gifford-Gonzalez 1989:187). This common disposal practice has the

potential to destroy bone specimens and cause burning damage to bones that can mistakenly be attributed to cooking methods (i.e., bone may be boiled and subsequently become charred as a result of discard, not cooking).

Conclusion

To paraphrase Diamond (1997), the paleoecology and prehistory of the Central African tropical forest are grand puzzles still only partly solved. Despite becoming increasingly known, fundamental questions about the nature and length of human occupation in this challenging environment remain unanswered. A growing body of literature has made clear that the forest is a dynamic, variably-productive setting that has probably been occupied by human foragers much longer than was previously suspected. It is within this context that contemporary Bofi and Aka foragers, and neighboring farmers, continue to display remarkably flexible and well-adapted subsistence strategies. These strategies, and their zooarchaeological and taphonomic consequences, are the subject of the following chapters.

4. METHODS AND BONE ASSEMBLAGES

Introduction

During ethnoarchaeological fieldwork in the Central African Republic (1999-2005) hunting data were obtained via focal person follows, interviews, and the collection of food bone refuse. Two major types of bones were collected: meal collections and midden collections. Meal collections consist of those bones collected directly from consumers. In some cases, bones were recovered from forager and villager trash middens and recently abandoned remote forest camps. The midden collections have been described in previous publications (Lupo and Schmitt 2005; Schmitt and Lupo 2008). This dissertation focuses on meal collections, and the current chapter details the treatment of these bones from their collection in the field to the zooarchaeological and taphonomic analyses conducted in the laboratory.

Bone Collection Methods

We collected bones in residential villages and remote forest camps. In both contexts, project members visited forager households daily and gave plastic bags to each member of the household. Bags were labeled with name of consumer, date, who killed the animal, and who gave it to the consumer. Consumers were asked to put anything that they did not eat in the bags, and each day empty plastic bags were exchanged for bags containing the remains of meals consumed over the previous 24 hours. Because the animal remains were directly collected from the consumers, the bones were never exposed to post-depositional attritional processes, particularly the actions of domestic dogs, which are present in Grima, Ndele, and accompany foragers to remote hunting

camps. This absence of non-cultural taphonomic damage has important implications for the analyses of this dissertation and future archaeological applications.

The collected bags were then recorded on data collection forms that listed: date, hunter, consumer, taxon, and anatomical element. Each individual bag of meal remains was assigned a preliminary field specimen number. After the food remains were recorded the bones were cleaned. The purpose of field cleaning was simply to remove any adhering flesh, making them sufficiently clean for shipping to the zooarchaeological laboratory at Washington State University. In the process of field cleaning, researchers and assistants made use of locally available cleaning implements, such as store-bought dish scrubbers and, occasionally, steel wool (see Landt 2004, 2007 for microanalysis of the potential effects of field cleaning). For reasons elaborated below, these cleaning methods did not produce macroscopic damage that could be misidentified as butchery damage. Cleaned bones were dried in the sun and repackaged for shipment to Washington State University.

Zooarchaeological Laboratory Methods

After the bones arrived at Washington State University's zooarchaeological laboratory, some were gently washed with warm water and, in the case of particularly greasy bones, a mild detergent. These specimens were then placed on trays containing their provenience information in an industrial strength slow air dryer to prevent breakage. Dry specimens were removed from the drying rack and each bone fragment was assigned a specimen number based on the original field specimen number (i.e., FS# 1 was subdivided into 1.1, 1.2, 1.3, etc., with each individual specimen receiving a unique number). Most bones were labeled with FS # in archival ink, avoiding diagnostic

landmarks or taphonomic damage. Alternatively, bones that contained residual grease, or were too small to carry a legible specimen number, were placed in individually labeled specimen bags. All of the bone specimens were repackaged into plastic bags labeled with complete provenience information.

Data Recorded

Taxonomic identifications of bone specimens were made with reference to comparative collections of Central African fauna. Specimen taxon was preliminarily labeled in the field based on informant identifications. However, occasionally field identifications were in error (e.g., rat bones in a blue duiker specimen bag), so all bones were compared against known specimens for final identification. The following data were recorded for each specimen: bone portion, bone segment, percent complete, symmetry, burn, burn location, cut marks, number of cut marks, cut code, cut mark function(s), chop marks, number of chop marks, chop code, chop function(s), fracture, fracture type, human tooth marks (for the 1999-2000 Grima collections only, see Landt 2004, 2007), and additional comments. I commonly made note of exceptionally young individuals (neonates and juveniles based on size and epiphyseal fusion), but did not consistently estimate age for all specimens since this information was not a component of my planned research questions.

Categorization of Taphonomic Damage

Anatomical elements, element portions, and element segment were coded following Gifford and Crader (1977. See Appendix A). Bone portion designates the general portion of a specific element (e.g., complete, proximal, proximal + shaft, shaft, distal + shaft, distal, and undifferentiated fragment). Segment provides additional

descriptive information about the specimen (e.g., anterior, posterior, medial, lateral, etc.). Symmetry was recorded as left, right, axial, or indeterminate. Burning was recorded following Brain (1981:54-55) based on the coloration: burned (brown), carbonized (black), calcined (gray/white). Since the term “burned” can refer to brown coloration or, more generally, to any fire-affected bone, those bones that display brown coloration are subsequently referred to as “browned.” The term “burned” is applied collectively to browned, carbonized, and calcined bones.

Taphonomic Damage

Butchery marks identified in the assemblages are assigned alphanumeric non-repeating codes, described, and illustrated in Appendix A. Marks that correspond in general location and orientation to those previously coded by Binford (1981) or Lupo (1993) were designated with pre-existing codes; those that were unique were assigned new codes based on Gifford and Crader’s (1977) element labels and a unique number (e.g., FEM-1). Some marks appeared with repetition in specific anatomical locations. Nevertheless, I carefully examined the entire bone portion, even where I *did not* expect to find cuts, to avoid bias toward previously identified marks. The inferred function(s) of some marks, based on location, orientation, form, and zooarchaeological literature, is presented in Chapter 5. However, in many cases, marks were attributable to multiple possible functions, or reflect unknown functions, and these are noted and discussed in Appendix A.

As a result of the comparatively brief taphonomic history of these bones, and their lack of exposure to numerous non-cultural processes, distinguishing butchery marks from similar damage such as scratches and tooth marks was not difficult. Landt (2004) notes

some concern over the taphonomic effects of field cleaning of specimens with abrasive scrubbers and speculated that microabrasions might mimic butchery damage, but the size, morphology, and often repetitive locations of butchery marks made them easily distinguishable from microabrasions. All butchery-related marks (cuts and chops) were identified macroscopically with the aid of bright light and a small 10x hand lens. Cut marks, specifically, are produced by drawing a blade across bone surfaces “in a direction continuous with the long axis of the edge” (Potts and Shipman 1981:577) and were identified based on established morphological criteria (e.g., Lyman 1994; Potts and Shipman 1981; Walker and Long 1977). The presence or absence of cut(s) on a specimen, the number of distinct cuts, and the location of cuts were recorded. Lyman writes:

The number of butchery marks is a potentially difficult counting unit to operationalize. I tally each discrete, nonadjacent (> 1 cm apart) and non-overlapping mark as an instance of force application...While somewhat subjective (e.g., a cluster of striae is tallied as one instance even though multiple instances of force application are clearly represented), this seems to be the practice generally followed (Lyman 1994:304).

Lyman’s approach to quantifying mark quantification is based on studies of large artiodactyls and sea mammals (Lyman 1987, 1992, 1995). Because of the small size of forest forager prey, marks were rarely more than 1 cm apart and, since my key analysis is quantifying processing intensity, I tallied each distinct striation as a mark. Distinct marks were those that appeared to be the result of a separate tool stroke. For example, two “marks” that were parallel and less than a millimeter apart were counted as one mark and cuts that were farther apart and/or oriented differently were counted as separate cuts.

Because the Bofi and Aka butcher carcasses with knives and machetes, chop marks are abundant on the bones and were classified and recorded as a separate type of damage. In these analyses, I distinguished between partial and complete chops, a

distinction introduced by Schmitt et al. (2001). Partial chops are morphologically comparable to hack marks (Binford 1984; Gifford-Gonzalez 1989), chopping scars (Lyman 1995), or cleavemarks (Nicholson 2005; Potts and Shipman 1981; Walker and Long 1977: See Figure 4.1). Cleavemarks are produced by striking bone surfaces with a blade at a perpendicular angle, and are wider and deeper than cut marks, often with bone fragments being crushed inward as a result of percussive force (Potts and Shipman 1981:577).

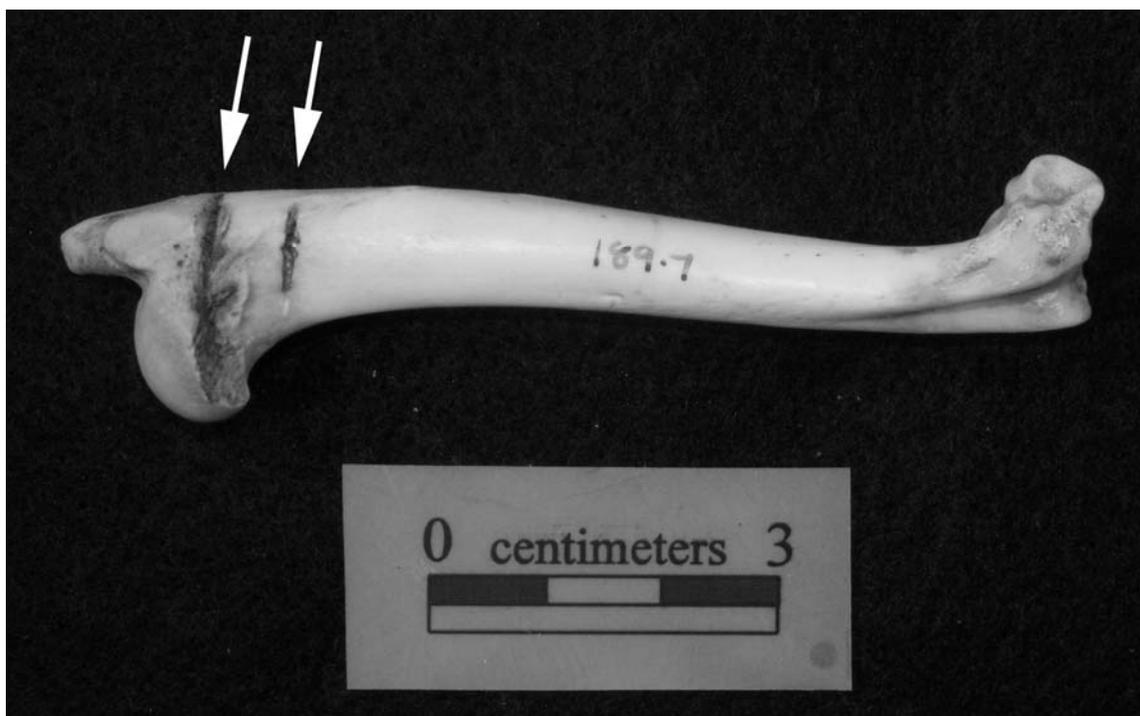


Figure 4.1. Partial chops in proximal blue duiker humerus.

Crader (1983:134) distinguishes between chop marks, which are deep and pass partially through bone, and shear faces, which pass completely through bone, leaving a planar surface. Gifford-Gonzalez (1989:200) uses the terms “hacking” or “chop mark” to refer

to partial chops and includes complete chops to large mammal bones (even those created by a metal machete) with “transverse breaks.” Most Bofi and Aka prey species are sufficiently small that shear faces, referred to here as complete chops, can be produced by both machetes and smaller iron knives.

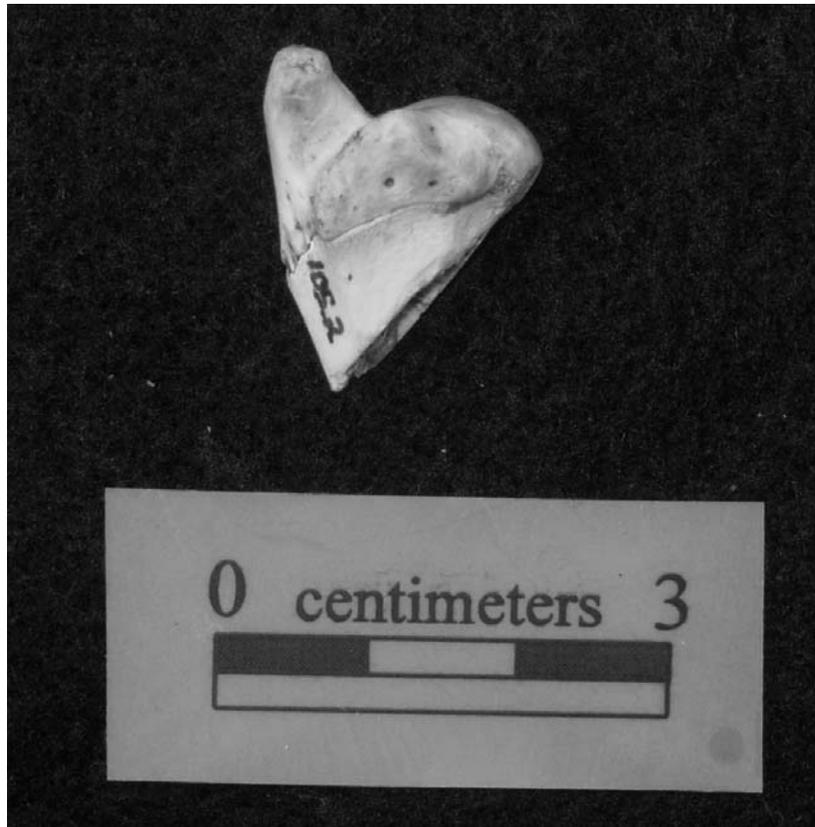


Figure 4.2. Complete chop through proximal shaft of blue duiker humerus.

Knife- and machete-produced complete chops are morphologically distinct from other forms of breakage, such as hand fracturing (Figure 4.2). As with cut marks, the number and location of partial and complete chop marks were recorded during analysis (see Appendix A).

For the purposes of this analysis, fracturing was defined as any bone breakage not clearly attributable to chopping. Fractures were recorded following terminology outlined by Marshall (1989:14). Fracture types are schematically illustrated (Figure 4.3) and are as follows: longitudinal, perpendicular (transverse) irregular, perpendicular (transverse) smooth, sawtoothed (jagged, splintered), spiral (radial, oblique, curvilinear), and stepped (checked, columnar) fractures. Since each fracture type represents an idealized form, actual fractured specimens were matched with the form that best characterized the specimen. I added the category “irregular” to denote specimens (particularly crania and other axial bones) that were fractured in highly irregular patterns not describable with Marshall’s (1989) classification system.

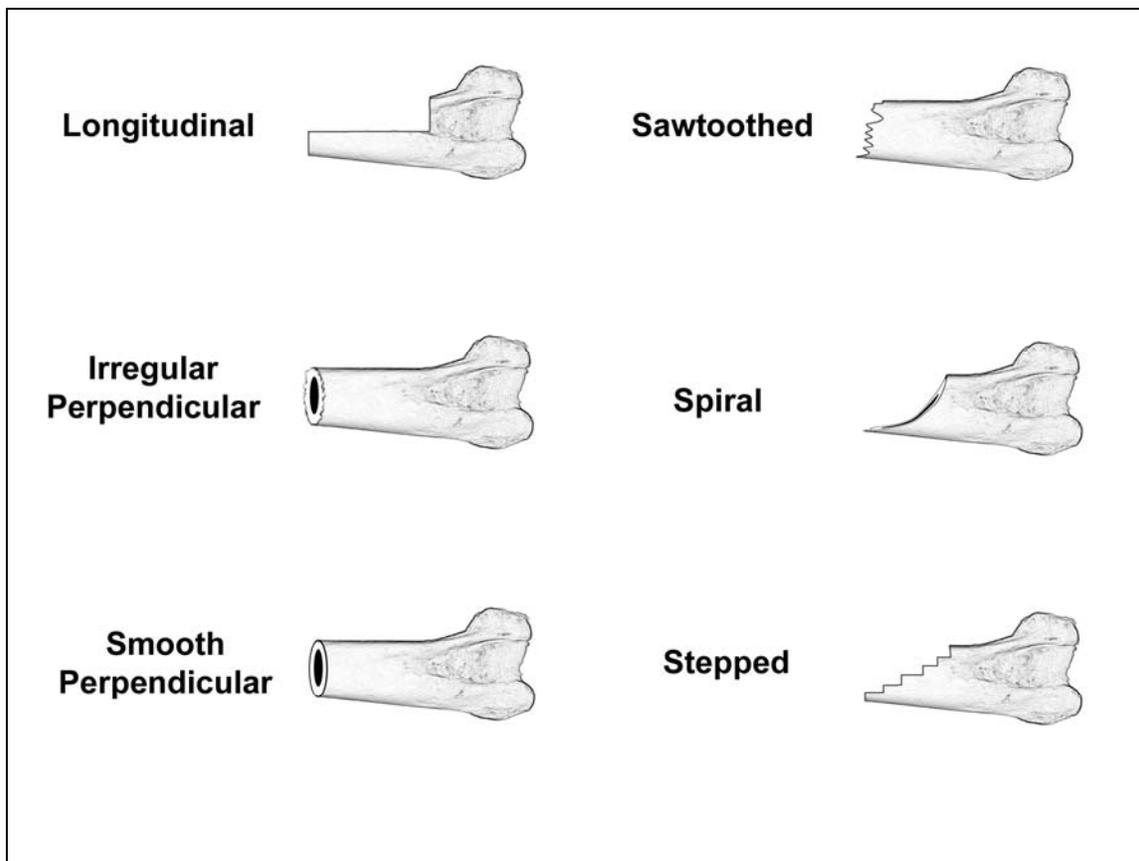


Figure 4.3. Fracture types (after Marshall 1989) illustrated on a distal blue duiker humerus.

In some cases, irregular perpendicular breaks may have been produced by chopping action, but, lacked a diagnostic shear fracture and were categorized as fractures.

Conversely, the designation “smooth perpendicular fracture” identified by Marshall (1989) was rarely used since, in most cases, such damage was consistent with and coded as a complete chop.

Other kinds of damage associated with human processing and consumption include tooth and gnawing marks (Landt 2004, 2007). This damage was examined macroscopic and microscopic characteristics of human tooth marks and mastication damage among the 1999-2000 Grima small mammal assemblage. The remaining assemblages (post-2000) have not been analyzed for the presence of tooth marks.

Descriptions of Bone Assemblages

Taxonomic Representation and Collection Locations

The bones that comprise this assemblage were collected in six distinct temporal and spatial contexts:

A. Grima Village (collected December 1999 – January 2000; dry season). Residential forager camp located next to farmer village. Represents 95 individual meals.

B. Grima Remote Camp (collected December 1999 – January 2000; dry season). Forest camp used for net hunting. Represents 119 individual meals.

C. Grima Village (collected December 2001 – January 2002; dry season). Same residential village as A. Represents 140 individual meals.

D. Ndele Village (collected January 2001 – February 2002; dry season). Residential forager village next to farmer village. Represents 181 individual meals.

E. Ndele Village (collected June 2002 – July 2002; wet season). Same residential village as D. Represents 85 individual meals.

F. Ndele Remote Camp (collected June 2002 – July 2002; wet season). Forest camp used for net and spear hunting. Represents 57 individual meals.

In later chapters, depending on the specific question being asked, bones from these contexts will be combined and analyzed as a complete assemblage, or subdivided in order to address aspects of intra-assemblage variability. In either case, the bones included in each stage of analysis are explicitly noted. The number of identified specimens (NISP) for each taxon and collection location are summarized in Table 4.1.

Table 4.1. Number of identified specimens subdivided by taxon and collection location.

Taxon	A. Grima Village 1999-2000	B. Grima Remote Camp 1999-2000	C. Grima Village 2001-2002	D. Ndele Village 2001-2002	E. Ndele Village 2002	F. Ndele Remote Camp 2002	TOTAL
River hog (<i>Potamochoerus porcus</i>)	0	0	0	11	0	0	11
Yellow-backed duiker (<i>Cephalophus silvicultor</i>)	7	0	0	0	0	0	7
Bay or Peters duiker (<i>C. dorsalis</i> or <i>C. callipygus</i>)	2	47	218	151	232	58	708
Civet (<i>Civettictus civetta</i>)	4	11	0	0	0	0	15
Blue duiker (<i>Cephalophus monticola</i>)	382	749	376	456	281	347	2591
Monkey (<i>Cercopithecus</i> sp.)	24	8	22	1	9	0	64
Brush-tailed porcupine (<i>Atherurus africanus</i>)	52	247	6	113	0	7	425
Tree pangolin (<i>Phataginus tricuspis</i>)	0	28	47	0	0	0	75
Tortoise (<i>Kinixys</i> sp.)	21	1	31	1	0	65	119
Giant pouched rat (<i>Cricetomys gambianus</i>)	371	308	456	0	82	21	1238
Rats and mice (Muridae)	376	0	0	0	0	0	376
Unidentifiable	0	7	0	4	0	0	11
TOTAL	1239	1406	1156	737	604	498	5640

Skeletal Part Representation

This section presents the number of identified specimens for each taxon, subdivided by element and long bone portion. Taxa are discussed in decreasing size order based on live weight (Table 4.2).

Table 4.2. Live weight ranges for taxa represented in the assemblage.

Taxon	Live weight range^a
River hog	45.0 – 115.0 kg.
Yellow-backed duiker	45.0 – 80.0 kg.
Bay or Peter's duiker	15.0 – 24.0 kg.
Civet	7.0 – 20.0 kg.
Blue duiker	3.5 – 9.0 kg.
Monkey	1.8 – 6.0 kg.
Brush-tailed porcupine	1.5 – 4.0 kg.
Tree pangolin	1.6 – 3.0 kg.
Tortoise	1.0 – 2.0 kg. ^b
Giant pouched rat	1.0 – 1.4 kg.
Murid rodent	.025 - .065 kg.

^aReported by Kingdon (1997)

^bReported by Alden et al. (1998)

Columns A-F correspond to the collection contexts detailed above, followed by the total for the combined Central African ethnoarchaeological assemblage (meal collections from 1999-2002).

Table 4.3. *Potamochoerus porcus* – River hog.

Element	D. Ndele Village 2001-2002
Cranium	1
Mandible	1
Sternum	3
DSH Rib	3
Scapula	3
TOTAL	11

Potamochoerus porcus is found in a wide range of habitats including lowland rain forest, gallery forest, dry forest, savannah woodland, and mixed scrub and cultivated

areas (Oduro 1989). Vercammen et al. (1993) write that this species occurs less commonly in the more arid and open of these habitats than forested or closed environments. River hogs live in groups comprised of up to 15 females and subadults, and one male. During the day, they sleep in dense vegetation or nests, waiting until night to forage for fruit, roots, and bulbs (Alden et al. 1998). Reproduction is seasonal, with most piglets being born near the end of the dry season/early wet season (Vercammen et al. 1993). When frightened, young river hogs tend to lie motionless, but are more prone to flight as they age (Kingdon 1997). Even immature river hogs are sufficiently large to pose a threat to hunting nets, and are usually killed by spear. Nearly all the bone specimens are from a single individual killed near Ndele on February 18, 2002. River hog bones are rare in collected bone assemblages because this species was often butchered and consumed in the forest at the time of the hunt.

Table 4.4. *Cephalophus silvicultor* – Yellow-backed duiker.

Element	A. Grima Village 1999-2000
Cranium	2
Mandible	5
TOTAL	7

Cephalophus silvicultor is found in rain forest, montane forest, riverine forest, and closed woodlands. The yellow-backed duiker is nocturnal, spending the day in repeatedly-used beds of vegetation and the night foraging for fruit, seeds, fungi, shrub bark, and foliage (Alden et al. 1998). Kingdon (1997) reports that up to 6 vegetation beds may be found within a square kilometer, often at the bases of trees, under fallen logs, or in dense tangles of vegetation. Yellow-backed duikers usually forage individually, but territories are often shared by a single male-female pair (Kingdon 1997).

This species gives birth throughout the year, usually to one offspring at a time. Adult yellow-backed duikers communicate with grunts and shrill bleats (Kingdon 1997) and, when frightened, emit a piercing alarm whistle (Alden et al. 1998). Yellow-backed duikers are the largest duiker species in the assemblage, ranging from 45-80 kg (Kingdon 1997). This live weight sets them apart from other duiker species, and in subsequent analyses, they are categorized as “large duiker” to differentiate them from “medium” Bay and Peters duikers and “small” blue duikers.

Table 4.5. *Cephalophus dorsalis/Cephalophus callipygus* – Bay duiker/Peters duiker.

Element	A	B	C	D	E	F	TOTAL
Cranium	0	0	19	22	52	17	110
Mandible	2	2	7	22	31	11	75
Tooth	0	0	1	0	0	0	1
Scapula	0	0	1	2	1	0	4
CO Humerus	0	0	1	0	1	0	2
Humerus SH	0	1	1	0	1	1	4
CO Radius	0	0	0	0	1	0	1
DS Radius	0	1	0	0	0	0	1
DSH Radius	0	1	0	0	1	0	2
PX Radius	0	0	0	0	1	0	1
PSH Radius	0	2	1	0	0	0	3
DS Ulna	0	2	0	0	0	0	2
PX Ulna	0	1	0	0	0	0	1
PSH Ulna	0	2	1	0	0	0	3
Ulna SH	0	0	1	0	1	0	2
Carpals	0	6	2	0	0	0	8
CO Metacarpal	0	0	0	0	2	0	2
DS Metacarpal	0	1	0	0	1	0	2
PSH Metacarpal	0	1	0	0	1	0	2
Metacarpal SH	0	0	0	0	1	0	1
Sternum	0	0	1	0	1	1	3
CO Rib	0	0	4	3	10	1	18
DS Rib	0	0	3	1	1	0	5
DSH Rib	0	2	11	9	4	0	26
PX Rib	0	0	2	5	0	0	7
PSH Rib	0	6	21	5	5	0	37
Rib SH	0	1	24	13	7	0	45
Cervical	0	0	41	17	27	1	86
Thoracic	0	4	38	27	24	4	97

Lumbar	0	0	14	7	3	5	29
Sacrum	0	0	0	4	1	0	5
Caudal	0	0	0	5	22	0	27
Vertebra	0	0	0	0	0	1	1
Innominate	0	2	6	3	5	4	20
DS Femur	0	0	0	0	3	1	4
DSH Femur	0	0	1	0	1	0	2
PX Femur	0	0	0	1	0	4	5
PSH Femur	0	1	1	0	1	0	3
Femur SH	0	1	1	0	1	0	3
Patella	0	0	1	0	0	1	2
DS Tibia	0	1	1	0	1	0	3
PX Tibia	0	2	0	1	5	0	8
PSH Tibia	0	1	1	0	2	0	4
Tibia SH	0	2	6	1	0	0	9
Lateral malleolus	0	1	1	0	0	0	2
Tarsals	0	1	3	0	3	0	7
DS Metatarsal	0	0	0	0	2	0	2
DSH Metatarsal	0	0	1	0	0	0	1
PSH Metatarsal	0	0	1	0	0	0	1
Metatarsal SH	0	0	0	0	1	0	1
DS Metapodial	0	0	0	0	0	2	2
Long bone FR	0	2	0	3	1	0	6
Cartilage FR ^a	0	0	0	0	3	2	5
Unidentifiable	0	0	0	0	3	2	5
TOTAL	2	47	218	151	232	58	708

^aBay, Peters, and blue duikers are represented in this assemblage by specimens labeled “cartilage”. In most cases, these specimens are preserved cartilaginous portions of distal ribs. It is questionable whether these specimens would be preserved archaeologically. Nevertheless, since they are present among the ethnoarchaeological collections, they are quantified and treated as bone specimens.

Cephalophus dorsalis and *Cephalophus callipygus* inhabit gallery forests, montane forests, dense bush, and coastal forest-savanna transition zones (Alden et al. 1998) and are generally solitary (Noss 1995). Despite being morphologically quite similar, Bay duikers are nocturnal and Peters duikers are diurnal (Dubost 1984). Bay duikers seek shelter in hollow trees, under fallen logs, or dense thickets and only leave their nests to forager after dark (Kingdon 1997). Hunters often encountered the Bay duiker asleep during the day, and Noss writes: “*C. dorsalis* is often found lying in its

resting place and is reluctant to move even when approached by hunters” (1998b:396). Peters duikers are more likely to move away from the sound of approaching hunters (Noss 1998b). The diet of both species is dominated by fruit (73% and 83% of the diet, respectively), with some foliage (27% and 16%), and Bay duikers have been reported to stalk, kill, and eat small birds (Kingdon 1997:381, 378). Bay and Peters’s duikers breed throughout the year and give birth to one offspring at a time (Alden et al. 1998). Female duikers usually conceive within days of giving birth and are virtually continuously pregnant (Noss 1995).

Since these species are morphologically similar, I combined and categorized these remains as “medium duiker.”

Table 4.6. *Civettictus civetta* – Civet.

Element	A	B	TOTAL
Scapula	0	1	1
CO Humerus	0	1	1
PSH Radius	1	0	1
PSH Ulna	0	1	1
Lumbar	0	5	5
Sacrum	0	1	1
Caudal	0	1	1
Innominate	0	1	1
CO Tibia	2	0	2
CO Fibula	1	0	1
TOTAL	4	11	15

Civettictis civetta is found in dense forest undergrowth, savannas, and farmlands. Civets are solitary, nocturnal omnivores that must live near water and spend the day in holes or other secure resting places (Alden et al. 1998). Civets mainly eat roots, shoots, and fruits, but are omnivorous, and capable of eating insects, snakes, hares, and mongoose (Kingdon 1997). In tropical Africa, civets breed year-round, producing 1-4

offspring after a 60-72 day gestation (Alden et al. 1998). According to Alden et al. (1998), Civets may be territorial, and they follow regular pathways that are scent-marked with urine, dung, or anal-gland secretions. Young civets will remain motionless to avoid detection, but hiss and spit when threatened by predators (Kingdon 1997).

Table 4.7. *Cephalophus monticola* – Blue duiker.

Element	A	B	C	D	E	F	TOTAL
Cranium	15	117	32	60	77	38	339
Mandible	19	32	6	52	15	14	138
Tooth	2	3	0	1	0	0	6
Hyoid	0	0	1	0	0	0	1
Scapula	22	12	3	11	8	10	66
CO Humerus	4	4	1	0	1	2	12
DS Humerus	1	3	0	0	1	1	6
DSH Humerus	7	3	4	4	1	1	20
PX Humerus	1	3	2	2	0	0	8
PSH Humerus	5	3	2	10	3	2	25
Humerus SH	1	2	2	2	0	3	10
CO Radius	4	2	1	4	2	1	14
DS Radius	0	1	1	1	0	0	3
DSH Radius	2	2	2	0	1	0	7
PX Radius	0	2	0	1	0	1	4
PSH Radius	4	7	4	5	2	2	24
Radius SH	0	0	1	1	1	3	6
CO Ulna	1	3	1	0	2	1	8
DS Ulna	0	0	1	2	0	0	3
DSH Ulna	3	2	1	4	1	1	12
PX Ulna	1	4	0	0	0	1	6
PSH Ulna	5	1	3	5	1	1	16
Ulna SH	1	3	2	1	1	2	10
Carpals	5	20	10	0	7	3	45
CO Metacarpal	3	2	1	1	1	0	8
DSH Metacarpal	0	3	3	0	0	0	6
PSH Metacarpal	0	1	3	0	0	0	4
Metacarpal SH	0	0	2	1	0	0	3
Sternum	1	4	1	4	5	18	33
CO Rib	6	18	4	2	6	7	43
DS Rib	0	3	4	0	3	0	10
DSH Rib	29	21	27	13	23	22	135
PX Rib	0	7	2	0	2	2	13
PSH Rib	47	77	36	37	20	21	238
Rib SH	30	35	23	14	5	24	131

Cervical	21	79	11	34	24	23	192
Thoracic	24	125	34	48	30	34	295
Lumbar	32	42	39	41	7	22	183
Sacrum	11	5	7	6	3	4	36
Caudal	0	0	0	11	1	0	12
Innominate	17	15	20	20	8	11	91
CO Femur	2	1	0	1	0	0	4
DS Femur	0	3	4	6	0	4	17
DSH Femur	5	3	4	4	1	4	21
PX Femur	2	1	5	4	4	4	20
PSH Femur	3	3	3	7	2	1	19
Femur SH	0	0	6	7	2	10	25
Patella	0	1	0	0	0	1	2
CO Tibia	3	0	0	1	0	0	4
DS Tibia	1	3	1	0	0	1	6
DSH Tibia	1	4	5	3	1	3	17
PX Tibia	0	3	5	4	0	5	17
PSH Tibia	8	2	4	4	1	3	22
Tibia SH	6	8	16	1	0	1	32
Lateral malleolus	2	1	1	2	1	3	10
Tarsals	6	23	3	7	1	14	54
CO Metatarsal	3	5	0	2	0	4	14
DS Metatarsal	0	1	1	0	0	0	2
DSH Metatarsal	0	2	4	0	0	0	6
PSH Metatarsal	0	6	5	2	0	1	14
Metatarsal SH	0	1	5	0	0	1	7
DS Metapodial	0	0	1	0	0	0	1
Phalanges	12	4	5	0	6	0	27
Long bone FR	0	0	0	2	0	1	3
Cartilage FR	0	2	0	1	0	9	12
Unidentifiable	4	6	1	0	0	2	13
TOTAL	382	749	376	456	281	347	2591

Cephalophus monticola inhabits rain forests, riverine forests, and montane forests below 3000 m elevation (Alden et al. 1998). Blue duikers share many characteristics with the larger duikers discussed above. One notable exception is that blue duikers are less solitary than other duikers, often foraging in pairs or small groups comprised of two parents and a young animal (Dubost 1980). Alden et al. (1998) note that blue duiker pairs maintain visual contact with one another by constant up and down movement of

their white tails – a cue that could be visible to human hunters as well. Noss (1995) comments that blue duikers as well as medium-sized duikers are all strongly territorial and probably remain in the same territory throughout their lives.

Like Peters duikers, blue duikers are diurnal (Dubost 1984), foraging in daylight for fruit, flowers, foliage, fungi, seedpods, and occasionally invertebrates (Alden et al. 1998), although Kingdon (1997) suggests that they have adapted to be more nocturnal in disturbed areas. Blue duikers are active for longer periods of the day during the dry season, a fact that Noss (1995) attributes to reduced availability of food. Interestingly, and perhaps relatedly, the dry season is also the peak period of forest forager net hunting. Kingdon (1982) explains that many duiker species consume small amounts of animal matter to obtain necessary salts.

Blue duikers reach sexual maturity at 11 months of age and produce their first offspring at 18 months (Noss 1995). They breed continuously throughout the year, producing one fawn after an estimated gestation period of 4.5-7 months (Alden et al. 1998). Noss argues that reproduction rates in the wild may be closer to one offspring per female per year and the natural lifespan of a blue duiker is probably 8-10 years (1995).

Adult female and juvenile blue duikers will freeze when alarmed, but may run when encountered unexpectedly. Harako (1981:538) describes the blue duiker escape tactic as running with their heads down into dense brush, then freezing until flushed out again. As discussed earlier, the role of beaters in a net hunt is to create sufficient commotion to cause duikers to flee toward nets. When threatened, adult males produce a whistle or sneezing call to alert other duikers and advertise their location and movement (Kingdon 1997).

Alden et al. (1998) indicate that blue duikers are, by far, the most abundant rain forest antelope and a mainstay of the West African bushmeat trade. Kingdon (1997) adds that blue duikers are subject to heavy hunting pressure throughout their range, yet are widespread and not endangered. Blue duikers are central to Bofi and Aka subsistence, the dominant prey species in these collections, and a major focus of the analyses of the following chapters.

Table 4.8. *Cercopithecus* sp. – Guenon monkey.

Element	A	B	C	D	E	TOTAL
Mandible	0	0	0	0	3	3
Humerus SH	1	0	0	0	0	1
DSH Ulna	0	0	0	0	1	1
CO Rib	1	0	3	0	0	4
DSH Rib	3	0	2	0	0	5
PSH Rib	6	0	3	0	0	9
Thoracic	7	0	3	0	0	10
Lumbar	2	0	8	0	0	10
Sacrum	0	0	1	0	0	1
Caudal	0	0	1	0	0	1
Innominate	1	0	1	0	4	6
PX Femur	0	0	0	1	0	1
PSH Femur	0	0	0	0	1	1
Tarsals	1	1	0	0	0	2
CO Metapodial	2	0	0	0	0	2
DS Metapodial	0	3	0	0	0	3
PSH Metapodial	0	4	0	0	0	4
TOTAL	24	8	22	1	9	64

Members of the genus *Cercopithecus* are commonly called guenons, and Alden et al. (1998) refer to them collectively as “forest monkeys.” All guenon species are omnivorous, arboreal quadrupeds that will sometimes forage for fruit on the ground. The majority of guenons live in one-male troops, and many associate with multi-species troops (Alden et al. 1998). Guenon species have evolved a range of niche-specific foraging strategies and diets and are able to forage side by side with little conflict.

Kingdon (1997) comments that communities comprised of up to six species may live together in most riverine and forest vegetation types. Blue duikers have been observed following monkeys to scavenge dropped fruit (Kingdon 1997).

Table 4.9. *Atherurus africanus* – Brush-tailed porcupine.

Element	A	B	C	D	F	TOTAL
Cranium	0	22	0	6	0	28
Mandible	0	9	0	4	0	13
Tooth	0	8	0	0	0	8
Scapula	2	13	1	4	0	20
CO Humerus	1	3	1	2	0	7
DS Humerus	0	1	0	0	0	1
DSH Humerus	0	2	0	0	0	2
PX Humerus	0	1	0	0	0	1
CO Radius	1	2	1	1	0	5
PSH Radius	0	1	0	0	0	1
Radius SH	0	1	0	0	0	1
CO Ulna	0	2	1	2	0	5
DS Ulna	0	1	0	0	0	1
DSH Ulna	1	0	0	0	0	1
PSH Ulna	0	2	0	0	0	2
Carpals	0	0	0	6	0	6
CO Rib	7	12	0	7	0	26
DSH Rib	10	15	0	3	0	28
PX Rib	3	1	0	0	0	4
PSH Rib	1	5	0	0	0	6
Rib SH	1	2	0	0	0	3
Cervical	0	14	0	8	0	22
Thoracic	3	22	2	17	0	44
Lumbar	8	40	0	12	0	60
Sacrum	2	7	0	3	0	12
Caudal	2	13	0	4	0	19
Vertebra	0	3	0	0	0	3
Innominate	4	16	0	3	1	24
CO Femur	2	3	0	0	0	5
DS Femur	0	1	0	0	0	1
DSH Femur	0	2	0	0	1	3
PX Femur	0	0	0	0	1	1
PSH Femur	0	2	0	0	1	3
CO Tibia	2	4	0	2	0	8
DSH Tibia	0	2	0	1	1	4
PX Tibia	0	1	0	0	0	1
PSH Tibia	0	2	0	0	1	3

SH Tibia	0	1	0	1	1	3
CO Fibula	2	1	0	2	0	5
DSH Fibula	0	2	0	0	0	2
Tarsals	0	4	0	13	0	17
CO Metatarsal	0	1	0	4	0	5
PSH Metatarsal	0	2	0	0	0	2
CO Metapodial	0	0	0	4	0	4
Phalanges	0	0	0	4	0	4
Unidentifiable	0	1	0	0	0	1
TOTAL	52	247	6	113	7	425

Atherurus africanus can live in a range of rainforest habitats, with a preference for valley bottoms (Kingdon 1997). Brush-tailed porcupines forage alone, but several individuals and families may share a sleeping area (Emmons 1983; Noss 1995). This species is nocturnal and spends days in thick brush or burrows abandoned by other animals. Such dens may be inhabited for multiple years and be connected to established feeding areas by well-defined paths. Brush-tailed porcupines primarily eat fallen fruit, but will also dig for roots and tubers (Noss 1995). Brush-tailed porcupines reach sexual maturity at two years of age (Rahm 1962), give birth to litters of 1-3 during the wet season after a 3.7 month gestation period (Alden et al. 1998), and have a life span of about 8 years (Noss 2000). When cornered, brush-tailed porcupines raise their quills and run backward, attempting to lodge quills into the attacker. Alden et al. (1998) further note that this species is actively hunted and trapped in horticultural locations because of the damage they inflict on garden crops.

Table 4.10. *Phataginus tricuspis* – Tree pangolin.

Element	B	C	TOTAL
Cranium	0	1	1
Scapula	1	0	1
DSH Humerus	1	1	2
PSH Humerus	1	0	1
CO Radius	1	1	2

CO Ulna	1	1	2
CO Rib	0	12	12
DSH Rib	0	2	2
PSH Rib	0	1	1
Thoracic	0	7	7
Lumbar	7	11	18
Sacrum	1	1	2
Caudal	4	0	4
Vertebra	4	0	4
Innominate	2	2	4
CO Femur	0	2	2
PX Femur	0	1	1
PSH Femur	1	0	1
Femur SH	1	0	1
CO Tibia	1	2	3
Tibia SH	1	0	1
CO Fibula	1	2	3
TOTAL	28	47	75

Some sources use the binomial *Manis tricuspis* for tree pangolin. Following Kingdon (1997), *Phataginus tricuspis* is used here. Tree pangolins are nocturnal, scaled mammals found in lowland rainforest settings, especially in secondary growth, cultivated areas, fallow and forest mosaics. Tree pangolins spend time in trees and on the ground and are the most widespread forest pangolin species (Kingdon 1997). During daylight hours, tree pangolins sleep in burrows dug in shallow ground or hollow tree trunks, emerging at night to consume a diet based on termites and ants. Adult females are highly sedentary, rarely foraging farther than a few hundred meters from their burrows. Males are more nomadic, with foraging ranges up to a kilometer (Kingdon 1997). Female pangolins give birth to a single offspring after a gestation period of approximately 150 days. Newborns remain in their mother's burrows for about two weeks, at which time they begin to ride on their mother's tails during foraging excursions. Mother and juvenile

pairs may continue to forage together for up to 5 months. Tree pangolins reach sexual maturity at 8 months and full adult size at 15 months of age (Kingdon 1997).

Table 4.11. *Kinixys* sp. – Tortoise.

Element	A	B	C	D	F	TOTAL
Cranium	1	0	4	0	0	5
Mandible	2	0	2	0	3	7
Scapula	1	0	2	0	2	5
CO Humerus	1	0	3	0	3	7
DSH Humerus	0	0	0	0	1	1
PX Humerus	0	0	0	0	2	2
CO Radius	1	0	2	0	1	4
CO Ulna	1	0	2	0	3	6
Carapace FR	6	0	4	1	19	30
Vertebra	2	0	5	0	21	28
Innominate	2	1	2	0	4	9
CO Femur	2	0	1	0	0	3
Long bone	1	0	4	0	3	8
Unidentifiable	1	0	0	0	3	4
TOTAL	21	1	31	1	65	119

Kinixys sp. tortoises are found in savanna woodlands, open grasslands, coastal plains and dry brush. They lay clutches of 2-10 eggs at 40-day intervals during the wet season. Tortoises of the genus *Kinixys* are feed on fruit, fungi, grasses, insects, leaves, sedges, sugarcane (where available), and snails (Alden et al. 1998). Tortoises defend themselves from a range of predators by retreating into their shells (Alden et al. 1998). Such a defense mechanism is ineffective against human predation, and Bofi and Aka foragers simply hand capture the slow-moving reptiles.

Table 4.12. *Cricetomys gambianus* – Giant pouched rat.

Element	A	B	C	E	F	TOTAL
Cranium	16	51	59	9	1	136
Mandible	18	11	13	3	1	46
Tooth	1	2	2	0	0	5
Scapula	13	9	16	1	1	40
CO Humerus	7	2	11	0	0	20

DSH Humerus	5	4	2	1	0	12
PX Humerus	2	1	0	0	0	3
PSH Humerus	1	0	2	0	1	4
CO Radius	4	3	10	1	0	18
DSH Radius	0	0	2	0	0	2
PSH Radius	3	2	4	0	0	9
CO Ulna	6	2	12	0	0	20
DSH Ulna	3	1	1	1	0	6
PSH Ulna	1	5	1	0	0	7
Carpals	0	4	1	0	0	5
CO Metacarpal	0	1	4	1	0	6
CO Rib	11	17	52	4	0	84
DSH Rib	5	4	4	5	0	18
PX Rib	2	0	7	1	0	10
PSH Rib	2	5	18	6	0	31
Rib SH	2	1	3	0	0	6
Cervical	3	8	21	7	0	39
Thoracic	21	2	25	12	0	60
Lumbar	44	24	62	10	6	146
Sacrum	20	15	15	2	2	54
Caudal	40	14	4	1	1	60
Vertebra	9	9	2	0	0	20
Innominate	19	21	17	4	3	64
CO Femur	6	4	6	0	0	16
DS Femur	4	6	0	1	1	12
DSH Femur	3	3	4	2	1	13
PX Femur	0	0	0	1	0	1
PSH Femur	9	4	4	0	1	18
Femur SH	2	2	1	0	0	5
CO Tibia	8	1	7	1	0	17
DS Tibia	0	1	0	0	0	1
DSH Tibia	6	4	7	1	0	18
PX Tibia	3	2	1	0	0	6
PSH Tibia	2	3	4	0	2	11
Tibia SH	6	2	2	0	0	10
CO Fibula	4	0	1	0	0	5
DSH Fibula	0	0	1	0	0	1
Tarsals	31	14	10	3	0	58
CO Metatarsal	7	5	0	1	0	13
CO Metapodial	18	10	31	3	0	62
DS Metapodial	0	1	0	0	0	1
PSH Metapodial	0	2	0	0	0	2
Phalanges	2	19	5	0	0	26
Long bone	0	3	0	0	0	3
Unidentifiable	2	4	2	0	0	8
TOTAL	371	308	456	82	21	1238

Cricetomys gambianus is found throughout Central Africa in wet and dry savannas, forest edges, and uplands below 2,100 m elevation. In areas where food is abundant, giant pouched rats breed year-round, producing 1-4 offspring after 28 days of gestation (Alden et al. 1998). Giant pouched rats are strictly nocturnal. During the night, they collect fruits, nuts, seeds, roots, and leaves in their cheek pouches and carry them back to their extensive underground tunnels. Of interest to archaeologists, pouched rats may also transport pebbles and small pieces of trash to their burrows (Kingdon 1997). The fact that this species is dormant during the day provides human foragers an opportunity to locate rats at rest in their burrows and attempt to flush them out.

Table 4.13. Muridae – Murid rats and mice.

Element	A. Grima Village 1999-2000
Cranium	42
Mandible	14
Tooth	15
Scapula	8
CO Humerus	4
DSH Humerus	5
CO Radius	2
PSH Radius	6
CO Ulna	3
PSH Ulna	5
Carpals	15
Sternum	5
CO Rib	13
DSH Rib	9
PX Rib	3
PSH Rib	1
Cervical	10
Thoracic	5
Lumbar	20
Sacrum	7
Caudal	14
Vertebra	3
Innominate	19
CO Femur	13
DS Femur	2

DSH Femur	2
PSH Femur	2
CO Tibia	7
DS Tibia	1
DSH Tibia	4
PX Tibia	7
PSH Tibia	7
Tibia SH	1
CO Fibula	1
DSH Fibula	1
Tarsals	20
CO Metatarsal	6
CO Metapodial	22
DS Metapodial	1
DSH Metapodial	2
PSH Metapodial	3
Phalanges	40
Unidentifiable	6
TOTAL	376

Currently, 313 distinct species of the family Muridae have been identified in Africa, encompassing a broad range of habitats and behavioral characteristics (Alden et al. 1998). In the following chapters Murid rats and mice are referred to as “Murid rodent” to distinguish them from pouched rats.

Conclusion

This chapter has described how 5640 bone specimens representing 11 different taxonomic groupings were collected in the villages of Grima and Ndele as part of the Washington State University Central African ethnoarchaeological project. These faunal specimens were collected after butchery and consumption, but prior to discard, eliminating post-depositional processes as factors in their taphonomic interpretation. As a result, they provide a unique opportunity to explore forest forager small animal processing and its consequences. The following chapter comprehensively describes the taphonomic characteristics of all prey species contained in the assemblage.

5. TAPHONOMY

This chapter is a descriptive overview of taphonomic data recorded for the Central African faunal collections. Data on burned bones is presented as the number of identified burned specimens (column “Burn NISP”). The degree of burning (browned, carbonized, or calcined) and patterning of burn locations are subdivided and described following each table. Cut mark data are presented in tabular format as the number of specimens exhibiting marks (Cut NISP) and the total number of distinct marks (# Cuts). Partial and complete chops are presented in the same way (PC NISP, # PC, CC NISP, and # CC). Cut and chop mark codes, frequencies, and functions are summarized here. Complete descriptions of codes and mark illustrations are presented in Appendix A. Fractured specimens are quantified as “Fracture NISP.” The breakdown of specific fracture types is discussed following each table or, for abundant taxa, in separate tables.

Table 5.1. River hog taphonomic summary.

Element	Burn NISP	Cut NISP	# Cuts	PC NISP	# PC	CC NISP	# CC	Fracture NISP
Cranium	0	0	0	1	5	0	0	0
Mandible	0	1	3	1	1	1	1	0
Sternum	0	0	0	0	0	0	0	0
DSH Rib	0	3	10	0	0	3	3	0
Scapula	0	1	1	2	5	3	3	0
TOTAL	0	5	14	4	11	7	7	0

Table 5.2. River hog cut and chop codes.

Code	NISP	#	Type	Function
S-3	1	2	PC	Dismemberment, consumption
S-7	1	1	PC	Consumption
ZYG-1	1	2	PC	Dismemberment
Man-3	1	1	PC	Dismemberment, fillet
MANT-2	1	3	Cut	Dismemberment
MANT-3	1	1	CC	Dismemberment
RIB-1	2	5	Cut	Unknown

Rib-17	3	5	Cut	Fillet
Rib-19	3	3	CC	Dismemberment
SCP-4	3	3	CC	Dismemberment
SCP-8	1	1	Cut	Dismemberment
SCP-10	2	5	PC	Dismemberment

The majority of marks that occur on river hog bones are associated with carcass dismemberment. Binford (1981) classifies the functions of S-3 as “Dismemberment, consumption” and S-7 as “Consumption.” Lupo (1993) classifies Man-3 as “Dismemberment, fillet” and Rib-17 as “Fillet.” The function(s) of the RIB-1 cut mark have not been determined.

Table 5.3. Yellow-backed duiker taphonomic summary.

Element	Burn NISP	Cut NISP	# Cuts	PC NISP	# PC	CC NISP	# CC	Fracture NISP
Cranium	0	2	24	1	18	1	3	1
Mandible	0	2	4	0	0	3	5	3
TOTAL	0	4	28	1	18	4	8	4

Cephalophus silvicultor is represented in this assemblage by extensively-damaged crania and mandible specimens (Figure 5.1 shows a representative yellow-backed duiker skull). There was no evidence of burning on these specimens. Note the difference between Cranium Cut NISP and Cranium # Cuts and between PC NISP and # PC. Specific codes for these marks are shown in Table 5.4.



Figure 5.1. Dorsal view of heavily cut and chopped yellow-backed duiker cranium.

Table 5.4. Yellow-backed duiker cut and chop codes.

Code	NISP	#	Type	Function
FRO-3	1	4	Cut	Unknown
HCO-1	1	1	CC	Dismemberment, horn removal
HCO-2	1	2	PC	Dismemberment, horn removal
MAXT-1	1	9	Cut	Dismemberment
OCC-1	1	5	PC	Unknown
OCC-2	1	1	Cut	Unknown
OCN-1	1	1	CC	Dismemberment, food preparation
OCN-2	1	2	PC	Dismemberment, food preparation
ORB-1	1	1	PC	Unknown
ORB-2	1	3	Cut	Unknown
PAR-2	1	4	Cut	Unknown
PAR-3	1	2	PC	Unknown
Sk-11	1	2	PC	Food preparation

Sk-13	1	3	Cut	Dismemberment
Sk-14	1	1	CC	Food preparation
ZYG-1	1	4	PC	Dismemberment
MANT-2	2	4	Cut	Dismemberment
MANT-6	2	2	CC	Dismemberment
MANT-7	3	3	CC	Dismemberment

The majority of marks that occur on yellow-backed duiker crania and mandibles reflect dismemberment, with a smaller number also related to food preparation. Several cranial cut marks and partial chops categorized as “unknown” are comparable to marks previously associated with skinning. Although we did not observe the removal of skin from duiker crania, it is possible that these marks reflect skinning and/or food preparation. One cranium was irregularly fractured and 3 mandible specimens displayed irregular perpendicular fractures (Table 5.3).

Table 5.5. Medium-sized duiker taphonomic summary.

Element	Burn NISP	Cut NISP	# Cuts	PC NISP	# PC	CC NISP	# CC	Fracture NISP
Cranium	10	25	92	5	6	17	20	41
Mandible	4	44	113	0	0	34	34	28
Scapula	0	1	1	1	1	2	2	0
Humerus SH	0	2	7	1	2	2	2	1
CO Radius	0	1	1	0	0	0	0	0
DSH Radius	0	0	0	0	0	1	1	1
PSH Radius	0	1	3	0	0	2	2	0
DS Ulna	0	0	0	0	0	0	0	1
PSH Ulna	0	0	0	0	0	2	2	1
Ulna SH	0	1	5	0	0	0	0	1
CO Metacarpal	0	1	10	0	0	0	0	0
Sternum	1	0	0	0	0	1	2	0
CO Rib	1	9	20	0	0	0	0	0
DS Rib	0	2	3	0	0	2	2	3
DSH Rib	1	17	34	0	0	12	12	7
PX Rib	0	6	10	0	0	4	4	1
PSH Rib	4	17	28	0	0	22	23	9
Rib SH	2	27	56	0	0	27	44	19
Cervical	2	12	22	17	29	60	79	15
Thoracic	32	23	45	6	7	85	114	20

Lumbar	6	12	29	3	3	24	39	3
Sacrum	0	1	1	0	0	5	8	0
Caudal	0	0	0	0	0	3	3	2
Vertebra	1	0	0	0	0	0	0	1
Innominate	2	7	12	1	2	15	21	6
DS Femur	0	1	1	0	0	2	2	0
DSH Femur	0	2	6	0	0	2	2	1
PX Femur	0	1	2	0	0	2	2	2
PSH Femur	1	1	5	1	1	3	4	0
Femur SH	0	2	7	1	1	3	4	2
Patella	0	1	2	0	0	0	0	0
DS Tibia	0	1	3	0	0	0	0	1
PX Tibia	0	2	4	0	0	1	1	1
PSH Tibia	0	2	5	1	1	1	1	2
Tibia SH	2	5	9	3	3	0	0	8
Tarsals	2	2	14	0	0	0	0	0
DSH Metatarsal	0	0	0	0	0	0	0	1
PSH Metatarsal	0	1	4	0	0	0	0	1
DS Metapodial	0	1	2	0	0	1	1	1
Long bone FR	0	1	1	0	0	0	0	6
Cartilage FR	2	1	1	0	0	2	2	0
Unidentifiable	0	0	0	0	0	0	0	5
TOTAL	73	233	558	40	56	337	433	191

Seventy-three medium duiker specimens were burned. The majority were carbonized (58), followed by 9 calcined specimens and 6 burned (e.g., “browned”) specimens. Specimens tended to be burned in consistent locations that varied by element, and most commonly on axial elements. Burn damage indicates the roasting of intact crania because cranium portions are consistently burned on exterior surfaces. For example, of the 10 burn-damaged cranial specimens, 3 were carbonized on the horn cores, 2 parietal portions were burned on the exterior surface, the dorsal surfaces of 3 nasal bones were carbonized, the underside of a premaxilla was carbonized, and the lateral face of a zygomatic arch was calcined. Only 4 mandible specimens displayed burning: 2 were calcined on the lateral surface of the dentary, and two were carbonized at breaks (chopped or fractured surfaces) indicating that these portions were subjected to

flame after being sub-divided. The most repetitive burn damage occurs on vertebrae and ribs. In both cases, burning is concentrated on the sheared surfaces produced by chopping ribs and vertebrae. Cervical vertebrae are most often chopped in the process of head removal, creating transverse shears with exposed bone grease that blackens when exposed to heat and flame. Thoracic and lumbar vertebrae are almost always sagittally bisected. Of 38 burned thoracic and lumbar specimens, 32 were carbonized on the medial face of sagittally-split specimens, and 3 were calcined in the same location. Comparably, when rib portions are burned, it is usually on the chopped or fractured end of the shaft. This consistent patterning reflects the roasting of sagittally-split duiker carcasses.

Table 5.6. Medium-sized duiker cut mark codes.

Cut Code	NISP	#	Function
FRO-2	1	1	Unknown
FRO-5	2	7	Unknown
HCO-3	2	3	Dismemberment, horn removal
MAXT-1	3	5	Dismemberment
OCC-2	1	3	Unknown
OCC-3	2	3	Unknown
ORB-2	3	5	Unknown
PAR-1	3	8	Unknown
PAR-2	4	24	Unknown
PMX-1	5	9	Unknown
S-1	1	1	Dismemberment
Sk-1	2	5	Nose removal (consumption)
Sk-8	4	10	Dismemberment
Sk-10	1	4	Unknown
Sk-12	2	2	Dismemberment, fillet
ZYG-2	1	2	Unknown
MANT-2	35	74	Dismemberment
MANT-5	8	18	Dismemberment
MANT-10	2	8	Dismemberment
MANT-11	1	3	Dismemberment
MANT-13	3	7	Dismemberment
MANT-15	1	2	Unknown
MANT-16	1	1	Unknown

SCP-1	1	1	Dismemberment
HUM-15	1	2	Unknown
HUM-18	1	4	Dismemberment
HUM-19	1	1	Unknown
RAD-1	1	1	Unknown
RAD-9	1	2	Dismemberment
RCp-5	1	1	Dismemberment
ULN-6	1	5	Unknown
MCM-5	1	2	Dismemberment
MCM-6	1	3	Dismemberment
Mc-7	1	5	Skinning
RIB-1	31	59	Unknown
RIB-2	8	10	Unknown
RIB-5	5	5	Unknown
RIB-6	12	15	Unknown
RIB-7	1	2	Unknown
RIB-8	1	1	Unknown
RIB-9	6	7	Unknown
RIB-10	2	2	Unknown
RIB-11	1	1	Unknown
RIB-12	1	1	Unknown
Rib-14	4	6	Fillet
Rib-16	14	27	Fillet
Rib-17	10	15	Fillet
AXI-6	2	2	Dismemberment
CER-5	4	9	Dismemberment
CER-9	2	3	Unknown
CER-10	1	2	Unknown
CER-11	2	4	Unknown
CER-16	1	2	Fillet
THO-2	14	30	Fillet
THO-8	1	2	Unknown
THO-9	2	2	Dismemberment
THO-10	4	5	Dismemberment
THO-12	1	3	Unknown
TV-3	3	3	Dismemberment
LUM-1	5	8	Dismemberment, food preparation
LUM-3	4	9	Dismemberment
Lum-5	2	5	Fillet
LUM-12	1	1	Unknown
LUM-13	1	1	Dismemberment
LUM-14	3	4	Dismemberment, food preparation
LUM-15	1	1	Dismemberment, food preparation
SAC-7	1	1	Unknown
ILI-4	3	6	Unknown
ILI-5	3	3	Unknown

ISC-3	1	1	Unknown
PS-7	1	1	Dismemberment
PS-10	1	1	Dismemberment
Fd-1	2	4	Dismemberment
Fem-3	1	2	Fillet
FEM-17	2	5	Unknown
FEM-21	2	8	Unknown
Fp-3	1	2	Dismemberment
PAT-1	1	2	Dismemberment
Td-1	1	1	Dismemberment
Td-3	2	3	Dismemberment
TIB-1	1	1	Unknown
TIB-3	2	4	Unknown
TIB-10	1	1	Unknown
Tib-12	1	1	Fillet
TIB-14	1	2	Unknown
TIB-17	1	2	Unknown
TIB-18	1	2	Unknown
Tib-21	2	2	Fillet
TIB-27	1	2	Unknown
Cal-2	1	4	Dismemberment
CAL-3	1	2	Dismemberment
TC-3	1	6	Unknown
TA-1	1	2	Dismemberment
MTM-13	1	4	Dismemberment
MTd-1	1	2	Dismemberment

The most common cuts on medium duiker specimens were MANT-2 (NISP 35, # Cuts 74) and RIB-1 (NISP 31, # Cuts 59). The frequency of MANT-2 and RIB-1, and the large difference between the number of specimens that featured these marks and the total number of marks, indicates that they are repetitive cut marks. MANT-2 is associated with the severing of the masseter muscle to facilitate mandible removal (Schmitt et al. 2001). Function(s) of the RIB-1 cut, a transverse cut on the medial mid-shaft of a rib, are unclear. However, the frequency with which RIB-1 occurs indicates that it is not a random or incidental mark.

Table 5.7. Medium-sized duiker partial chop codes.

PC Code	NISP	#	Function
HCO-2	3	4	Dismemberment, horn removal
S-3	1	1	Dismemberment, consumption
ZYG-1	1	1	Dismemberment
SCP-7	1	1	Dismemberment
HUM-6	1	2	Dismemberment
ATL-1	5	5	Dismemberment, head removal
ATL-5	3	5	Dismemberment, food preparation
AXI-8	2	2	Dismemberment, food preparation
CER-1	2	2	Dismemberment
CER-7	5	7	Dismemberment, food preparation
CER-12	1	1	Dismemberment, food preparation
CV-5	3	7	Dismemberment, head removal
THO-4	5	6	Dismemberment, food preparation
THO-5	1	1	Dismemberment
LUM-4	1	1	Dismemberment
LUM-11	1	1	Dismemberment, food preparation
LUM-16	1	1	Unknown
ILI-14	1	2	Dismemberment
FEM-13	1	1	Dismemberment
FEM-14	1	1	Dismemberment
FEM-23	1	1	Dismemberment
TIB-5	1	1	Dismemberment
TIB-19	1	1	Dismemberment
TIB-24	2	2	Dismemberment

Virtually all partial and complete chops that occur on medium duiker bones reflect carcass dismemberment and/or food preparation activities.

Table 5.8. Medium-sized duiker complete chop codes.

CC Code	NISP	#	Function
FRO-1	1	1	Food preparation, consumption
HCO-1	7	7	Dismemberment, horn removal
OCN-1	8	8	Dismemberment, food preparation
S-3	3	3	Dismemberment, consumption
S-7	1	1	Consumption
MANT-7	34	34	Dismemberment
SCP-3	1	1	Dismemberment
SCP-4	1	1	Dismemberment
HUM-2	1	1	Dismemberment
HUM-3	1	1	Dismemberment

RAD-4	2	2	Dismemberment
RAD-10	1	1	Dismemberment
ULN-4	1	1	Dismemberment
ULN-5	1	1	Dismemberment
STE-2	1	2	Dismemberment
Rib-3	2	2	Dismemberment
Rib-4	26	26	Dismemberment
Rib-19	33	36	Dismemberment
Rs-2	23	23	Dismemberment
Atl-10	8	8	Dismemberment, food preparation
AXI-5	2	2	Dismemberment, head removal
AXI-7	3	3	Dismemberment, food preparation
CER-3	23	24	Dismemberment, head removal, food preparation
Cer-13	7	7	Dismemberment, food preparation
Cer-15	32	34	Dismemberment, food preparation
Tho-3	75	76	Dismemberment
Tho-6	9	10	Dismemberment, preparation
Tho-7	2	2	Dismemberment, food preparation
Tho-11	26	27	Dismemberment, food preparation
Lum-2	1	1	Food preparation
Lum-9	21	25	Dismemberment
Lum-10	11	13	Dismemberment, food preparation
SAC-1	5	6	Dismemberment
SAC-2	2	2	Dismemberment, food preparation
CAU-1	2	2	Dismemberment, food preparation
CAU-3	1	1	Dismemberment
ILI-1	2	2	Dismemberment
ILI-16	1	1	Dismemberment
ILI-17	1	1	Dismemberment
PUB-1	3	3	Dismemberment
Pel-2	7	7	Dismemberment
Pel-3	4	4	Food preparation
Pel-4	3	3	Food preparation
FEM-9	5	5	Dismemberment
FEM-11	3	3	Dismemberment
FEM-12	5	5	Dismemberment
TIB-7	1	1	Dismemberment
TIB-22	1	1	Dismemberment
MTM-3	1	1	Dismemberment

The most common complete chops occur on medium duiker axial elements:
mandibles, ribs, cervical, thoracic, and lumbar vertebrae. These common chops: MANT-

7, Rib-4, Rib-19, Rs-2, CER-3, Cer-15, Tho-3, Tho-11, Lum-9, and Lum-10 are all associated with carcass dismemberment.

Table 5.9. Medium duiker fractured specimens^a.

Element	L	IP	SP	Saw	Spiral	I	TOTAL
Cranium	0	3	0	0	0	38	41
Mandible	0	6	0	0	1	21	28
Humerus SH	0	0	0	0	1	0	1
DSH Radius	1	0	0	0	0	0	1
DS Ulna	0	1	0	0	0	0	1
PSH Ulna	0	1	0	0	0	0	1
Ulna SH	0	1	0	0	0	0	1
DS Rib	0	1	0	2	0	0	3
DSH Rib	0	6	0	0	0	1	7
PX Rib	0	0	0	0	0	1	1
PSH Rib	1	5	1	2	0	0	9
Rib SH	1	6	1	8	2	1	19
Cervical	0	0	1	0	0	14	15
Thoracic	0	11	0	0	0	9	20
Lumbar	0	2	0	0	0	1	3
Caudal	0	0	2	0	0	0	2
Vertebra	0	0	0	0	0	1	1
Innominate	0	0	0	0	0	6	6
DSH Femur	1	0	0	0	0	0	1
PX Femur	0	0	0	0	0	2	2
Femur SH	1	1	0	0	0	0	2
DS Tibia	0	0	0	0	1	0	1
PX Tibia	0	0	0	1	0	0	1
PSH Tibia	0	0	0	0	2	0	2
Tibia SH	5	0	0	0	3	0	8
DSH Metatarsal	1	0	0	0	0	0	1
PSH Metatarsal	1	0	0	0	0	0	1
DS Metapodial	1	0	0	0	0	0	1
Long bone FR	4	2	0	0	0	0	6
Unidentifiable	0	0	0	0	0	5	5
TOTAL	17	46	5	13	10	100	191

^aAfter Marshall (1989). L=Longitudinal, I=Irregular Perpendicular, SP=Smooth Perpendicular, Saw=Sawtoothed, Spiral=Spiral, I=Irregular.

Duikers of all types are most often killed by a blow to the head from a blunt object. Skulls may also be smashed to access and consume the brain. Both processes

routinely create irregular breakage patterns on duiker crania (see Figure 5.2 in blue duiker section), and this is reflected by the number of irregularly-fractured medium duiker cranial specimens. Mandibles are frequently chopped and fractured in the process of dismemberment and tongue removal. Medium duiker cervical vertebrae are chopped and fractured when the animal is decapitated. Both elements are usually chopped in diagnostic, repeated locations (see Table 5.8 and Appendix A). When they are not, the breakage is commonly categorized as irregular (Table 5.9). The relatively high number of irregular perpendicular fractured thoracic specimens is a result of broken-off dorsal spines.

Table 5.10. Civet taphonomic summary.

Element	Burn NISP	Cut NISP	# Cuts	PC NISP	# PC	CC NISP	# CC	Fracture NISP
Humerus	0	1	3	0	0	0	0	0
PSH Radius	0	0	0	0	0	0	0	1
PSH Ulna	1	1	1	0	0	0	0	1
Lumbar	0	1	4	0	0	0	0	1
Sacrum	0	1	1	0	0	0	0	0
Innominate	0	1	3	0	0	0	0	0
Tibia	0	1	2	0	0	0	0	0
TOTAL	1	6	14	0	0	0	0	3

A single civet ulna was calcined at its mid-shaft spiral fracture. Most cuts recorded on civet bones are the result of carcass dismemberment. Of the exceptions, ULN-3 and TIB-9 are mid-shaft cuts of unknown purpose. Lupo (1993) classifies Hum-7 as “Fillet.” Despite occurring in the same anatomical location as Hum-7 among larger prey, this mark probably does not reflect the filleting of civet meat. In addition to the fractured ulna, a civet radius exhibited a mid-shaft spiral fracture, and a lumbar vertebra was irregularly fractured.

Table 5.11. Civet cut mark codes.

Code	NISP	#	Function
Hp-2	1	2	Dismemberment
Hum-7	1	1	Fillet
ULN-3	1	1	Unknown
LUM-3	1	4	Dismemberment
SAC-5	1	1	Dismemberment
ILI-9	1	3	Dismemberment
TIB-9	1	2	Unknown

Table 5.12. Blue duiker taphonomic summary.

Element	Burn NISP	Cut NISP	# Cuts	PC NISP	# PC	CC NISP	# CC	Fracture NISP
Cranium	21	37	95	14	28	31	37	199
Mandible	7	79	180	10	14	20	21	59
Scapula	1	25	48	6	6	20	20	19
CO Humerus	1	7	26	1	2	0	0	0
DS Humerus	0	3	3	3	3	4	4	1
DSH Humerus	0	11	25	2	2	6	7	10
PX Humerus	0	2	4	1	1	5	5	2
PSH Humerus	0	10	22	0	0	10	14	17
Humerus SH	0	3	10	1	2	5	9	5
CO Radius	0	3	9	0	0	0	0	0
DS Radius	0	0	0	0	0	0	0	1
DSH Radius	2	4	6	1	1	0	0	7
PX Radius	0	1	2	0	0	0	0	4
PSH Radius	2	4	5	1	1	2	3	17
Radius SH	1	1	1	0	0	1	2	2
DSH Ulna	1	1	5	0	0	5	5	5
PX Ulna	0	0	0	0	0	0	0	5
PSH Ulna	1	5	6	0	0	2	2	13
Ulna SH	2	2	4	0	0	2	4	6
CO Metacarpal	1	1	2	1	1	0	0	1
DSH Metacarpal	1	1	1	0	0	1	1	6
PSH Metacarpal	0	0	0	0	0	2	2	2
Metacarpal SH	1	0	0	1	1	1	1	3
Sternum	4	6	11	0	0	6	6	6
CO Rib	1	9	18	0	0	1	2	5
DS Rib	1	3	3	0	0	7	7	3
DSH Rib	7	40	67	0	0	92	92	42
PX Rib	2	1	3	0	0	2	2	11
PSH Rib	25	82	141	0	0	153	156	82
Rib SH	22	37	57	0	0	83	104	94

Cervical	4	45	74	56	71	65	72	20
Thoracic	45	31	56	8	10	235	261	93
Lumbar	23	52	97	9	10	167	193	38
Sacrum	1	6	6	0	0	26	32	8
Innominate	3	45	94	11	12	68	88	37
CO Femur	0	4	15	0	0	0	0	0
DS Femur	1	4	8	3	3	4	4	4
DSH Femur	3	12	33	7	12	11	12	10
PX Femur	1	6	15	0	0	6	6	13
PSH Femur	1	12	36	2	2	10	11	10
Femur SH	0	11	26	3	3	11	14	21
CO Tibia	0	2	3	0	0	0	0	0
DS Tibia	2	1	1	0	0	3	3	3
DSH Tibia	1	6	20	1	2	4	4	10
PX Tibia	2	4	5	2	2	3	3	7
PSH Tibia	4	8	21	3	3	7	7	12
Tibia SH	2	9	20	1	1	3	4	30
Tarsals	1	3	4	4	5	4	4	1
CO Metatarsal	1	1	5	1	1	0	0	0
DSH Metatarsal	0	2	3	2	2	2	2	3
PSH Metatarsal	0	3	5	2	2	3	3	6
Metatarsal SH	0	4	6	3	3	1	2	6
Long bone	0	0	0	1	1	0	0	3
Cartilage	6	1	3	0	0	6	6	4
Unidentifiable	0	0	0	0	0	0	0	10
TOTAL	205	650	1310	161	207	1100	1237	976

Of 205 burned blue duiker specimens, 35 were browned, 100 were carbonized, and 70 were calcined. As with medium-sized duikers, blue duiker cranial specimens indicate the roasting of complete skulls. Twenty of 21 burned cranial specimens were burned on exterior surfaces and 12 of these were burned on the horn cores. Mandibles were burned in multiple locations: one on the articular condyle, one on the tip of the mandibular symphysis, two on the lateral face, and two on the ventral mandible. A single mandible specimen was carbonized along a break, suggesting that it was broken prior to roasting. Burn patterning on blue duiker vertebrae and ribs reflects the roasting of sagittally-split carcasses. The majority (56 of 68) of burned thoracic and lumbar

specimens were browned, carbonized, or calcined on the sheared surface of the vertebral centrum. Forty-seven of 58 burned rib specimens were burned at the fractured or chopped end of the shaft.

Table 5.13. Burned blue duiker appendicular elements.

Element	Burn Description
Scapula	Browned on glenoid fossa
CO Humerus	Carbonized on distal end
DSH Radius	Calcined at mid-shaft break
DSH Radius	Browned at mid-shaft break
PSH Radius	Carbonized on proximal end and mid-shaft break
PSH Radius	Carbonized on proximal end
Radius SH	Browned at distal break
DSH Ulna	Calcined at mid-shaft break
PSH Ulna	Browned at mid-shaft break
Ulna SH	Carbonized at proximal break
Ulna SH	Carbonized on shaft
CO Metacarpal	Browned on anterior surface
DSH Metacarpal	Calcined at mid-shaft break
Metacarpal SH	Browned anterior proximal shaft
Innominate (AILI)	Browned on pubis
Innominate (ISC)	Carbonized at ischium break
Innominate (AISI)	Carbonized on sagittal chop
DS Femur	Calcined medial surface
DSH Femur	Carbonized at mid-shaft break
DSH Femur	Carbonized on shaft
DSH Femur	Carbonized on distal end
PX Femur	Carbonized on posterior femoral head
PSH Femur	Browned on anterior shaft
DS Tibia	Carbonized on distal end
DS Tibia	Browned at distal shaft break
DSH Tibia	Carbonized on tip of tibial crest
PX Tibia	Carbonized on medial surface
PX Tibia	Carbonized on proximal end
PXS Tibia	Browned on proximal-medial surface

PXS Tibia	Carbonized at mid-shaft break
PXS Tibia	Browned on antero-medial shaft
PXS Tibia	Carbonized on antero-medial shaft
Tibia SH	Carbonized at proximal shaft break
Tibia SH	Carbonized on shaft
Astragalus	Browned on medio-ventral surface
CO Metatarsal	Carbonized on anterior surface of distal end

Blue duiker appendicular elements rarely exhibited burn damage, and the location of burning was less consistent than on axial elements. Repeatedly burned locations include the articular ends of long bones, multiple surfaces of shaft portions, and, similar to ribs, the exposed ends of chopped or fractured long bones (Table 5.13).

Table 5.14. Blue duiker cut mark codes.

Cut Code	NISP	#	Function
FRO-2	4	7	Unknown
FRO-4	2	3	Unknown
FRO-5	2	6	Unknown
FRO-6	1	3	Unknown
HCO-3	3	8	Dismemberment, horn removal
MAXT-1	5	8	Dismemberment
OCC-2	2	2	Unknown
OCC-3	2	2	Unknown
ORB-2	3	9	Unknown
PAR-1	6	13	Unknown
PAR-2	6	17	Unknown
PMX-1	4	5	Unknown
S-1	2	3	Dismemberment
Sk-2	1	2	Unknown
Sk-8	3	7	Dismemberment
ANG-1	3	3	Dismemberment
MANT-2	64	132	Dismemberment
MANT-5	17	28	Dismemberment
MANT-8	4	6	Unknown
MANT-10	2	3	Dismemberment
MANT-12	2	4	Dismemberment
MANT-13	2	3	Dismemberment
MANT-15	1	1	Unknown

SCP-1	17	35	Dismemberment
SCP-2	8	10	Dismemberment
SCP-8	1	2	Dismemberment
SCP-9	1	1	Unknown
Hd-1	3	4	Dismemberment
Hd-2	10	15	Dismemberment
Hd-3	6	13	Dismemberment
Hp-1	2	3	Dismemberment
HUM-1	2	2	Unknown
HUM-4	3	7	Unknown
HUM-5	3	5	Unknown
Hum-7	11	17	Fillet
Hum-9	2	3	Dismemberment
HUM-10	1	1	Dismemberment
Hum-11	1	1	Fillet
Hum-13	2	9	Fillet
HUM-15	3	5	Unknown
HUM-16	1	1	Dismemberment
HUM-18	1	4	Dismemberment
RAD-1	9	15	Unknown
RAD-2	2	2	Unknown
RAD-3	1	1	Unknown
RAD-6	1	1	Dismemberment
RAD-12	1	2	Dismemberment
RCd-3	1	2	Dismemberment
RCp-1	2	2	Dismemberment
ULN-2	5	7	Dismemberment
ULN-6	3	6	Unknown
MCM-2	1	1	Unknown
MCM-8	1	2	Unknown
STE-1	1	3	Dismemberment
STE-4	3	3	Unknown
STE-5	1	2	Unknown
STE-6	2	3	Unknown
RIB-1	51	72	Unknown
RIB-2	29	40	Unknown
RIB-5	8	11	Unknown
RIB-6	26	37	Unknown
RIB-7	20	28	Unknown
RIB-8	5	6	Unknown
RIB-9	8	11	Unknown
RIB-10	3	4	Unknown
RIB-11	2	4	Unknown
Rib-14	3	4	Fillet
Rib-16	33	50	Fillet
Rib-17	14	25	Fillet

ATL-2	5	8	Dismemberment
ATL-4	1	1	Unknown
ATL-6	2	3	Dismemberment
Axi-1	1	1	Unknown
AXI-2	5	7	Dismemberment
AXI-3	4	5	Dismemberment
AXI-4	3	6	Dismemberment
CER-2	6	6	Dismemberment
CER-4	9	16	Dismemberment
CER-5	10	19	Dismemberment
CER-6	1	1	Unknown
CER-8	1	1	Unknown
THO-1	2	2	Unknown
THO-2	9	23	Fillet
THO-8	2	4	Unknown
THO-10	1	1	Dismemberment
THO-13	1	1	Unknown
THO-14	1	1	Unknown
THO-15	1	2	Unknown
TV-3	15	22	Dismemberment
LUM-1	42	82	Dismemberment, food preparation
LUM-3	2	2	Dismemberment
Lum-5	1	1	Fillet
Lum-7	7	10	Fillet
LUM-13	2	2	Dismemberment
SAC-3	2	2	Dismemberment
SAC-4	1	1	Unknown
SAC-5	1	1	Dismemberment
SAC-6	2	2	Unknown
ACE-2	3	4	Dismemberment
APUB-1	2	2	Unknown
ILI-4	3	4	Unknown
ILI-5	4	10	Unknown
ILI-6	7	11	Unknown
ILI-9	2	3	Dismemberment
ILI-11	3	5	Dismemberment
ILI-12	2	4	Unknown
ISC-2	2	3	Unknown
ISC-3	1	1	Unknown
PS-6	3	7	Filleting
PS-7	8	15	Dismemberment
PS-8	5	7	Dismemberment
PS-10	12	18	Dismemberment
Fd-1	16	36	Dismemberment
FEM-1	4	9	Unknown
FEM-2	2	7	Unknown

Fem-3	4	6	Fillet
FEM-4	6	8	Unknown
FEM-5	4	4	Unknown
FEM-7	1	2	Unknown
FEM-10	5	7	Unknown
FEM-17	1	2	Unknown
FEM-19	1	4	Unknown
FEM-20	3	3	Unknown
FEM-22	1	1	Unknown
FEM-24	1	2	Unknown
FEM-25	3	3	Unknown
FEM-27	1	1	Unknown
Fp-1	3	3	Dismemberment
Fp-3	1	1	Dismemberment
Fp-4	7	11	Filleting
Fp-5	3	4	Dismemberment
Fp-7	6	19	Filleting
Td-3	3	5	Dismemberment
TIB-1	6	9	Unknown
TIB-3	8	15	Unknown
Tib-8	1	2	Fillet
TIB-9	2	2	Unknown
TIB-10	1	2	Unknown
Tib-11	2	6	Fillet
Tib-12	4	5	Fillet
TIB-13	1	1	Unknown
TIB-14	3	4	Unknown
TIB-15	3	6	Unknown
TIB-16	3	4	Unknown
TIB-18	2	2	Unknown
Tib-21	2	2	Fillet
TIB-26	1	1	Dismemberment
TIB-Unknown	2	4	Unknown
TA-1	1	1	Dismemberment
TA-2	1	1	Dismemberment
NVC-1	1	2	Dismemberment
MTM-2	2	3	Unknown
MTM-4	6	9	Unknown
MTM-5	1	1	Dismemberment
MTM-8	1	2	Dismemberment
MTM-9	1	3	Unknown
MTM-12	1	1	Unknown

The most common cut marks on blue duiker specimens were MANT-2, RIB-1, and LUM-1. As with medium duiker bones, MANT-2 was the most frequently-occurring mark on blue duiker bones, and the ratio of # Cuts to Cut NISP was greater than 2 to 1 (NISP 64, # Cuts 133). The functions of RIB-1 and LUM-1 are undetermined, but their frequency and the consistency of location suggests that they are the result of a repeated butchery process. Several rib cuts (RIB-7, RIB-6, RIB-2, and Rib-16) were moderately abundant, ranging from 20-33 specimens. The functions of RIB-2, RIB-6, and RIB-7 are unknown. Lupo (1993) classifies Rib-16 as “Fillet” and, despite rarely observing the filleting of blue duiker meat, this mark may reflect a similar preparation-related function on blue duiker ribs.

Table 5.15. Blue duiker partial chop codes.

PC Code	NISP	#	Function
HCO-2	5	6	Dismemberment, horn removal
OCC-1	2	4	Unknown
OCN-2	2	2	Dismemberment, food preparation
ORB-1	2	9	Unknown
PAR-3	3	5	Unknown
Sk-11	1	1	Food preparation
ZYG-1	1	1	Dismemberment
MANT-4	7	10	Dismemberment
MANT-9	2	3	Dismemberment
MANT-14	1	1	Dismemberment
SCP-7	4	4	Dismemberment
SCP-10	2	2	Dismemberment
HUM-6	1	2	Dismemberment
HUM-8	2	3	Dismemberment
HUM-12	5	5	Dismemberment
RAD-5	1	1	Dismemberment
RAD-8	1	1	Dismemberment
MCM-3	1	1	Dismemberment
MCM-4	1	1	Dismemberment
ATL-1	15	21	Dismemberment, head removal
ATL-5	1	2	Dismemberment, food preparation
CV-5	8	10	Dismemberment, head removal
CER-1	32	37	Dismemberment

CER-7	1	1	Dismemberment, food preparation
THO-4	5	6	Dismemberment, food preparation
THO-5	3	4	Dismemberment
LUM-4	5	5	Dismemberment
LUM-11	4	5	Dismemberment, food preparation
ACE-1	3	3	Dismemberment
ILI-2	1	1	Dismemberment
ILI-3	1	1	Dismemberment
ILI-7	1	1	Dismemberment
ILI-8	1	1	Dismemberment
ILI-10	1	1	Dismemberment
ILI-13	1	1	Dismemberment
ISC-1	2	2	Dismemberment
PUB-2	1	1	Dismemberment
FEM-6	3	6	Dismemberment
FEM-8	6	8	Dismemberment
FEM-14	1	1	Dismemberment
Fem-15	3	3	Food preparation
FEM-23	2	2	Dismemberment
TIB-5	4	5	Dismemberment
TIB-6	1	1	Dismemberment
TIB-20	1	1	Dismemberment
TIB-23	1	1	Dismemberment
CAL-4	1	1	Dismemberment
AST-1	3	4	Dismemberment
MTM-1	1	1	Dismemberment
MTM-7	1	1	Dismemberment
MTM-10	5	5	Dismemberment
MTM-11	1	1	Dismemberment

Virtually all partial and complete chops on blue duiker bones reflect carcass dismemberment. The most common partial chop on blue duiker specimens is CER-1. CER-1 is a partial transverse chop (i.e., hack or cleave mark) to a cervical vertebra. ATL-1 and CV-5 represent the same mark on the atlas and axis, respectively. All three marks are associated with decapitating blue duikers during the initial dismemberment.

Table 5.16. Blue duiker complete chop codes.

CC Code	NISP	#	Function
FRO-1	1	1	Food preparation, consumption
HCO-1	21	21	Dismemberment, horn removal
OCN-1	11	11	Dismemberment, food preparation
S-3	2	2	Dismemberment, consumption
S-7	2	2	Consumption
MANT-1	5	5	Dismemberment
MANT-3	2	2	Dismemberment
MANT-7	13	14	Dismemberment
SCP-3	15	15	Dismemberment
SCP-4	4	4	Dismemberment
SCP-6	1	1	Dismemberment
HUM-2	23	23	Dismemberment
HUM-3	16	16	Dismemberment
RAD-4	1	1	Dismemberment
RAD-7	1	1	Dismemberment
RAD-10	1	1	Dismemberment
RAD-11	2	2	Dismemberment
ULN-1	8	8	Dismemberment
ULN-4	2	2	Dismemberment
ULN-5	1	1	Dismemberment
MCM-1	4	4	Dismemberment
STE-3	6	6	Dismemberment
Rib-3	10	11	Dismemberment
Rib-4	17	17	Dismemberment
Rib-19	220	223	Dismemberment
Rs-2	118	118	Dismemberment
ATL-3	3	3	Dismemberment, head removal
AXI-5	8	8	Dismemberment, head removal
AXI-7	1	1	Dismemberment, food preparation
CER-3	36	36	Dismemberment, head removal, food preparation
Cer-13	7	8	Dismemberment, food preparation
Cer-15	16	16	Dismemberment, food preparation
Tho-3	221	223	Dismemberment
Tho-6	5	5	Dismemberment, preparation
Tho-11	32	33	Dismemberment, food preparation
Lum-9	164	167	Dismemberment
Lum-10	26	26	Dismemberment, food preparation
SAC-1	25	25	Dismemberment
SAC-2	6	7	Dismemberment, food preparation
ILI-1	6	6	Dismemberment
ISC-4	2	2	Dismemberment
Pel-2	28	28	Dismemberment
Pel-3	10	10	Food preparation

Pel-4	13	13	Food preparation
PUB-1	27	29	Dismemberment
FEM-9	17	17	Dismemberment
FEM-11	13	13	Dismemberment
FEM-12	16	16	Dismemberment
FEM-13	1	1	Dismemberment
TIB-2	5	5	Dismemberment
TIB-4	8	8	Dismemberment
TIB-7	3	3	Dismemberment
TIB-22	5	5	Dismemberment
CAL-1	1	1	Dismemberment
AST-2	3	3	Dismemberment
MTM-3	5	6	Dismemberment
MTM-6	1	1	Dismemberment

The most common complete chops on blue duiker bones occur on ribs and vertebrae: Tho-3, Rib-19, Lum-9, and Rs-2. Tho-3 and Lum-9 are complete sagittal chops through vertebrae and reflect the sagittal bisection of duiker carcasses during the initial dismemberment. Rib-19 and Rs-2 are transverse chops through the rib mid-shaft and distal shaft. Both chops are associated with duiker dismemberment.

Table 5.17. Blue duiker fractured specimens^a.

Element	L	IP	SP	Saw	Spiral	Stepped	I	TOTAL
Cranium	0	3	0	0	0	0	196	199
Mandible	1	28	8	2	2	0	18	59
Scapula	7	0	0	1	0	0	11	19
DS Humerus	0	0	0	0	0	1	0	1
DSH Humerus	1	0	0	0	9	0	0	10
PX Humerus	0	0	0	0	1	0	1	2
PSH Humerus	1	1	0	1	14	0	0	17
Humerus SH	1	0	0	0	4	0	0	5
DS Radius	0	0	0	1	0	0	0	1
DSH Radius	1	2	0	1	2	1	0	7
PX Radius	0	1	0	0	3	0	0	4
PSH Radius	1	3	0	1	11	1	0	17
Radius SH	1	1	0	0	0	0	0	2
DSH Ulna	0	2	3	0	0	0	0	5
PX Ulna	0	1	2	0	0	0	2	5
PSH Ulna	0	5	6	1	1	0	0	13
Ulna SH	0	2	2	0	0	0	2	6

CO Metacarpal	0	0	0	0	0	0	1	1
DSH Metacarpal	1	0	0	1	4	0	0	6
PSH Metacarpal	1	0	0	0	1	0	0	2
Metacarpal SH	2	0	0	0	1	0	0	3
Sternum	0	0	0	1	0	0	5	6
CO Rib	1	3	0	0	0	0	1	5
DS Rib	0	3	0	0	0	0	0	3
DSH Rib	2	32	0	1	2	0	5	42
PX Rib	0	2	0	3	2	0	4	11
PSH Rib	8	54	0	6	9	0	5	82
Rib SH	7	63	0	2	12	0	10	94
Cervical	0	0	0	0	0	0	20	20
Thoracic	0	41	2	2	0	0	48	93
Lumbar	0	17	2	0	0	0	19	38
Sacrum	0	0	0	0	0	0	8	8
Innominate	0	15	0	2	6	1	13	37
DS Femur	0	1	0	2	1	0	0	4
DSH Femur	2	0	0	0	8	0	0	10
PX Femur	4	2	0	0	5	0	2	13
PSH Femur	0	1	0	0	9	0	0	10
Femur SH	4	0	0	0	17	0	0	21
DS Tibia	0	1	0	0	2	0	0	3
DSH Tibia	1	0	0	2	7	0	0	10
PX Tibia	5	1	0	0	1	0	0	7
PSH Tibia	1	0	0	0	10	1	0	12
Tibia SH	18	0	1	1	10	0	0	30
Tarsals	0	0	0	0	0	0	1	1
DSH Metatarsal	0	1	0	0	2	0	0	3
PSH Metatarsal	1	3	0	1	1	0	0	6
Metatarsal SH	3	0	0	0	3	0	0	6
Long bone	1	0	0	0	1	0	1	3
Cartilage	0	4	0	0	0	0	0	4
Unidentifiable	0	0	0	0	0	0	10	10
TOTAL	76	293	26	32	161	5	383	976

^aAfter Marshall (1989). L=Longitudinal, I=Irregular Perpendicular, SP=Smooth Perpendicular, Saw=Sawtoothed, Spiral=Spiral, Stepped=Stepped, I=Irregular.

As noted for larger duiker species, blue duiker crania are often smashed when the animal is killed and further smashed to provide access to the brain, resulting in a high number of irregularly fractured cranial specimens (Table 5.17 and Figure 5.2). Likewise, blue duiker mandibles are chopped and fractured in the process of dismemberment and

tongue removal. When they are not clearly chopped, the damage is most often recorded as an irregular or irregular perpendicular break.



Figure 5.2. Examples of smashed blue duiker crania.

Blue duiker vertebrae, especially cervical vertebrae, were usually fractured in irregular, unclassifiable patterns. Those thoracic and lumbar vertebrae recorded as “irregular perpendicular” are the result of broken-off dorsal spines and transverse processes. Rib portions display various fracture types, with irregular perpendicular being the most common form of breakage. Appendicular long bones are more likely to exhibit spiral fracturing.

Table 5.18. Guenon monkey taphonomic summary.

Element	Burn	Cut	#	PC	#	CC	#	Fracture
	NISP	NISP	Cuts	NISP	PC	NISP	CC	NISP
Mandible	0	2	5	0	0	3	3	0
DSH Ulna	0	0	0	0	0	0	0	1
CO Rib	0	0	0	0	0	0	0	0
DSH Rib	0	2	2	0	0	0	0	3
PSH Rib	0	3	3	0	0	0	0	6
Thoracic	0	0	0	0	0	9	10	0
Lumbar	2	0	0	0	0	3	4	0
Sacrum	0	0	0	0	0	1	1	0
Caudal	0	0	0	0	0	1	1	0
Innominate	0	1	2	2	3	4	4	0
PX Femur	0	0	0	1	1	1	1	0
PSH Femur	0	1	2	0	0	0	0	1
TOTAL	2	9	14	3	4	22	24	11

Two carbonized lumbar centra were the only evidence of burning among the *Cercopithecus* sp. specimens. The most common blade-produced mark on guenon bones was the Tho-3 sagittal chop through thoracic vertebrae. As with most cut and chop marks on monkey bones, Tho-3 is associated with dismemberment.

Table 5.19. Guenon monkey cut and chop codes.

Code	NISP	#	Type	Function
MANT-2	2	5	Cut	Dismemberment
MANT-7	3	3	CC	Dismemberment
RIB-2	5	5	Cut	Unknown
Tho-3	8	8	CC	Dismemberment
Tho-11	2	2	CC	Dismemberment, food preparation
Lum-9	3	3	CC	Dismemberment
Lum-10	1	1	CC	Dismemberment, food preparation
SAC-1	2	2	CC	Dismemberment
CAU-3	1	1	CC	Dismemberment
ACE-1	1	1	PC	Dismemberment
ILI-1	1	1	CC	Dismemberment
ILI-13	1	2	PC	Dismemberment
Pel-2	2	2	CC	Dismemberment
Pel-3	1	1	CC	Food preparation
PS-8	1	2	Cut	Dismemberment
FEM-9	1	1	CC	Dismemberment

FEM-10	1	1	Cut	Unknown
FEM-25	1	1	Cut	Unknown
FEM-26	1	1	PC	Dismemberment

Six monkey DSH ribs, 3 PSH ribs, and 1 DSH ulna displayed irregular perpendicular fractures. In addition, a single PSH femur was spirally fractured.

Table 5.20. Brush-tailed porcupine taphonomic summary.

Element	Burn	Cut	#	PC	#	CC	#	Fracture
	NISP	NISP	Cuts	NISP	PC	NISP	CC	NISP
Cranium	4	1	1	0	0	1	1	15
Mandible	0	11	16	0	0	0	0	4
Scapula	0	2	3	0	0	0	0	14
CO Humerus	0	2	3	0	0	0	0	0
DS Humerus	0	1	3	0	0	1	1	0
DSH Humerus	0	0	0	0	0	0	0	1
PX Humerus	0	0	0	0	0	0	0	1
CO Rib	0	0	0	0	0	0	0	1
DSH Rib	0	1	1	0	0	8	8	19
PX Rib	0	0	0	0	0	2	2	2
PSH Rib	0	1	1	0	0	0	0	6
Rib SH	0	2	2	0	0	1	2	2
Cervical	0	0	0	0	0	6	6	7
Thoracic	0	3	3	0	0	13	13	6
Lumbar	0	3	3	0	0	31	32	18
Sacrum	0	0	0	0	0	8	8	1
Caudal	0	0	0	0	0	1	1	2
Vertebra	0	0	0	0	0	0	0	2
Innominate	2	9	13	2	2	14	16	7
CO Femur	1	4	9	0	0	0	0	0
DS Femur	0	1	1	0	0	1	1	0
DSH Femur	0	2	5	0	0	0	0	3
PX Femur	1	0	0	0	0	0	0	0
PSH Femur	0	0	0	0	0	2	2	3
CO Tibia	0	3	9	0	0	0	0	0
DSH Tibia	0	0	0	0	0	1	1	2
PSH Tibia	0	1	2	1	1	0	0	2
Tibia SH	0	1	1	1	1	1	1	0
DSH Fibula	0	0	0	0	0	0	0	2
PSH Metatarsal	0	0	0	0	0	0	0	2
Unidentifiable	0	0	0	0	0	0	0	1
TOTAL	8	48	76	4	4	91	95	123

Three porcupine cranial specimens were carbonized on exterior surfaces and 1 was calcined. One innominate was browned at a breakage point in the ilium neck and another was carbonized on the pubis. Two femur specimens were carbonized: 1 on the femoral head and 1 on the distal condyles.

Table 5.21. Brush-tailed porcupine cut mark codes.

Cut Code	NISP	#	Function
S-1	1	1	Dismemberment
MANT-2	7	10	Dismemberment
MANT-5	1	1	Dismemberment
MANT-8	3	5	Unknown
SCP-1	1	2	Dismemberment
SCP-5	1	1	Unknown
HUM-4	1	1	Unknown
HUM-14	1	3	Unknown
HUM-17	1	2	Unknown
RIB-1	2	2	Unknown
Rib-17	2	2	Fillet
THO-2	1	1	Fillet
THO-9	1	1	Dismemberment
TV-3	1	1	Dismemberment
Lum-7	1	1	Fillet
LUM-12	1	1	Unknown
LUM-15	1	1	Dismemberment, food preparation
APUB-1	1	1	Unknown
ILI-4	1	1	Unknown
ILI-6	1	2	Unknown
ILI-11	2	4	Dismemberment
ISC-2	1	1	Unknown
PS-7	4	4	Dismemberment
Fd-1	3	3	Dismemberment
FEM-2	1	1	Unknown
Fem-3	1	3	Fillet
FEM-5	1	2	Unknown
FEM-17	2	2	Unknown
Fp-5	1	1	Dismemberment
Fp-7	1	3	Filleting
TIB-1	1	3	Unknown
TIB-3	1	1	Unknown
Tib-11	1	5	Fillet
TIB-16	1	1	Unknown
TIB-17	2	2	Unknown

Porcupine bones exhibited many cuts in various locations, none of them significantly more common than the others. The most frequently-occurring mark (by a small margin) was the MANT-2 cut. This dismemberment mark is also the most common cut on medium and blue duikers. Most marks categorized as “fillet” or “unknown” likely occur during food preparation processes, although porcupines are not filleted in the same way that larger game are.

Table 5.22. Brush-tailed porcupine partial chop codes.

PC Code	NISP	#	Function
ILI-8	2	2	Dismemberment
TIB-20	1	1	Dismemberment
TIB-23	1	1	Dismemberment

Partial chops were extremely rare on porcupine bones, likely because chops easily pass through the relatively small bones of this species. All partial chops, and nearly all complete chops, that occur on porcupine bones reflect carcass dismemberment.

Table 5.23. Brush-tailed porcupine complete chop codes.

CC Code	NISP	#	Function
OCN-1	1	1	Dismemberment, food preparation
HUM-3	1	1	Dismemberment
Rib-3	11	11	Dismemberment
Rib-19	1	1	Dismemberment
ATL-3	1	1	Dismemberment, head removal
Cer-15	5	5	Dismemberment, food preparation
Tho-3	11	11	Dismemberment
Tho-11	2	2	Dismemberment, food preparation
Lum-9	27	27	Dismemberment
Lum-10	5	5	Dismemberment, food preparation
SAC-1	8	8	Dismemberment
CAU-1	1	1	Dismemberment, food preparation
ILI-1	2	2	Dismemberment
Pel-2	5	5	Dismemberment
Pel-3	9	9	Food preparation
FEM-11	1	1	Dismemberment
FEM-13	1	1	Dismemberment

FEM-16	1	1	Dismemberment
TIB-22	2	2	Dismemberment

The most common complete chop on porcupine specimens was Lum-9, a complete sagittal chop through a lumbar vertebra. Other common chops are also associated with dismemberment and/or food preparation. Like Lum-9, Tho-3 and SAC-1 are sagittal chops that result from bisecting the porcupine carcass. Rib-3 is a complete chop through the rib neck and Pel-3 is a complete transverse chop through the acetabulum.

Table 5.24. Brush-tailed porcupine fractured specimens^a.

Element	L	IP	SP	Saw	Spiral	I	TOTAL
Cranium	0	1	0	0	0	14	15
Mandible	0	0	1	0	0	3	4
Scapula	3	1	0	0	0	10	14
DSH Humerus	0	1	0	0	0	0	1
PX Humerus	0	0	0	0	1	0	1
CO Rib	1	0	0	0	0	0	1
DSH Rib	0	17	2	0	0	0	19
PX Rib	0	1	0	0	0	1	2
PSH Rib	0	4	2	0	0	0	6
Rib SH	0	2	0	0	0	0	2
Cervical	0	0	0	0	0	7	7
Thoracic	0	3	0	0	1	2	6
Lumbar	0	0	0	1	0	17	18
Sacrum	0	0	0	0	0	1	1
Caudal	0	0	0	0	0	2	2
Vertebra	0	0	0	0	0	2	2
Innominate	0	1	0	1	2	3	7
DSH Femur	0	1	0	0	2	0	3
PSH Femur	0	1	0	0	2	0	3
DSH Tibia	0	0	0	0	2	0	2
PSH Tibia	0	0	0	0	2	0	2
DSH Fibula	0	1	0	0	1	0	2
PSH Metatarsal	0	0	0	0	2	0	2
Unidentifiable	0	0	0	0	0	1	1
TOTAL	4	34	5	2	15	63	123

^aAfter Marshall (1989). L=Longitudinal, IP=Irregular Perpendicular, SP=Smooth Perpendicular, Saw=Sawtoothed, Spiral=Spiral, I=Irregular.

Table 5.25. Tree pangolin taphonomic summary.

Element	Burn NISP	Cut NISP	# Cuts	CC NISP	# CC	Fracture NISP
Cranium	0	0	0	0	0	1
Scapula	0	1	1	0	0	1
DSH Humerus	0	0	0	1	1	0
PSH Humerus	0	0	0	1	1	0
DSH Rib	0	0	0	1	1	1
PSH Rib	0	1	2	1	1	0
Thoracic	0	0	0	7	7	0
Lumbar	5	3	4	12	14	0
Sacrum	0	1	2	1	1	0
Caudal	4	0	0	0	0	4
Vertebra	0	0	0	0	0	4
Innominate	1	1	1	3	3	1
CO Femur	0	2	3	0	0	0
PX Femur	0	0	0	1	2	0
PSH Femur	1	1	1	0	0	0
Femur SH	0	0	0	0	0	1
TOTAL	11	10	14	28	31	13

Burn patterning on tree pangolin remains indicates the roasting of sagittally-split carcass halves. Five sagittally-chopped lumbar vertebrae were carbonized on the sheared surface and 4 caudal vertebrae were calcined along the lateral/medial edge. One innominate was carbonized on the acetabulum and a PSH femur was carbonized at the mid-shaft break.

Table 5.26. Tree pangolin cut and chop codes.

Code	NISP	#	Type	Function
SCP-5	1	1	Cut	Unknown
HUM-2	2	2	CC	Dismemberment
RIB-1	1	2	Cut	Unknown
Rib-3	1	1	CC	Dismemberment
Rib-19	1	1	CC	Dismemberment
Tho-3	7	7	CC	Dismemberment
LUM-3	2	2	Cut	Dismemberment
LUM-6	1	1	Cut	Unknown
Lum-7	1	1	Cut	Fillet

Lum-9	11	13	CC	Dismemberment
Lum-10	1	1	CC	Dismemberment, food preparation
SAC-1	2	2	CC	Dismemberment
SAC-4	1	2	Cut	Unknown
Pel-3	1	1	CC	Food preparation
PS-10	1	1	Cut	Dismemberment
PUB-1	1	1	CC	Dismemberment
FEM-2	1	1	Cut	Unknown
FEM-7	1	1	Cut	Unknown
FEM-10	1	2	Cut	Unknown
FEM-16	1	2	CC	Dismemberment

The most common blade-produced marks on pangolin bones were Lum-9 and Tho-3, complete sagittal chops through lumbar and thoracic vertebrae. Both result from the sagittal splitting of the carcass when it is initially divided. A single pangolin cranium was irregularly fractured. Four indeterminate vertebrae and 4 caudal vertebrae featured broken-off transverse processes recorded as smooth perpendicular fractures. Such damage may have been produced by a blade skipping along the edge of the vertebral centrum. In addition, 1 DSH rib exhibited a spiral fracture, and 1 femur shaft, scapula, and innominate were irregularly fractured.

Table 5.27. Tortoise taphonomic summary.

Element	Burn NISP	Cut NISP	# Cuts	PC NISP	# PC	CC NISP	# CC	Fracture NISP
CO Humerus	2	0	0	0	0	0	0	0
DSH Humerus	1	0	0	0	0	1	1	0
PX Humerus	0	1	2	0	0	2	2	0
CO Ulna	2	0	0	0	0	0	0	0
Carapace FR	25	0	0	0	0	0	0	0
Vertebra	0	0	0	0	0	0	0	1
Innominate	0	1	3	1	1	3	3	2
Long bone	0	0	0	0	0	0	0	1
TOTAL	30	2	5	1	1	6	6	4

PSH Ulna	0	0	0	0	0	1	1	2
CO Rib	0	4	5	0	0	0	0	2
DSH Rib	0	0	0	0	0	4	4	14
PX Rib	2	1	1	0	0	0	0	10
PSH Rib	3	4	5	0	0	2	2	29
Rib SH	1	0	0	0	0	0	0	6
Cervical	0	3	5	0	0	2	2	6
Thoracic	2	5	7	2	2	13	13	7
Lumbar	1	15	20	3	3	20	20	19
Sacrum	1	3	5	0	0	4	4	12
Caudal	1	2	3	0	0	1	1	0
Vertebra	0	0	0	0	0	0	0	5
Innominate	1	17	41	2	3	17	20	8
CO Femur	0	7	15	0	0	0	0	0
DS Femur	0	0	0	0	0	2	2	1
DSH Femur	0	8	15	0	0	5	5	7
PX Femur	0	1	1	0	0	1	1	0
PSH Femur	0	6	11	0	0	4	4	3
Femur SH	0	0	0	0	0	1	2	0
CO Tibia	0	2	4	0	0	0	0	3
DS Tibia	0	0	0	0	0	0	0	1
DSH Tibia	0	0	0	0	0	1	1	5
PX Tibia	0	0	0	0	0	0	0	1
PSH Tibia	0	3	8	0	0	2	2	9
Tibia SH	0	0	0	0	0	0	0	6
CO Fibula	0	2	3	0	0	0	0	2
DSH Fibula	0	0	0	0	0	0	0	1
Tarsals	0	1	1	0	0	0	0	1
CO Metapodial	0	0	0	0	0	0	0	1
DS Metapodial	1	0	0	0	0	0	0	1
PSH Metapodial	0	0	0	0	0	0	0	2
Phalanges	0	0	0	0	0	0	0	2
Long bone	0	0	0	0	0	0	0	3
Unidentifiable	0	0	0	0	0	0	0	7
TOTAL	14	104	184	7	8	85	89	245

Burning is rare among pouched rat bones, but concentrated on axial elements, most commonly at the broken ends of rib shafts (Table 5.30).

Table 5.30. Burned giant pouched rat bones.

Element	Burn Description
Mandible	Burned along the edge of broken ascending ramus
Thoracic	Carbonized on ventral surface of centrum
Thoracic	Completely carbonized
Lumbar	Carbonized on broken transverse process
Sacrum	Browned on anterior surface of centrum
Caudal	Carbonized on transversely-chopped surface
PX Rib	Calcined at break
PX Rib	Calcined at break
PSH Rib	Carbonized on proximal end and at break
PSH Rib	Carbonized at break
PSH Rib	Calcined at break
Rib SH	Carbonized at distal break
Innominate	Calcined on medial pubis
DS Metapodial	Carbonized on distal tip

Table 5.31. Giant pouched rat cut mark codes.

Cut Code	NISP	#	Function
MANT-2	2	3	Dismemberment
MANT-8	9	16	Unknown
SCP-1	1	2	Dismemberment
SCP-5	2	4	Unknown
Hd-3	1	1	Dismemberment
HUM-4	1	3	Unknown
Hum-7	2	3	Fillet
Hum-9	1	1	Dismemberment
RAD-12	1	1	Dismemberment
RIB-1	1	2	Unknown
RIB-2	2	2	Unknown
RIB-9	5	6	Unknown
Rib-17	1	1	Fillet
AXI-3	1	1	Dismemberment
CER-2	1	1	Dismemberment

CER-5	1	1	Dismemberment
CER-8	2	2	Unknown
THO-1	2	3	Unknown
THO-14	1	1	Unknown
TV-3	2	3	Dismemberment
LUM-1	4	6	Dismemberment, food preparation
LUM-3	2	2	Dismemberment
Lum-5	1	1	Fillet
LUM-6	3	5	Unknown
Lum-7	2	2	Fillet
LUM-8	1	1	Unknown
LUM-13	2	2	Dismemberment
LUM-15	1	1	Dismemberment, food preparation
SAC-3	1	2	Dismemberment
SAC-4	2	3	Unknown
CAU-2	1	2	Dismemberment
CAU-4	1	1	Dismemberment
ACE-2	1	1	Dismemberment
APUB-1	1	1	Unknown
ILI-4	1	1	Unknown
ILI-5	1	1	Unknown
ILI-6	1	1	Unknown
ILI-9	4	4	Dismemberment
ILI-11	4	8	Dismemberment
ILI-15	2	2	Unknown
ISC-2	1	1	Unknown
PS-7	6	9	Dismemberment
PS-8	4	8	Dismemberment
PS-10	2	4	Dismemberment
Fem-3	10	13	Fillet
FEM-5	3	8	Unknown
FEM-7	2	2	Unknown
FEM-10	1	1	Unknown
FEM-18	1	2	Dismemberment
Fp-1	4	5	Dismemberment
Fp-3	2	4	Dismemberment
Fp-4	2	2	Filleting
Fp-7	3	5	Filleting
TIB-3	1	1	Unknown
Tib-8	1	6	Fillet
Tib-11	3	4	Fillet
TIB-25	1	1	Dismemberment
FIB-1	2	2	Unknown
FIB-2	1	1	Unknown
CAL-3	1	1	Dismemberment

The most common cut marks on pouched rat specimens were Fem-3 and MANT-8. Fem-3 is a transverse cut on the posterior mid-shaft of the femur. Lupo (1993) relates cuts at the location of Fem-3 to filleting among larger east African taxa, but it undoubtedly results from a different process among pouched rat bones. MANT-8 is a longitudinal cut of indeterminate function on the horizontal ramus of the mandible.

Table 5.32. Giant pouched rat partial chop codes.

PC Code	NISP	#	Function
THO-4	2	2	Dismemberment, food preparation
LUM-4	1	1	Dismemberment
LUM-11	2	2	Dismemberment, food preparation
ILI-8	1	1	Dismemberment
ILI-10	1	1	Dismemberment
ILI-14	1	1	Dismemberment

As with brush-tailed porcupines, partial chops were rare on pouched rat bones, likely a result of the small size and fragility of these bones. All partial and complete chops to pouched rat bones are associated with carcass dismemberment and/or food preparation.

Table 5.33. Giant pouched rat complete chop codes.

CC Code	NISP	#	Function
OCN-1	1	1	Dismemberment, food preparation
SCP-4	1	1	Dismemberment
SCP-6	1	1	Dismemberment
HUM-3	1	1	Dismemberment
RAD-11	1	1	Dismemberment
ULN-4	1	1	Dismemberment
Rib-3	3	3	Dismemberment
Rib-19	1	1	Dismemberment
Rs-2	2	2	Dismemberment
Cer-15	2	2	Dismemberment, food preparation
Tho-3	12	12	Dismemberment
Tho-11	1	1	Dismemberment, food preparation
Lum-2	1	1	Food preparation
Lum-9	13	13	Dismemberment
Lum-10	6	6	Dismemberment, food preparation
SAC-1	3	3	Dismemberment

SAC-2	1	1	Dismemberment, food preparation
CAU-1	1	1	Dismemberment, food preparation
ILI-1	9	10	Dismemberment
Pel-2	2	2	Dismemberment
Pel-3	1	1	Food preparation
Pel-4	5	5	Food preparation
PUB-1	2	2	Dismemberment
FEM-9	6	6	Dismemberment
FEM-11	5	5	Dismemberment
FEM-12	2	2	Dismemberment
FEM-16	1	1	Dismemberment
TIB-2	1	1	Dismemberment
TIB-28	2	2	Dismemberment

The most common complete chops on pouched rat bones were Lum-9 and Tho-3, complete sagittal chops through the lumbar and thoracic vertebrae. Again, these chops reflect the common Bofi and Aka practice of sagittally bisecting carcasses of animals, large and small, during dismemberment and food preparation. ILI-1, a complete transverse chop through the ilium blade related to carcass division, is also relatively common.

Table 5.34. Giant pouched rat fractured specimens^a.

Element	L	IP	SP	Saw	Spiral	Stepped	I	TOTAL
Cranium	0	0	0	0	0	0	26	26
Mandible	0	5	4	0	0	0	5	14
Scapula	2	3	0	0	1	0	11	17
DSH Humerus	1	0	0	1	0	0	0	2
PSH Humerus	0	1	0	1	0	0	0	2
DSH Radius	1	0	1	0	0	0	0	2
PSH Radius	0	2	0	0	1	0	0	3
DSH Ulna	0	2	0	0	1	0	0	3
PSH Ulna	0	1	0	0	1	0	0	2
CO Rib	2	0	0	0	0	0	0	2
DSH Rib	0	8	3	0	3	0	0	14
PX Rib	0	9	1	0	0	0	0	10
PSH Rib	0	22	4	0	3	0	0	29
Rib SH	0	3	1	1	1	0	0	6
Cervical	0	0	0	0	0	0	6	6
Thoracic	0	5	1	0	0	0	1	7

Lumbar	0	12	6	0	0	0	1	19
Sacrum	0	1	6	0	0	0	5	12
Vertebra	0	0	0	0	0	0	5	5
Innominate	0	6	2	0	0	0	0	8
DS Femur	0	0	0	0	1	0	0	1
DSH Femur	0	0	0	1	5	0	1	7
PSH Femur	0	0	0	0	3	0	0	3
CO Tibia	0	3	0	0	0	0	0	3
DS Tibia	1	0	0	0	0	0	0	1
DSH Tibia	0	0	2	0	3	0	0	5
PX Tibia	0	0	0	0	1	0	0	1
PSH Tibia	0	2	1	0	5	1	0	9
Tibia SH	4	0	0	0	2	0	0	6
CO Fibula	0	0	2	0	0	0	0	2
DSH Fibula	0	0	0	0	1	0	0	1
Tarsals	0	0	0	0	0	0	1	1
CO Metapodial	1	0	0	0	0	0	0	1
DS Metapodial	0	0	0	0	1	0	0	1
PSH Metapodial	0	0	0	0	2	0	0	2
Phalanges	2	0	0	0	0	0	0	2
Long bone	3	0	0	0	0	0	0	3
Unidentifiable	0	0	0	0	0	0	7	7
TOTAL	17	85	34	4	35	1	69	245

^aAfter Marshall (1989). L=Longitudinal, I=Irregular Perpendicular, SP=Smooth Perpendicular, Saw=Sawtoothed, Spiral=Spiral, Stepped=Stepped, I=Irregular.

Table 5.35. Murid rodent taphonomic summary.

Element	Burn NISP	Cut NISP	# Cuts	Fracture NISP
Cranium	0	0	0	34
Mandible	0	1	1	7
Scapula	0	0	0	4
DSH Humerus	0	0	0	2
PSH Radius	2	0	0	6
PSH Ulna	0	0	0	5
DSH Rib	0	0	0	9
PX Rib	0	0	0	3
PSH Rib	0	0	0	1
Cervical	0	0	0	1
Thoracic	0	0	0	1
Lumbar	0	0	0	6
Caudal	0	0	0	2
Vertebra	0	0	0	3
Innominate	0	1	2	14

CO Femur	0	1	1	0
DSH Femur	0	0	0	2
PSH Femur	0	0	0	1
DS Tibia	0	0	0	1
DSH Tibia	0	0	0	3
PSH Tibia	1	0	0	7
Tibia SH	0	0	0	1
Fibula SH	0	0	0	1
DS Metapodial	1	0	0	1
DSH Metapodial	1	0	0	2
PSH Metapodial	0	0	0	3
Phalanges	4	0	0	3
Unidentifiable	0	0	0	4
TOTAL	9	3	4	127

Nine Murid specimens were burned, all of them from lower limbs. Two PSH radii and 1 PSH tibia were carbonized at mid-shaft breaks. A distal metapodial, DSH metapodial, and 3 phalanges were carbonized at the distal ends. An additional phalange was carbonized on its dorsal surface.

Only three Murid specimens exhibited cut marks: MANT-2, PS-10, and FEM-5. MANT-2 and PS-10 are associated with dismemberment when they occur on larger taxa, but are rare and may be essentially random on these small Murid bones. The function of FEM-5, particularly on such tiny specimens, is unknown.

Table 5.36. Murid rodent fractured specimens^a.

Element	L	IP	SP	Spiral	Stepped	I	TOTAL
Cranium	0	0	0	0	0	34	34
Mandible	0	0	0	0	0	7	7
Scapula	0	1	0	0	0	3	4
DSH Humerus	0	1	0	1	0	0	2
PSH Radius	0	0	0	6	0	0	6
PSH Ulna	0	2	0	3	0	0	5
DSH Rib	0	5	3	1	0	0	9
PX Rib	0	1	2	0	0	0	3
PSH Rib	0	0	1	0	0	0	1
Cervical	0	0	1	0	0	0	1
Thoracic	0	0	1	0	0	0	1

Lumbar	0	5	1	0	0	0	6
Caudal	0	0	2	0	0	0	2
Vertebra	0	0	0	0	0	3	3
Innominate	0	10	3	0	0	1	14
DSH Femur	0	0	0	2	0	0	2
PSH Femur	0	1	0	0	0	0	1
DS Tibia	0	0	0	1	0	0	1
DSH Tibia	0	2	0	0	0	1	3
PSH Tibia	0	2	1	2	2	0	7
Tibia SH	0	1	0	0	0	0	1
Fibula SH	0	0	1	0	0	0	1
DS Metapodial	0	0	1	0	0	0	1
DSH Metapodial	1	0	1	0	0	0	2
PSH Metapodial	1	0	2	0	0	0	3
Phalanges	0	2	1	0	0	0	3
Unidentifiable	0	0	0	0	0	4	4
TOTAL	2	33	21	16	2	53	127

^aAfter Marshall (1989). L=Longitudinal, I=Irregular Perpendicular, SP=Smooth Perpendicular, Spiral=Spiral, Stepped=Stepped, I=Irregular.

The relatively high rate of fracturing (and rarity of other damage categories) is likely a result of the effectiveness of hand fracturing among such very small rodents and the inherent fragility of their bones.

The following chapter expands on this descriptive coverage of Bofi and Aka taphonomy, examines the role of prey size in taphonomic analyses, and explores patterning in the assemblage and how it compares to other ethnoarchaeological collections of large and small prey.

6. PREY SIZE AND TAPHONOMY: THE BOFI AND AKA COLLECTIONS IN GLOBAL CONTEXT

Decades of taphonomic research have illuminated the complex interrelationship of variables that influence how a particular animal carcass is processed by humans. Butchery technology, cooking methods, prey abundance, prey size, the specific animal resources utilized (skin, bone, meat, marrow, or grease), number of consumers (guided by sharing goals and culturally-specific sharing rules), and transport distance all contribute to processing decisions. In this chapter, I focus on one of these variables with significant implications for the behavioral interpretation of taphonomic patterning: prey size. In order to make well-informed inferences about behavioral variation from taphonomic patterning, we must understand how patterning varies among different-sized prey and how interpretive expectations must also vary with prey size.

In zooarchaeological analysis, prey are often divided into ranked size categories, usually based on live weight ranges of modern species (e.g., Brain 1981; Bunn 1982; Klein 1989; Potts 1988; Thomas 1969). This is done to simplify analysis and allow for the inclusion of bones that cannot be identified to genera or species. Size ranks vary geographically depending on the range of prey represented, making comparisons based on qualitative size terminology difficult. For example, Potts (1988) divides mammals into five classes: A. Very small (2-10 kg), B. Small (10-72 kg), C. Medium (72-320 kg), D. Large (320-820 kg), and E. Very large (> 820 kg). Viewed from the perspective of Potts' broad scale, only one species represented in these Central African collections crosses the Small/Medium weight threshold and most would be categorized as "Very small." Despite the presence of "Medium" giant hog, sitatunga, bongo, forest buffalo,

and even “Very large” elephant in the Ngotto Forest, these species are rarely hunted and do not occur in our ethnoarchaeological bone collections.

Previous intra-assemblage analyses (Lupo and Schmitt 2005; Schmitt and Lupo 2008) divide the collections into small (< 10 kg), medium (10-25 kg), and large (> 25 kg. See Table 6.1).

Table 6.1. Prey size categories.

Taxon	Live weight range (kg)^a
Large (> 25 kg). Combined NISP = 18	
Red river hog (<i>Potamochoerus porcus</i>)	45.0 – 115.0
Yellow-backed duiker (<i>Cephalophus silvicultor</i>)	45.0 – 80.0
Medium (10-25 kg). Combined NISP = 723	
Bay or Peters duiker (<i>Cephalophus dorsalis</i> or <i>callipygus</i>)	15.0 – 24.0
Civet (<i>Civettictus civetta</i>)	7.0 – 20.0
Small (< 10 kg). Combined NISP = 4888	
Blue duiker (<i>Cephalophus monticola</i>)	3.5 – 9.0
Monkey (<i>Cercopithecus</i> sp.)	1.8 – 6.0
Brush-tailed porcupine (<i>Atherurus africanus</i>)	1.5 – 4.0
Tree pangolin (<i>Phataginus tricuspis</i>)	1.6 – 3.0
Tortoise (<i>Kinixys</i> sp.)	1.0 – 2.0 ^b
Giant pouched rat (<i>Cricetomys emini</i>)	1.0 – 1.4
Murid rats and mice (Muridae)	.025 - .065

^a Live weights as reported by Kingdon (1997)

^b Tortoise live weight from Alden et al. (1998)

As outlined in previous chapters, seven of 11 taxa identified (and over 86% of assemblage NISP) have live weights under 10 kg. Thus, by any categorization, the assemblage is dominated by small prey. The following analyses approach the Central African fauna as a unique assemblage of small animal bones, while evaluating intra-assemblage variation between the smallest and largest taxa represented, and comparing taphonomic patterning to other collections of large and small prey from ethnographic, archaeological, and experimental contexts.

Burned Bone

Burn damage on animal bones may be a product of both natural and cultural processes. As a result, distinguishing the attributes of bones burned by natural processes and those burned by human behavioral processes is of primary importance (Buikstra and Swegle 1989; David 1990; Marshall 1989; Shipman et al. 1984). But humans are the only agents capable of creating patterned burning (i.e., natural fires do not selectively burn). Virtually all modern zooarchaeological reports record and analyze the frequency, intensity, and characteristics of burned bone. Ethnoarchaeological studies have revealed informative variability in the patterning of burned specimens among contemporary peoples. These data can be used to do much more than simply indicate the agency of humans in accumulating faunal assemblages; they allow us to make a broad range of inferences about butchery practices, cooking methods, bone discard, and the environmental availability of fuel for cooking fires, among others (see Cain 2005 for a recent example). This section explores how cooking methods, prey size, and butchery patterns influence the frequency of burned bone in forest forager faunal assemblages.

Lyman (1994:388) lists three causes of intentional burning of bones by humans: cooking, disposal of food waste, and as fuel for anthropogenic fires. In the context of our study area, burned bone can be attributed to cooking practices. Animal bones may be discarded in fire hearths, but all bones in this assemblage were collected prior to discard. It's worth noting here that rates of burned bone in the Central African collections should be considered *minimum* frequencies since these bone specimens were collected prior to discard. Fuel wood for fires is abundant in our area, and we never observed small prey bones intentionally burned for this purpose. Further, the abundance of fire wood suggests

that fuel availability should not be a constraining factor on the choice of cooking methods used.

Whether animal segments are boiled or roasted can have a significant impact on rates of burned specimens, and studies have demonstrated that cut, chop, and fracture patterning (discussed later in the chapter) may also vary with cooking method (Gifford-Gonzalez 1989, 1993; Jones 1983, 1993; Kent 1993; Lupo 1993; Speth 2000; Yellen 1977b). A commonly stated expectation is that burned bone will occur less frequently in assemblages produced in contexts where boiling is the predominant method of cooking meat. Conversely, situations in which bone is directly exposed to heat and flame should result in more burned specimens. Since foragers in our study area consume most meat in the form of boiled stews, the overall frequency of burned bone should be relatively low, and, in fact, only 352 specimens (6.24% of assemblage NISP) exhibit burning damage of any kind.

Ethnoarchaeological studies, however, show evidence that roasting of small prey does not necessarily increase the frequency of burned bone (Kent 1993; Nicholson 2005). Kent (1993), in a study of Basarwa (aka “Bushman” or San) faunal assemblages that were dominated by prey weighing less than 25 kg, reports no significant difference between bones recovered from camps where meat was boiled and those where meat was roasted. In both cases, burned specimens represent less than 1% of assemblage NISP. She attributes the scarcity of burned bone to the fact that hunters roast segments of meat with very little exposed bone, thus cooking attached flesh without charring bone. In addition, most of the bone burning that Kent (1993) observed occurred when bones were

deposited in the fire in the process of trash disposal and clean up, rather than during cooking.

Kent's (1993) findings are reinforced by ethnoarchaeological work among the Aché of eastern Paraguay (Jones 1983, 1984; Nicholson 2005). In an early study of small animal (< 10 kg) taphonomy, Jones (1983) reports no burned specimens. He explains the lack of burning by noting that many prey are boiled, not roasted. Another of Jones' important observations is that among the Aché roasted prey are usually dismembered *after* cooking. Nicholson (2005) greatly expands on Jones' analysis of the Aché collections. Generally, the Aché boil small prey (< 10 kg) and roast larger animals (20-35 kg), with the exception that small prey taken in large quantities may be roasted for preservation. Despite the frequent use of both boiling and roasting as preparation methods, less than 1% of identified bone specimens were burned (.50% of "large" species and .19% of "small" ones; Nicholson 2005:111). Of those specimens that were burned, most were burned on exterior surfaces and the articular ends of long bones (Nicholson 2005), which reflects the roasting of complete, unbroken elements.

Much higher percentages of burned bone have been documented among larger African prey (Bunn 1983; Gifford-Gonzalez 1989; Lupo 1993). Bunn (1983) compares faunal remains from a modern San hunter-gatherer camp to animal bones recovered from a spotted hyena (*Crocuta crocuta*) den. Among the diagnostic characteristics of the San-produced assemblage was the presence of burned bone. Bunn's San assemblage is comprised of large ungulate specimens: springbok (*Antidorcas marsupialis*. 26-48 kg), greater kudu (*Tragelaphus strepsiceros*. 120-350 kg), eland (*Tragelaphus oryx*. 317-942

kg), and giraffe (*Giraffa camelopardalis*. 700-1395kg; weight ranges from Alden et al. 1998) and 20.4% of the specimens were burned (1983:146).

Gifford-Gonzalez' (1989) taphonomic analysis of bones produced by Dassanetch farmers includes both domestic taxa ("Bos & Large Bovid" and "Caprini & Small Bovid" categories) and wild zebra (*Equus burchelli*. 220-250 kg; Alden et al. 1998). Gifford-Gonzalez notes that cooking pots were concentrated at home settlements and residential sites yet, apparently, much meat was roasted at such sites. At residential Site 105, 28.83% of zebra bone specimens were burned, compared to 40.04% for "Bos & Large Bovid" and 53.10% for "Caprini & Small Bovid" (1989:223-224). Burn damage for all three taxonomic groupings was concentrated on crania and mandibles (from the roasting of heads over coals), articular surfaces of long bones (providing evidence of the roasting of limb segments), and on break surfaces (indicating the subdivision of segments *before* exposure to fire) (Gifford-Gonzalez 1989:193).

As part of an ethnoarchaeological analysis of Hadza-produced large prey assemblages, Lupo (1993) documents a significant difference between the frequency and intensity of burning at Mugugu (a short-term hunting blind) and Tsipitibe (a base camp). At Mugugu, burn damage occurs on 34% of identified specimens and across species, but is most prevalent on impala (*Aepyceros melampus*. 40-76 kg; Alden et al. 1998) and zebra (*Equus burchelli*) bones. Of these burned bones, 33.5% are carbonized or calcined, reflecting longer exposure to heat and/or flame (Lupo 1993:156). Lupo argues that the extreme degrees of burning represented at Mugugu are probably a result of bone discard in fire during site clean-up, or the use of large bones as fuel, rather than casual roasting (1993:156-157). In contrast, at Tsipitibe, significantly fewer (only 8%) specimens of

impala, warthog (*Phacochoerus africanus*. 45-100 kg), alcelaphine (e.g., *Alcelaphus buselaphus*. 129-228 kg; weight ranges from Alden et al. 1998), and zebra exhibited burning, and only 24% of these were carbonized or calcined (Lupo 1993:167).

Observing that cooking pots and water are more available at base camps than hunting blinds, Lupo concludes: “The lower frequencies and degrees of burning displayed at Tsipitibe are undoubtedly related to the dominant mode of meat preparation conducted at this site, bone and meat boiling” (1993:167).

Burn Analyses

Based on the preceding overview of Aché, Dassanetch, Hadza, and San ethnoarchaeological fauna, it is clear that cooking methods, prey size, and butchery patterns intertwine with other context-specific variables to affect the frequency and intensity of burned bone in an assemblage. In general, ethnoarchaeological collections of large animals display a greater proportion of burned specimens resulting from an interrelated combination of cooking mechanics, cooking methods, and prey size. Small prey are more difficult to skewer for roasting than large prey, and may fit into a pot for boiling with minimal butchery. In other words, they require little pot-sizing. Small carcasses may be boiled or roasted, yet produce negligible differences in the frequency of burned bone specimens (Kent 1993; Nicholson 2005; Speth 2000). Large carcasses, however, are more likely to exceed the size of a cooking pot, and fire roasting allows for larger portions to be cooked with less investment in butchery. In either case, subdivision of large carcasses is common prior to boiling *or* roasting. Boiling of meat, regardless of prey size, produces few, if any, burned specimens. Alternatively, if a large carcass is subdivided prior to roasting, additional bone surfaces are exposed to flame and subject to

burn damage (Johnson 1989:441). In addition to prey size, the choice of cooking methods employed may be constrained by contextual factors such as the availability of cooking technology (e.g., boiling requires cooking pots and water, boiling and roasting require wood fuel, etc.). The extent to which burn frequency and intensity are related to prey size, cooking methods, and bone discard among smaller fauna (< 100 kg, and most species considerably less than this) is testable with the Central African collections, with an emphasis on the following hypotheses:

1. Prey Size and Burned Bone Frequency: Since the larger prey in this forest forager faunal assemblage (duikers) were more commonly roasted than smaller prey (rodents) I expect the proportion of burn-damaged specimens to increase with prey body size.
2. Prey Size and Burning Intensity: If the intensity of burning (as reflected by bone discoloration) varies with the frequency of burning, then the proportion of carbonized and calcined specimens is expected to increase with prey body size as well. However, since bones in this context were never discarded in fire or hot ashes or used as fuel, overall rates of carbonization and calcination should be relatively low.
3. Butchery Patterns and Burned Bone: Because larger taxa are often butchered before being cooked, they should feature more burning on chopped and fractured surfaces.
4. Camp Context and Burning Frequency: Since the availability of cooking pots, water, and wood fuel are not constraining factors at Bofi and Aka village or remote camps, I expect little variation in cooking methods (as reflected by the frequency of burn damage) between these contexts.

Prey Size and Burned Bone Frequency

These hypotheses are tested here by examining the frequency, intensity, and location of burn damage to bones, and how each varies in relation to prey size. First, a comparison of bones from all recovered taxa for the presence of burning indicates that there is a significant difference in the proportion of burned specimens between taxonomic groupings ($\chi^2 = 195.7$; $df = 11$; $p < .001$). However, sample sizes among these taxonomic

groupings vary widely which can influence statistical outcomes. To account for the widely divergent samples sizes among taxonomic groups, it is necessary to establish a minimum sample size. Minimum sample size, or abundance, was established using a 5% of the total assemblage NISP criterion. Thus, those taxonomic grouping with sample sizes that reach the minimum of 5% of the total assemblage NISP are designated “common prey.” Based on this standard for minimum sample size, medium duiker, blue duiker, brush-tailed porcupine, giant pouched rat, and Murid rodent qualify as common (see Chapter 5 for descriptive coverage of the burn characteristics of all taxa).

After selecting only the most abundant prey, a significant difference in the proportion of burned specimens between taxa remains ($\chi^2 = 117.0$; $df = 4$; $p < .001$; Figure 6.1).

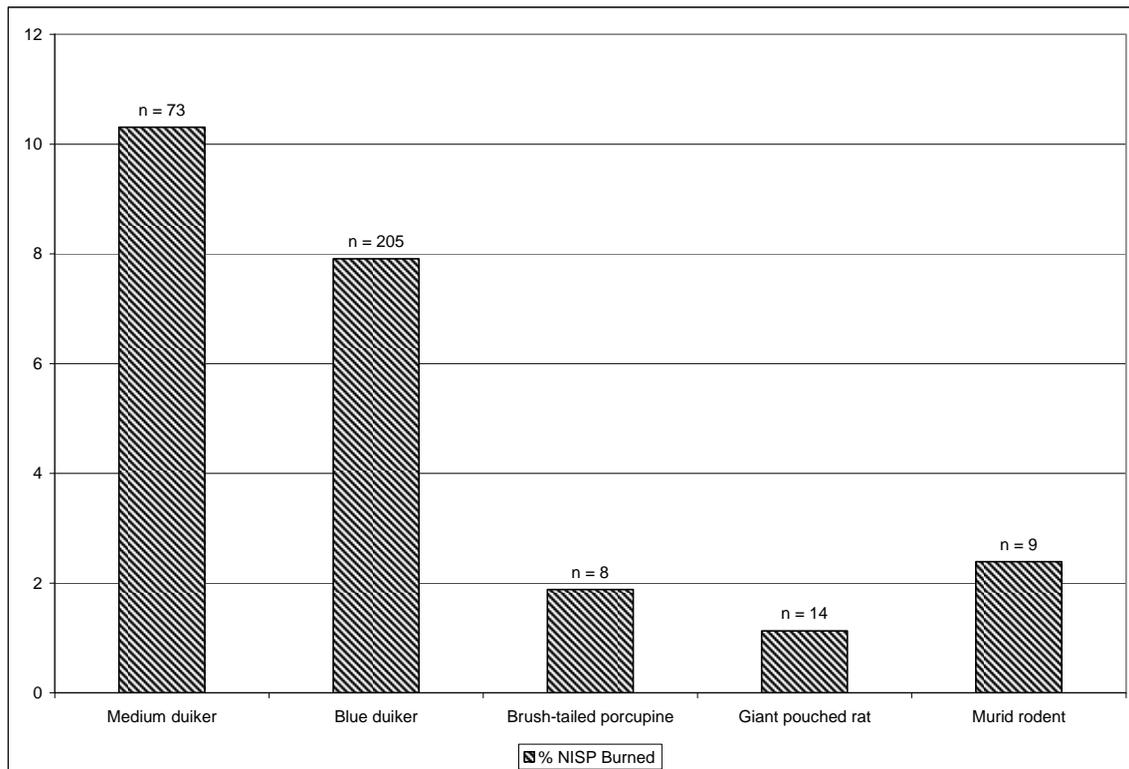


Figure 6.1. Percentage of burned specimens for common prey (Total sample = 5338 specimens).

Figure 6.1, based on proportions of burned specimens, demonstrates a clear distinction between duiker and rodent species. Median weights for each taxon were calculated from the published live weight ranges presented in Table 6.1. These median weights were entered for each specimen as a meaningful scale of taxa size differences. That is, prey size is represented here by the median weight for each common prey taxon. Results of an independent samples *t*-test comparing: A) the combined burned specimens from common prey with B) the combined unburned specimens from common prey reveal that each group (burned vs. unburned) is associated with a significantly different prey size ($t = -8.78$; $df = 5337$; $p < .001$). As a group, burned specimens are associated with a larger mean prey size, whereas unburned specimens are associated with a smaller mean prey size.

Prey Size and Burning Intensity

In contrast to frequency of burning, the intensity of burning (browned vs. carbonized or calcined) does not appear to vary in relation to prey size. Within burned specimens, there are no significant differences between degree of burning and prey size ($t = -1.33$; $df = 307$; $p > .10$). Regardless of prey size, partial carbonization was the most frequent type of burning, representing nearly 60% of burned specimens. Only 14% and 27% were burned and calcined, respectively. The dominance of carbonization is contrary to predictions, and demonstrates that bones of small prey, as opposed to the large artiodactyls investigated by Lupo (1993), can easily become carbonized by roasting and without discard in fire hearths.

Butchery Patterns and Burned Bone

The general location of burn damage on different-sized prey is also revealing. Figure 6.2 divides common prey into duiker (medium and blue duiker) and rodent (porcupine, pouched rat, and Murid) categories and illustrates the percentage of burned specimens from each category that were burned on exterior bone surfaces (those surfaces exposed on a complete, unbroken element) and those that were burned on surfaces created by chopping or fracturing (“break surfaces”). An additional eight specimens extensively burned on both exterior and break surfaces are excluded here.

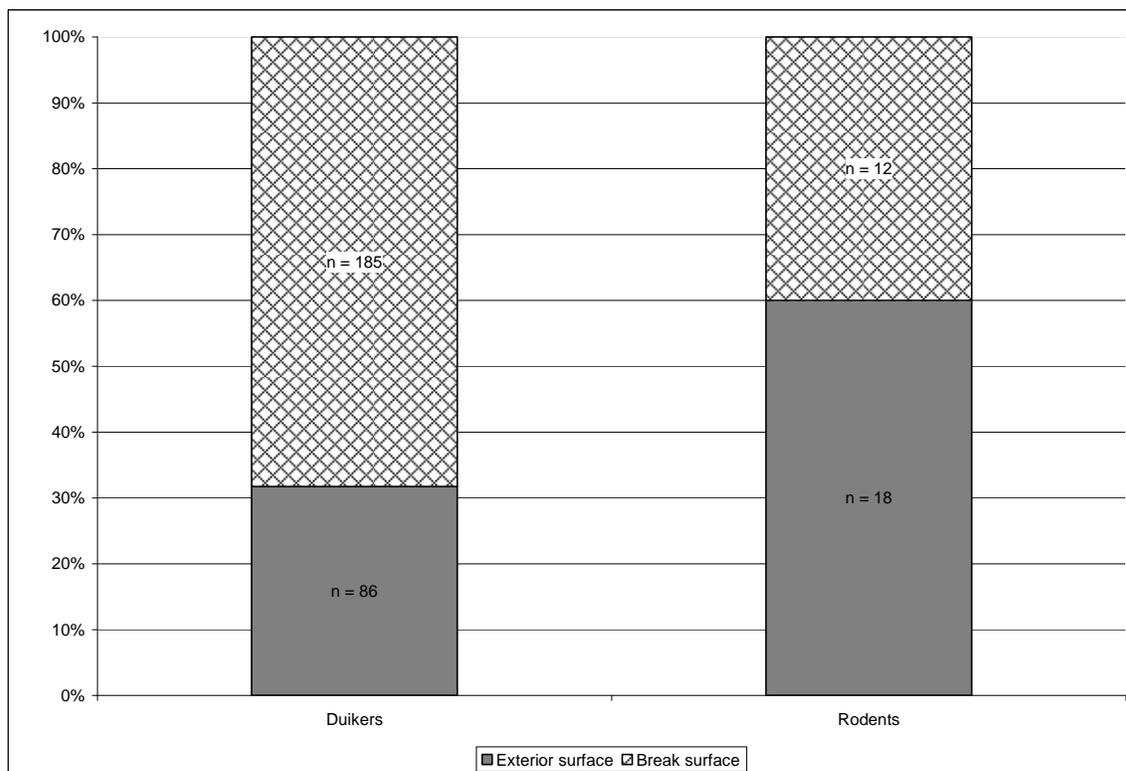


Figure 6.2. Burn locations for duiker and rodent specimens (Total sample = 301 specimens).

The proportions of exterior and break surface burns between duikers and rodents are significantly different ($\chi^2 = 9.543$; $df = 1$; $p < .01$). Considering the different butchery sequences of duikers and rodents (see Chapter 3), it is not surprising that duikers have many more exposed bone surfaces and when meat is roasted, either for short-term preservation or consumption, these surfaces may be burned. Sagittally-split duiker vertebral columns and broken ribs are particularly subject to carbonization and greatly increase the proportion of burned duiker specimens. Despite being routinely exposed to fire as complete carcasses, rodents do not record the activity of roasting to the extent that larger, more subdivided, duikers do. To reiterate, the frequency of burned specimens is indirectly related to prey size, but is more directly attributable to the fact that large prey are dismembered prior to roasting.

Camp Context and Burning Frequency

In addition to size-related variation in burn damage, between-site differences may also be apparent. Lupo (1993) was able to relate burn frequency to differential cooking methods at Hadza base camps and hunting blinds. Comparably, the Bofi and Aka fauna were collected in village and remote camp contexts. However, there are significant contextual differences between Hadza hunting blinds (usually only occupied for days) and forest forager remote hunting camps. In some environments, such as those inhabited by the Basarwa or Hadza, the availability of fresh water and cooking pots constrains the choice of cooking methods used (Kent 1993:341; Lupo 1993:167). In contrast, at relatively long-term (i.e., weeks of occupation) forest forager remote camps, water is rarely lacking and cooking pots are routinely transported to these camps (Hudson

1990:59). Therefore, the frequency of burn-damaged bones should not vary between village and remote camps in this context.

To investigate variability in the frequency of burned bones between the village and remote camp samples, I first evaluated the taxonomic composition of each assemblage. An independent samples *t*-test indicates that prey size significantly varies between these samples ($t = 5.76$; $df = 5628$; $p < .001$). Certain prey, such as river hog, yellow-backed duiker, civet, guenon monkey, brush-tailed porcupine, and Murid rodent are better represented in the village assemblages and poorly represented in the remote camps. These taxa are excluded because one or more cells had counts of zero. Of the remaining taxa common to both assemblages, there were no significant differences in the proportion of burned specimens between village and remote camp samples for tree pangolin, tortoise, and giant pouched rat. Contrary to predictions, burned medium and blue duiker specimens vary significantly between samples ($\chi^2 = 20.99$; $df = 1$; $p < .001$, $\chi^2 = 54.77$; $df = 1$; $p < .001$: Figure 6.3).

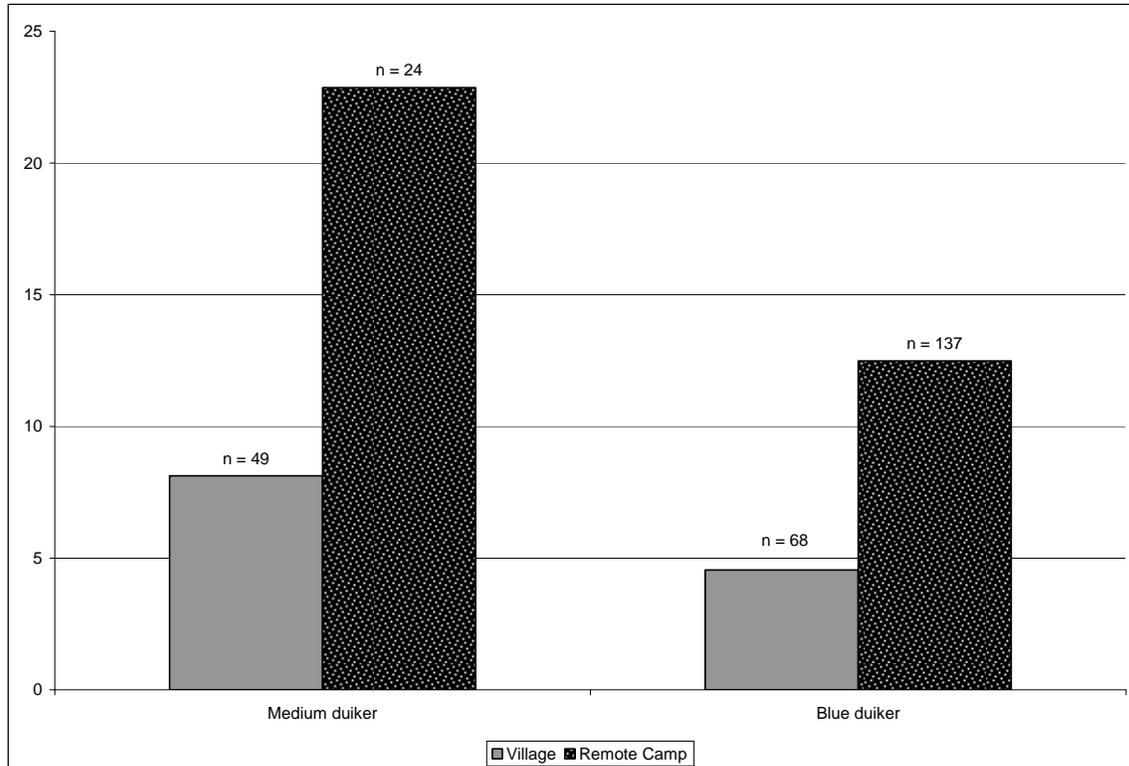


Figure 6.3. Percentage of burned specimens by collection location (Total sample = 3299 specimens).

In this context, the percentage of burn damaged duiker specimens could be one indicator of site function. But, given the lack of constraints on cooking methods, there's no straightforward functional explanation as to why duiker meat is more frequently roasted (or at least bones more frequently burned) at remote camps. It's possible that additional factors, including population size and composition, the expediency of roasting meat compared to boiling, or the smoking of meat for short-term preservation differentially influence the choice of duiker cooking methods in village and forest camps. More simply, it may be a matter of the cook's personal preference.

Cut Marks

The relationship between prey size and cut mark frequency is one of the fundamental questions of mammal taphonomy because answers to this question help clarify how carcass size, anatomy, and other contextual factors affect human processing decisions. This knowledge helps zooarchaeologists avoid making unwarranted behavioral interpretations based on prey that, owing to size or context, may be only weakly analogous to the prey species being studied. For example, in the following chapter, cut mark frequencies (both the percentage of cut specimens and actual frequency of distinct marks) are evaluated as a measure of processing intensity among small prey. Prior to that analysis, it is important to explore how cut mark frequency varies with prey size and how this might influence interpretations of processing intensity.

Although a positive relationship between prey size and cut mark frequency is generally supported (e.g., Lyman 1992; Marshall 1986; Pobiner and Braun 2005), archaeological, ethnoarchaeological, and experimental research into this question remains inconclusive because: 1) the range of animals examined show only a *general* size-related patterning in cut mark frequency. 2) the common use of relative terms (e.g., “small,” “medium,” and “large”) and different size classification systems (e.g., Brain 1981; Bunn 1982, Potts 1988, etc.) used to distinguish animals makes comparability between samples difficult and 3) Numerous contingencies and variables, in addition to relative size differences, also influence cut mark frequency and distribution in any given context.

Beyond cut mark *frequency*, prey of different size and anatomy are demonstrably processed in ways that lead to differential distribution of cut marks on the mammalian skeleton. Since the butchery function of cut marks is often based largely on location, we

must understand if the function of cut marks in similar anatomical locations varies between different-sized prey. The following discussion reviews previous studies, particularly ethnoarchaeological and experimental research, of the relationships between prey size and cut mark characteristics.

Prey Size: Cut Mark Frequency, Distribution, and Function

Do Large Carcasses Require More Cuts, in More Places, for More Purposes?

The expectation of a positive (as opposed to negative or neutral) relationship between carcass size and cut mark frequency has become zooarchaeological conventional wisdom. That is, the frequency of cut specimens is assumed to increase with prey size. This relationship has been demonstrated in archaeological (e.g., Lyman 1992; Marshall 1986), ethnographic (Jones 1983, 1984; Nicholson 2005), and experimental contexts (Dominguez-Rodrigo and Barba 2005; Pobiner and Braun 2005). Further, larger carcasses are expected to be subject to a wider range of butchery processes, possibly creating a greater variety of butchery marks in different anatomical locations (Marshall 1986). At the Kenyan Neolithic site of Ngamuriak, Marshall (1986:667) reports that a significantly greater proportion of large bovid (Brain 1981 size classes 3 and 4; 77-945 kg) specimens are cut than small bovid (Brain 1981 size classes 1 and 2; 4.5-84 kg) specimens. In addition, cut mark distribution varies with prey size; small bovid limb bones are cut on shafts and ends in approximately equal numbers, whereas large bovid limb bones are significantly more cut on shafts than ends (Marshall 1986:667). Marshall (1986) attributes these differences to the fact that small bovinds are easier to disarticulate and were probably not filleted (producing mid-shaft marks) like large bovinds.

Lyman (1992) compares butchery mark data from Steller's sea lion (*Eumetopias jubatus*) and harbor seal (*Phoca vitulina*) remains recovered from Oregon coast archaeological sites. These sea mammal species represent substantially different size classes, and the discrepancy is amplified by the fact that 75% of the harbor seal specimens are from newborns (6-7 kg live weight) and 75% of the sea lion specimens are from adult males (900 kg live weight; Lyman 1992:251). Overall, 48.8% of the sea lion specimens displayed cut marks, compared to only 11.9% of harbor seal specimens. Further, a significantly greater proportion of sea lion marks reflect dismemberment, and sea lion dismemberment marks occur in a greater variety of anatomical locations. Lyman (1992:255) relates both results to the more extensive effort required to dismember the larger taxon prior to transport and/or consumption.

In his analysis of a small sample of ethnoarchaeological Aché fauna, Jones (1983) indicates that 60.7% of red brocket deer (*Mazama americana*. 18.50 kg) specimens exhibit butchery damage, compared to 40.1% for smaller nine-banded armadillo (*Dasypus novemcinctus*. 4.41 kg), capuchin monkey (*Cebus apella*. 2.30 kg), and paca specimens (*Agouti paca*. 7.65 kg; all avg. live weights from Nicholson 2005:112). An important difference between these species is that brocket deer bones contain more marrow and are more likely to be broken open for marrow. Thus, greater fragmentation has the potential to produce more brocket deer bone specimens (Jones 1983:182; 1984:101). However, increased fragmentation tends to *reduce* percentages of butchery-marked specimens. For example, complete bones need only be cut in one location to count as cut, creating a 1:1 cut specimens/total specimens ratio (i.e., 100 % cut). Fragmentation creates additional specimens, many of which are likely to be unmarked,

decreasing this ratio (< 100 %). If anything, when quantifying percentages of butchery-marked specimens, differential fragmentation may lead analysts to underestimate the number of butchery marks per individual large animal carcass (Jones 1984:101). Jones combines both chops (“shears”) and cut marks in his analysis of butchery damage, and focusing solely on cuts might produce different patterning. Jones (1983) cautions that small sample size is a limiting factor, but suggests “it may be that larger animals are more difficult to dismember than smaller animals, resulting in more bone damage. Cutting larger animals into manageable pieces will also result in more cuts per animal than on small animals” (1983:182).

Nicholson’s (2005) recent analysis of Aché fauna identifies a strong positive correlation between prey size and tool mark frequency in a sample ranging from 0.23 kg snake to 18.50 kg red brocket deer. Like Jones (1983), Nicholson’s measures of toolmark frequency include all specimens that were cut and/or cleavemarked (2005:38). Within this sample, deer and white-lipped peccary (*Tayassu pecari*, 18.00 kg; avg. live weights from Nicholson 2005:112) are considerably larger than the remaining species. Nicholson demonstrates that excluding these taxa (the only ones exceeding 10 kg) from the analysis produces a strong but non-significant correlation between average live weight and tool mark frequency. He explains this pattern by noting that the smallest Aché prey are boiled whole and dismembered by hand, “Thus, for small prey [< 10 kg], little variation in toolmark frequency should be expected” (Nicholson 2005:112).

Recent experimental studies provide limited support for a positive relationship between carcass size and cut mark frequency. Domínguez-Rodrigo and Barba (2005) compare experimentally-butchered limb bones from “small-sized” (Bunn 1982 sizes 1

and 2; approximately 0-23 and 24-113 kg, respectively) and “middle-sized” animals (Bunn 1982 size 3; approximately 114-341 kg) and conclude that the middle-sized bones (sample from Domínguez-Rodrigo 1997) are cut at a slightly higher frequency. This conflicts with the negative relationship reported by Domínguez-Rodrigo (2003a). Pobiner and Braun (2005) present more compelling evidence derived from the controlled butchery of goats (Bunn 1982 Size 1), juvenile cows (Size 2), and zebra (Size 3). The authors state that “As carcass size increases, the average frequency of cutmarks produced on a bone from that carcass during experimental butchery increases” (Pobiner and Braun 2005:117). Importantly, this result compares the *frequency of cut marks*, as opposed to the *frequency of cut specimens* employed by most previously cited studies. The attributes of both measures are discussed further as part of the processing intensity analyses of Chapter 7. Based on their results, Pobiner and Braun (2005) conclude that zooarchaeological assemblages should be divided into size categories before conducting cut mark frequency analyses.

Exceptions to the Positive Correlation Between Prey Size and Cut Mark Frequency

Some ethnoarchaeological and experimental data have been used to argue for a negative relationship between carcass size and cut mark frequency (Crader 1983; Egeland 2003; Gifford-Gonzalez 1989; Haynes 1991), usually to demonstrate that a positive correlation between these variables is not universal. In some contexts, the bones of smaller prey are more frequently cut than the bones of larger prey, but data supporting this position are often equivocal (e.g., Domínguez-Rodrigo 2003a; Egeland 2003; Gifford-Gonzalez 1989) or rely on exceptionally large taxa (e.g., Crader 1983; Haynes 1991). Crader (1983) and Haynes (1991) are commonly cited in support of a negative

relationship but, as noted by O'Connell and Lupo (2003) and Pobiner and Braun (2005), both studies emphasize the scarcity of cut marks on modern elephant bones. Crader (1983) and Haynes (1991) effectively demonstrate that elephant (*Loxodonta africana*) butchery may result in very few cut marks, and an absence of marks should not be viewed as a lack of human agency. Considering their massive size (average male weight = 5000 kg; Alden et al. 1998), elephants may be exceptional and incomparable to taxa more commonly encountered in zooarchaeological assemblages. However, Bunn and Kroll (1988:143) make a similar observation among species smaller than African elephants, asserting that Hadza butchers can remove meat from African buffalo (*Syncerus caffer*. 500-700 kg; Alden et al. 1998) and giraffe (*Giraffa camelopardalis*. 700-1395 kg; Alden et al. 1998) without marking bone.

Gifford-Gonzalez' (1989) results are also not straightforwardly in favor of a negative relationship between prey size and cut marks, and the support they do offer is often overstated in the taphonomic literature (e.g., Domínguez-Rodrigo 2003a; Domínguez-Rodrigo and Barba 2005; Egeland 2003; Pobiner and Braun 2005). Overall patterning within Gifford-Gonzalez' (1989:202) Dassanetch Site 105 assemblage reveals that cut marks ("hack marks" are included with cuts) occur *more frequently* on larger taxa, with zebra exhibiting significantly greater proportions of cut specimens than "Bos & Large Bovid" or "Caprini & Small Bovid" categories. However, when only long bones are included in the analysis, small caprines actually display a slightly greater proportion of cut specimens (39% vs. 32% for zebra and 26% for large bovids). Neither result offers strong support for a negative relationship between size and cut frequency, and the first result could be used to argue the opposite. Gifford-Gonzalez explains the second result,

writing “I believe it relates less to the greater intensity of cutting on caprine limb segments than to the role soft tissues play in fortuitously protecting bone of larger animals from the impacts of cutting implements” (1989:202). As noted previously, this statement has been generally applied to infer suggest more cut marks on caprine-sized or smaller bones, but Gifford-Gonzalez’ (1989) data do not support such a broad interpretation.

Domínguez-Rodrigo (2003a, 2003b; Domínguez-Rodrigo and Barba 2005) repeatedly asserts that analysts don’t fully understand the relationship between carcass size and total cut mark percentages. His (2003a) comparison of experimentally-produced assemblages of East African prey indicates that his (1997) sample of “middle-sized carcasses” (based on Bunn’s 1982 size 3; approximately 114-341 kg) is less highly cut-marked than Selvaggio’s (1994) sample of “small-sized carcasses” (based on Bunn’s 1982 sizes 1 and 2; approximately 0-113 kg). Similarly, Egeland (2003) is often cited as an example of increased cut marks on smaller taxa, but Egeland’s only statement to that effect is “Further experimental data (Egeland and Byerly in preparation) tentatively suggest that smaller animals display more cut marks as suggested by other researchers (e.g., Gifford-Gonzalez 1989)” (2003:48). All in all, the evidence in support of a negative relationship between prey size and cut mark frequency is not very extensive or compelling and the minimal evidence that does suggest such a relationship appears to be driven by animals that, from the perspective of many zooarchaeological contexts, are exceptionally large.

It should also be noted that for prey of comparable anatomy, prey size may have *no influence* on cut mark frequency. That is, the occurrence of cut marks may remain

nearly constant across different-sized prey. Although Lupo and O'Connell (2002:89) report a greater percentage of cut zebra specimens when compared to smaller alcelaphine and impala bones, the difference is not statistically significant. A smaller sub-sample from a Hadza hunting blind (the previously referenced Mugugu; Lupo 1993), did indicate that zebra bones were significantly more cut than the bones of smaller taxa, but Lupo and O'Connell (2002; O'Connell and Lupo 2003) state that this result could be a function of relatively small sample size. Despite site-level variability, at the assemblage level, the Hadza ethnoarchaeological bone collections reveal only minor size-related differences in cut mark frequency.

Like Lupo and O'Connell (2002), Lyman (2005) presents data suggesting an ambiguous relationship between carcass size and cut mark frequency. Comparison of elk (*Cervus elaphus*. 204-494 kg) and deer (*Odocoileus* sp. 32-215 kg; live weights from Whitaker, Jr. 1998) bones from two archaeological sites in the Portland Basin of Oregon and Washington reveals a significantly greater proportion (arcsine $t = 2.71$, $p < 0.01$; Lyman 2005:1728) of cut elk specimens (14.2% vs. 10.2%) at one site, but not the other (13.7% vs. 11.3%).

Why Do Cut Mark Characteristics Vary with Prey Size?

Archaeological, ethnographic, and experimental assemblages of animal bone have been examined to explore size-related trends in cut mark frequency, distribution, and function. Although conflicting directional trends have been identified, the bulk of available evidence from land and sea mammals (especially those within the size range of taxa typically found in archaeological contexts) supports a positive relationship between prey size and frequency of cut-marked specimens. Evidence of the opposite pattern

among extraordinarily large species (e.g., Crader 1983; Haynes 1991) may be the exception that proves the rule. In other words, proportions of cut specimens may generally increase as prey size increases, ultimately reaching a threshold where animals are so large (and so meaty) that the relationship ceases. Gifford-Gonzalez' (1989; also see Milo 1998) suggestion that the muscle mass of very large animals fortuitously protect bone from a butcher's blade also plays a role.

Additional explanations for the disparity in cut mark frequency between "large" and "small" prey have been offered. Whatever role soft tissues (primarily muscle, but see Lyman 2008:179-180 for an overview of periosteum) play in shielding bone from blade damage might be outweighed by the fundamental logistics of butchering a large carcass. Larger prey may simply be subjected to a greater variety, and possibly greater intensity, of butchery processes, resulting in a greater variety and quantity of butchery marks. Lyman writes "large animals are more likely than smaller ones of similar anatomy to require disarticulation and dismemberment prior to transport and also prior to cooking..." (2005:1728). Marshall (1986) demonstrates that large bovids are much more prone to filleting than small bovids, and that this additional process produces a significantly greater proportion of cut marks.

Yellen (1991a) defines small prey as those that can be comfortably carried by a single adult (< 21 kg) and these animals can be transported whole, require much less dismemberment and/or filleting and, among the smallest prey, butchery can be conducted without the aid of tools (Landt 2007). Nevertheless, and despite the undoubted prehistoric reliance on small fauna, cut specimens are rarely encountered in the zooarchaeological record (Fernández-Jalvo 1999; Hockett 1994; Hockett and Haws 2002;

Olsen 1990; Simonetti and Cornejo 1991; Szuter 1991). Relationships between prey size and cut mark frequency, distribution, and function in the context of forest forager-produced faunal assemblages are examined in the following section.

Cut Mark Analyses

A number of important size-related cut mark characteristics (frequency, distribution, and function) emerge from the preceding discussion and the small mammal assemblage discussed here can shed light on several issues:

1. Prey Size and Cut Mark Frequency: Data suggest that the proportion of cut specimens vary significantly between different-sized animals in ethnoarchaeological assemblages. If so, I expect a positive relationship between carcass size and cut mark frequency. Nicholson (2005) notes little variation in tool mark frequency among Aché prey weighing less than 10 kilograms. Excluding medium duiker (the only common taxon exceeding 10 kg), I expect the proportion of cut specimens to vary significantly between the remaining species.
2. Prey Size and Cut Mark Diversity: A question related to cut mark frequency is whether there is any relationship between prey size and the variety of cut marks represented. Considering the greater range of processes necessary to prepare larger prey (particularly duiker species), I expect a positive relationship between prey size and cut mark diversity (as reflected by the number of distinct cut codes recorded for each taxon).
3. Prey Size and the Functional Interpretation of Cut Marks: Marshall (1986) observes that large bovid limb bones are significantly more cut on shafts than on ends (a result of extensive filleting). Small bovid limb bones are cut on shafts and ends in approximately equal numbers (reflecting infrequent filleting). Central African medium and blue duiker limb bones are anatomically comparable, but considerably smaller than Marshall's (1986) small bovid limb bones. Field observations indicate that these duiker bones are virtually never filleted. Therefore, if the anatomical location of limb bone cut marks (end vs. shaft) has the same functional "meaning" among duikers, I expect end and shaft cuts to occur in comparable numbers on duiker limb bone specimens.

Prey Size and Cut Mark Frequency

First, comparison of common prey indicates a significant difference in the proportion of cut specimens between taxa ($\chi^2 = 332.97$; $df = 4$; $p < .001$; Figure 6.4).

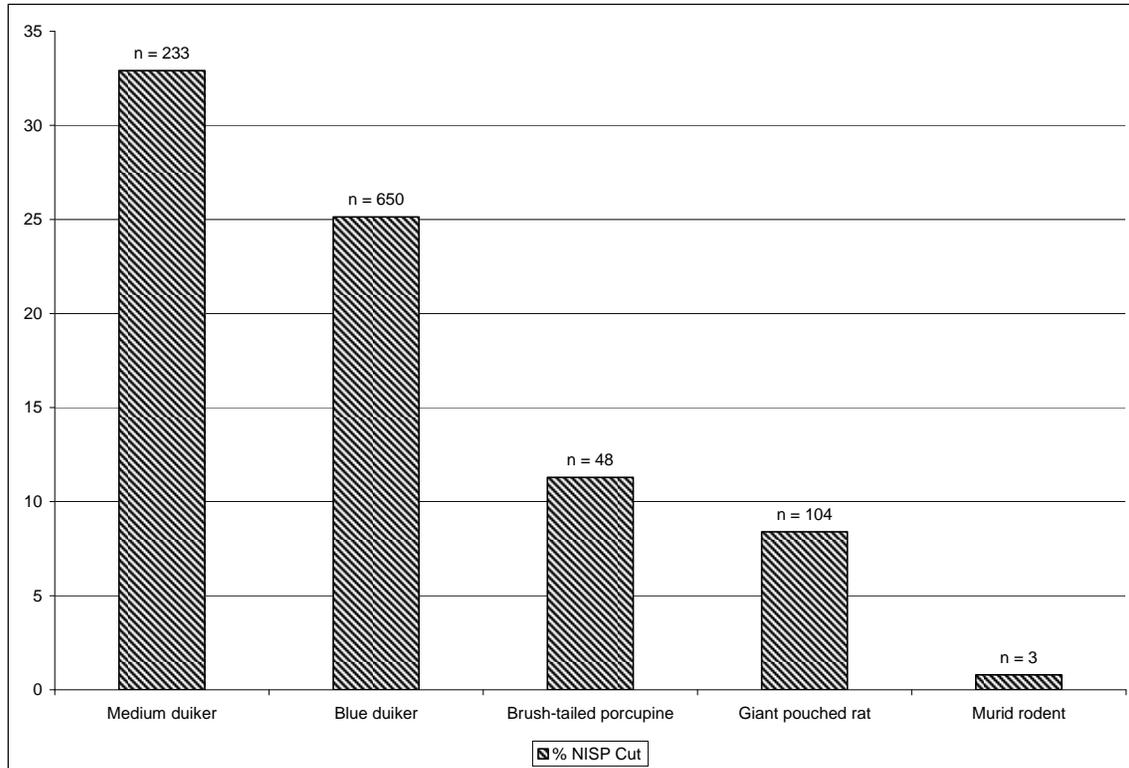


Figure 6.4. Percentage of cut specimens for common prey (Total sample = 5338 specimens).

Figure 6.4, based on proportions of cut specimens, illustrates a positive relationship between prey size and cut mark frequency, as measured by the proportion of cut specimens. In addition, a distinction between duiker and rodent species is apparent, and indicated by the large gap in percentages between blue duiker and brush-tailed porcupine. As with the burn analysis, median weights were utilized for each specimen as a scale of prey size differences. Results of an independent samples *t*-test comparing: A) the combined cut specimens from common prey with B) the combined uncut specimens from common prey reveal that each group (cut vs. uncut) is associated with a significantly different prey size ($t = -15.47$; $df = 5336$; $p < .001$). As a group, cut specimens are associated with a larger mean prey size, whereas uncut specimens are

associated with a smaller mean prey size. Focusing on prey with live weights less than 10 kg, therefore excluding medium duiker from the analysis, does not alter this result; the proportion of cut specimens remains significantly different ($\chi^2 = 260.4$; $df = 3$; $p < .001$) and cut specimens are consistently more associated with larger prey (based on median weights) than uncut specimens ($t = -16.50$; $df = 4628$; $p < .001$).

Prey Size and Cut Mark Diversity

Cut and chop codes were established to differentiate between marks deemed sufficiently different in anatomical location, morphology, and/or orientation to warrant a separate designator (See Chapter 5 and Appendix A). I assigned different marks individual, non-repeating codes to assess the skeletal distribution of cut marks (chop marks are discussed later in the chapter). As a result, the quantity of cut codes (i.e., the number of distinct locations in which forest forager butchery left identifiable marks) represented within any taxonomic grouping is an effective measure of cut mark variety. However, as a diversity measure, cut mark variety is particularly subject to influence by sample size (NISP) differences between taxonomic groupings. To account for the effects of differing sample sizes, I divided the cut code quantity of each taxon by taxon NISP (e.g., 157 cut codes were used to describe the location of cuts on blue duiker specimens, so this number is divided by the total blue duiker NISP of 2591). The resulting ratio indicates the relative diversity of cut marks associated with each taxon (Figure 6.5).

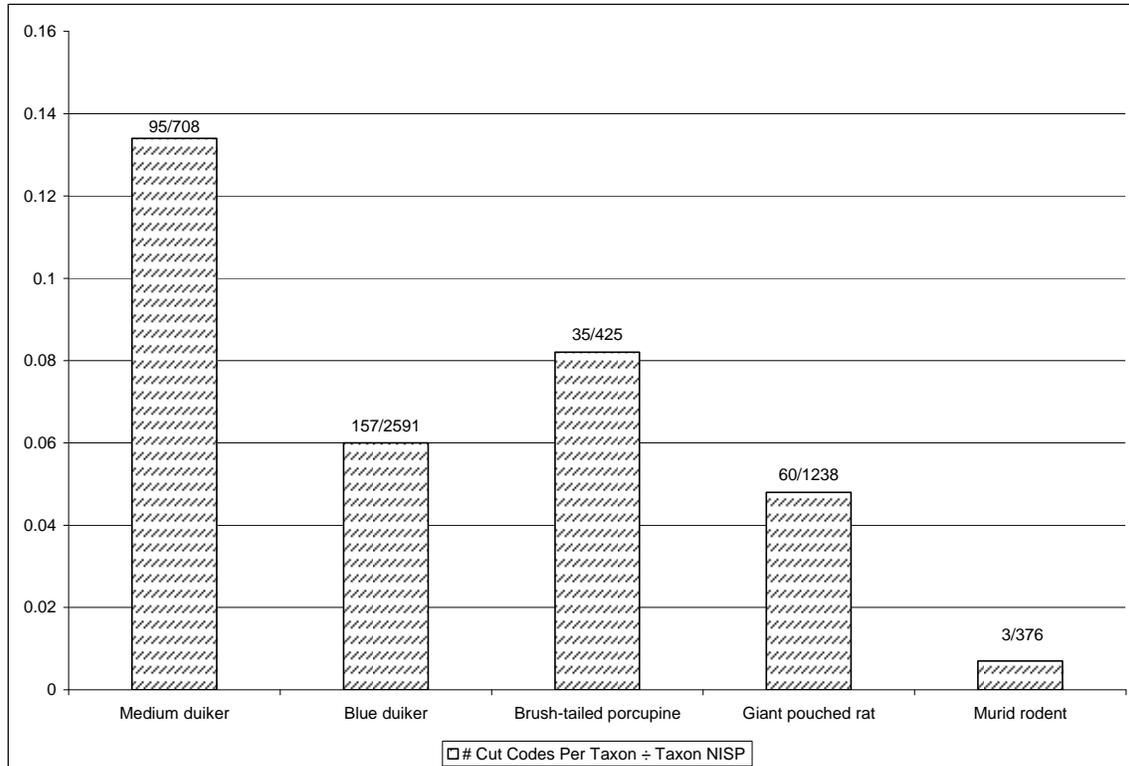


Figure 6.5. Diversity of cut marks associated with common prey (Total sample = 5338 specimens).

Chi-squared analysis indicates that cut mark variety is significantly different between taxa ($\chi^2 = 11.13$; $df = 4$; $p < .05$). Figure 6.5 depicts a general size-related trend in cut code diversity, suggesting that larger prey in the assemblage feature a relatively wider distribution of cut mark locations. However, contrary to predictions, there is a large gap between medium and blue duikers (as opposed to between duikers and rodents), and the ratio for brush-tailed porcupine actually exceeds that of larger blue duiker. These results may reflect the greater range of processes necessary to prepare larger prey in the assemblage, but also demonstrate that prey size alone is insufficient to predict cut mark diversity.

Prey Size and the Functional Interpretation of Cut Marks

To quantify the dispersion of cut marks on duiker limb bones, cuts on humeri, radii, ulnae, femora, tibiae, and metapodia were divided into “end cuts” and “shaft cuts.” Cut marks that occurred on or adjacent to epiphyses were classified as end cuts, as were those that occurred on intermediary elements such as patellae and tarsals. No carpal bones displayed cut marks. Cut marks that occurred on limb bone diaphyses, regardless of orientation, were classified as shaft cuts. Interestingly, the proportion of end and shaft cuts does not vary significantly for medium or blue duiker ($\chi^2 = 3.60$; $df = 1$; $p = .06$ and $\chi^2 = 3.09$; $df = 1$; $p = .08$, respectively). Among medium duiker limb bones, end cuts are slightly more prevalent than shaft cuts, but the reverse is true for blue duiker limb bones (Figure 6.6).

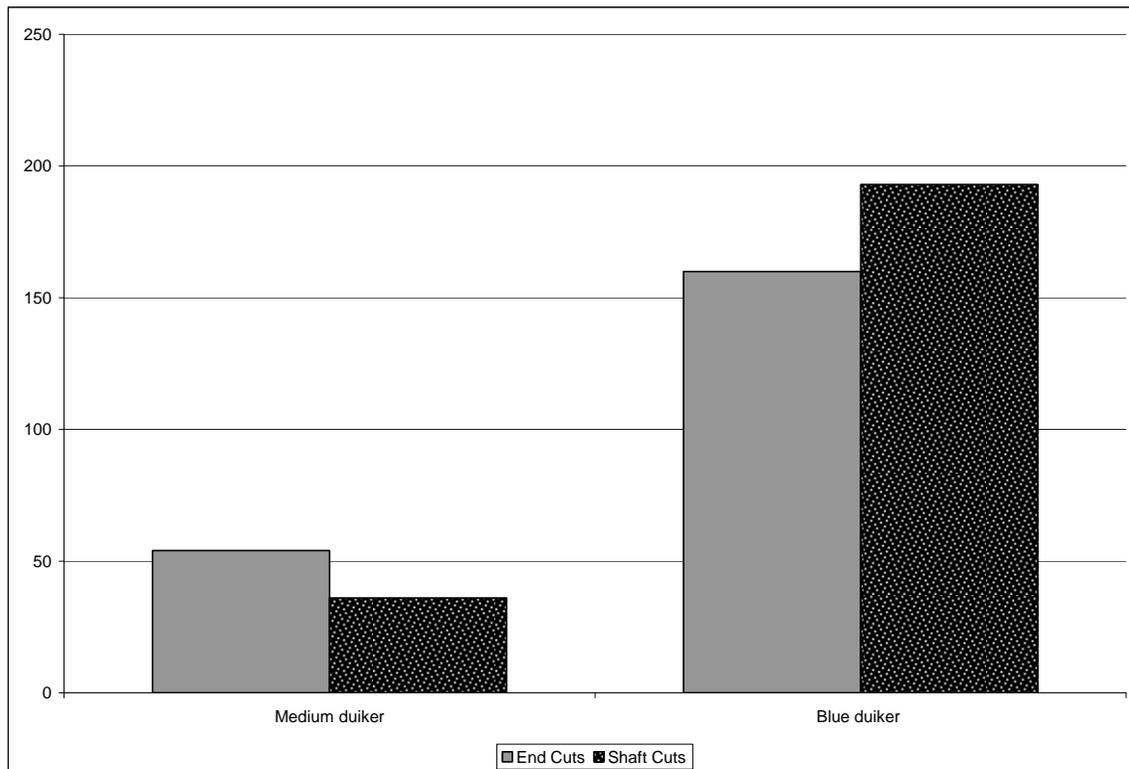


Figure 6.6. Number of duiker limb bone cut marks divided by anatomical location (end vs. shaft).

This pattern is remarkably similar to that identified among Marshall's small bovid remains, which she used to argue that small bovid remains were not filleted (1986:667). Therefore, interpretations of cut mark function, based on limb bone end vs. shaft patterning, may also be applicable to duiker-sized artiodactyls. Approximately equal numbers of shaft and end cut marks reflect the prominence of dismemberment-related damage on Bofi and Aka small mammal bones – a reflection that becomes clearer when additional dismemberment methods, chopping and fracturing, are considered.

Chop Marks

Investigating chopping as a distinct form of blade-produced butchery damage is extremely important, especially in contemporary contexts where processing decisions and their taphonomic consequences are fundamentally dictated by the availability of iron knives/machetes and cooking pots (Hudson 1990; Nicholson 2005). Chopping of bone not only produces diagnostic damage, it may also affect the frequency of other damage types (i.e., burning, cut marks, and fracture patterns), which would likely differ if the expedient chopping of bone and pot boiling of meat were not such efficient and available options. This comparison allows us to determine how modern ethnoarchaeological collections in this context differ from zooarchaeological fauna, and ways prehistoric technology could have achieved similar functions while producing different taphonomic patterning.

Archaeological (Binford 1984; Lyman 1987, 1995; Marshall 1986; Potts and Shipman 1981; Welbourne 1975), ethnoarchaeological (Crader 1983; Gifford-Gonzalez 1989; Lupo 1993; Nicholson 2005), and experimental (Walker and Long 1977) studies have described bone damage morphologically comparable to the chops identified in the

Central African faunal assemblage. Partial chops are equivalent to hack marks (Binford 1984; Gifford-Gonzalez 1989), chopping scars (Lyman 1995), chop marks (Crader 1983; Lupo 1993), and cleavemarks (Nicholson 2005; Potts and Shipman 1981; Walker and Long 1977). Complete chops are equivalent to transverse breaks (Gifford-Gonzalez 1989), shear faces (Crader 1983), shear fractures (Lupo 1993), or functionally, as “ax blows” (Guilday et al. 1962).

Binford (1981) describes how very large Nunamiut prey can be dismembered using a combination of leverage to dislocate joints and small cutting tools. For example, he describes the Nunamiut butchery of a 354 kg moose (*Alces alces*) using only a pen knife, and without any chopping of bone. Binford (1981) suggests that chopping may be a more common dismemberment technique among animals the size of sheep or kangaroos. Nevertheless, chop-produced marks associated with both dismemberment and marrow breakage have been identified in many contexts, and Lyman considers the process of chopping “a hybrid between cutting and percussion” (2008:281).

At Bisa elephant and hippo (*Hippopotamus amphibius*. 655-3200 kg; Alden et al. 1998) bone scatters, chops (65.3% of identified marks) greatly outnumber shear faces (17.9% of identified marks; Crader 1983:135). Considering the size and robustness of these animals, the relative rarity of complete chops through bone is not surprising. Most importantly, chops and shear faces are both more frequent than cut marks, and chops are more common on “non-meaty” elements, reiterating the ability of soft tissues to protect bones from blade marks (Crader 1983:134).

Gifford-Gonzalez (1989:201) notes that Dassanetch butchers use both a blunt instrument/anvil technique and metal pangas to break into long bone marrow cavities and

to fracture bone as part of a systematic dismemberment strategy. Among these prey, pangas may create transverse breaks (i.e., complete chops), but more often results in hack marks and/or irregularly fractured bone. Gifford-Gonzalez reports that the specific breakage technique used is much easier to diagnose on zebra and large bovid bones than on smaller caprine bones, a pattern “that could reflect breakage of sheep and goat bones by direct percussion, or the tendency of these more delicate bones to shatter at points of impact, thereby deleting percussor traces...” (1989:196).

Lupo (1993) discusses a variety of chops and shear fractures comparable to those recorded in the Central African assemblage, although almost entirely on larger animals. Chops and shear fractures were both particularly common at the Hadza base camp, and less so at hunting blinds or butchering stands. Lupo (1993:85) relates this pattern to cooking methods since elements must be pot-sized prior to boiling, and meat is predominantly boiled at the base camp. Hadza data suggest that crania of medium and large prey are chopped open to access the brain, whereas smaller impala crania were consistently smashed open with a blunt object (Lupo 1993:87). O’Connell et al. (1988) classify Hadza medium and large prey as those exceeding 40 kilograms live weight and impala (40-76kg; Alden et al. 1998) fall at the small end of this size spectrum. With the exception of fetal individuals, innominate shear fractures only occurred on medium and large taxa (Lupo 1993:91).

Other archaeological and ethnoarchaeological research documents the process of chopping bone without emphasizing the taphonomic characteristics that result (Bunn 1983; Kent 1993; Marshall 1986; Yellen 1991a). Bunn (1983) states that 69.2% of large ungulate bones from his San collections feature chop marks made by metal axes. He

relates these marks to fragmenting bone to fit into cooking pots, but does not describe or illustrate them (1983:146). Likewise, Kent (1993) describes chopping as a method of carcass dismemberment, but does not explain the resulting damage morphology.

Marshall reports “plane fracture surfaces probably indicative of heavy longitudinal and transverse chopping” on large bovid limb bones recovered from the Ngamuriak site in Kenya (1986:668). Yellen (1991a) notes that African porcupine (*Hystrix africaeaustralis*, 8-23 kg; Alden et al. 1998) limbs are struck with an axe to subdivide them. He writes “From an archaeological perspective it is worth noting that shafts are broken while meat is still on the bone and that hack marks may be either difficult to identify or lacking” (1991a:9). The following section examines the characteristics of chopped bone among Central African fauna.

Chop Analyses

The discussion of previous ethnoarchaeological chop analyses suggests a number of issues that may be investigated with the Central African small mammal assemblage:

1. Forms of Blade-produced Butchery Damage: Crader (1983) reports, in descending order of frequency, chop, shear face, and cut mark data from modern elephant and hippo carcasses. When duiker bones are struck with percussive force, it is far easier for the blade to pass completely through the bone (resulting in a shear face) than for exceptionally large taxa. In addition, soft tissues don’t appear to play a significant role in protecting duiker bones from blade damage (see previous section). Therefore, I expect complete chops and cut marks to represent a significantly greater proportion of identified medium and blue duiker marks than they do in Crader’s (1983) study.
2. Prey Size and Chop Mark Frequency: Considering the butchery sequences described in Chapter 3, larger common prey (medium duiker and blue duiker) undergo much more extensive division than smaller common prey (brush-tailed porcupine, giant pouched rat, Murid rodent) during dismemberment and food preparation. Thus, I expect the frequency of chopped specimens to vary significantly by size, with the highest percentages of chopped specimens occurring among duiker taxa.

3. Camp Context and Chop Mark Frequency: Analyses presented in the burned bones section indicated a significantly greater percentage of burned medium and blue duiker specimens from remote camp assemblages than those from village camp assemblages. This result was unexpected because water and cooking pots for boiling meat are available in both contexts, and should not constrain choice of cooking methods. If this pattern is, in fact, related to more frequent roasting of meat at remote forest camps, chop mark frequency might provide another avenue of investigation. Lupo (1993) reports a greater occurrence of chopped specimens in Hadza base camp assemblages where boiling was the dominant cooking method. Therefore, if duiker is more commonly boiled at village camps than remote camps, I expect a significantly greater proportion of chopped duiker specimens in village faunal collections.

4. Specific Size-related Patterns of Element Breakage: Lupo's (1993) analysis of Hadza fauna indicates some important size-related differences in chop patterning. Brain removal from larger Hadza prey is facilitated by chopping the cranium, while smaller impala crania are consistently smashed (fractured) to gain access to the brain. Despite similar anatomy, duikers, especially blue duikers, are substantially smaller than even impala. Accordingly, I expect cranial chops associated with brain removal to be rare among taxa of this size. Further, the innominate of Hadza prey weighing less than 40 kg are rarely chopped. I expect chopped innominate specimens to be more common in forest forager-produced duiker assemblages since I frequently observed medium and blue duiker innominates chopped with knives and machetes during fieldwork.

Forms of Blade-produced Butchery Damage

Within the Central African ethnoarchaeological collections, blade-produced damage occurs in three forms: cut marks, partial chops, and complete chops. Crader (1983) reports the same damage types among recent hippo and elephant scatters in Zambia. Her results indicate that among such exceptionally large species, blade damage is dominated by partial chops (hack marks). Cut marks and complete chops (shear faces) occurring far less frequently. Comparison of Crader's (1983) results with the Bofi and Aka duikers (medium and blue) reveals some expected, yet informative, results. As predicted, the relative frequency of different blade-produced marks varies significantly between assemblages ($\chi^2 = 152.39$; $df = 2$; $p < .001$; Figure 6.7).

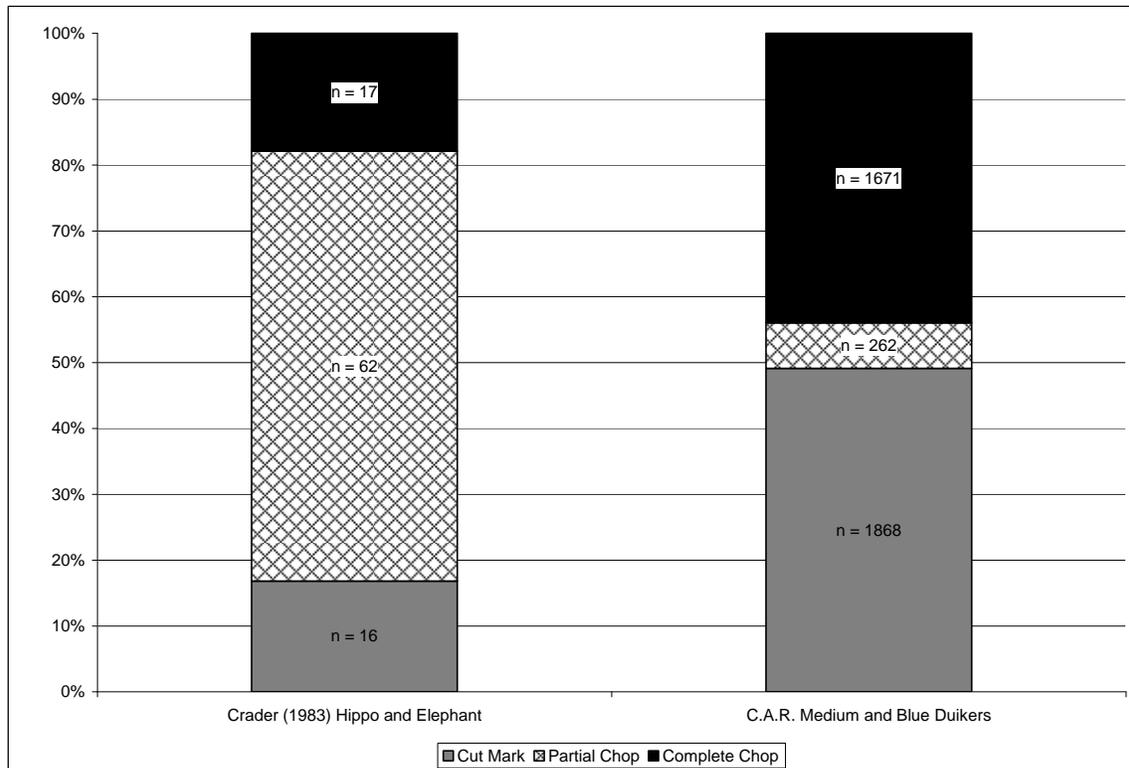


Figure 6.7. Blade-produced damage divided into cut marks, partial chops, and complete chops.

Figure 6.7 shows the percentage of combined blade marks represented by cuts, partial chops, and complete chops. Crader's (1983) sample size is very small and does not allow for more specific comparisons, but it does illustrate major differences in the types of blade-produced damage that result from processing exceptionally large and small animals. The stacked columns indicate nearly opposite patterns between hippos/elephants and duikers. Cut marks occur far more frequently on duiker bones than hippo and elephant bones. As noted in the cut mark analyses, the flesh of extremely large animals may fortuitously protect bone from striations (Bunn and Kroll 1988; Crader 1983; Gifford-Gonzalez 1989; Haynes 1991), but substantially smaller prey are not afforded such protection. In addition, Crader (1983:134-135) notes that 84% of blade-

produced marks occur on “non-meaty” axial elements. Whether blade damage varies with element meat utility within the Central African assemblage is explored in the following chapter.

Partial chops are the most common type of blade damage in Crader’s (1983) sample and the rarest among duikers. This result reiterates that butchering an elephant and butchering a duiker, *despite the presence of comparable damage types*, are fundamentally different processes. Removing meat from the robust bones of an elephant or hippo leaves many identifiable hack marks. Duiker meat is usually not filleted, but carcasses are routinely dismembered by chopping. The amount of percussive force necessary to create a hack mark on large mammal bone passes completely through duiker bones, resulting in a high number of shear faces or complete chops and relatively fewer partial chops.

In the context of the Bofi and Aka faunal assemblage, partial chops most often reflect “unsuccessful” attempts at complete chops – and this is one reason that we initially designated them “partial” chops (Schmitt et al. 2001). In fact, partial chops commonly occur parallel to complete chops, as if the butcher “hacked” once before successfully severing the bone. Thus, partial chops do not usually reflect an accidental byproduct of meat removal (as cuts might), but intentional bone breakage. This interpretation corresponds to those of Gifford-Gonzalez (1989) and Yellen (1991a). Gifford-Gonzalez (1989) attributes the rarity of hack marks on sheep and goat specimens to the relative fragility of these bones, compared to larger taxa in her assemblage. Undoubtedly, an unknown proportion of the irregular breakage classified in the Bofi and Aka fauna as “fracturing” was produced with a blade, but the use of knives and machetes

for dismemberment is clearly recorded by unambiguous partial and complete chops, as well. Yellen (1991a:9) proposed that hack marks would be difficult to identify or lacking on African porcupine bones since they are dismembered with meat on the bone.

Similarly, African porcupines, which are more comparable in live weight to duikers than brush-tailed porcupines, Central African duikers are also dismembered with meat on the bone. This may contribute to the relative rarity of identified partial chops, but this damage type is, by no means, lacking. The examples used here help demonstrate why butchery damage more commonly occurs in the form of complete chops and cuts in forest forager-produced bone assemblages.

Prey Size and Chop Mark Frequency

As detailed in Chapter 3, duiker species are much more extensively subdivided by cutting and chopping than smaller rodent prey. In the previous section, the difference in butchery processes was clearly reflected in the proportion of cut specimens from different-sized prey. The proportion of chopped specimens also varies significantly between taxa ($\chi^2 = 887.37$; $df = 4$; $p < .001$). That is, examination of the five most common prey shows a significant difference in the percentage of each taxon's specimens that exhibits evidence of chopping (Figure 6.8).

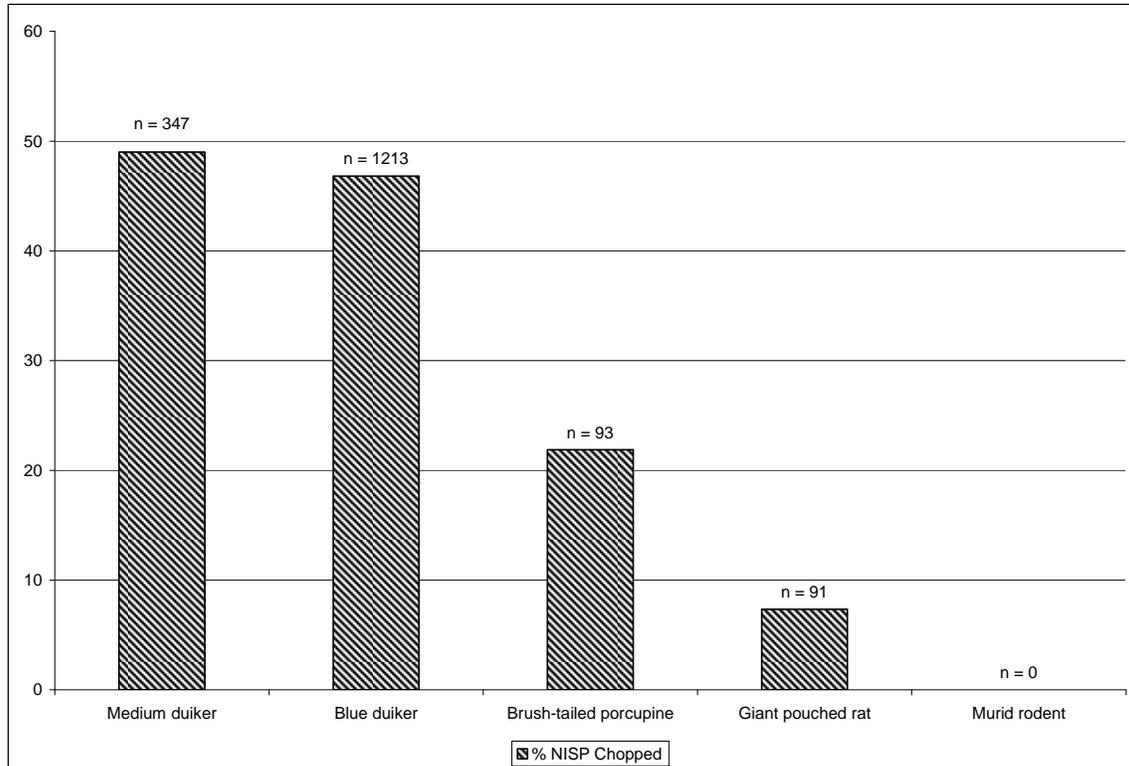


Figure 6.8. Percentage of chopped specimens for common prey (Total sample = 5338 specimens).

Brush-tailed porcupine and giant pouched rat bones are much less frequently chopped than duiker bones, and no damage identifiable as chopping was recorded on Murid rodent specimens. As with the burn and cut analyses, median weights were utilized for each specimen as a scale of prey size differences. Results of an independent samples *t*-test comparing: A) the combined chopped specimens from common prey with B) the combined unchopped specimens from common prey reveal that each group (chopped vs. unchopped) is associated with a significantly different prey size ($t = -21.42$; $df = 5336$; $p < .001$). As a group, chopped specimens are associated with a larger mean prey size, whereas unchopped specimens are associated with a smaller mean prey size. This result

reflects the ease with which the smallest Bofi and Aka prey can be dismembered, prepared, and consumed with little reliance on metal blades.

Camp Context and Chop Mark Frequency

Analyses presented in the burn section showed that a significantly greater proportion of medium and blue duiker specimens were burned in the remote camp sample than in the village sample, suggesting more frequent roasting in remote camps. Lupo (1993) reports a similar pattern and, conversely, increased frequency of chopped specimens in Hadza base camp collections. Similarly, a greater proportion of medium and blue duiker specimens are chopped (partial and complete) in Central African village collections than in remote camp collections (Figure 6.9). However, owing to sample size, only the blue duiker specimens vary significantly ($\chi^2 = 11.26$; $df = 1$; $p < .01$). Most importantly, a high percentage (~ 40-50%) of duiker specimens display chopping damage in *both* locations.

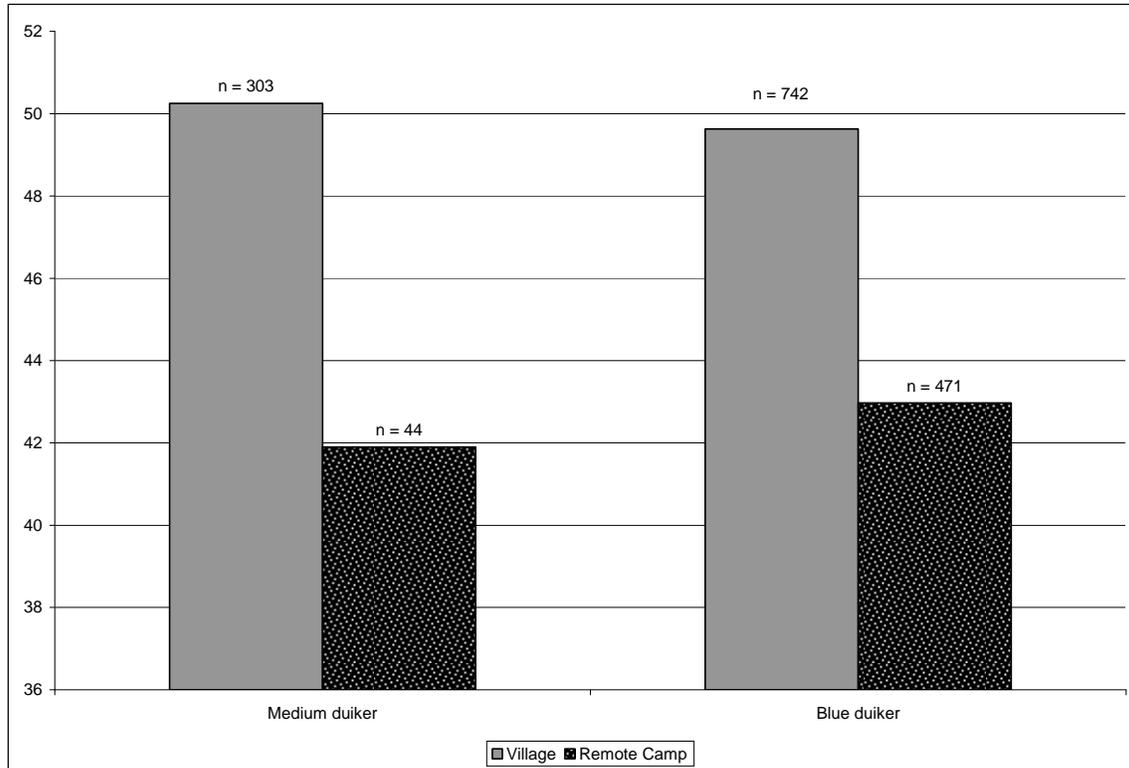


Figure 6.9. Percentage of chopped duiker specimens by collection location (Total sample = 3299 specimens).

Specific Size-related Patterns in Element Breakage

Lupo's (1993) observation that crania of the largest Hadza prey are heavily chopped, while smaller crania are smashed open, is also evident in the Central African bone assemblage. The largest prey are represented by very few specimens, but it is noteworthy that a single yellow-backed duiker cranium exhibited 21 distinct chops. Only six medium and blue duiker crania displayed Binford's (1981) S-3 chop that breaches the braincase, providing access to the brain. In contrast, 240 medium and blue duiker cranial specimens (53.45%) showed evidence of fracturing. Thus, the crania of these duiker species were probably smashed with a blunt object, as Lupo (1993) suggests for Hadza

impala. Alternatively, they may have been machete-chopped in a way that did not produce diagnostic damage.

Lupo's (1993) data demonstrate that, with the exception of fetal animals, innominate shear fractures are limited to medium and large prey (> 40 kg) in the Hadza assemblage. Central African medium and blue duikers fall well below this live weight range, yet 74.77% of duiker innominate specimens display complete chops. Despite their small size, duiker innominates are routinely sagittally and transversely chopped during carcass dismemberment and may be further subdivided prior to sharing or boiling (see Chapters 3 and 5). Lupo's argument that "In an archaeological context high frequencies of chopped bones, in particular axial elements, may reflect boiling as a culinary technique" (1993:93) is well supported by chop patterning in the Bofi and Aka assemblage.

Fractures

Archaeologically, the location and morphology of bone fractures are used to distinguish between cultural and non-cultural accumulations of bone, and to infer a wide range of human subsistence behaviors (See Lyman 1994:315-338 for a summary). In the analyses of the following chapter, bone fracturing and fragmentation are evaluated as methods of quantifying the intensity with which duiker carcasses are processed. Prior to that analysis, it is necessary to examine the role of prey size in bone fragmentation patterns, as investigated in previous ethnoarchaeological studies. Although natural processes (e.g., trampling; Behrensmeier et al. 1986) can mimic cut marks, fractured bone creates more potential ambiguity since it can be easily caused by animal activity, post-depositional processes, or human butchery. Broadly speaking, butchery-related

bone fracturing serves two major purposes. First, it creates smaller carcass portions, which facilitates transport, sharing, and food preparation. Second, fracturing bone provides access to marrow and grease.

The ethnoarchaeological studies summarized below illustrate the processes by which the bones of different-sized prey may become fractured. Introducing taphonomy, Marshall writes “Two basic types of patterns of modification are recognized: *fractures* and *marks*” (1989:11). In most zooarchaeological analyses, bone breakage, regardless of cause or morphology, is categorized as fracturing. The Central African assemblage includes damage readily identified as fracturing, and damage described elsewhere as tool marks (i.e., cut marks and partial chops). Complete chops, however, combine aspects of both fractures and marks. A methodological limitation of evaluating chops and fractures as distinct damage types is that both are carcass reduction techniques; both may be used to dismember carcasses and both may provide access to marrow and grease. Gifford-Gonzalez suggests that this fact, “requires that chop marks and fracture patterns sometimes be considered together to allow a fuller understanding of carcass processing...” (1989:201). One solution, especially among heavily chopped and fractured ethnographic collections, is to evaluate the damage types together as bone *fragmentation* (Fancher 2006a; Nicholson 2005).

Numerous ethnoarchaeological studies have described the circumstances of large artiodactyl bone fracturing (e.g., Binford 1981; Gifford-Gonzalez 1989; Lupo 1993). Binford (1981:147) reports that very few Nunamiut caribou (*Rangifer tarandus*. 68-299 kg; Whitaker, Jr. 1998) and moose (315-635 kg; Whitaker, Jr. 1998) elements were broken during the process of dismemberment. Most dismemberment-related breakage

occurred when rib slabs were broken away from the vertebral column. As mentioned previously, limbs were dismembered using leverage and the cutting of connective tissue. The limb bones of large game were routinely smashed just above or below their articular ends with blunt instruments such as a hammerstone, knife handle, or even another dense limb bone, to provide access to the marrow cavity. Among Nunamiut prey, this process of marrow fracturing produced extensive irregular breakage, detached long bone epiphyses, and shaft fragments and splinters (Binford 1981:148-163).

Gifford-Gonzalez' (1989) Dassanetch informants fracture bone for purposes of dismemberment and marrow extraction using both metal pangas and a hammer and anvil technique. The instrument responsible for fracturing was less discernible on small caprine bones than on larger bovid and zebra elements. Contrary to Binford's (1981) ethnographic observations, zebra and large bovid limb bones were consistently broken mid-shaft, as opposed to near the epiphyses. Mid-shaft breaks reported by Binford (1981) were associated with frozen carcasses, and Gifford-Gonzalez' (1989) research demonstrates that mid-shaft breaks can occur on large mammal bones in a very different environmental context. Dassanetch marrow fracturing created many non-diagnostic shaft fragments. As a result, approximately $\frac{1}{3}$ of Gifford-Gonzalez' (1989:194) Site 105 mammalian assemblage was not identifiable to element, and an additional $\frac{1}{3}$ was only identifiable to general body segment.

Lupo (1993) details the ways in which Hadza butchers fracture large mammal bones during processing and consumption. As noted in the previous section, crania were chopped or smashed open (depending on prey size) to access the brain. Mandibles of all species were fractured to extract the marrow. Vertebrae were chopped with metal blades,

or smashed into smaller pieces. Ribs were chopped or broken off of the vertebral column in slabs of three to six ribs and most recovered rib specimens were small shaft fragments (O'Connell et al. 1988; Lupo 1993). Lupo (1993:138-149) reports that all marrow bearing limb bones from the Hadza assemblage were broken open for marrow, producing a variety of spiral, transverse, and longitudinal fractures, and associated impact marks. In contrast to Binford's work (1978, 1981), Lupo (1993:151-155) notes that the Hadza routinely process low-utility elements (such as mandibles, metapodia, and phalanges) that the Nunamiut only process in specific circumstances. Differential processing of low-utility elements, and behavioral inferences that may be drawn from it, are discussed at length in the following chapter.

Ethnoarchaeological analyses of small prey fracturing are less common. Yellen (1991a) provides an exceptionally detailed account of !Kung San processing of African porcupine, steenbok (*Raphicerus campestris*. 9-13 kg), common duiker (*Sylvicapra grimmia*. 15-25 kg), and springhare (*Pedetes capensis*. 2.4-3.9 kg; all weights from Alden et al. 1998), summarized in Table 6.2. Yellen's informants also boil meat in pots and butcher small prey using metal knives and axes, but he does not specify the characteristics of resulting bone breakage. Presumably, some unknown portion of this blade-produced breakage would be classified as "chopping" based on the morphological criteria outlined in Chapter 4.

Table 6.2. Yellen (1991a) description of !Kung small prey processing.

Porcupine	Steenbok/Duiker	Springhare
Heads and paws removed and roasted	Metapodia disarticulated and split lengthwise to extract marrow (eaten raw)	Bones contain little marrow and little effort is made to extract it
Occipitals broken to provide brain access	Carcass sagittally split (head attached to one "half")	Crania smashed with stick to access brain
Mandibles discarded intact	Forelimbs+scapula cut away from torso with knife	Mandibles left intact
Limbs dismembered cleanly at joint	Hindlimbs cut away from acetabulum	Forelimbs+scapula cut away from torso and boiled intact
Humeri and femora hacked with an axe into three portions (PX+upper shaft, shaft, DS+lower shaft)	Individual limb elements separated at articulations	Meat eaten from forelimbs and bones discarded intact
Radii, ulnae, fibulae already "pot-sized" and contain little marrow, so left intact	Meat filleted from bone and cut into small pieces	Hindlimbs separated at acetabulum and between elements
Tibiae may be chopped or boiled intact	Meat and intact long bones boiled together	After boiling femora left complete or fractured mid-shaft
Ribs hacked from vert column and chopped into transverse pieces	!Kung San informants preferred steenbok/duiker marrow in-bone, rather than released into soup	Tibiae fractured mid-shaft or split lengthwise
Vert column hacked sagittally and transversely	Limbs of young animals (with little marrow) sometimes left intact	Fibulae remain unbroken
All axial appendicular portions boiled together	Limbs may be chopped transversely or lengthwise	Ribs cut from verts, meat consumed, and bone discarded intact
	Individual ribs cut away from verts at proximal articulations	Vert portions separated by cutting transversely between verts, which usually survived intact
	Head and neck severed and roasted on hot coals	
	Crania fractured to remove brain and eyes	
	Mandibles split along lower margin of body to access marrow	
	Vert columns chopped transversely, but not sagittally, to "pot-size"	
	Innominate cut from lumbar verts and separated into left and right halves	
	Depending on size/age of animal, innominate chopped transversely through acetabulum or left intact	

In another analysis of small prey bone fragmentation, Nicholson (2005:118) notes that, with the exception of crania, axial elements from the Aché ethnoarchaeological collections are minimally fragmented. Limb bone fragmentation, measured as the

percentage of complete limb elements, is significantly and positively correlated with prey size. In other words, the limb bones of larger Aché prey are substantially more broken than the limb bones of smaller prey, a pattern Nicholson associates with relative differences in marrow content. As with Nicholson's analysis of prey size and cut mark frequency, the relationship becomes non-significant when the largest Aché prey (deer and peccary) are excluded from the analysis. Jones (1983, 1984) and Nicholson (2005) both report a high frequency of limb bone cylinders in Aché collections, a pattern archaeologically linked to small prey marrow extraction by humans (Hockett 1994; Jones 1984; Schmitt et al. 2004). Relationships between prey size and patterns of bone fracturing and fragmentation are examined in the following section.

Fracture Analyses

A number of size-related trends in dismemberment- and marrow-fracturing emerge from the preceding discussion of ethnoarchaeological fauna. The following expectations are tested with reference to the Central African assemblage:

1. Fractured Bone: Ethnoarchaeological studies demonstrate that bone fracturing is related to carcass dismemberment and marrow extraction. Since duiker species require more extensive dismemberment than rodent species, and duiker bones contain greater quantities of marrow than rodent bones, I expect fractured bone specimens to be more common among duikers.
2. Bone Fragmentation: In the Central African bone assemblage, bone specimens may be subdivided by chopping or fracturing. Methodologically, bone breakage that clearly resulted from chopping (i.e., complete chops/shear fractures) was identified as chopping. Irregular breakage, or that not clearly attributable to chopping, was classified as fracturing. However, since chopping and fracturing may serve identical functions, they must also be evaluated together as bone fragmentation. Nicholson (2005) positively correlates the extent of limb bone fragmentation, measured as the proportion of complete limb elements, with prey size. I expect a similar size-related pattern of limb bone fragmentation to be evident among Bofi and Aka small prey. Fragmentation patterns of axial elements such as mandibles, ribs, and vertebrae are also explored. Since duiker

mandibles contain more marrow than ribs and vertebrae, I expect the extent of mandible fragmentation, but not ribs or vertebrae, to increase with prey size.

Fractured Bone

It should be reiterated that these bone collections were collected prior to deposition, and all bone breakage can be attributed to human processing. Interestingly, the proportion of fractured specimens varies significantly between common taxa ($\chi^2 = 56.401$; $df = 4$; $p < .001$), but not in the predicted direction (Figure 6.10).

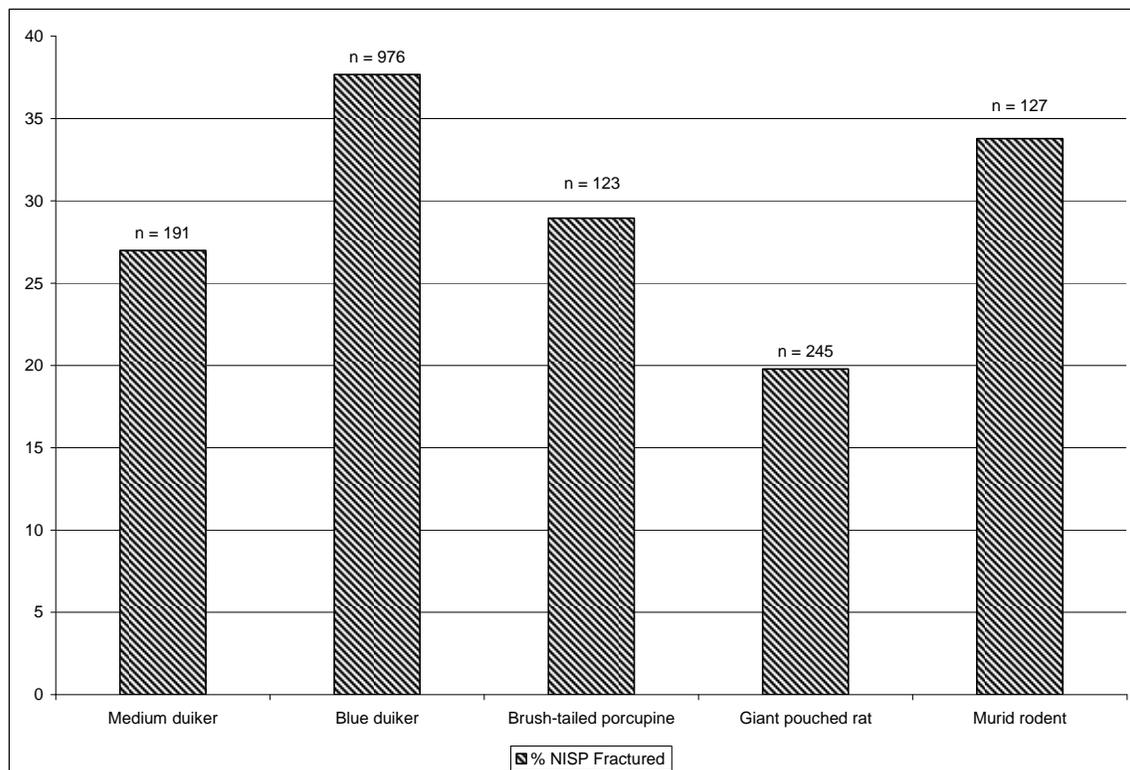


Figure 6.10. Percentage of fractured specimens for common prey (Total sample = 5338 specimens).

Blue duiker, brush-tailed porcupine, and giant pouched rat, follow a pattern similar to that identified for burns, cuts, and chops. The largest and smallest common prey, medium duiker and Murid rodent, reverse the predicted pattern. As with analyses of previous

damage types, median weights were utilized for each specimen to quantify prey size differences. Results of an independent samples t -test comparing: A) the combined fractured specimens from common prey with B) the combined unfractured specimens from common prey reveal that each group (fractured vs. unfractured) is associated with a significantly different prey size ($t = 3.401$; $df = 5336$; $p = .001$). Contrary to the direction of other size-related damage types, however, fractured specimens are associated with a *smaller* mean prey size, whereas unfractured specimens are associated with a larger mean prey size. Both χ^2 and t -test results appear to be a consequence of the high proportion of fractured Murid rodent specimens. Murid rodent bones are not dismembered or processed for marrow, but they are extremely small, fragile, and susceptible to breakage that, based on the analytical criteria employed here, is classified as fracturing.

Bone Fragmentation

Nicholson's (2005) Aché data indicate a significantly greater proportion of incomplete limb elements among the largest animals in his assemblage. In other words, and consistent with the findings of other analysts, the marrow-bearing bones of smaller prey are more likely to be left intact. The present analysis compares the proportion of broken and unbroken shafts (regardless of damage morphology) for humeri, radii, ulnae, femora, and tibiae of common prey. Since unfused epiphyses reflect separate specimens, but not breakage that provides access to the marrow cavity, they are excluded. In addition, because metapodia of duikers and rodents are not anatomically comparable, they are examined separately. Similarly, Nicholson (2005:35) evaluated the metapodia and phalanges of ungulates separately from those of armadillos, coatis, monkeys, and pacas. Mandibles, which contain an easily accessible marrow cavity, are also analyzed

separately here. Results of an independent samples *t*-test comparing broken and unbroken limb shaft specimens indicate that broken shaft specimens are associated with significantly larger taxa than unbroken specimens ($t = -9.720$; $df = 741$; $p < .001$; Figure 6.11).

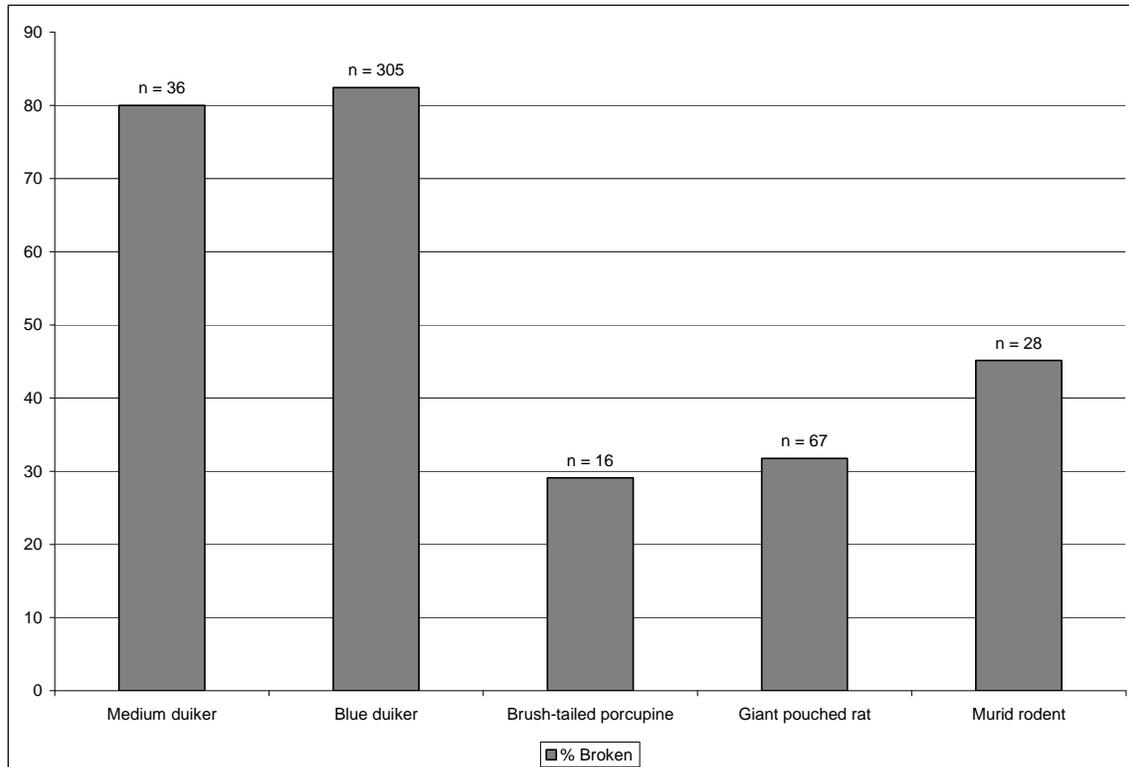


Figure 6.11. Percentage of broken limb elements for common prey (Total sample = 743 specimens).

Evaluated individually, separate limb elements vary significantly with prey size, with the exception of radii (Table 6.3). Considering differences in size and anatomy between duiker and rodent metapodia, it is not surprising that the proportion of broken metapodia also varies significantly with prey size ($t = -4.529$; $df = 193$; $p < .001$).

Table 6.3. Percentage of broken limb bones subdivided by element and taxon.

	HUM^a	RAD^b	ULN^c	FEM^d	TIB^e	Total
Medium duiker	33.33	66.67	83.33	100.00	87.50	80.00
Blue duiker	80.77	60.71	74.00	93.55	90.32	82.43
Brush-tailed porcupine	27.27	0.00	0.00	58.33	35.29	29.09
Giant pouched rat	8.33	28.57	18.18	44.64	43.10	31.75
Murid rodent	22.22	75.00	62.50	17.65	60.00	45.16

^a $t = -4.106$; $df = 138$; $p < .001$

^b $t = -1.935$; $df = 103$; $p = .056$

^c $t = -4.176$; $df = 103$; $p < .001$

^d $t = -7.094$; $df = 187$; $p < .001$

^e $t = -4.744$; $df = 202$; $p < .001$

Notably, the limb bone shaft cylinders recorded by Nicholson (2005) among Aché small prey are virtually absent from the Bofi and Aka collections, since limb bones are usually broken at some point mid-shaft, leaving shaft portions with articular ends still attached. The large number of unidentifiable shaft fragments associated with large mammal marrow processing (e.g., Gifford-Gonzalez 1989) is not evident, as the Central African assemblage includes only 11 unidentifiable specimens.

Previous ethnoarchaeological studies describe size-dependent variability in the extent to which mandibles are broken for marrow extraction. The mandibles of large Hadza prey studied by Lupo (1993) were consistently broken open to access marrow. Yellen (1991a) reports that, among his !Kung San assemblage, the mandibles of steenbok and common duiker were processed for marrow, but the mandibles of smaller African porcupine and springhare were not. According to Nicholson (2005), mandibles of Aché small prey were rarely broken. Among Central African prey, particularly duikers, mandibles are usually chopped or fractured through the ascending ramus in a way that does not breach the marrow cavity (as illustrated by the top mandible in Figure 6.12). Breaks through the dentary (illustrated by the bottom mandible) occur much less

frequently. In the following analyses, the category “marrow-broken” does not reflect all mandible breakage, only breakage providing access to the mandibular marrow cavity.



Figure 6.12. Fractured and “marrow-broken” blue duiker mandibles.

Marrow-broken specimens were rare among all taxa, suggesting that the mandibles of Bofi and Aka prey, although frequently broken during dismemberment, were rarely fractured to gain access to marrow. Those mandible specimens that were marrow-broken occurred disproportionately among medium duikers. As expected, given their negligible marrow content, no pouched rat mandible specimens were marrow-broken. Similar to Murid rodent limb bones, the high proportion of broken mandibles among this taxon may be related to the extreme fragility of their bones. Results of an independent samples *t*-test comparing marrow-broken and non-marrow broken specimens reveal that marrow-broken

specimens come from significantly larger taxa than non-marrow-broken specimens ($t = -3.518$; $df = 284$; $p = .001$; Figure 6.13).

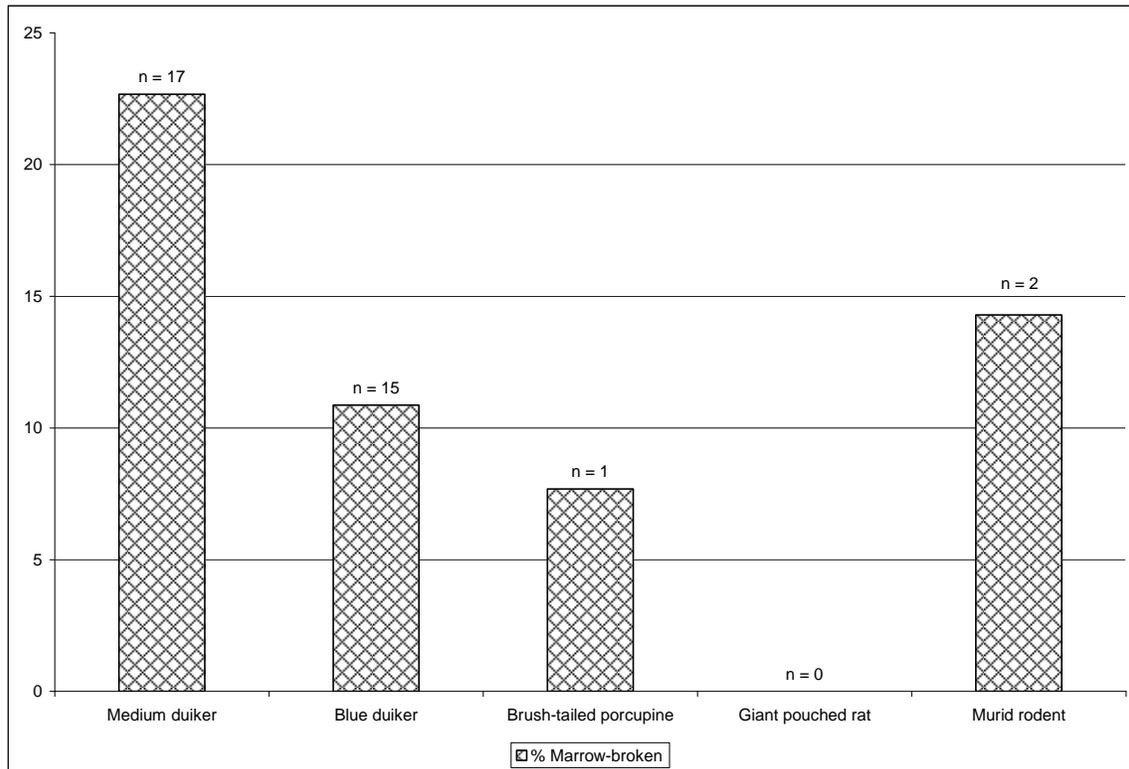


Figure 6.13. Percentage of “marrow-broken” mandible specimens for common prey (Total sample = 286).

As discussed in the chop section, the crania of blue duiker and smaller taxa are almost universally smashed to provide access to the brain. Other axial elements of interest include vertebrae and ribs. Lupo (1993) reports that Hadza large mammal vertebrae were chopped with blades and smashed into smaller fragments prior to boiling. Yellen states that the African porcupine spinal column is “hacked a few times along its length in an attempt to split individual vertebrae...,” but steenbok, common duiker, and springhare vertebrae usually survive butchery processes intact (1991a:9).

Table 6.4. Percentage of complete vertebrae and ribs by taxon (Total sample = 2238 specimens).

	CER	THO	LUM	RIB
Medium duiker	12.79	2.06	3.45	13.04
Blue duiker	38.54	4.07	0.00	7.54
Brush-tailed porcupine	40.91	56.82	23.33	38.81
Giant pouched rat	74.36	63.33	73.29	56.38
Murid rodent	90.00	80.00	65.00	50.00

Within the Central African fauna, medium and blue duiker are systematically chopped along a sagittal plane, creating a high percentage of split thoracic and lumbar vertebrae. Cervical vertebrae are more commonly chopped transversely and/or irregularly fractured among larger prey. Likewise, the ribs of rodent species are more likely to remain complete (Table 6.4).

Summary and Conclusions

Summary

This chapter has emphasized the relationship between prey size and taphonomic damage from a variety of ethnographic, archaeological, and experimental contexts to explore the variability that exists, and to determine how zooarchaeologists can most accurately interpret the range of behaviors reflected in small mammal taphonomic patterning. Prey species of varying size and structural anatomy provide human consumers with comparable sets of primary resources: skin, bone, meat, marrow, and grease. Whether these resources are utilized, the extent to which they are utilized, the processes employed to gain access to them, and the taphonomic damage patterns that result, vary greatly between different-sized animals. Analyses of burns, cut marks, chop marks, and fractures indicate informative differences between the Central African

ethnoarchaeological bone assemblage and fauna from other contexts. In addition, these analyses reveal significant size-related trends in taphonomic patterning *within* the Central African assemblage.

The location and frequency of burn damage is directly related to cooking methods, prey size, and butchery patterns. Obviously, to be burned, animal carcasses must be exposed to heat and flame. The fact that the Bofi and Aka boil most meat explains the relative rarity of burned bone in this assemblage. However, ethnoarchaeological research has demonstrated that the bones of small prey may be roasted, yet result in few burned bone specimens (Jones 1983; Kent 1993; Nicholson 2005). Whether carcasses are dismembered *before* or *after* roasting appears to significantly impact rates of burned bone, since bones that are insulated by meat are unlikely to be burned. Within the Central African collections, burned bone specimens increase with prey size. Beyond prey size, this pattern is best explained by the differential processing of duikers and rodents. Duikers are extensively chopped and fractured (creating many exposed bone surfaces) prior to roasting. Rodents are more often exposed to fire as complete carcasses, shielding bone from the direct effects of flames.

The extent to which cut mark frequency is influenced by prey size remains a contentious issue in the taphonomic literature (Domínguez-Rodrigo 2003a; Domínguez-Rodrigo and Barba 2005; Lupo and O'Connell 2002; Lyman 2005; O'Connell and Lupo 2003). Although data supporting positive, negative, and neutral relationships between carcass size and cut mark quantity have been published, the majority of archaeological, ethnographic, and experimental studies conducted thus far favor a positive relationship.

Analyses of the Central African fauna reinforce this interpretation, as the proportion of cut specimens varies positively and significantly with prey size. The proportion of cut specimens varies predictably with prey size, since duiker species require more blade-processing than porcupines, rats, or Murid rodents. Evidence presented here suggests that prey size likely plays a role in the variety of cut marks associated with a particular taxon, but prey size alone is not sufficient to predict cut code diversity. As opposed to studies of larger artiodactyls (e.g., Binford 1981), duiker species are skinned less often and rarely filleted, and virtually all identified cut marks are associated with carcass dismemberment and food preparation. The prevalence of dismemberment as a mark function is even more apparent when chop marks, all of which serve to subdivide carcasses, are considered in addition to cuts.

In the Central African bone assemblage, chop marks occur in two forms: partial and complete. Morphologically comparable damage has been reported in other ethnoarchaeological contexts (Crader 1983; Gifford-Gonzalez 1989; Lupo 1993; Nicholson 2005). Prey size appears to affect the presence, identifiability, and proportion of partial to complete chops. Not unexpectedly, Crader (1983) reports many partial chops, but very few complete chops through the robust bones of elephants and hippos. Gifford-Gonzalez (1993) suggests that chop-produced breakage might be more easily identifiable on larger prey, since these bones are less likely to be crushed (erasing diagnostic chop characteristics) than the bones of smaller species.

Among Central African fauna, complete chops are much more common than partial chops and are most often distinguishable from other types of breakage. Like cut marks, chop marks vary significantly with prey size, as duiker carcasses are subject to

more extensive blade-processing than rodents. The prevalence of complete chops through duiker bones demonstrates the ease with which animals of this size can be subdivided by chopping during the processes of dismemberment and food preparation.

Lupo (1993) argues that an archaeological pattern that combines low frequencies of burning with high frequencies of chops could be used to identify boiling as a meat preparation technique. In fact, all three conditions (infrequent burning, frequent chops, and boiling as the primary method of meat preparation) do co-occur among the Bofi and Aka, but with much smaller prey than those examined by Lupo (1993). Knife and machete chopping, paired with pot-boiling meat, serves the same three functions that Yellen (1991a:10) observed during !Kung San small prey butchery: creating distributable carcass portions, pot-sizing these portions, and breaking bone shafts so marrow is released into the broth.

In the Central African assemblage, fracturing is the only damage type that does not increase with prey size. Chopping among the Bofi and Aka achieves the same results (dismemberment and marrow access) that hand fracturing or hammerstone percussion would among groups without access to metal implements. Thus, in most archaeological contexts, chopping and bone fracturing might not be as morphologically distinct, and must be evaluated together as bone fragmentation. The proportion of broken (chopped and/or fractured) mandibles, limb elements, ribs, and vertebrae does vary significantly and positively with prey size. However, the characteristics of this breakage differ from other ethnoarchaeological examples. Large artiodactyl limbs are often marrow-processed using methods that produce numerous, sometimes unidentifiable, shaft fragments (Binford 1981; Gifford-Gonzalez 1989). Smaller prey marrow processing has been

archaeologically and ethnographically documented to result in long bone shaft cylinders (Hockett 1994; Jones 1984; Nicholson 2005; Schmitt et al. 2004). Bofi and Aka limb bones are most often broken in ways that create neither shaft fragments or shaft cylinders.

Conclusions

Despite growing recognition of the importance of small prey in prehistoric subsistence, actualistic data on small mammal butchery are still limited. The behavioral interpretation of small fauna requires a thorough re-evaluation of assumptions, primarily because conventional wisdom and theoretical expectations have so often been developed from archaeological and ethnoarchaeological studies of larger animals. Considering the size-related variability in prey processing described in this chapter, it's clear that taphonomic expectations derived from large mammal studies may not be directly applicable to analyses of Bofi and Aka prey. In particular, methods of analyzing processing intensity among prey of this size have not been established, leaving zooarchaeologists little choice but to refer to larger prey. The following chapter formulates an evolutionary model of small prey processing intensity and applies it to the taphonomic identification of resource intensification in the Central African faunal assemblage.

7. RESOURCE INTENSIFICATION AND PROCESSING INTENSITY

During ethnoarchaeological fieldwork in the Central African Republic, subsistence data were obtained via focal person follows, interviews, and the collection of food refuse bones. In 2001-2002, I spent comparable periods of time recording subsistence data in the villages of Grima and Ndele. In the course of this research, it became apparent that Ndele hunters consistently acquired more prey, and particularly more duikers, than hunters in Grima. The contrast between day-to-day hunting success in the two contexts prompted me to question whether such differences in prey availability, and behavioral responses to these differences, could be identified zooarchaeologically. Or, as Binford (1977) phrases it, whether dynamic differences in contemporary subsistence behavior could be reconstructed from static faunal remains. This chapter addresses the question by reviewing foraging theory and its archaeological implications. It then explores which aspects of particular evolutionary models are most applicable to the present study. The chapter concludes by evaluating zooarchaeological and taphonomic evidence for resource intensification and processing intensity in forest forager-produced faunal assemblages.

Theoretical Background

Resource Depression and Intensification

Foragers, past and present, make decisions about how to best extract energy from their environment, and from resources once acquired. Anthropological research has demonstrated the diversity, and contextual variability, of strategies that exist (Bettinger 1991; Binford 2001; Kelly 1995). Evolutionary ecology models predict that foraging species will alter subsistence strategies in response to fluctuations in the availability of

high-ranked resources. Given the adaptability of human subsistence practices, this prediction has been profitably applied to the generation of hypotheses regarding human foraging behavior and the interpretation of archaeological fauna (Bird and O'Connell 2006; Lupo 2007; refer to Chapter 1 for a full discussion).

As introduced in the first chapter, Charnov et al. (1976) originally defined resource depression as a decline in prey capture rates resulting from the foraging activities of a predator, noting that these activities are not limited to the killing of prey. The mere presence of predator species in an environment can affect prey behavior, often spurring behavioral adaptations for better predator avoidance (referred to as behavioral depression), and alteration of prey microhabitats may have the effect of causing prey to leave an area (microhabitat depression; Charnov et al. 1976:248). Both behavioral and microhabitat depression are capable of decreasing encounter rates between predator and prey, thus reducing prey *availability*, without major declines in prey populations. Alternatively, exploitation depression is an actual reduction in prey *abundance* resulting from unsustainable harvesting (Charnov et al. 1976:247).

Broughton et al. characterize resource depression as “declines in the capture rates of prey that result from the activities of foragers” (2007:374), which typifies the definition of resource depression used by most archaeologists. Betts and Friesen (2006) argue that ecological depression related to changing environmental conditions and the territorial behavior of competing predators can mimic the appearance of resource depression, as archaeologically defined, without being directly caused by foraging activities. Acknowledging these depression phenomena that are indirectly related (territorial depression) or unrelated (ecological depression) to foraging behavior, some

archaeologists use the term “anthropogenic depressions” (Byers and Broughton 2004) to specify decreased prey availability that results from the activities of human foragers. Butler collectively categorizes exploitation depression, behavioral depression, and microhabitat depression as “human-caused resource depression” (2001:96).

Resource depression, anthropogenic or ecological, can result in intensification of resource use by human foragers. Most ethnographic and archaeological studies rely on the identification of resource intensification to infer resource depression. Boserup (1965) introduced the concept of resource intensification to human subsistence studies with the specific goal of relating agricultural change to population pressure. Boserup’s model proposes that farmers respond to population increases and limited farming land (in effect, agricultural depression) by intensifying their use of the land available to them. This intensification results in a short-term net energy loss (measured as output per man-hour; Boserup 1965:43), but sustained agricultural intensification can eventually lead to *both* increased production and increased efficiency in the long term. The latter expectation distinguishes Boserup’s use of resource intensification from its common archaeological usage (Butler and Campbell 2004). In most archaeological applications, especially those based on foraging theory, resource intensification reflects an attempt to extract more energy from a set of resources or patch of land accompanied by a decline in energetic efficiency.

Within the framework of foraging theory, zooarchaeological data can be used to explain changes in the efficiency of resource use through time or between geographically-separated contexts. Interpretations of resource intensification in the archaeological record are often guided by rationale derived from the prey choice model

developed by Emlen (1966), sometimes called the “diet breadth” or “optimal diet” model. In this model, prey resources are ranked based on their caloric efficiency, as measured by the search and handling costs necessary associated with them. The basic predictions of Emlen’s prey choice model are that the highest-ranked resource will always be taken on encounter, and progressively less-efficient resources will be incorporated into the diet in descending rank order. Consequently, diet breadth is predicted to increase as encounters with high-ranking resources decrease. In zooarchaeological applications, since direct observations of search and handling costs are impossible, animal prey are commonly ranked according to size. Using prey size as a proxy measure of prey rank is generally effective (Broughton 1999; but see discussion of exceptions in Chapter 1), thus as encounters with the highest-ranking prey decrease, foragers are expected to intensify their use of lower-ranked, and presumably smaller, prey. This prediction is explored here by comparing the taxonomic composition and diversity of the Grima and Ndele faunal assemblages.

Processing Intensity

To account for some problematic assumptions of the prey choice model, MacArthur and Pianka (1966) developed an ecological model in which optimal predators encounter resources in patches or clumps. This model predicts that patches are exploited in decreasing order of the expected search and handling return rates of resources within them. Travel time to a given patch is included as a search cost, which leads to the expectation that a nearby relatively low-ranked patch may be exploited before a more distant higher-ranked one. However, the patch choice model only predicts which patches of resources will be *chosen*, not how patches will be utilized once chosen or the length of

time spent in a patch (Charnov and Orians 1973). In order to specifically address patch use, Charnov (1976) developed the marginal value theorem. Charnov's marginal value theorem predicts that foragers will leave a patch when its resource return rate drops below the average for the environment as a whole. That is, it predicts that foragers will abandon a resource patch at a point of diminishing returns that may occur before the patch is entirely depleted.

The patch choice model and marginal value theorem are derived from prey choice models, but there are significant differences between these models that have the potential to make the marginal value theorem more directly applicable to studies of processing intensity. Fancher et al. (2003), suggest that it might be possible to apply the marginal value theorem to questions of duiker processing intensity, particularly if duiker carcasses are viewed as a patch of resources rather than an individual resource (Figure 7.1), a concept applied by Burger et al. (2005) in the "prey as patch model." Comparably, Nagaoka (2006) proposes examining individual skeletal elements as patches. In order to do this, it is necessary to reconsider the definition of what is traditionally considered a resource. But there is theoretical justification for doing so. Recalling how Smith (1991) approached specific hunt types as patches, Lupo notes that "patches do not need to be so strictly defined and can refer to any entity with a predictable gain function" (2007:149). In terms of animal prey, Lyman writes: "There are many kinds of potential resources to extract from, say, a 200 kg artiodactyl, and many processes that can be used to extract them" (1994:295). Despite being significantly smaller than large artiodactyls, duikers also contain many resources, such as meat, marrow, grease, skin, tongue, brain, and other internal organs. In addition, duiker skins and bone could be used as material resources.

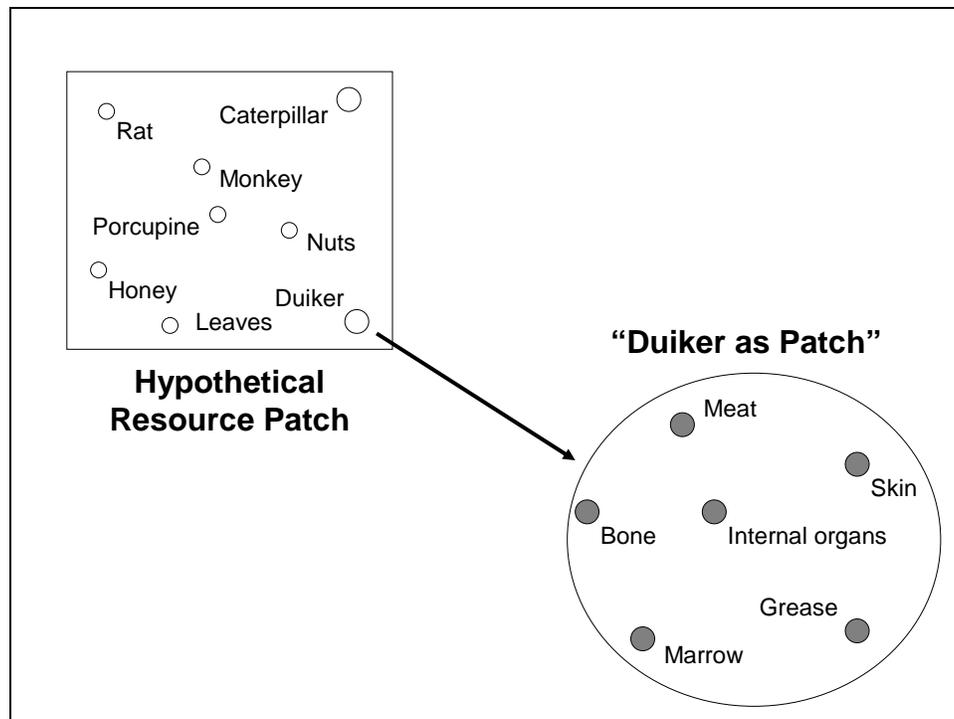


Figure 7.1. Duiker conceptualized as both a resource and a patch of resources.

Burger et al. (2005) introduced the prey as patch model and argued that the marginal value theorem is underutilized in analyzing relationships between ecological constraints and foraging decisions. Most importantly, their work goes beyond examining prey choice, and begins to theoretically explore relationships between resource intensification and processing decisions. Figure 7.2 is a graphical depiction of the prey as patch model.

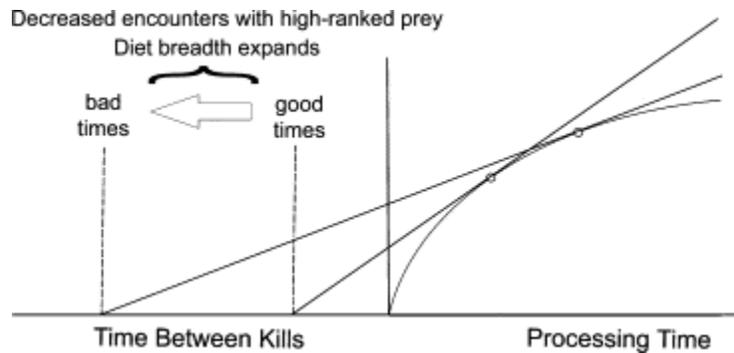


Figure 7.2. The Prey as Patch Model^a.

^aReprinted from *Journal of Archaeological Science*, Volume 32, by Oskar Burger, Marcus J. Hamilton, and Robert Walker, *The Prey as Patch Model: Optimal Handling of Resources with Diminishing Returns*, pp. 1147-1158, Copyright (2005), with permission from Elsevier.

Burger et al. (2005) envision “good” and “bad” times as qualitative categorizations representing encounter rates, which they assume to be a reflection of mean foraging return rate. Similar to earlier approaches to diet breadth, this model includes the expectation that as time between prey captures increases, lower-ranked patches will enter the diet. Further, it maintains that energy extraction from each patch will increase at an increase in cost.

If duikers are viewed as a patch, the patch choice model, marginal value theorem, and prey as patch model provide a theoretical basis for expected variation in processing intensity among Central African fauna. Stated in patch choice terminology, the hypothesis tested in the remainder of the chapter is that Ndele foragers will “abandon” (stop butchering) a “patch” (duiker) sooner than Grima foragers. The marginal value theorem predicts the point at which a forager will abandon one patch to move on to another; more precisely, the point at which the cost of leaving the current patch is exceeded by the potential benefit of moving on to another patch. The potential benefit of moving to another patch is largely a function of the overall abundance of patches in the environment. If patches are close to one another there is little cost to moving between

them. If patches are few and far between, then the cost of moving from one to another increases. According to the marginal value theorem, “A forager moves more quickly through an environment dense with rich patches, taking less from each one encountered, than through an environment with fewer and/or lower-quality patches” (Winterhalder 2001:17). The prey as patch model explicitly applies the marginal value theorem to prey butchery and suggests that effort expended in prey processing may be analogous to time spent in a patch (Burger et al. 2005).

Bettinger provides similar support for this argument: “More intensive use of many kinds of patches in a small geographical area is, thus, a logical response to diminishing resource availability” (1991:89-90). Bettinger describes an increase in both breadth *and* intensity. This concept has been empirically demonstrated in ecological studies. Smith (1974a, b) shows that thrushes increased the amount of time spent in an area where they had already made a kill in inverse proportion to the availability of food in the overall habitat. That is, they spent more time in a good hunting spot when food was rare in the environment. A related concept is the GUT or “giving up time” (Krebs et al. 1974). Krebs et al. (1974) conducted experiments with chickadees and defined the GUT as the time between the last capture of a mealworm and the time when the chickadee moved on to the next patch. Especially relevant here, they concluded that the GUT should be lower in rich environments. This reinforces the idea that a patch will be abandoned more quickly in a rich environment.

Forest foragers have an intimate knowledge of their environment and individual hunters in Grima and Ndele can likely estimate with some degree of accuracy the approximate number of duikers that they will encounter on any given day. This analysis

proceeds from the premise that Grima foragers, acknowledging the decreased likelihood of encountering a “rich patch” in the near future, will invest a greater amount of time in the patch that they currently occupy. In other words, the expectation is that Grima foragers will have a higher GUT than those in Ndele. Conversely, Ndele foragers, who acquire duikers on a more regular basis than the Bofi, should pursue a different strategy. They might be more inclined to “abandon the patch” at an earlier point, since expending effort to consume every ounce of meat, marrow, and grease when duiker are plentiful in the environment may be unnecessary or, at least, inefficient. One implication of this line of reasoning is that it presumes that Ndele hunters will waste resources, but the possibility exists that the additional handling/processing time is so negligible that foragers will maximize duiker resources regardless of their encounter rates, resulting in no difference in processing intensity.

The questions explored in the remainder of the chapter are grounded in evolutionary models previously used to evaluate prehistoric resource depression and intensification. Although my hypotheses are derived from these models of subsistence behavior, they do not fit neatly within any of them. Here I modify these models by redefining some variables, including or excluding others, and, ultimately, produce an entirely new model, albeit one that draws heavily from the original models. The recent prey as patch model, which parallels this research and was greatly expanded upon by Burger et al. (2005), is the model most directly applicable to this analysis.

Resource Depression and Intensification in Grima?

Table 7.1 shows prey capture data for Grima and Ndele, including observational data from all study periods in which bones were collected 1999-2002. Bones were not collected during the 2003 and 2005 field seasons.

Table 7.1. Prey capture rates in Grima and Ndele^a.

Taxon	Grima	Ndele
Red river hog (<i>Potamochoerus porcus</i>)	0	1
Yellow-backed duiker (<i>Cephalophus silvicultor</i>)	1	2
Bay or Peters duiker (<i>Cephalophus dorsalis</i> or <i>callipygus</i>)	8	42
Civet (<i>Civettictis civetta</i>)	2	1
Blue duiker (<i>Cephalophus monticola</i>)	88	242
Mongoose (Herpestidae)	0	1
Monkey (<i>Cercopithecus</i> sp.)	2	10
Brush-tailed porcupine (<i>Atherurus africanus</i>)	17	10
Tree pangolin (<i>Phataginus tricuspis</i>)	6	0
Tortoise (<i>Kinixys</i> sp.)	3	3
Giant pouched rat (<i>Cricetomys emini</i>)	59	6
Murid rats and mice (Muridae)	11	1
Bird (Aves)	1	3
TOTAL	198	322

^aSource: Lupo unpublished data (based on 43 observation days in Grima and 53 in Ndele).

Each number in Table 7.1 represents the number of each taxon that was captured during field observations. The taxonomic composition of acquired prey is significantly different between villages ($\chi^2 = 141.85$; $df = 12$; $p < .001$). Dividing the total number of duikers (Yellow-backed, bay, Peters, and blue duikers = 97 total animals) captured on 43 days on which meat of any kind was obtained in Grima results in a ratio of 2.26. The same calculation in Ndele (286 duikers \div 53 meat days) produces a ratio of 5.40. On days when meat was procured, duikers were captured over twice as often in Ndele. Yet another measure of the differences between the villages are “duikerless days,” or the percentage of meat days in each village on which duikers were not obtained (Figure 7.3).

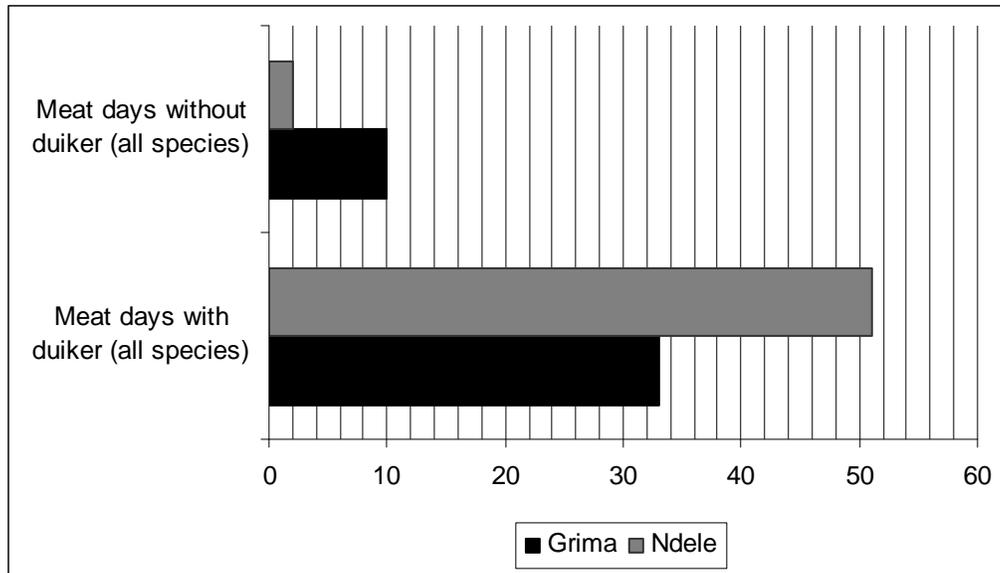


Figure 7.3. Duikerless days in Grima and Ndele.

There are likely a number of factors that contribute to the decreased abundance of duikers in Grima, including overhunting by human foragers (i.e., exploitation depression). Many studies in equatorial Africa have shown how intensified human hunting pressure depletes duiker populations (Eves and Ruggiero 2000; Hart 2000; Muchaal and Ngandjui 1999; Noss 1998a, b, 2000, 2001). Increased logging activity around Grima and habitat depletion (microhabitat depression), especially when compared to Ndele, may cause declining availabilities of these taxa in the surrounding environment (also see Auzel and Wilkie 2000). Another legitimate possibility is that duikers are not less abundant in the vicinity of Grima, simply encountered less often (behavioral depression) and, thus, less available. Mass migrations of duikers away from intensively hunted areas seems unlikely, since blue duikers in particular are reluctant to leave their small home ranges (Noss 2000:300), but Lahm (1991) and Muchaal and Ngandjui (1999) suggest that blue duiker pairs may avoid areas of human disturbance. Whether the causes

are anthropogenic, ecological, or some combination, what can be stated for certain is that medium and blue duikers were taken less frequently over our sample period by the foragers of Grima than by the foragers of Ndele. Table 7.1 clearly indicates that the Bofi of Grima acquire higher-ranking, relatively large prey less often than hunters in Ndele. The present work focuses not on the *causes* of differential meat availability, but on the ways that foragers *respond* to such differences and, ideally, ways that these different responses may be identified archaeologically.

Taxonomic Diversity in Grima and Ndele

Resource depression and subsequent resource intensification in archaeological contexts are identified by spatial or, more often, temporal, changes in prey diversity or richness (Bayham 1979; Broughton 1994a, b, 1997, 1999; Butler 2000, 2001; Cannon 2000; Nagaoka 2001, 2002a,b). Theoretically, it follows that resource intensification is marked by increased reliance on smaller, less-calorically efficient taxa (but see Broughton 2002). I test this proposition by comparing the taxonomic composition of the Grima and Ndele bone assemblages, as measured by richness and evenness. My expectation is that there should be greater taxonomic diversity in Grima (greater richness and evenness), and a greater proportion of smaller prey in the Grima assemblage in comparison to Ndele. As with many applications of prey choice models, the assemblage-level focus of this study may obscure fine-grained variation in diet breadth resulting from individual foraging goals and hunting technologies that target specific suites of prey (see Lupo and Schmitt 2005).

If one assumes that larger-bodied animals are higher-ranked than smaller-sized prey (with exceptions noted in Chapter 1), then applying the categorical ranking of taxa

represented in faunal assemblages collected from the Bofi and Aka results in the following rank orders, with 1 signifying the highest rank and 11 the lowest (Table 7.2).

Table 7.2. Prey ranks based on published live weight data.

Taxon	Live weight range (kg)^a
1. Red river hog (<i>Potamochoerus porcus</i>)	45.0 – 115.0
2. Yellow-backed duiker (<i>Cephalophus silvicultor</i>)	45.0 – 80.0
3. Bay or Peter's duiker (<i>Cephalophus dorsalis</i> or <i>callipygus</i>)	15.0 – 24.0
4. Civet (<i>Civettictus civetta</i>)	7.0 – 20.0
5. Blue duiker (<i>Cephalophus monticola</i>)	3.5 – 9.0
6. Monkey (<i>Cercopithecus</i> sp.)	1.8 – 6.0
7. Brush-tailed porcupine (<i>Atherurus africanus</i>)	1.5 – 4.0
8. Tree pangolin (<i>Phataginus tricuspis</i>)	1.6 – 3.0
9. Tortoise (<i>Kinixys</i> sp.)	1.0 – 2.0 ^b
10. Giant pouched rat (<i>Cricetomys emini</i>)	1.0 – 1.4
11. Murid rats and mice (Muridae)	.025 - .065

^a Live weights as reported by Kingdon (1997)

^b Tortoise live weight from Alden et al. (1998)

Approaching the Grima and Ndele bone collections as if they were actual archaeological assemblages, data are presented here as Number of Identified Specimens (NISP). This is particularly important because NISP is a more accurate measure of duiker meat *consumed*, rather than *procured*, since a portion of procured duiker meat in both villages is sold or traded.

In archaeological applications, calculating the percentage that each species, or other taxonomic category, contributes to total assemblage NISP is sufficient for the purpose of comparing abundances (Table 7.3). Regardless, based on the number of recorded captures or the number of identified specimens ($\chi^2 = 1008.70$; $df = 10$; $p < .001$), the taxonomic composition of the two assemblages is significantly different. Table 7.3 indicates the proportion of total assemblage NISP contributed by each taxonomic category.

Table 7.3. Grima and Ndele NISP by taxon.

Taxon	Grima NISP	Ndele NISP
River hog	0	11
Yellow-backed duiker	7	0
Medium duiker	267	441
Civet	15	0
Blue duiker	1507	1084
Monkey	54	10
Porcupine	305	120
Pangolin	75	0
Tortoise	53	66
Pouched rat	1135	103
Murid	376	0
TOTAL	3794	1835

Grayson (1984) defines taxonomic richness as the number of taxa represented in a faunal assemblage (\sum_i). In terms of richness, the Grima faunal assemblage is represented by 10 of the 11 previously identified taxonomic categories. The exception is the red river hog, which is absent. The Ndele assemblage includes 7 of 11 taxa, except yellow-backed duiker, civet, pangolin, and mouse. Following Grayson (1984) and Janetski (1990), Schmitt and Lupo (1995, 2008) calculate taxonomic evenness as $1/\sum p_i^2$. The variable p_i represents the proportion of specimens in the assemblage that occur within each taxonomic category. Higher evenness values indicates that specimens are more evenly distributed across taxa, but a recent study by Jones concludes that, in most cases, greater taxonomic evenness can be interpreted as a reflection of “increasing dietary breadth and/or decreasing availability of preferred prey types” (2004:316). Using this method to calculate evenness results in values of 3.71 for Grima and 2.41 for Ndele. Figure 7.4 graphically depicts the greatest points of divergence between the Grima and Ndele fauna.

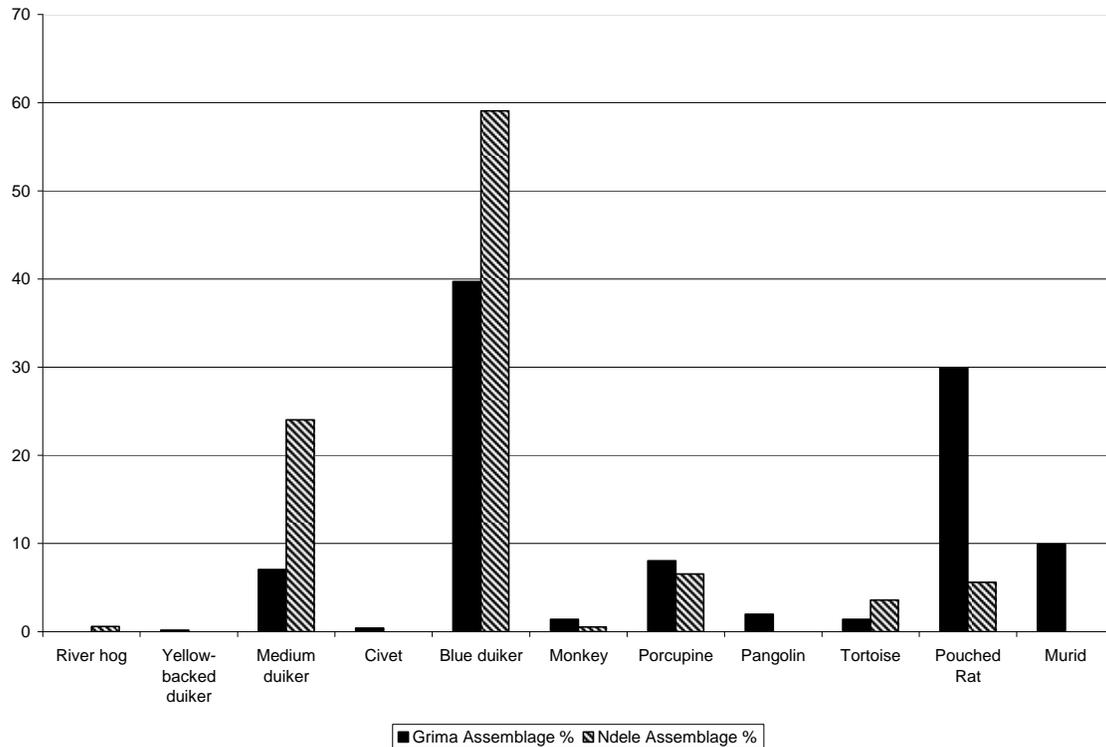


Figure 7.4. Percentage of Grima and Ndele assemblage NISP contributed by each taxon.

The most revealing differences are illustrated by the relative abundance of medium duiker, blue duiker, pouched rat, and mouse. Medium and blue duiker combined account for over 83% of Ndele NISP, whereas pouched rat and mouse are rare and absent, respectively. In Grima, pouched rat and mouse contribute nearly 40% of assemblage NISP. These data suggest a proportionally greater emphasis on the lowest ranking taxa in Grima. Results of an independent samples *t*-test comparing the village assemblages reveal that more Ndele specimens come from significantly larger taxa than Grima specimens ($t = -24.07$; $df = 5627$; $p < .001$). This suggests a greater dietary breadth for the Grima foragers as compared to the Ndele foragers. Lupo and Schmitt (2002:157, 2004:251) demonstrate that net-hunting, the primary means of capturing blue duikers, is

generally high-yield, but also relatively high-risk. Spear-hunting of medium duikers produces a very high post-encounter return rate, with relatively low risk of failure, which supports the size-based high rank of this prey type (Lupo and Schmitt 2005:341).

Individual techniques, such as hand capturing pouched rats, are generally low-yield and low-risk. The increased abundance of rats in Grima's faunal assemblage may reflect strategies that are risk-averse relative to Ndele.

As noted in Chapter 3, hunting methods vary seasonally among forest forager populations. Since the Ndele collections contain both dry and wet season bones and the Grima collections contain only dry season bones, it is important to identify potential seasonal effects on taxonomic diversity. Figure 7.5 compares richness and evenness between each sub-assemblage. Note that there is no overlap in richness or evenness between any of the Grima and Ndele sub-assemblages. Grima collections are consistently more diverse in comparison to the Ndele collections.

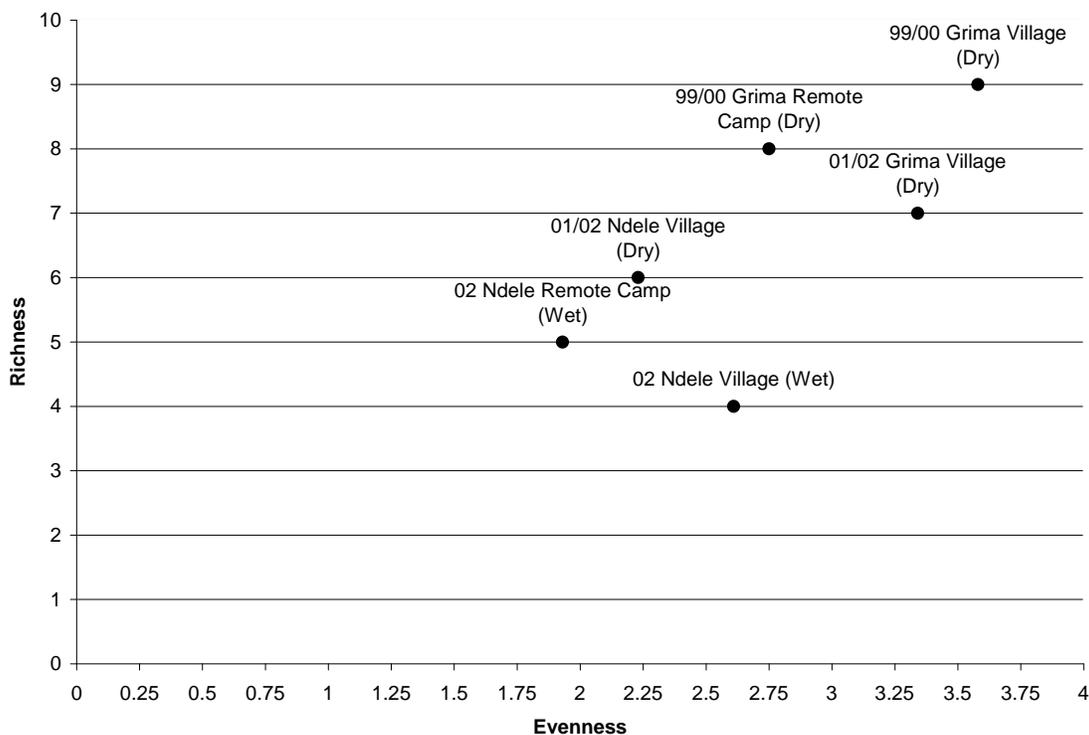


Figure 7.5. Taxonomic richness and evenness values divided by sub-assemblage.

The taxonomic composition of sub-assemblages can be evaluated with an ordinal regression method called the Polytomous Universal Model (PLUM), which determines the probability of rank-ordered dependent variable outcomes by multilevel predictors. This analysis evaluated whether taxonomic composition is predicted by season and village. The results indicate that the overall model is significant ($\chi^2 = 912.35$; $df = 2$; $p < .001$), and these variables together account for 16% of the variance in taxa represented (Nagelkerke's $Pseudo R^2 = .157$). This suggests that season and village affect the taxonomic composition of these assemblages, but that other factors also contribute to the observed variance. Evaluated separately, season is not a significant predictor of the taxonomic composition of a sub-assemblage ($wald = .04$, $df = 1$, $p < .001$), but village

environment (broadly defined, since both ecology and behavior may be influential) is a significant predictor of taxonomic composition ($wald = 422.78$, $df = 1$, $p < .001$). This means that season can be ruled out as a significant variable influencing taxonomic composition of assemblages.

The Duiker Index

Most archaeological analyses use abundance indices (or AI's) to quantify the relative abundance of small and large prey in faunal assemblages (Broughton 1999; Cannon 2000; Szuter and Bayham 1989; Nagaoka 2002a). The artiodactyl index ($\text{Artiodactyl NISP} \div \text{Artiodactyl NISP} + \text{Lagomorph NISP}$) is a well-known example used to gauge the degree to which zooarchaeological assemblages are dominated by large deer in comparison to smaller prey (Muir and Driver 2002; Potter 1995; Szuter and Bayham 1989). I developed a comparable "duiker index" is used here to illustrate differences in the representation of high-ranking duikers between Grima and Ndele. The duiker index is calculated as: $\text{Duiker (all species) NISP} \div \text{Duiker NISP} + \text{Rodent (porcupine, rat, and mouse) NISP}$ (Figure 7.6).

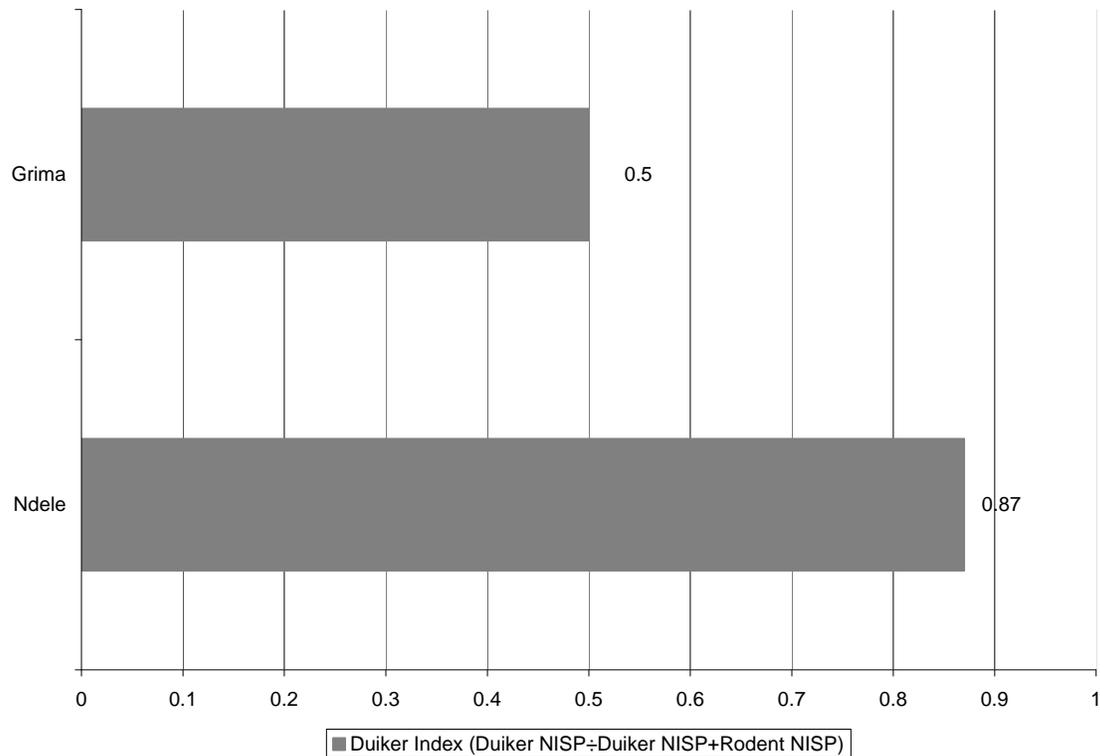


Figure 7.6. Duiker Index values for Grima and Ndele.

Here I combine duikers (Yellow-backed, medium, and blue duikers) and rodents (brush-tailed porcupines, giant pouched rats, and Murid rodents) into categories representing “large” and “small” prey to access the dominance of high-ranked prey in Ndele. The duiker index is another expression of the dominance of duikers in the Ndele assemblage. All of these measures reinforce the difference between Grima and Ndele and, although they do not unequivocally confirm resource depression, are consistent with a relative depression and intensified use of animal resources in Grima. The Bofi focus on small rodents and use of individual hunting techniques can be viewed loosely as “diversification into new strategies” (or more accurately, “the use of a different strategy,” since we do not have long term data on the local history of this strategy), using Earle’s

(1980:20) phrasing. The following sections extend Earle's analogy by examining "intensification of existing strategies" (1980:20) in the form of duiker processing, as reflected by butchery damage.

Processing Intensity and Cut Marks

"However, the behavioral interpretation of cut mark frequencies remains enigmatic."

Pobiner and Braun 2005:107

Significant differences in the taxonomic composition of the Grima and Ndele bone assemblages, with an emphasis on low-ranking prey in Grima, lead me to expect that higher-ranking prey will be processed more intensively in Grima. I selected medium and blue duikers for analysis because they are the highest-ranking prey common to both the Grima and Ndele assemblages. As discussed in the previous chapter, despite being larger than other Bofi and Aka prey, duikers are relatively small when compared to most other ethnoarchaeologically analyzed species. This raises a fundamental question: If there are discernible taphonomic differences in processing intensity among mammals of this size, what form will they take?

Since the very beginnings of zooarchaeology and taphonomy, cut marks have been an essential component of butchery studies. No other damage type has received as much analytical attention or been used to infer a broader range of human activities. Variation in cut mark frequency has been examined in relation to prey procurement strategies (Bunn and Kroll 1986; Lupo and O'Connell 2002; Marean 1998; Marean et al. 2000; Milo 1998; Monahan 1996; Shipman 1986), prey size (Domínguez-Rodrigo and Barba 2005; Lyman 1992; Marshall 1986), and carcass condition (Binford 1981, 1988; Lupo 1994), among other variables. The logic linking processing intensity and cut mark frequency is straightforward; as a butcher intensifies removal of meat from bone, more

tool strokes are necessary, and a greater number of cut marks will result. But this formulation is largely untested. Some have argued that a consistent relationship between processing intensity, tool strokes, and cut mark frequency cannot be assumed without a more comprehensive understanding of these variables (Egeland 2003; Lyman 1992, 1995, 2005). Others (e.g., Guilday et al. 1962; Olsen and Shipman 1988) have related cut mark frequency to a butcher's skill, arguing that butchers avoid dulling their blades by contact with bone, and cut marks represent "mistakes." This concern may be less prevalent in contexts where iron blades are utilized, and I did not observe Bofi or Aka butchers make any effort to avoid cutting bones. However, careful processing, no matter how intense, may leave few marks since (with the exception of marrow breakage) it is carcasses and carcass parts that are butchered, not bones (Lyman 2008:282).

Arguably, the most influential, if not the earliest, reference to the relationship between processing intensity and cut marks is a statement by Binford:

my experience suggests that the number of cutmarks, exclusive of dismemberment marks, is a function of differential investment in meat or tissue removal. When a butcher who is filleting meat seeks to get all the adhering tissue off the bones, there will be many cut marks; if little effort is made to clean the bones, relatively few cut marks result (1988:127).

Binford's experience (e.g., 1978, 1981) is based on the Nunamiut filleting of caribou in a specific context, but has been interpreted generally and applied beyond its original context. Despite increasing awareness that the relationship between processing intensity and cut mark frequency is empirically unsupported, many continue to make the assumption in zooarchaeological applications (Abe et al. 2002; Grayson and Delpeche 2003; Milo 1998), although most acknowledge that until further data are available, it *is* an assumed relationship. The limited experimental data available suggest no easily-interpretable relationship between the number of tool strokes and resulting cut marks on

the appendicular elements of domestic horses (*Equus caballus*) and domestic cows (*Bos taurus*) (Egeland 2003). To my knowledge, experimental studies among smaller taxa have not yet been published. Therefore, this chapter proceeds from the assumption that cut mark frequency is one reflection of a butcher's increased investment in carcass processing. The following analyses evaluate the efficacy of cut marks as indicators of processing intensity in the context of these ethnoarchaeological collections.

Cut Marks and Processing Intensity Analyses

Zooarchaeological studies commonly compare the percentage of cut-marked specimens in bone assemblages and the total number of distinct cut marks. Abe et al. (2002:645), in an overview of cut mark quantification methods, refer to the former as “NISP data” and the latter as “cutmark-count data.” The NISP data measure has been more widely applied in archaeological contexts, allowing for inter-site comparisons of cut mark frequency, but it is also subject to influence by differential fragmentation (i.e., highly fragmented bone assemblages may artificially decrease the proportion of specimens that display cut marks; Abe et al. 2002). As introduced in the previous chapter, and further explored below, duiker bones from the Central African assemblage are not highly fragmented. Thus, the cutmark-count measure is not affected by fragmentation and, if greater investment equals a greater number of distinct marks, then it may be a more accurate indicator of processing intensity. Both measures are used here to test the hypothesis that processing intensity varies between the Grima and Ndele duiker assemblages, and is reflected by cut mark frequencies.

Chi-squared analysis of medium ($\chi^2 = .035$; $df = 1$; $p = .852$) and blue duikers ($\chi^2 = .242$; $df = 1$; $p = .623$) indicates no significant differences between the proportion of cut

specimens in the Grima and Ndele assemblages. In fact, the proportion of cut to non-cut specimens is nearly identical between the two contexts, with slightly more specimens of each taxon displaying cut marks in Grima (Figure 7.7). This demonstrates that NISP data, when applied at the assemblage level, reveal minimal variation in the quantity of cut marks between the two villages. Clearly, this variation is not sufficient to support any difference in processing intensity.

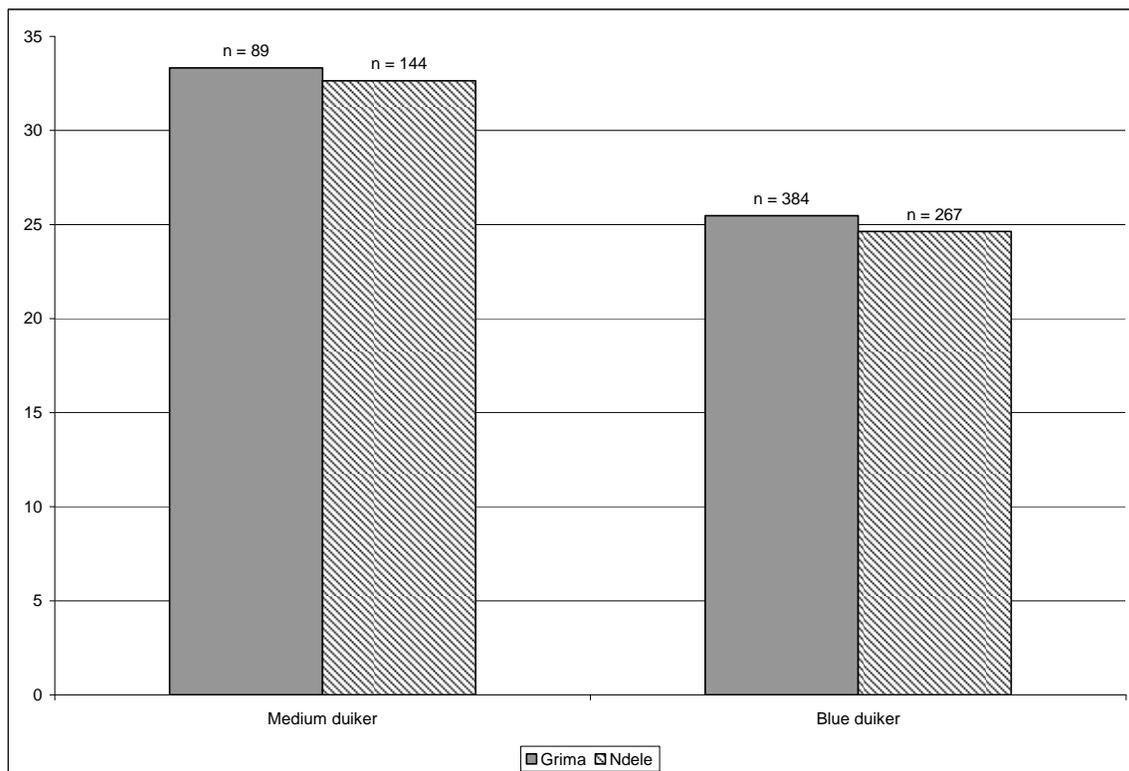


Figure 7.7. Percentage of medium duiker and blue duiker NISP exhibiting cut marks in the Grima and Ndele assemblages (Total sample = 3299 specimens).

A limitation of NISP data, especially in terms of processing intensity, is that specimens are only quantified as “cut” or “not cut,” regardless of the number of distinct marks present. It is possible that proportions of cut specimens remain constant, without reflecting changes in mark frequency (i.e., cutmark-count data). To evaluate this

possibility, an independent samples *t*-test was conducted to determine whether there is significant variation in the number of identifiable cut marks per cut specimen. In other words, within the sub-category of cut specimens, are bones cut a greater number of times in either village? Results indicate no significant difference in the number of cut marks per cut medium duiker specimen ($t = -1.236$; $df = 231$; $p = .218$) or blue duiker specimen ($t = -1.292$; $df = 649$; $p = .197$) between the Grima and Ndele assemblages. Contrary to expectations, Ndele medium and blue duiker specimens display slightly higher mean values for cut marks (Figure 7.8).

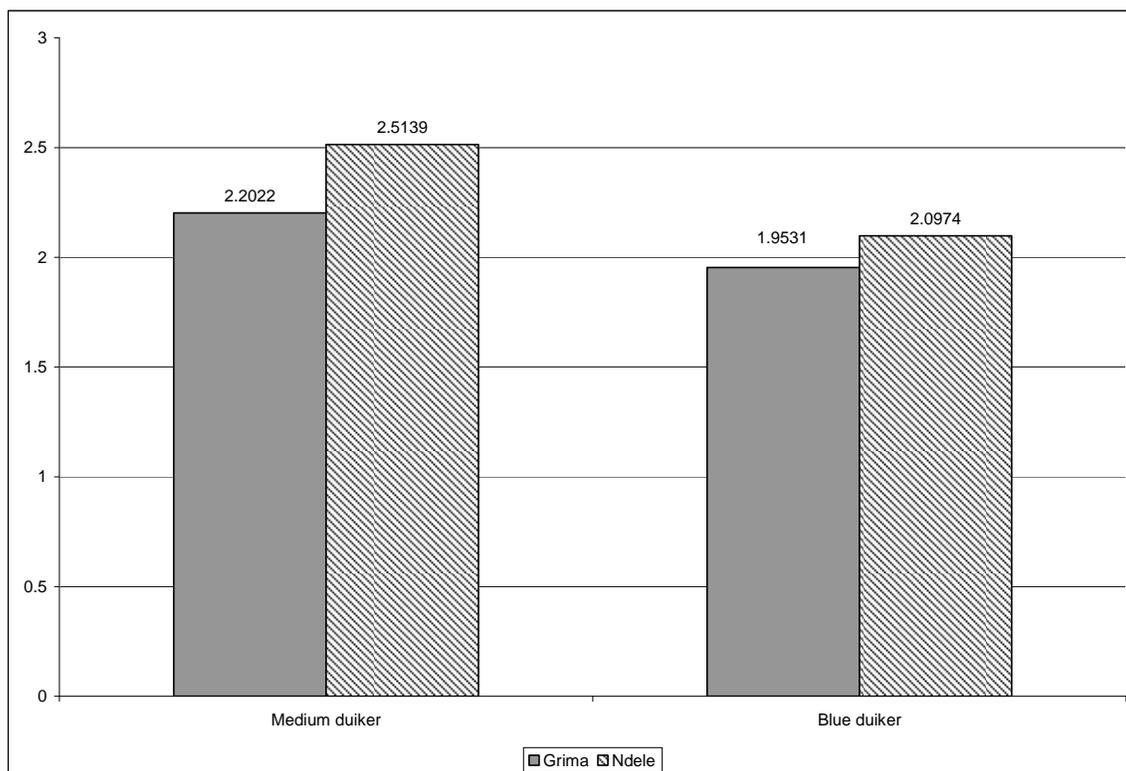


Figure 7.8. Mean number of cut marks per cut specimen in the Grima and Ndele assemblages.

The close similarity between cut mark frequencies in Grima and Ndele is surprising, but not unprecedented. Lyman tests the following hypothesis: “if two

collections of faunal remains of the same taxon derive from environmentally, temporally, culturally, and technologically similar contexts, those collections should display at least some similarities in frequencies of cut-marked bones” (2005:1723). Lyman’s (2005:1727-1728) results demonstrate that archaeological assemblages of deer and elk bones recovered from comparable sites in the Portland Basin of the northwestern United States include nearly identical frequencies of cut marked bones; an approximately 1% difference in the proportion of cut specimens between sites for both taxa. This result suggests a consistent butchery pattern, but Lyman cautions that there is little similarity in the distribution of cuts across six major limb joints between sites. That is, when cut frequencies are examined at the level of specific elements (or in Lyman’s case, specific joints), inter-site patterning is not as identical as it appears based on overall frequencies of cut deer and elk specimens (Lyman 2005:1728). To further explore variation in cut mark frequency between Grima and Ndele, Tables 7.4 and 7.5 subdivide cut-marked medium and blue duiker specimens by anatomical element.

Table 7.4. Medium duiker cut mark data subdivided by element.

Element^a	Grima NISP	Ndele NISP	Grima Cut NISP	Ndele Cut NISP	Grima % Cut	Ndele % Cut
<i>Cranium</i>	19	91	1	24	5.26	26.37
Mandible	11	64	9	35	81.82	54.69
Cervical	41	45	7	5	17.07	11.11
Thoracic	42	55	9	14	21.43	25.45
Lumbar	14	15	6	6	42.86	40.00
Sacrum	0	5	0	1	-	20.00
Rib	74	64	37	41	50.00	64.06
Scapula	1	3	0	1	0	33.33
Humerus	3	3	0	2	0	66.67
Radius	5	3	1	1	20.00	33.33
Ulna	7	1	1	0	14.29	0
Metacarpal	2	5	0	1	0	20.00
Innominate	8	12	4	3	50.00	25.00
Femur	5	12	3	4	60.00	33.33

Tibia	14	10	7	3	50.00	30.00
Patella	1	1	1	0	100.00	0
Tarsals	4	3	2	0	50.00	0
Metatarsal	2	3	1	0	50.00	0
Metapodial	0	2	0	1	-	50.00

^aMedium duiker elements that were not cut in either village are excluded.

Owing to relatively small sample sizes for individual medium duiker elements, some of the percentages presented in Table 7.4 exaggerate the difference between the proportion of cut specimens in the Grima and Ndele assemblages. In fact, chi-squared analysis of all medium duiker elements that exhibited cut marks indicates that only crania differ significantly between villages ($\chi^2 = 3.989$; $df = 1$; $p < .05$).

Table 7.5. Blue duiker cut mark data subdivided by element.

Element^a	Grima NISP	Ndele NISP	Grima Cut NISP	Ndele Cut NISP	Grima % Cut	Ndele % Cut
<i>Cranium</i>	164	175	11	26	6.71	14.86
Mandible	57	81	29	50	50.88	61.73
Cervical	111	81	28	17	25.23	20.99
Thoracic	183	112	23	8	12.57	7.14
Lumbar	113	70	36	17	31.86	24.29
Sacrum	23	13	5	1	21.74	7.69
Rib	369	201	118	54	31.98	26.87
Sternum	6	27	0	6	0	22.22
Scapula	37	29	12	13	32.43	44.83
Humerus	48	33	22	14	45.83	42.42
Radius	33	25	9	4	27.27	16.00
Ulna	32	23	3	5	9.38	21.74
Metacarpal	18	3	2	0	11.11	0
Innominate	52	39	28	17	53.85	43.59
Femur	45	61	24	25	53.33	40.98
Tibia	70	28	21	9	30.00	32.14
Tarsals	32	22	3	0	9.38	0
<i>Metatarsal</i>	33	10	10	0	30.30	0

^aBlue duiker elements that were not cut in either village are excluded.

Chi-squared analysis indicates no significant differences in the proportion of cut specimens for most blue duiker elements, with the exception of crania ($\chi^2 = 5.783$; $df = 1$; $p < .05$) and metatarsals ($\chi^2 = 3.949$; $df = 1$; $p < .05$). Interestingly, crania were significantly more cut in Ndele, while metatarsals were significantly more cut in Grima. Ndele metatarsal specimens were uncut. In contrast, Grima metatarsal specimens displayed 19 cut marks, representing six cut codes (MTM-2, MTM-4, MTM-5, MTM-8, MTM-9, MTM-12; See Appendix A). Most of these marks occur mid-shaft and likely reflect the skinning of blue duiker carcasses in Grima, but not Ndele. The possible role of element utility in cut mark frequency is further explored below. Contrary to Lyman's (2005) results, and with noted exceptions, inter-village patterning of cut mark frequency on skeletal parts is not significantly different, whether viewed at the assemblage level or on an element-by-element basis.

The location of cut marks on medium and blue duiker limb bones may provide additional information about intervillage differences in duiker processing. Results presented in the previous chapter demonstrate no significant difference between frequencies of cuts near limb bone ends (associated with dismemberment) and cuts on limb bone shafts (associated with filleting). Given Binford's (1988) emphasis on fillet marks as an indicator of processing intensity, it is important to evaluate the frequency of cuts in anatomical locations traditionally related to filleting. As in Chapter 6, cuts on humeri, radii, ulnae, femora, tibiae, and metapodia were divided into "end cuts" and "shaft cuts." Cut marks that occurred on or adjacent to epiphyses were classified as end cuts, as were those that occurred on intermediary elements such as patellae and tarsals. No carpal bones displayed cut marks. Cut marks that occurred on limb bone diaphyses,

regardless of orientation, were classified as shaft cuts. Results indicate that end cuts significantly outnumber shaft cuts among medium duiker specimens in Grima ($\chi^2 = 6.564$; $df = 1$; $p < .05$), but not in Ndele ($\chi^2 = .029$; $df = 1$; $p = .866$; Figure 7.9).

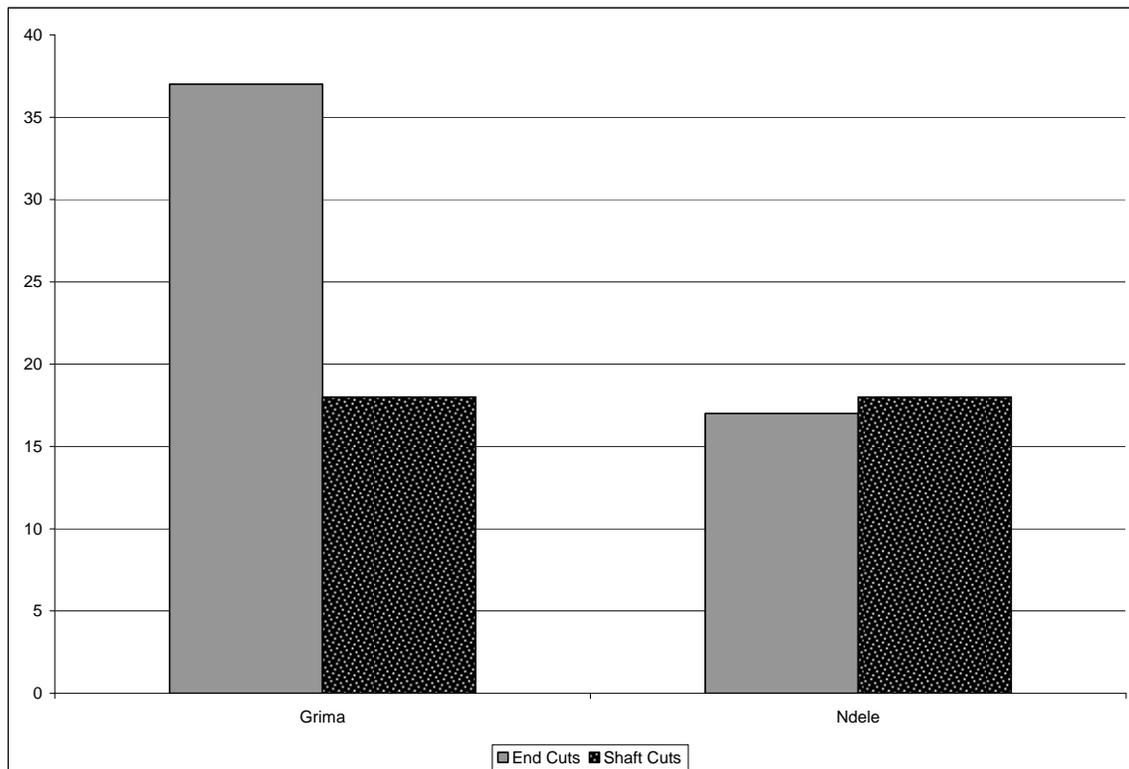


Figure 7.9. Number of medium duiker limb bone end and shaft cuts by village.

This means that cuts usually associated with dismemberment are significantly more abundant than those associated with filleting among Grima's medium duiker limb bones. The prevalence of dismemberment marks in Grima could indicate that medium duikers were butchered into more portions to be shared more widely. Among Ndele's medium duiker limb bones, end and shaft cuts occur in approximately equal numbers. Results indicate no significant difference between the number of end and shaft cuts on blue

duiker limb bones in Grima ($\chi^2 = .679$; $df = 1$; $p = .410$) or Ndele ($\chi^2 = 3.128$; $df = 1$; $p = .077$; Figure 7.10).

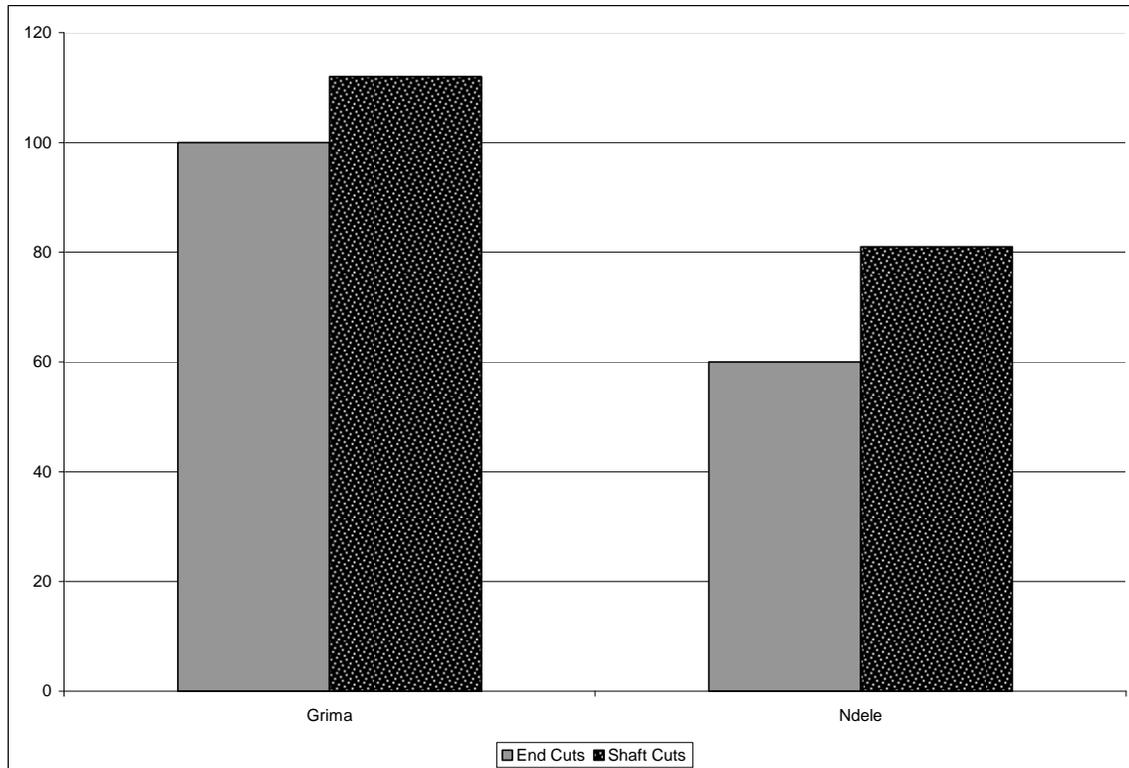


Figure 7.10. Number of blue duiker limb bone end and shaft cuts by village.

In both villages, marks on the shafts of limb bones exceed marks on ends by a non-significant margin. Field observations of forest forager butchery suggest that duiker meat is rarely, if ever, filleted. Thus, these mid-shaft cuts may occur during dismemberment or food preparation, not filleting, the function posited for larger prey with similar anatomy. In addition, patterning in the distribution of cuts on duiker limb bones, if encountered in a zooarchaeological assemblage, would not demonstrate significant differences in the intensity of filleting between villages.

Cut Marks and Element Utility

Measures of overall cut mark frequency indicate no significant differences between Grima and Ndele. However, studies guided by HBE argue that variability in processing intensity is most taphonomically visible on low-utility skeletal elements, since these elements may be the most sensitive to variation in intensity. Low-utility elements provide little nutritional value and are expected to be exploited only in cases of diminished resource availability (Broughton 1999; Burger et al. 2005; Nagaoka 2005, 2006). Broughton (1999) provides extensive evidence for resource intensification in the form of taxonomic diversity measures, but supplements his analysis by seeking a relationship between processing intensity and cut marks:

Insofar as the number of cut marks left on bones increases with the intensity of utilization, cut mark frequencies may provide an additional index of the efficiency of resource extraction. In particular, cut mark frequencies on or adjacent to low-utility skeletal parts should increase with declining overall returns and increasing processing intensity of acquired resources (1999:19).

Notably, Broughton presupposes a correlation between intensity and cut marks, but suggests that element utility may be a more relevant variable. He uses the modified general utility index (MGUI; Binford 1978) and food utility index (FUI; Metcalfe and Jones 1988), both derived from large artiodactyls, to quantify element utility (see Chapter 1 for discussion of utility indices). Citing the lack of specific utility indices, Broughton applies artiodactyl utility rankings to sea otter elements. Among medium artiodactyls (*Odocoileus hemionus* and *Antilocapra americana*) and sea otters (*Enhydra lutris*), his results indicate a significant increase in cuts on low utility elements during the temporal period of posited resource intensification at the Emeryville Shellmound of San Francisco Bay (1999:64).

Broughton (1999) classifies crania, mandibles, atlas and axis vertebrae, carpals, tarsals, metapodia, and phalanges as “low utility.” Comparison of these elements for medium duikers reveals no significant differences in the proportion of cut specimens ($\chi^2 = 1.409$; $df = 1$; $p = .235$) or the number of cuts recorded on cut specimens ($t = -.251$; $df = 74$; $p = .803$) between Grima and Ndele. Results of analysis of medium duiker low utility elements (as identified as Broughton) do not differ from overall results including all skeletal elements. Also in agreement with overall patterning, the number of distinct cut marks recorded on cut blue duiker low utility elements does not vary significantly between Grima and Ndele ($t = .552$; $df = 147$; $p = .582$).

Contrary to expectations, a significantly greater proportion of blue duiker low utility elements exhibit cut marks in the Ndele sample ($\chi^2 = 7.706$; $df = 1$; $p < .01$). However, when evaluated individually, crania are the only low utility element identified by Broughton (1999) that varies significantly between villages ($\chi^2 = 5.783$; $df = 1$; $p < .05$), with 14.86% of Ndele blue duiker cranial specimens displaying cuts compared to only 6.71% in Grima. Table 7.6 illustrates the cranial cut marks represented in the Grima and Ndele assemblages.

Table 7.6. Cranial cut marks represented in Grima and Ndele.

Cut Code	Function	Grima	Ndele
FRO-2	Unknown	0	7
FRO-4	Unknown	0	3
FRO-5	Unknown	0	6
FRO-6	Unknown	0	3
HCO-3	Dismemberment	4	4
MAXT-1	Dismemberment	0	8
OCC-2	Unknown	0	2
OCC-3	Unknown	1	1
ORB-2	Unknown	8	1
PAR-1	Unknown	5	8
PAR-2	Unknown	10	7

PMX-1	Unknown	0	5
S-1	Dismemberment	0	3
Sk-2	Unknown	2	0
Sk-8	Dismemberment	7	0

The greater proportion of cut cranial specimens in Ndele does not appear to be attributable to any specific cut mark reoccurrence or location (as reflected by code) or known function. The majority of these cranial cuts occur in anatomical locations not associated with a documented function. Dismemberment-related marks are only slightly more abundant in Ndele than Grima (15 and 11 marks, respectively). The most informative difference is evident in the variety of marks represented; Ndele blue duiker crania exhibit 13 different cut mark codes, compared to only 7 in Grima.

The Blue Duiker Food Utility Index

Analysis of Broughton's (1999) low utility elements among medium and blue duikers provides little evidence of differential processing intensity between villages, with the exception of blue duiker crania, which contradict the predicted pattern. Relationships between element utility and cut mark frequency may also be ascertained by comparing cut mark data to a complete scale of body part utility, as opposed to focusing only on low utility elements. The relationship between the amount of attached flesh on a bone and resulting frequency of cut marks has been central to the hunting vs. scavenging debate in early hominid studies (Binford 1986; Blumenschine 1988; Bunn and Kroll 1986; Capaldo 1997; Lupo and O'Connell 2002; Selvaggio 1994). Binford (1986:446) argues that the defleshing of desiccated, carnivore-ravaged bones by scavengers will result in more cuts because carcasses in such condition require extra effort to process. Alternatively, Bunn and Kroll (1986:449-450) argue that fully-fleshed bones, particularly meaty elements, are

more difficult to deflesh without leaving marks because meat prevents butchers from seeing (and avoiding blade contact with) bone.

Studies of meat weight and cut mark frequency have ramifications and relevance beyond the food acquisition strategies of early hominids, particularly when analysts seek to identify processing intensity. As emphasized in the previous chapter, numerous interrelated variables influence cut frequency; a fundamental variable is prey size. Even within size categories, butchers may selectively expend more energy, and leave more marks, on high utility elements – regardless of prey availability. However, recent ethnoarchaeological (Lupo and O’Connell 2002) and experimental data (Pobiner and Braun 2005) suggest that cut mark frequency does not consistently vary with meat weight.

Lupo (personal communication, 2006) calculated FUI rankings based on the average meat weight associated with various portions of a blue duiker carcass. This index, derived directly from experimental butchery conducted in the 2000 season, provides a scale to evaluate the relationship between blue duiker element utility and cut mark frequency – and whether this relationship varies between villages. This section tests the following hypotheses:

1. In light of the results of Lupo and O’Connell (2002) and Pobiner and Braun (2005), it is predicted that cut mark frequency will not vary significantly with medium or blue duiker food utility index (FUI) values.
2. If differences in the relationship between FUI and cut mark frequency exist between villages (and, again, testing the assumption that greater processing intensity produces more cut marks), then the Grima medium and blue duikers should display a greater proportion of cuts on low FUI portions.

FUI rankings were derived from blue duikers, but are also used here to model the relative utility of medium duiker body parts. Table 7.7 lists portions of a medium duiker carcass and associated FUI values. FUI values were not calculated for elements distal to the tibia and radius. Notably, crania, an element classified as “low utility” in Broughton’s (1999) analysis, is highly ranked in terms of FUI when paired with the mandible. Stiner argues that artiodactyl crania are highly valued because they represent “the final bastion of fat tissue in prey suffering from seasonal or other causes of malnutrition” (1991:471). In the event that low utility elements are processed more intensively in Grima, there should be a greater discrepancy between Grima and Ndele for those elements at the bottom of the table. However, there appears to be no linear relationship between FUI and % NISP cut or cut intensity (Table 7.7).

Table 7.7. Medium and blue duiker Food Utility Index rankings and cut mark frequencies.

Medium Duiker Portion	FUI^a	Grima % Cut	Ndele % Cut	Grima Cut Intensity^b	Ndele Cut Intensity^b
Thoracic/ribs	312.50	39.66	46.22	1.67	2.16
Femur	291.45	60.00	33.33	4.33	2.00
Cranium/Mandible	278.00	33.33	38.06	2.90	2.98
Lumbar	210.30	42.86	40.00	2.50	2.33
Innominate/Sacrum	193.00	50.00	23.53	2.00	1.25
Cervical	158.00	17.07	11.11	1.71	2.00
Scapula	58.97	0	33.33	0	1.00
Tibia	58.05	50.00	30.00	2.00	2.33
Humerus	51.75	0	66.67	0	3.50
Radius	24.80	20.00	33.33	3.00	1.00
Blue Duiker Portion	FUI^a	Grima % Cut	Ndele % Cut	Grima Cut Intensity^b	Ndele Cut Intensity^b
Thoracic/ribs	312.50	25.54	19.81	1.65	1.83
Femur	291.45	53.33	40.98	3.00	2.44
Cranium/Mandible	278.00	18.10	29.69	2.68	2.21
Lumbar	210.30	31.86	24.29	1.92	1.65
Innominate/Sacrum	193.00	44.00	34.62	1.81	2.22
Cervical	158.00	25.23	20.99	1.61	1.71

Scapula	58.97	32.43	44.83	1.75	2.08
Tibia	58.05	30.00	32.14	2.10	2.89
Humerus	51.75	45.83	42.42	2.41	2.64
Radius	24.80	27.27	16.00	1.67	2.00

^aSource: Lupo unpublished data. ^bMean number of cuts per cut specimen.

I used an ANOVA analysis to further explore the relationship between cut mark occurrence, FUI, and village context. This approach facilitates the analysis of the main effects of cut bone specimens as it relates to duiker FUI, the main effects of village as it relates to FUI, and the interaction of cut specimens and village. For this analysis, all medium and blue duiker specimens were categorized as cut or not cut, and non-cut specimens serve as a control group to gauge variability among the cut specimens.

Results for medium duiker indicate that there is a significant difference between cut and non-cut specimens related to FUI ($F = 9.24$; $df = 1$; $p < .01$). Review of the mean FUI values for cut specimens indicates that there are statistically larger FUI values associated with cut specimens ($M = 265.81$, $SD = 71.38$) than non-cut specimens ($M = 245.40$, $SD = 78.35$). In other words, the “average” cut medium duiker specimen is associated with a slightly higher FUI than the average non-cut specimen. While statistically significant, this 20 point mean difference in FUI is relatively small in terms of the complete FUI scale and does not provide strong evidence of a processing emphasis on high-utility body parts. The test of the main effect of village on medium duiker FUI approaches significance ($F = 3.47$; $df = 1$; $p = .06$), with a trend toward higher medium duiker FUI associated with Ndele ($M = 257.35$; $SD = 68.62$) than Grima ($M = 245.42$, $SD = 87.31$), but, again, the difference between mean FUI values is very minor. There is no significant interaction pertaining to medium duiker cut specimens and village ($F = .07$; df

= 1; $p = .80$) indicating that FUI patterning in cut specimens and village are not interrelated for this taxon.

Results for blue duiker indicate that there is a significant difference between cut and not cut specimens related to FUI ($F = 9.36$; $df = 1$; $p < .01$). Contrary to medium duikers, review of the mean FUI values for cut and not cut blue duiker specimens indicates that there are statistically *smaller* FUI values associated with cut specimens ($M = 231.46$, $SD = 3.66$) than non-cut specimens ($M = 244.60$, $SD = 2.45$). This 13 point mean difference in FUI is statistically significant, but relatively small in terms of the FUI scale and probably does not represent a meaningful difference. There is no significant main effect of village on FUI ($F = .71$; $df = 1$; $p = .40$). Comparison of mean FUI values in Ndele ($M = 239.84$, $SD = 3.29$) and Grima ($M = 236.22$, $SD = 2.77$) indicates that they are not significantly different. There is also no significant interaction between cut blue duiker specimens and village ($F = .08$; $df = 1$; $p = .78$).

Regression analysis was utilized to evaluate the same relationships, however, with an emphasis on the number of cuts per cut specimen (cut intensity). This ratio level data could not be addressed with an ANOVA, therefore, the following regression equation was employed:

$$y_{\text{FUI}} = a + b_{\text{village}} + b_{\text{ratio of cuts per cut specimen}}$$

When combined, the ratio of cuts per cut specimen and village do not significantly predict FUI for medium duiker ($F = .76$, $df = 2$, $p = .47$) or blue duiker ($F = .99$, $df = 2$, $p = .37$). Neither predictor significantly predicted FUI and together only accounted for .2% and .9% of FUI variance, respectively. Ultimately, element utility has little impact on the creation or frequency of cut marks in this context, and there is little utility-related

variation in cut duiker specimens between villages. The most likely explanation is that forest forager duiker butchery is relatively standardized, primarily based on chopping carcasses into pot-sized portions, rather than focusing on the removal of meat from particular skeletal parts.

Discussion: Evaluating Processing Intensity with Cut Mark Data

The results above reveal only minor variation in cut mark frequency on duiker bones, regardless of element utility, collection location, or proposed differences in processing intensity. Lyman reasonably concludes that “any single site or assemblage may not be ‘representative’ of some larger entity such as the butchering pattern of an archaeological culture” (2005:1728). However, results presented here suggest that the duiker butchery pattern of Bofi and Aka foragers, at least as reflected by cut marks, could be equally well inferred from either of these two spatially distinct faunal assemblages.

These results also reiterate that zooarchaeologists should be wary of universally applying Binford’s experiential relationship between processing intensity and cut mark frequency. Binford (1988:127) argued specifically that cut marks, *exclusive of dismemberment marks*, reflect a butcher’s investment in meat or tissue removal. In other words, he proposed that fillet and skinning marks increase with a butcher’s investment (processing intensity) among samples of large Nunamiut prey. This statement has been interpreted generally to mean that greater processing intensity results in more cut marks. As demonstrated in previous chapters, the processing of duikers differs in important ways from the processing of larger artiodactyls. First and foremost, filleting, the non-dismemberment process that Binford (1988) emphasizes, was rarely observed among the

Bofi and Aka. On the contrary, most cut marks with identifiable functions are associated with dismemberment.

Prey size and cooking methods greatly reduce the necessity of filleting meat from bone prior to consumption. Landt (2007) suggests that meat can be removed from duiker bones without tools, using only hands and teeth, during consumption. Considering the fact that duiker carcass portions are created not by filleting meat from bone, but by chopping completely through bone prior to boiling, the frequency and characteristics of chop marks may provide an additional measure of processing intensity among prey of this size.

Processing Intensity and Chop Marks

“If there are a lot of people to feed relative to the meat available, each major skeletal element will be subdivided.”

Hudson 1990:116

In the quote featured above, Hudson (1990) describes a process whereby Aka foragers increase the output of duiker elements by subdividing them into smaller portions. Unlike cut marks, which may reflect multiple functions, chop marks are almost always the result of carcass dismemberment. Among duiker-sized prey, knife- and machete-chopping is an expedient method of subdividing carcasses prior to sharing, cooking, and consumption. Thus, the frequency and characteristics of chop marks in the Central African assemblage must be examined in conjunction with cut marks to fully evaluate duiker processing intensity.

Chop Marks and Processing Intensity Analyses

Given the increased taxonomic diversity and decreased capture rates for duikers in Grima, it is predicted here that foragers will attempt to maximize acquired duiker carcasses by chopping them into smaller portions to feed more individuals. If that is the

case, then a greater proportion of medium and blue duiker specimens should be chopped in Grima, when compared to Ndele. Figure 7.11 illustrates the proportion of duiker specimens that are chopped (partial and complete) in each village assemblage.

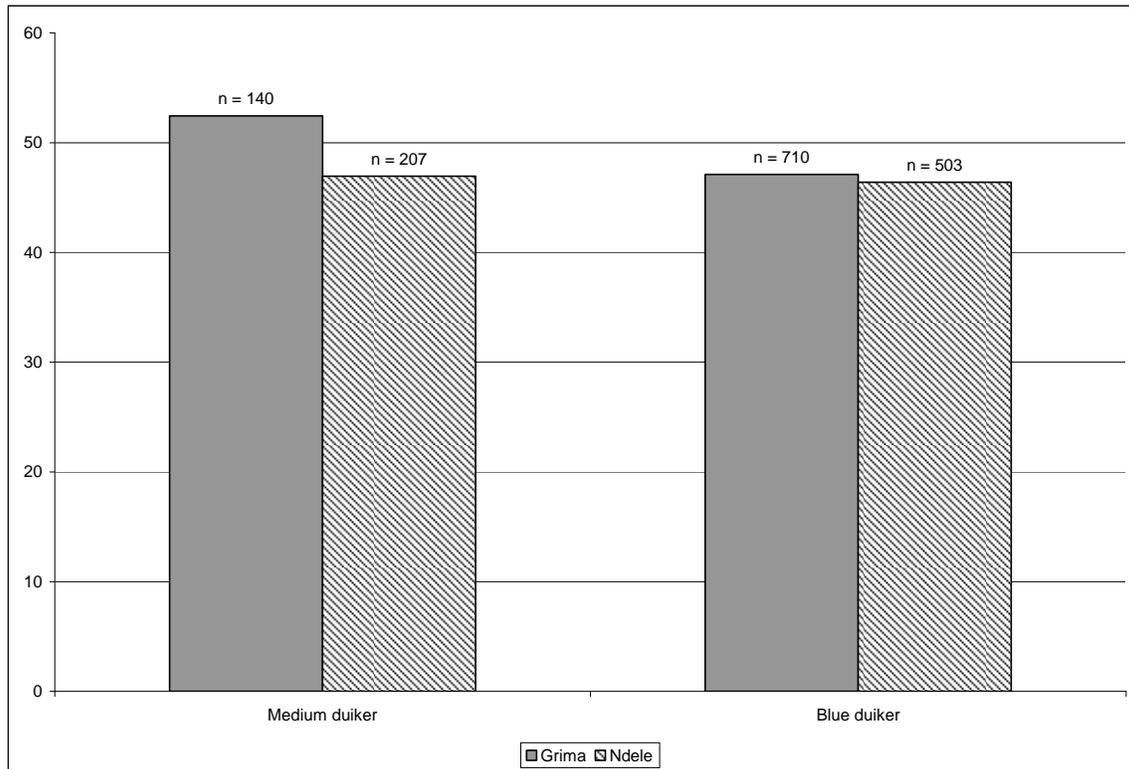


Figure 7.11. Percentage of medium duiker and blue duiker NISP exhibiting chop marks in the Grima and Ndele assemblages (Total sample = 3299 specimens).

Contrary to expectations, chi-squared analysis of the proportion of chopped specimens in the Grima and Ndele assemblages indicates no significant differences for medium ($\chi^2 = 2.010$; $df = 1$; $p = .156$) or blue duikers ($\chi^2 = .128$; $df = 1$; $p = .720$). In fact, the proportion of chopped to non-chopped specimens is comparable between the two contexts, with only slightly more specimens of each taxon displaying chop marks in Grima (Figure 7.11).

As part of the cut mark analyses, both the proportion of cut specimens and the number of distinct cut marks were investigated, since both may reflect variation in processing intensity. Comparably, the prediction that chopped duiker specimens are more likely to be chopped repeatedly, resulting in a higher ratio of chop marks to chopped specimens is tested here. Results of an independent samples *t*-test indicate no significant difference in the number of chop marks per chopped blue duiker specimen ($t = -.139$; $df = 1211$; $p = .889$) between the Grima and Ndele assemblages. The ratio of chop marks to chopped specimens does vary significantly for medium duiker specimens between villages ($t = 2.585$; $df = 345$; $p < .05$), with a somewhat higher mean ratio in Grima (Figure 7.12), although not enough to warrant firm conclusions.

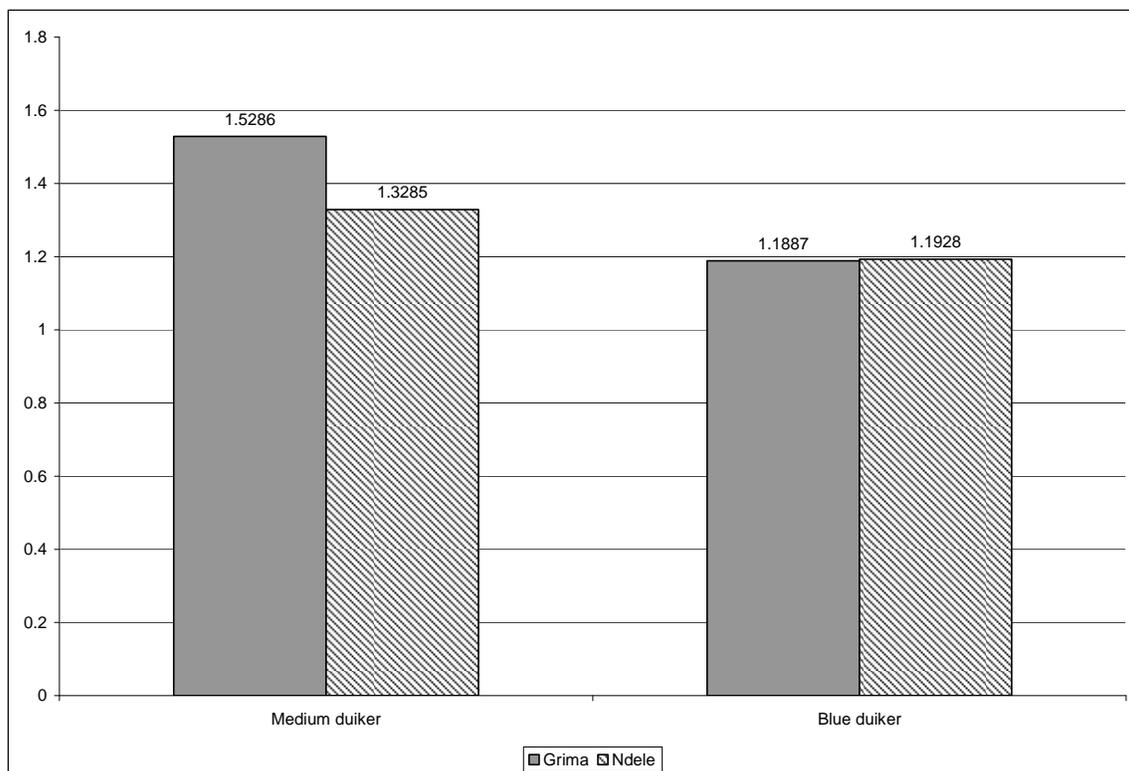


Figure 7.12. Mean number of chop marks per chopped specimen in the Grima and Ndele assemblages.

Unlike cut marks (e.g., Figure 7.12 illustrates approximately 2 cuts per cut specimen), chop marks are less likely to occur repeatedly on a single specimen among duiker-sized prey, as a single machete chop is usually sufficient to dismember bone. As demonstrated in the previous chapter, repeated “hacking” is not common on bones in this assemblage. The higher ratios for medium duikers in both villages suggest that repeated chops are less often required among blue duikers, reiterating the importance of prey size in interpreting taphonomic damage patterns.

As discussed in Chapter 3, the primary dismemberment of medium duiker carcasses in both villages is conducted by chopping through axial elements such as sterna, ribs, and vertebrae. For example, the ribs, thoracic and lumbar vertebrae of medium and blue duikers are almost always chopped regardless of context. Thoracic and lumbar vertebrae are sagittally chopped to split the carcass into marketable units as part of a relatively standardized butchery pattern, and have no bearing on differential processing intensity. To explore this possibility, the current section evaluates chop mark frequency within the sub-category of appendicular elements. Consistent with previous results, chi-squared analysis of the proportion of chopped appendicular specimens in the Grima and Ndele assemblages indicates no significant differences for medium duikers ($\chi^2 = .432$; $df = 1$; $p = .511$). Contrary to patterning observed in the complete sample of medium duiker elements, the ratio of chop marks to chopped appendicular specimens does not vary significantly between Grima and Ndele ($t = .149$; $df = 42$; $p = .883$), although the mean ratio is still slightly higher in the Grima assemblage (1.3333 compared to 1.3043 in Ndele).

Also introduced in Chapter 3, field observations suggest that the primary dismemberment of blue duikers differs subtly between Grima and Ndele. In Grima, blue duiker carcasses are generally divided into six portions: lower organs, upper organs, sternum/distal ribs, head/neck/first ribs, and ½ post-cranial carcass (2). The same portions were created in Ndele, plus three more: detached skin and forelimbs (2). Internal organs, skin, and forelimbs were cut away from the remainder of the carcass with knives and should not result in additional chops. However, the fact that Grima blue duiker primary butchery results in two more “food portions” (excluding skin) than observed in Ndele may, in and of itself, indicate resource intensification. As with medium duikers, chi-squared analysis of the proportion of chopped appendicular specimens in the Grima and Ndele assemblages indicates no significant differences for blue duikers ($\chi^2 = 2.204$; $df = 1$; $p = .138$). Also consistent with patterning observed in the complete sample of blue duiker elements, the ratio of chop marks to chopped appendicular specimens does not vary significantly between Grima and Ndele ($t = .349$; $df = 248$; $p = .727$), although the mean ratio is still slightly higher in the Grima assemblage (1.2867 compared to 1.2617 in Ndele).

Discussion: Evaluating Processing Intensity with Chop Mark Data

Chop-produced marks have not been utilized as a gauge of processing intensity separate from other forms of bone breakage in previous zooarchaeological studies. Examining chop marks as a distinct damage type in this study reveals little variation in chop mark frequency between the Grima and Ndele duiker assemblages. As with cut marks, chop mark patterning suggests a remarkably standardized duiker butchery sequence in Grima and Ndele. These results argue against the idea that greater

subdivision of duiker carcasses in response to their reduced abundance would result in a greater number of chops or chop-marked specimens in Grima. Butchering duikers with metal tools, most clearly represented by the small blue duiker, appears to be a fundamentally different process than butchering larger game. As a result of these different processes, it is possible that processing intensity simply is not reflected by blade-produced marks among animals of this size. Analysis of bone fragmentation patterns, the subject of the following section, may be more promising.

Processing Intensity and Bone Fragmentation

“If each skeletal element is regarded as a patch, then the MVT [marginal value theorem] predicts that more time will be spent extracting resources, such as within-bone nutrients, from skeletal elements as foraging efficiency declines.”

Nagaoka 2006:1476

The previous sections examined cut and chop mark patterning in the Grima and Ndele duiker collections, revealing inter-village consistency in blade marks that did not support the predicted pattern of intensification-related processing. If there is a relationship between resource intensification and processing intensity in Grima, it is not accompanied by a proportional increase in cut or chop marks.

This section explores bone fragmentation; another class of butchery damage that has been archaeologically linked to resource depression, intensification, and processing intensity. As introduced in the previous chapter, one methodological limitation of evaluating chops and fractures as distinct damage types is that both are carcass reduction techniques; both may be used to separate shares of meat and both may provide access to marrow and grease. Gifford-Gonzalez suggests that this fact, “requires that chop marks and fracture patterns sometimes be considered together to allow a fuller understanding of carcass processing...” (1989:201). Chopping among the Bofi and Aka achieves many of

the same results that hand fracturing or hammerstone percussion would among forager groups without access to metal implements. In light of these considerations, this section begins by evaluating the frequency of fractured duiker bones in Grima and Ndele, but the majority of analyses focus on the specifics of duiker bone breakage, regardless of the process that produced the breakage. Results suggest that both the extent and intensity of fragmentation vary between the Grima and Ndele assemblages in informative ways. As emphasized in previous chapters, meaningful interpretation of this patterning benefits greatly from an understanding of the context in which the faunal assemblages were produced.

During taphonomic analysis of these collections, any bone breakage not unambiguously attributable to chopping was recorded as fracturing. Here, the term *fragmentation* is applied broadly to bone elements that have been subdivided by fracturing and/or chopping. Lyman (2008:250-251) distinguishes between extent of fragmentation and intensity of fragmentation. *Extent* of fragmentation refers to the percentage of incomplete specimens in an assemblage, regardless of the number of actual fragments produced since a complete element may become “incomplete” by being chopped in half or by being smashed into splinters. The *intensity* of fragmentation gauges the number of fragments created relative to the number of complete elements necessary to produce them.

Bone fragmentation is a frequently-cited zooarchaeological measure of processing intensity (Broughton 1999; Burger et al. 2005; Grayson and Delpeche 2003; Munro 2004; Munro and Bar-Oz 2005; Nagaoka 2005, 2006; Outram 2001; Quirt-Booth and Cruz-Urbe 1997; Todd and Rapson 1988; Wolverton 2002). Broughton (1999)

examines temporal changes in marrow and grease exploitation by comparing the ratio of artiodactyl and sea otter long bone shafts to long bone articular ends between different archaeological strata. He predicts that the shaft/end ratio will increase as long bones are increasingly broken to access marrow, but ultimately decline as articular ends are smashed during grease extraction. Small sample sizes in Broughton's lowest strata preclude conclusions about the first prediction, but his data support a significant decrease in the shaft/end ratio across the six uppermost strata. Broughton concludes that, if shaft/end ratios are a valid measure of grease extraction, then "these data are consistent with the hypothesis that overall declines in the efficiency of resource use occurred throughout the period of site residence at Emeryville" (1999:63). Marshall (1986) makes a similar argument, suggesting that intensive fragmentation of bovid limb bones ends at the Neolithic site of Ngamuriak "may have been an attempt to get the additional nutrients made available by boiling" (1986:669).

Comparable to Broughton (1999) and the present analysis, Grayson and Delpeche (2003) utilize taxonomic representation, cut mark frequency and location, and bone fragmentation to identify change in ungulate utilization across the Middle-to-Upper Paleolithic transition at Grotte XVI along the Dordogne River in France. Like Broughton, Grayson and Delpeche (2003:1642) calculate diaphysis/epiphysis (shaft/end) ratios, with the expectation that increased intensity of marrow utilization will result in higher ratios. Their results argue for consistency in ungulate utilization as taxa, cut mark frequency and location, and bone fragmentation do not vary significantly across the archaeological strata that represent the Middle-to-Upper Paleolithic transition (Grayson and Delpeche 2003:1644-1645).

Munro states that fragmentation analyses, including bone survivorship, fragmentation rates, and impact damage, allow zooarchaeologists to “assess how intensively humans extracted energy from their prey” (2004:S8). The results of Munro’s (2004) extent of fragmentation (measured by percentages of complete elements) and intensity of fragmentation (measured by NISP:MNE ratios) analyses indicate consistently intensive processing of gazelle (*Gazella gazella*) carcasses across the Natufian period in the southern Levant. The analyses of Grayson and Delpeche (2003) and Munro (2004; Munro and Bar-Oz 2005) demonstrate that fragmentation-based intensity analyses can reveal stability in processing strategies across vast temporal periods.

Zooarchaeological studies have explored spatial variation in processing intensity in addition to temporal change. Quirt-Booth and Cruz-Urbe (1997) compare archaeological leporid remains from the Sinagua culture of northern Arizona to other prehistoric fauna from the Great Basin and Southwest United States. Their results indicate that rabbit bones from Sinagua sites are consistently more complete, or minimally-broken, than the regional norm. Whereas, numerous shaft fragments and long bone cylinders are common in human-produced leporid assemblages from these regions, the Sinagua bones are frequently intact or simply broken mid-shaft. Quirt-Booth and Cruz-Urbe present this aberrant patterning (in the form of NISP:MNI ratios for specific elements) to support their conclusion that Sinagua leporids were less intensively processed and the Sinagua did not “suffer from extreme dietary stress” (1997:945).

In a comparable study of moa (*Dinornithiformes*) bones from New Zealand archaeological sites, Nagaoka (2005) conclusively linked declining foraging efficiency and reduced moa abundance with a significant increase in the extent of fragmentation

among low-marrow phalanges. Her results for intensity of fragmentation and grease extraction were less straightforward, though possibly indicating an intensification-based increase in grease utilization. Nagaoka's (2005) emphasis on low utility anatomical elements as the best place to seek evidence of intensification is well-grounded in foraging theory (e.g., Broughton 1999; Burger et al. 2005). In his study of small fauna (1991a) Yellen did not emphasize element utility, but he did address the role of prey size and marrow content in !Kung processing:

Depending on the age of the animal, different long bones may be either broken or discarded intact. !Kung informants state that bones from immature individuals contain little marrow and therefore often undergo no further processing...A point is reached where potential reward no longer justifies effort and informants consistently state that some bones – the springhare humerus for example – don't contain enough marrow to make extraction worthwhile (Yellen 1991a:13, 18).

Yellen's observations are consistent with the "giving up time" predicted by the marginal value theorem (Charnov 1976; Krebs et al. 1974). However, Gould (1996) provides an archaeological exception to this generalized relationship between processing intensity and bone fragmentation by demonstrating that bone reduction is not a function of meat stress in the context of two rockshelters in the western desert of Australia. Among sea mammals, Otariid seal data (Nagaoka 2006) indicate no significant increase in extent or intensity of fragmentation, a result Nagaoka suggests may be related to seal blubber, an alternate form of fat not available in most terrestrial mammals.

Fragmentation and Processing Intensity Analyses

A number of interrelated processes, including the pursuit of meat, internal organs, marrow, grease, and food sharing can produce variation in bone fragmentation. The hypothesis tested here is that intensification of these processes in Grima, relative to Ndele, should result in higher overall percentages of fractured bone in the Grima

assemblage. Figure 7.13 illustrates the proportion of medium and blue duiker specimens that display evidence of fracturing in each village.

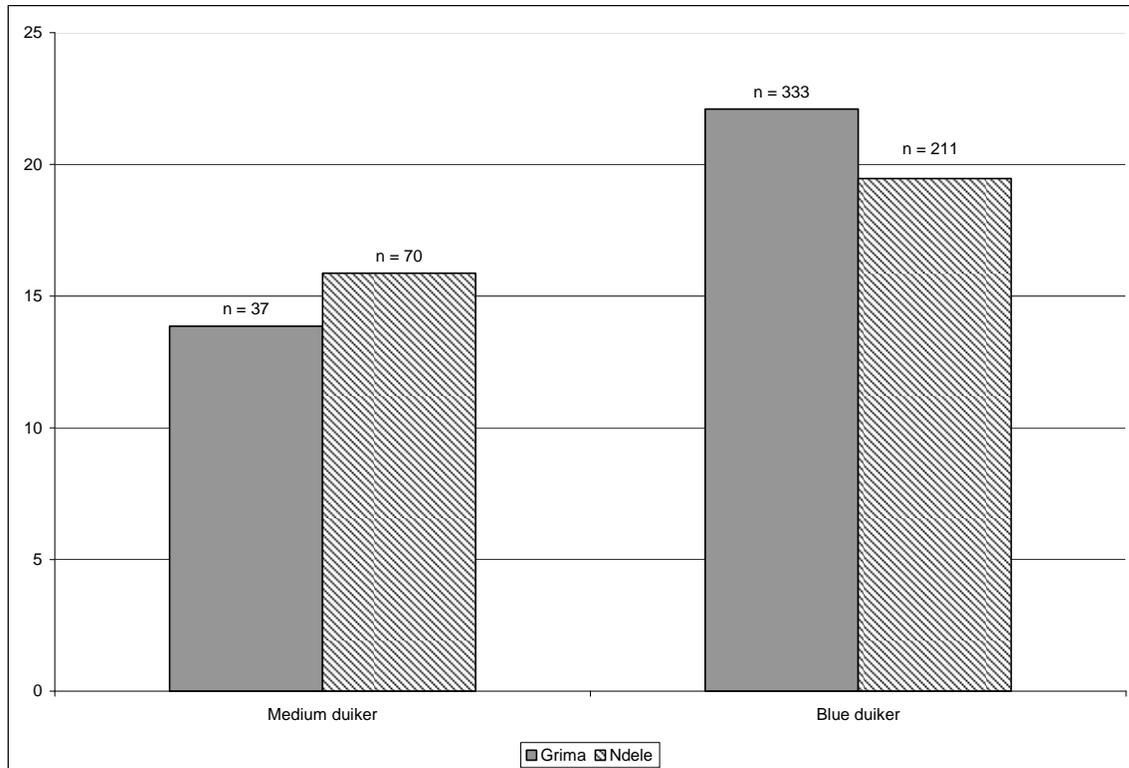


Figure 7.13. Percentage of medium duiker and blue duiker NISP exhibiting fractures in the Grima and Ndele assemblages (Total sample = 3299 specimens).

Contrary to predictions, the percentage of fractured medium duiker ($\chi^2 = .527$; $df = 1$; $p = .468$) and blue duiker ($\chi^2 = 2.633$; $df = 1$; $p = .105$) bones do not vary significantly between villages. A greater proportion of medium duiker specimens are fractured in Ndele than Grima, a reversal of the predicted pattern. Among blue duikers, fractured specimens represent a greater proportion of the Grima assemblage than the Ndele assemblage by a statistically non-significant margin.

Extent of Fragmentation

There are numerous methods for measuring the extent of fragmentation of zooarchaeological collections. Two common methods, cited previously, are diaphysis/epiphysis ratios and the ratio of complete to incomplete specimens. The ratio of complete to incomplete specimens is most applicable in this context since, as will be apparent below, duiker shaft fragments (unattached to epiphyses) are exceedingly rare. As shown in the previous chapter, complete limb bones are also rare in the Central African assemblage and the percentage of broken limb bone shafts varies significantly with prey size. In most cases, and especially among duiker species, these elements were subdivided by chopping, fracturing, or both.

Despite not being limb bones, duiker mandibles contain an easily accessible marrow cavity and are included in this analysis. As with fragmentation analyses in Chapter 6, unfused epiphyses are excluded and mandibles broken through the ascending ramus (thus, not breaching the marrow cavity) are not tallied as “marrow broken” specimens. Given the very small sample size for medium duiker limb elements and mandibles ($n =$ only 1 or 2 in multiple cases), the following analyses focus on blue duikers, for which larger samples exist. Comparison of these marrow-bearing blue duiker elements reveals some interesting patterns (Table 7.8).

Table 7.8. Extent of fragmentation for selected blue duiker elements.

Element	Grima NISP	Ndele NISP	Grima % Incomplete	Ndele % Incomplete
Mandible	57	81	14.04	8.64
<i>Humerus</i>	45	33	71.11	93.94
Radius	32	24	68.75	50.00
Metacarpal	17	3	58.82	66.67
Femur	39	54	92.31	94.44
Tibia	69	24	89.86	91.67
<i>Metatarsal</i>	31	10	64.52	20.00

Contrary to expectations, Ndele actually has a greater proportion of incomplete specimens for four of the selected elements: humeri, metacarpals, femora, and tibiae. Of these elements, only the humerus represents a statistically significant difference in the proportion of broken specimens between villages ($\chi^2 = 6.388$; $df = 1$; $p < .05$). The small sample size of blue duiker metacarpals in the Ndele assemblage (two of three were broken) severely limits any conclusions about this element. In the Grima assemblage, mandibles, radii, and metatarsals were more often incomplete than in Ndele, and the difference for metatarsals was significant ($\chi^2 = 6.026$; $df = 1$; $p < .05$). Thus, patterning does not demonstrate consistently higher rates of marrow-breakage in the Grima assemblage. These mixed results preclude straightforward interpretation, but the emerging pattern suggests a possible relationship between marrow-utility and extent of fragmentation.

Precise quantitative data on blue duiker marrow content are unavailable, but if these elements are divided into generalized categories based on the volume of their marrow cavities, the role of marrow utility becomes clearer. The term “high marrow” is used in this analysis to refer to bones with relatively large amounts of marrow and “low marrow” to refer to long bones with relatively small amounts of marrow. Both

categorizations are estimates based on the relative marrow cavity size of individual elements.

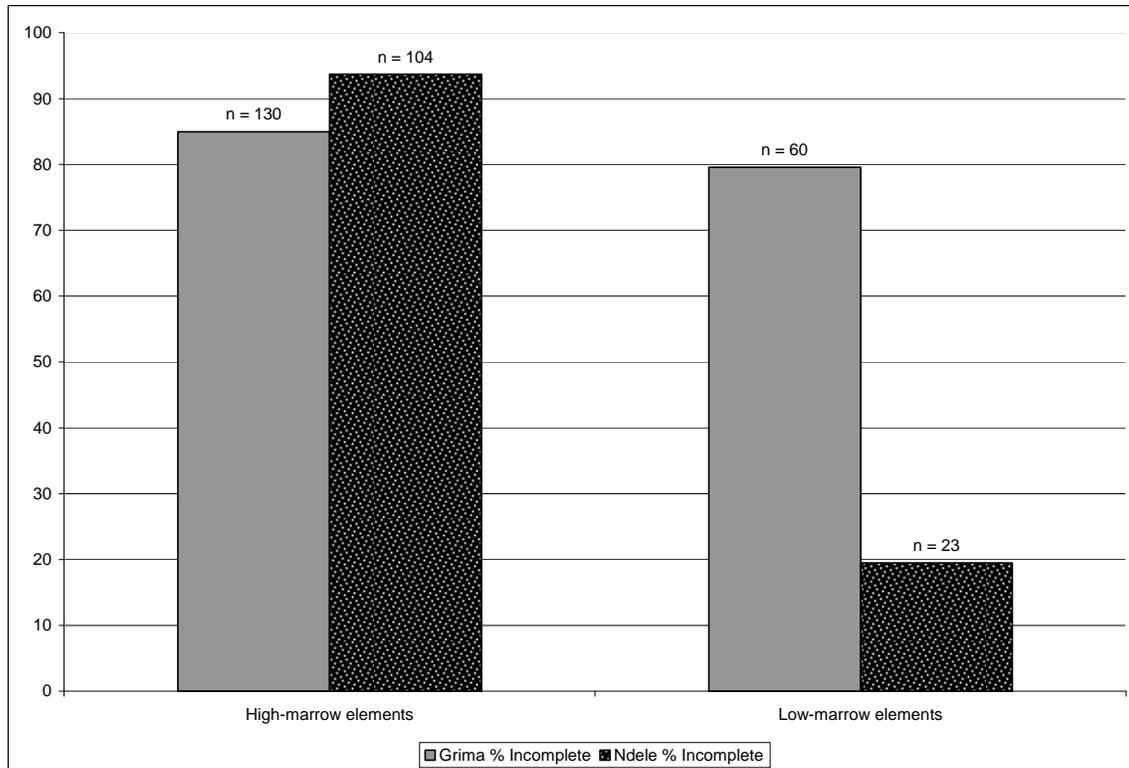


Figure 7.14. Extent of fragmentation for “high” and “low” marrow blue duiker elements (Total sample = 519 specimens).

Combined, humeri, femora, and tibiae are broken in similar percentages, and this result is largely attributable to humeri. If differences in marrow-processing intensity exist between Grima and Ndele, they are not visible among these high-marrow elements. The low marrow mandibles, radii, and metapodia result in a substantial difference in favor of Grima (Figure 7.14). In other words, with the exception of metacarpals (n =3), long bones with relatively low marrow content are much more likely to be broken in Grima than Ndele. Contrary to blade-produced damage types, there does appear to be a relationship between element utility, in this case marrow content, and fragmentation. As

will be discussed below, bones can be broken in different ways and for different purposes, but this result suggests a greater investment in processing and consumption by the foragers of Grima.

Intensity of Fragmentation

Among larger ungulates, it has been argued that intensity of fragmentation, the number and size of bone fragments, is an indicator of processing intensity, since intensive grease processing can result in more and smaller fragments. One method of measuring the intensity of bone fragmentation is to compare the number of identified specimens to the minimum number of elements, referred to as NISP:MNE ratios (e.g., Lyman 2008; Outram 2001; Wolverton 2002). A higher ratio indicates greater fragmentation intensity. It is important to note again that these specimens have not been subjected to myriad post-depositional processes, which would undoubtedly increase fragmentation an unknown degree. Therefore, the Grima and Ndele ethnoarchaeological assemblages may be compared to each other, but not to archaeological fauna with more complex taphonomic histories.

Table 7.9. Comparison of NISP:MNE ratios for selected blue duiker elements

Element	Grima NISP^a	Grima MNE^b	Ndele NISP	Ndele MNE	Grima NISP:MNE	Ndele NISP:MNE
Mandible	34	28	39	33	1.21	1.18
Humerus	33	27	30	21	1.22	1.43
Radius	23	17	12	12	1.35	1.00
Metacarpal	11	7	1	1	1.57	1.00
Femur	37	18	52	26	2.06	2.00
Tibia	62	23	22	15	2.70	1.47
Metatarsal	20	12	2	2	1.67	1.00
TOTAL	220	132	158	110	1.67	1.44

^aComplete elements and unfused epiphyses are excluded from Grima and Ndele NISP in this table.

^bComplete elements are excluded from Grima and Ndele MNE in this table.

NISP:MNE ratios for the same elements examined in the extent of fragmentation section indicate greater fragmentation intensity among all Grima elements, with the exception of humeri. The ratios for the remaining elements are higher in Grima than in Ndele, by varying margins. The difference is discernible among most limb elements, if not overwhelming, with the biggest difference occurring among the tibiae, followed by metatarsals and metacarpals. Based on models developed for larger taxa, this patterning would suggest greater processing intensity in Grima than Ndele. However, even the highest ratios in the assemblage do not reflect highly intensive fragmentation or grease rendering. Lyman writes: “A ratio of 2:1 suggests elements were basically broken in half; a ratio of 15:1 suggests elements were almost pulverized” (2008:252). Only two elements, femora in both villages and tibiae in Grima, exceed this 2:1 ratio, and none even approaches pulverization. Among large artiodactyls in certain contexts, NISP:MNE ratios are used to infer grease rendering, resource depression and intensification, and seasonality. To apply the same logic to a 3.5-9.0 kg artiodactyl would underestimate the significance of prey size and other context-specific variables observed among forest foragers.

Discussion: Evaluating Processing Intensity with Fragmentation Data

Of the two measures used here, I argue that the extent of fragmentation is more relevant to evaluating processing intensity, and provides more informative results, than intensity of fragmentation. In the study of bone fragmentation, as opposed to blade-produced marks, the logic of anatomical element utility applies to blue duikers in the same sense that it does to large artiodactyls. The difference is simply one of scale. Regardless of the artiodactyl in question, a metapodial represents less meat, marrow, and

grease than a femur. The relationship between blue duiker availability and metapodial breakage is not perfect; foragers in Grima do not *always* fracture low marrow elements and foragers in Ndele do not *always* discard them intact, but there is a notable difference in the frequency of incomplete specimens between the villages that is suggestive of different extraction strategies.

The variation in intensity of fragmentation between the two villages could also be a result of processing decisions, but does not demonstrate variability in grease processing, as inferred in some zooarchaeological contexts. Field observations show that grease extraction is minimal among the Bofi and Aka, which can be explained by the anatomy of blue duikers and the environment in which they live. Many studies of marrow and grease usage have been conducted in northern latitudes, where artiodactyls seasonally store large amounts of fat (e.g., Binford 1978). Tropical artiodactyls, such as the blue duiker, show little if any seasonal fluctuation in fat content and duiker meat is consistently very lean (Hart and Hart 1986:46). While marrow and grease extraction would be one means of compensating for this, the nutritive gain provided by duiker marrow is not directly comparable to that of a bison, moose, or other large artiodactyl. The amount of marrow yielded by blue duikers is tiny in comparison to these taxa. Moreover, as discussed in the third chapter, blue duikers do not represent the only source of fat utilized by forest foragers. Admittedly, the single-species focus of this fragmentation analysis simplifies the true complexity of the Bofi and Aka diet.

As emphasized in the previous chapter, several authors have explored the impact of cooking method on faunal assemblages, especially when making analogies between contemporary and prehistoric foragers (e.g., Gifford-Gonzalez 1989; Jones 1993; Kent

1993; Speth 2000; Yellen 1977). The fact that the foragers of Grima and Ndele boil most of their meat has greatly influenced the taphonomic characteristics of these duiker assemblages. The necessity of pot-sizing duiker portions surely results in greater carcass reduction than if meat were routinely roasted, but, considering prey size, the effects of pot-sizing should be much less pronounced among duikers than larger artiodactyls.



Figure 7.15. Humeri of blue duiker (*Cephalophus monticola*), black-tailed deer (*Odocoileus hemionus*), and bison (*Bison bison*).

Despite being anatomically similar, the process of pot-sizing the blue duiker humerus on the left of Figure 7.15 is substantively different than pot-sizing the deer humerus in the middle or the bison humerus on the right, and should result in very different fragmentation patterns. Most relevant to the present analysis, the boiling of

duiker meat is a relative constant between Grima and Ndele. Significant differences in cooking method (boiling vs. roasting) in either village could introduce variation since boiled bones are more highly fragmented than roasted bones in some contexts (Speth 2000; but see Kent 1993).

Marrow consumption, as measured by percentages of broken limb bones, is a simple means of gaining access to fat-rich calories, especially considering the use of boiling pots to cook most duiker meat. Once a bone is broken, its marrow is released into the broth, but the extensive smashing of bone fragments to render grease is unnecessary. Beyond a certain point, there is little to be gained by the continued smashing of bones, especially with a duiker-sized animal. Recent experimental research by Church and Lyman (2003; also see Pickering and Egeland 2006) demonstrates that, even among larger white-tailed deer (*Odocoileus virginianus*), the efficiency of grease extraction does not increase significantly by creating smaller bone fragments prior to boiling. Although, as measured by NISP:MNE, duiker limb bones are more intensively fragmented in Grima, they are not pulverized. In both village assemblages, there is a notable lack of unidentifiable shaft fragments, and unidentifiable specimens in general – partially as a result of their short taphonomic history. The Bofi and Aka practice of stewing duiker meat on the bone with vegetables is another factor, since it provides adequate access to marrow and grease. The blue duiker limb bones shown in Figure 7.16 are typical of bones in these collections in that they are broken, but not smashed beyond recognition.



Figure 7.16. Representative minimally-broken blue duiker long bones.

Nevertheless, the general pattern of higher NISP:MNE ratios for long bones in Grima is curious. Possible explanations include: 1). Greater fragmentation intensity in this context, among animals of this size, might simply be a function of dividing carcasses into smaller portions to be shared more widely. 2). Something as trivial as different pot sizes may also be involved, though we have no data on the diameter of cooking pots, or reason to expect that pots would be smaller, on average, in one village or the other. 3). Fragmentation might be related in some vague and variable way to the amount of “attention” a carcass portion receives, in other words, the intensity with which it is processed and consumed. Yellen writes: “some fragmentation occurs during consumption and that breakage may reflect more complete picking of the meat off the

bone. Breaking may occur either purposefully to allow access to difficult nooks and crannies or as an unintentional byproduct of consumption” (1991b:175).

Summary and Conclusions

Based on evolutionary models discussed at the beginning of this chapter, relative resource intensification in Grima led me to expect differences in the intensity with which higher-ranking duikers are processed. What form, if any, increased processing intensity would take among duiker-sized mammals is largely unexplored in existing zooarchaeological research. As a result, a series of taphonomic damage patterns developed for larger prey in previous literature were tested: cut marks, chop marks, and the extent and intensity of bone fragmentation.

The frequency of cut marks among medium and blue duikers, regardless of quantification method, was nearly identical for the Grima and Ndele assemblages. Consistent with previous studies of prey size and cut mark frequency, medium duikers exhibited a greater number of cut marks, and greater percentages of cut specimens, than blue duikers in both assemblages. Among medium duiker limb bones, cuts on epiphyseal ends of limb bones (associated with carcass dismemberment) were significantly more abundant than shaft cuts (associated with filleting) in Grima, but not Ndele. Despite no field observations of blue duiker filleting, shaft cut marks exceeded end cuts by a non-significant margin in both villages. These results suggest that cut marks on limb bone shafts do not necessarily reflect the filleting of meat from bone, as posited for large mammals, and analysts should be cautious in attributing mark functions derived from larger species when evaluating duiker-sized prey.

Among larger mammals, cut marks are expected to increase as a result of specific processes such as dismemberment and filleting. Deer, for example, may be dismembered by repeated cutting and hacking at articulation points. Duikers, particularly the small blue duiker, can be dismembered without repeated tool strokes – in many cases, a single machete chop is sufficient to separate duiker body parts. Intensive filleting, the cutting of meat from bone, can result in more cut marks among larger animals. Duiker meat, and again, especially blue duiker meat, is usually cooked on the bone. Considering their size, there is little incentive to expend effort stripping meat from duiker bones. In essence, two butchery processes that may result in greater cut mark frequency among larger mammals are not directly applicable to blue duikers.

Investigation of the role of element utility in duiker processing, measured using Broughton's (1999) low utility artiodactyl elements and Lupo's (2006, personal communication) FUI, demonstrate that utility has little impact on the creation or frequency of cut marks in this context, and there is no significant utility-related variation in cut medium or blue duiker specimens between Grima and Ndele. Overall, the results of all cut mark analyses support the conclusion that there is no patterning that, if encountered in a zooarchaeological assemblage, would suggest a substantial difference in duiker processing intensity between the villages.

In previous ethnoarchaeological taphonomic studies, chop marks have not been sufficiently distinguishable from other forms of bone breakage to warrant separate analyses. Thus, chop-produced marks have not been utilized as a gauge of processing intensity before. Examining chop marks as a distinct damage type reveals virtually no variation in chop frequency between the Grima and Ndele duiker assemblages and a

remarkably standardized butchery sequence regardless of collection location. These results reiterate the conclusion that butchering duikers with metal tools, paired with the pot-boiling of meat, appears to result in fundamentally different taphonomic patterning than that recorded among larger prey in ethnographic and archaeological contexts.

Analysis of fractured duiker bone indicated no significant difference in the proportion of fractured medium or blue duiker specimens between Grima and Ndele. Our observations of forest forager methods of carcass reduction, demonstrate that carcass portions and individual elements may be subdivided by cutting, chopping, hand fracturing, or some combination of these methods. Therefore, the segregation of fracturing as a unique damage type (despite its diagnostic morphological characteristics) is somewhat arbitrary.

In order to view carcass reduction from a more functional perspective, bone fragmentation was quantified, regardless of the process responsible for the fragmentation. Results demonstrate that both the extent and intensity of fragmentation vary between these assemblages in informative, but potentially misleading, ways. Most blue duiker limb bones with relatively high marrow content display comparable proportions of complete and incomplete specimens between villages. Bones with relatively low marrow content, especially metatarsals, are significantly more incomplete in the Grima assemblage. This result supports expectations of increased marrow processing as one reflection of resource intensification. Blue duiker limb bones also indicated greater intensity of fragmentation, as measured by NISP:MNE ratios, in Grima. Increased fragmentation has been proposed as an indicator of grease extraction among mammalian and avifaunal taxa. However, a number of factors, including prey size and environment,

argue against grease rendering in this context. Alternatively, greater intensity of fragmentation, if a result of processing decisions, is likely a product of wider sharing or more intensive carcass reduction.

Of the taphonomic damage types evaluated as potential gauges of processing intensity among duiker-sized animals, bone fragmentation appears to have the most potential to link processing decisions and resulting taphonomic patterning. The assumption that initially prompted this study is that a consumer's effort to extract nutrients from a resource, in this case the meat, marrow, and grease associated with a bone results in more damage to that bone. Although this assumption was not supported by cut and chop mark frequencies, it may be evident in the measures of limb bone fragmentation. Identifying similar butchery patterns in different animals can explain much about general extractive strategies, but we cannot assume that the pattern has the same meaning – *and the same range of related inferences* – in all cases. To reiterate an obvious, but essential point: basic variables such as environment, cooking method, prey anatomy, and prey size all have the potential to greatly affect interpretations and must be considered, especially when we don't have the ethnoarchaeological luxury of complete contextual knowledge.

8. SUMMARY AND CONCLUSIONS

“The scientific investigation of the human past and the ethnographic present has many of the attributes of a theatrical presentation whose theme is the growth of knowledge. But unlike the conventional stage – where action is organized in terms of a plot with a beginning, a middle, and an end – the drama in this metaphorical example is more open-ended and improvisational.”

Binford 2001:44

Ethnoarchaeology and Human Behavioral Ecology

As Binford (2001) suggests, the scientific pursuit of archaeological knowledge is a progressive, ongoing endeavor that often benefits from following unforeseen pathways. In this pursuit, virtually all interpretations of past human behavior rely on the use of analogy. The question, then, is not whether to apply analogical reasoning to archaeological interpretation, but how to apply it in the strongest, most constructive ways possible. The subdiscipline of ethnoarchaeology encompasses a topically and theoretically diverse range of research (see Chapter 1), all of which shares the systematized application of ethnographic analogy: the premise that the material expressions of culture, and behavior, of ethnographically-documented peoples can provide insights applicable to prehistory. These insights gain strength and broader applicability when united by a general theory of behavior, such as human behavioral ecology (HBE).

The greatest strength of HBE is its ability to incorporate diverse environments, temporal periods, and cultures, and constructively explain the interaction between these variables. HBE theory posits that the underlying relationship, or causal mechanism, necessary for the development of strong, relational ethnographic analogies is natural selection. HBE proceeds from the premise that humans, as biological organisms, tend to behave in ways that directly or indirectly maximize reproductive fitness. From this foundation, behavioral ecologists formulate testable hypotheses related to subsistence,

reproduction, and a range of related behavioral questions. The ways that context-specific case studies conform to or diverge from theoretically-derived expectations can be equally informative, enabling the open-ended, improvisational investigations that Binford (2001) envisions.

The Prehistory of African Forest Foragers

This dissertation is an HBE-guided ethnoarchaeological case study of small prey hunting and processing by contemporary African forest foragers. Research was conducted among Bofi and Aka foragers in the villages of Grima and Ndele, both located in the Ngotto Forest of the Lobaye region of the southwestern Central African Republic. Ideally, archaeological research documents and explains human behavior in well-understood temporal and spatial contexts, and it is equally important to understand the environmental context and history of forest foragers for the purposes of this ethnoarchaeological study (see Chapters 2 and 3).

The late Quaternary paleoenvironmental record of the Congo Basin (Chapter 2 summarizes the last 70,000 years) reflects a complex ecological history marked by cycles of rain forest and savanna expansion and contraction. Mercader (2002:117) explains that the Guineo-Congolian Forest did not reach its current geographical distribution, morphology, structure, and tree species composition until the late Holocene. These climatic and vegetational shifts undoubtedly influenced the use of forest and savanna resources by human foragers through the late Pleistocene and Holocene, but the environmental record of West and Central Africa is still relatively coarse and locally variable. Despite being increasingly revealed by paleoenvironmental and archaeological

studies, questions about the nature and length of human occupation of Central African rain forests remain unanswered.

The subsistence challenges observed among modern tropical foragers, mainly access to non-domesticated sources of carbohydrates and fats, led some scholars (e.g., Bailey et al. 1989) to question whether independent rain forest foraging was a viable strategy prior to the arrival of farming populations in the world's forested regions. The fact that all ethnographically documented African forest forager groups (see Chapter 3) maintain economic and social relationships with farmers reinforced this view, particularly since forest foragers acquire a substantial proportion of their caloric intake from cultivated sources (Hewlett 1996a).

For decades, the scarcity of archaeological evidence, owing largely to a lack of research and well-stratified archaeological sites, established the misconception that African rain forests were uninhabited and/or anthropologically uninteresting in the distant past. However, in recent years, a growing consensus of archaeological evidence (e.g., Mercader 2003a) supports the interpretation that humans (and possibly earlier hominids) occupied Central African rain forests millennia before the advent of food production. These archaeological findings suggest that cultivated calories efficiently supplement, but are not necessary for, subsistence systems based on rain forest foraging. Thus, the lifeways of modern forest foragers, including economic interactions with farmers, are probably a relatively recent development. Nevertheless, they represent a continuation of a long history of flexible and adaptive subsistence strategies, amenable to further study with HBE-derived models of optimal foraging.

Contemporary Forest Foragers

Bofi and Aka foragers belong to the larger grouping referred to as Western Pygmies of Cameroon, Congo, and CAR. This group is genetically, culturally, and linguistically distinct from the Eastern Pygmies of DRC (Bahuchet 1993; Cavalli-Sforza 1986; Hewlett 1996a; Murdock 1959). Hewlett emphasizes the variability between individual forest forager groups and cautions against referring to “African ‘pygmy’ culture” (1996a:243-244). As a result, although the Bofi and Aka are both forest foragers of the western Congo Basin, they are discussed as distinct ethnolinguistic groups. Anthropological research has been conducted among the Bofi, but they have not been studied to the extent of better-known groups such as the Mbuti, Efe, or Aka. Despite sometimes being lumped together with Bantu-speaking Aka foragers, the Bofi speak an Oubanguian language. Ethnic, cultural, and material culture similarities between the Bofi and Aka may be explained by the recent origin of Bofi foragers and their ancestral relationship with the Aka (Hewlett 1996b).

The mobility and settlement of contemporary and recent forest foragers are heavily influenced by economic, logistical, and social concerns, primarily their relationship with farming populations. The economic aspect of these relationships centers on the procurement of forest products by foragers and the Bofi and Aka employ a variety of hunting methods and techniques to acquire animal prey. They rely on a range of cooperative and individual hunting techniques, the use of which varies according to many interrelated variables, including: seasonal considerations, number of participants, targeted prey, method efficiency, proximity to farming populations, market involvement, and possibly the foraging goals of individual men, women, and children (see Chapter 3).

Predominant forms of communal hunting among the Aka and Bofi are net hunts and spear hunts, both of which may occur simultaneously, given a sufficiently large hunting party. The technique of Central African net hunting has been well-covered in previous literature (Harako 1976; Hart 1978; Noss 1997; Takeuchi 1995b; Tanno 1976; Turnbull 1965). The small blue duiker is the species most commonly taken in nets. Small groups of male spear hunters, using iron-tipped spears, generally target porcupines or larger prey that are not easily taken in nets, such as medium and large-sized duikers and river hogs. Individual (1-3 people) hunting techniques used by the Aka and Bofi include hand capture, trapping, and bow hunting (Bahuchet 1985; Kitanishi 1995; Lupo and Schmitt 2005). Lupo and Schmitt (2004) describe the technique of hand-capturing animals, using dogs and fire to flush small prey such as monitor lizards, pangolins, and tortoises from dense vegetation and giant pouched rats and Murid rodents from underground burrows.

Prey Processing

Once prey are acquired, the processes of field butchery, meat sharing, food preparation and cooking, and consumption affect the eventual taphonomic characteristics of bone specimens (Chapter 3). Bofi and Aka process animal carcasses in the field prior to transport back to camp. Butchery is conducted with an iron knife and/or machete. If the animal was procured in a net, it is usually carried by a female relative of the hunter until near the end of the hunt, at which point it is processed by a male relative (or female relative among the Aka) of the owner of the net in which it was captured. In some cases, if no one is nearby, hunters will occasionally butcher their own carcasses and prey captured using individual hunting methods may be processed immediately after capture, rather than at the end of the hunt.

An understanding of meat sharing, directly observable in ethnographic contexts, contributes to zooarchaeological analysis because sharing behavior affects butchery processes and resulting taphonomic damage patterns. Among the Bofi and Aka, post-acquisition meat sharing is divided into three levels. The first level entails the field distribution of meat portions introduced in the preceding section. Second level sharing occurs when meat units acquired in the forest are further subdivided and redistributed upon returning to camp. Additional, third level, sharing may occur when individuals join families at their fires for meal time, a practice referred to as meal sharing. During meal sharing, meat and vegetable stews are shared with multiple households (Bahuchet 1990a; Lupo and Schmitt 2004).

The activities of cooking and consumption further alter the characteristics of animal bones. Whether animal segments are boiled or roasted can have a significant impact on rates of burned bone, and studies have demonstrated that cut, chop, and fracture patterning may also vary with cooking method (e.g., Gifford-Gonzalez 1989; Jones 1993; Kent 1993; Lupo 1993; Speth 2000; Yellen 1977b). Thus, an understanding of how forest foragers cook food has important ramifications for the taphonomic analyses of this dissertation. The Bofi and Aka most often prepare meat by boiling it in pots with koko leaves or other vegetables, and less frequently roast meat over an open fire (Schmitt et al. 2001; de Garine and Bahuchet 1990). However, there are exceptions for particular prey and body parts, including tortoises, which are roasted in the shell. The heads of all prey are commonly roasted and portions of meat from particularly large prey may be roasted as well. Brush-tailed porcupines, giant pouched rats, and sometimes monkeys are singed with fire prior to being stewed. Bones are chopped or hand fractured in order to

“pot-size” them before boiling, a process that Hudson (1990:116) considers the guiding principle of the final stage of butchery. Boiling facilitates the exploitation of bone marrow and grease. This preparation method greatly impacts the ways that consumers extract nutritional value from the meat, marrow, and grease associated with a bone portion (Chapters 6 and 7).

The final cultural process that may damage bones prior to discard occurs during consumption, often without the benefit of tools. Research indicates that humans can modify the surface of a bone by relying on their teeth and hands to dismember and consume carcasses (e.g., Binford 1981; Brain 1981; Elkin and Mondini 2001; Jones 1983; Yellen 1991b). Landt (2007) shows that Bofi foragers leave identifiable tooth marks on small mammal bone. Such marks may be created incidentally while chewing meat, muscle attachments, and connective tissues adhering to bone or intentionally in an attempt to access embedded bone grease.

The Archaeology and Taphonomy of Small Prey

Since the beginning of faunal analyses, small fauna have faced a number of theoretical and methodological biases, leading them to receive “short shrift” (Yellen 1991a:1) in zooarchaeological literature. In the context of early hominids, Yellen (1991a:1-2) argues that the desire to understand the behavioral capacity of extinct hominids has contributed to the research emphasis on large mammal hunting, which is presumed to require more technological skill and social coordination than small mammal procurement. However, in other contexts, archaeological explorations of technologically- and socially-sophisticated cooperative small prey hunting provide compelling insights

into the subsistence behavior of modern humans (e.g., Driver 1990; Lupo and Schmitt 2002; Shaffer and Gardner 1995; Stiner et al. 2000).

A related preconception, formalized in HBE-derived optimal foraging models, is that large, high-ranking prey are usually more efficient, and assumed to be more central to hunter-gatherer subsistence. Stahl (1982) challenges this assumption with several attributes of even the smallest rodents and insectivores that make them beneficial to humans: they have small home ranges, tend to be attracted to human settlements, have high reproduction rates, low acquisition and processing costs, and a relatively high edible meat to live weight ratio. To the detriment of zooarchaeologists, in some cases, processing costs are so low because small rodents can be consumed whole, leaving no identifiable bones (Stahl 1982:826). The possibility of complete consumption of bone by domestic dogs, including those kept by African forest foragers (e.g., Hudson 1990, 1993), and the resulting potential for under-representation of small prey bones, is another problem inherent in taphonomic studies of small fauna.

Even when small prey bones survive attritional processes, Stahl (1982) argues that traditional excavation methods are biased against the recovery of the smallest rodents. Excavations employing ¼" screens inadequately recover these bones and their potential for environmental and dietary reconstruction is lost (Shaffer and Sanchez 1994). The work of Shaffer and Sanchez (1994) illustrates the dual use of small animal bones, even those from cultural contexts, as sources of behavioral, but more often, environmental data. Small rodents are ubiquitous and particularly susceptible to subtle variation in climate and vegetation, making them excellent paleoenvironmental indicators (e.g., Grayson 2000; Schmitt 2004). Despite the value of small animals to ecological studies,

Jones (1984:88) worries that their relegation to this “secondary position” in archaeological interpretation diverts attention from their analysis as food resources. In fact, most taphonomic analyses of small mammals have focused on the many ways these bones are modified by non-cultural processes.

Jones (1984) notes a lack of established criteria for distinguishing between cultural and non-cultural small animal bone and the historical reticence to viewing small animal bones as food refuse stems, at least partially, from the difficulty of disentangling subsistence-related small mammal remains from natural deaths and assemblages accumulated by non-human predators (see Chapter 1). But over the last 25 years, this situation has been vastly improved by numerous studies clarifying the taphonomic characteristics of small mammal assemblages produced by non-human agents, particularly raptorial birds, burrowing rodents, and small mammalian carnivores (e.g., Andrews 1990; Andrews and Evans 1983; Cruz-Uribe and Klein 1998; Fernández-Jalvo and Andrews 1992; Fernández-Jalvo et al. 1998; Hockett 1994; Schmitt 1995; Schmitt and Juell 1994; Shaffer 1992b).

A total of 5640 bone specimens representing 11 different taxonomic groupings: river hog, yellow-backed duiker, “medium” duiker (comprised of bay and Peters duikers), civet, blue duiker, guenon monkey, brush-tailed porcupine, tree pangolin, tortoise, giant pouched rat, and Murid rodents, were collected in the villages of Grima and Ndele as part of the Washington State University Central African ethnoarchaeological project (see Chapter 4). These faunal specimens were collected after butchery and consumption, but prior to discard, eliminating post-depositional processes as factors in their taphonomic interpretation. As a result, they provide a unique opportunity to explore forest forager

small animal processing and its consequences. A primary purpose of this study is to describe the taphonomic characteristics of bones from a known cultural context (not impacted by natural processes), and from a generally under-studied size class of small (< 25 kg) mammalian prey (see Chapter 5). These descriptive data provide a comparative dataset for future small mammal taphonomic research.

Prey Size and Taphonomy

Comparative results discussed here (Chapter 6) reiterate that taphonomic patterning is strongly influenced by context-specific variables such as butchery technology, cooking methods, and particularly prey size. Prey carcasses of varying size and structural anatomy provide human consumers with similar sets of potential resources, such as skin, meat, internal organs, bone, marrow, and grease. How consumers make use of these resources, the extent to which they are utilized, the processes employed to gain access to them, and the taphonomic patterns that result vary between different-sized animals. Analyses of bone burning, butchery marks, and bone fragmentation identify informative differences between the Central African ethnoarchaeological fauna and bones from other archaeological, ethnoarchaeological, and experimental contexts.

The skeletal locations and frequency of burn damage to bones is directly related to prey size, butchery patterns, and cooking methods. Bofi and Aka foragers boil most meat while it is still attached to bone, resulting in relatively few burned bone specimens in this assemblage. However, ethnoarchaeological research among Aché and Basarwa hunter-gatherers (Jones 1984; Kent 1993; Nicholson 2005) shows that the bones of small prey can be roasted over fire and still result in very few burned bone specimens. Butchery patterns, specifically whether carcasses are dismembered *before* or *after*

roasting, significantly affect rates of burned bone, since bone portions that are insulated by attached meat are rarely burned. Within the Central African collections, burned bone specimens increase with prey size (see Chapter 6). But differential butchery sequences between prey types appear to be more directly relevant than prey size. Medium and blue duikers are extensively chopped and fractured prior to roasting, creating many exposed bone surfaces with the potential to record burning. Brush-tailed porcupines, giant pouched rats, and Murid rodents are usually exposed to fire as complete carcasses, shielding bone from direct heat and flame. In terms of zooarchaeological analysis, these patterns are consistent with previous ethnoarchaeological research (Jones 1983, 1984; Kent 1993; Nicholson 2005) and suggest that an absence or rarity of burned small prey bone does not necessarily demonstrate that carcasses were not processed using fire.

The relationship between prey size and cut mark frequency and distribution is a basic, yet unresolved, question of mammal taphonomy because answers to this question help clarify how carcass size, anatomy, and other contextual factors affect human processing decisions. This knowledge helps zooarchaeologists avoid making unwarranted behavioral interpretations based on prey that, owing to size or context, may be only weakly analogous to the prey species being studied. The majority of archaeological, ethnoarchaeological, and experimental studies conducted (e.g., Domínguez-Rodrigo and Barba 2005; Jones 1984; Lyman 1992; Marshall 1986; Nicholson 2005; Pobiner and Braun 2005) support a positive relationship between carcass size, and overall cut mark frequency. Results presented here (Chapter 6) reinforce this interpretation, as the proportion of cut-marked specimens varies positively and significantly with prey size. This result was predicted because medium and blue

duikers require more blade-processing than smaller porcupines, pouched rats, and Murid rodents. Prey size likely plays a role in the variety of cut marks associated with specific taxa, but prey size alone is not sufficient to predict cut mark diversity. In contrast to studies of larger artiodactyls (e.g., Binford 1978, 1981), duiker species are skinned and filleted less often, and most identified cut marks are associated with carcass dismemberment and food preparation.

The dominance of dismemberment-related butchery damage in the Central African bone assemblage is strengthened when data on chop marks, all of which serve to subdivide carcasses, are used to complement cut mark data (Chapter 6). Investigating chopping as a distinct form of blade-produced butchery damage is beneficial, especially in contemporary contexts where processing decisions and their taphonomic consequences are fundamentally dictated by the availability of iron knives/machetes and cooking pots (e.g., Hudson 1990; Nicholson 2005). Chopping of bone not only produces diagnostic damage, it may also affect the frequency of other damage types (i.e., burning, cut marks, and fracture patterns), which would likely differ if the expedient chopping of bone and pot boiling of meat were not such efficient and available options. Results of chop mark analyses allow us to determine how modern ethnoarchaeological collections in this context differ from zooarchaeological fauna, and ways prehistoric technology could have served similar functions while producing different taphonomic patterning.

Among Central African small prey, complete chops (i.e., shear faces) are far more common than partial chops (i.e., hack marks) and are usually distinguishable from other types of bone breakage. Chop marks vary significantly with prey size, as medium and blue duiker carcasses are subject to more extensive blade-processing (both cutting and

chopping) than porcupines, pouched rats, and Murid rodents. The prevalence of complete chops through duiker bones demonstrates the ease with which animals of this size are subdivided by chopping with metal implements during the processes of field butchery, meat sharing, and food preparation. As part of an analysis of Hadza-produced large mammal bone assemblages, Lupo (1993) argues that zooarchaeological patterning combining low frequencies of burned bone and high frequencies of chops could be used to identify boiling as a meat preparation technique. Results of the present study show that all three conditions (infrequent burn damage, frequent chops, and boiling as the primary cooking method) co-occur among Central African forest foragers, but with much smaller prey than those investigated in the Hadza context. Chopping of bone, combined with pot-boiling of meat, serves the same basic functions for forest foragers that Yellen (1991a) observed during !Kung San small prey butchery: the creation of distributable meat portions, reducing portions to pot-size, and breaching marrow cavities to release marrow into a broth. Therefore, the behavioral interpretation of burn and chop taphonomic patterning proposed by Lupo (1993) could be applicable to a broader size-range of animal prey.

Archaeologically, the location and morphology of bone fractures are used to distinguish between cultural and non-cultural accumulations of bone, and to infer a wide range of human subsistence behaviors (Chapter 6). In Central African bone assemblages, fracturing is the only recorded form of taphonomic damage that does not increase with prey size. Chopping by Bofi and Aka foragers accomplishes the same functions (carcass dismemberment and marrow access) that hand fracturing and/or hammerstone percussion would among butchers without access to metal knives or machetes. Thus, in pre-iron

zooarchaeological assemblages, chopping and bone fracturing may not be as morphologically distinct as they are in these ethnoarchaeological collections. One way to account for these overlapping functions is to examine chopping and fracturing together as bone fragmentation.

The characteristics of bone breakage among Central African small prey differ from other ethnoarchaeological contexts. Whereas large artiodactyl limb bones are commonly marrow-processed with methods that produce many non-diagnostic shaft fragments (e.g., Binford 1981; Gifford-Gonzalez 1989), smaller prey marrow processing has been linked to long bone shaft cylinders in ethnoarchaeological (Jones 1984; Nicholson 2005) and archaeological contexts (Hockett 1994; Schmitt et al. 2004). Forest forager-processed limb bones (particularly blue duikers) are most often chopped mid-shaft, creating *neither* unidentifiable shaft fragments or long bone shaft cylinders. This processing pattern maximizes nutritional gain with minimal processing effort, and may be common in archaeological contexts where small prey, metal tools, and cooking pots (and sufficient water for boiling) occur together.

Small Prey Processing Intensity

Considering the size-related variability in prey processing observed in published ethnoarchaeological studies, it becomes apparent that taphonomic expectations derived from large mammal studies are not directly applicable to the small prey acquired by Bofi and Aka foragers. In particular, methods for measuring processing intensity among small-sized prey have not been established, leaving zooarchaeologists few options but to rely on larger prey as potentially weak analogues. Research presented here (Chapter 7) formulates an evolutionary model of small prey processing intensity and applies it to the

zooarchaeological and taphonomic identification of resource intensification in forest forager-produced faunal assemblages.

Resource depression and subsequent resource intensification in archaeological contexts are identified by spatial or, more often, temporal, changes in prey diversity or richness (e.g., Broughton 1999; Butler 2001; Cannon 2000; Nagaoka 2001). From the perspective of foraging theory, it follows that resource intensification is marked by increased reliance on smaller, less-calorically efficient taxa. This prediction is tested here (Chapter 7) by comparing the taxonomic composition of the Grima and Ndele bone assemblages, as measured by richness and evenness. Since relatively high-ranking medium and blue duikers are encountered less frequently in the vicinity of Grima than Ndele, I expect Grima bone assemblages to reflect greater taxonomic diversity, and a greater proportion of smaller prey, when compared to Ndele fauna. Measures of taxonomic richness and evenness, paired with a duiker abundance index, reinforce the difference between Grima and Ndele and are consistent with a relative depression and intensified use of animal resources in Grima. Based on previous foraging theory-based zooarchaeological analyses (e.g., Broughton 1999), these results suggest the possibility of differential prey processing intensity between the village contexts of Grima and Ndele.

The particular taphonomic characteristics of increased processing intensity among duiker-sized mammals are largely unexplored in the existing zooarchaeological literature. To further explore the linkage between processing intensity and taphonomic damage patterns in this context, I test a series of damage patterns developed for larger prey including cut marks, chop marks, and the extent and intensity of bone fragmentation. Results indicate that cut mark frequency, regardless of quantification method, did not

vary significantly between Grima and Ndele duiker specimens. Consistent with earlier ethnoarchaeological studies of prey size and cut mark frequency (see Chapter 6), medium duiker bones exhibited a greater percentage of cut-marked specimens, and a greater number of distinct cut marks, than smaller blue duikers in both Grima and Ndele. Despite rarely observing the filleting of blue duiker meat from bone in the field, marks in anatomical locations typically associated with filleting outnumbered those associated with dismemberment in both villages. This result suggests that cut marks on limb bone shafts do not necessarily reflect filleting, as commonly stated for larger mammals. Thus, zooarchaeologists should be cautious in attributing mark functions derived from larger species when analyzing duiker-sized prey.

Among large artiodactyls, cut marks are expected to reflect specific butchery processes such as dismemberment, skinning, and filleting. For example, caribou may be dismembered by repeated cutting and hacking at articulation points (Binford 1981). In contrast, small blue duikers can be dismembered without repeated tool strokes; in most cases, a single chop from an iron blade is sufficient to separate duiker body parts. Intensive filleting can increase cut mark frequency among larger animals. Duiker meat is usually cooked on the bone. Considering the small size of the blue duiker, there is little economic incentive to increase handling time by cutting meat from their bones. Ethnoarchaeological field observations, and taphonomic analysis, indicate that two butchery processes theoretically linked to cut mark frequency, particularly filleting (e.g., Binford 1988), are not applicable to blue duikers. Further, results of statistical analyses (Chapter 7) demonstrate that meat utility has little impact on the distribution of cut marks in this context, and there is no significant utility-dependent variation in cut medium or

blue duiker specimens between Grima and Ndele. The combined results of all cut mark analyses support the conclusion that there is no patterning that indicates a notable difference in duiker processing intensity between the villages. If there are differences in duiker processing intensity between Grima and Ndele, they are not reflected by the attributes of cut marks examined here.

To my knowledge, chop marks have not been explored as a measure of processing intensity in previous ethnoarchaeological or archaeological studies. Analysis of chop marks as a separate damage type reveals virtually no variation in chop frequency between the Grima and Ndele duiker assemblages (Chapter 7). The similarity of patterning suggests a remarkably standardized butchery sequence regardless of collection location. This result reiterates the conclusion that processing duiker carcasses with iron tools, paired with boiling as a cooking method, results in fundamentally different taphonomic patterning than that recorded for larger prey in other ethnoarchaeological contexts.

Comparison of fractured medium and blue duiker specimens (Chapter 7) shows no significant difference in the proportion of fractured (bone breakage not attributable to chopping) specimens between Grima and Ndele. To examine carcass reduction from a more functional perspective, I quantified bone fragmentation (bone breakage produced by chopping and/or hand fracturing). Results demonstrate that the extent and intensity of fragmentation vary between the Grima and Ndele collections in the predicted ways. But viewing the fragmentation data without reference to their specific contextual setting could lead to misinterpretation of these results. Most blue duiker limb bones with relatively high marrow content display similar percentages of complete to incomplete specimens (extent of fragmentation) between villages. Bones with relatively low marrow

content are more frequently incomplete in the Grima assemblage. This result is consistent with expectations that increased marrow processing, especially of low utility skeletal parts, is one reflection of resource intensification. Blue duiker limb bones also indicated greater intensity of fragmentation (as measured by NISP:MNE ratios) in Grima. Increased fragmentation intensity has been employed as a measure of grease extraction among mammalian and avifaunal taxa. But several factors, including prey size and environment, argue against grease rendering in the context of Central Africa. If this observed pattern of differential fragmentation intensity is related to processing decisions, it is likely a product of wider sharing or more intensive duiker carcass reduction.

The hypothesis that prompted this study is that increased processing effort (i.e., handling time) to extract nutrients from a resource, in this case the meat, marrow, and grease associated with a bone, results in more damage to that bone. This expectation was not supported by cut and chop mark patterning, but may be evident in attributes of bone fragmentation. Results of this analysis suggest that, of the conventional methods used to assess processing intensity, patterns of bone fragmentation have the greatest potential to link dynamic processing decisions to static taphonomic patterning in zooarchaeological assemblages of small prey, and could be a productive avenue of future research.

Ethnoarchaeological analysis of small prey bone assemblages produced by contemporary African forest foragers shows that identifying similar butchery patterns, and related taphonomic patterning, in the archaeological record can clarify much about general extractive strategies and resource optimization. But we cannot assume that patterns have the same meaning in all cases, particularly when drawing analogies between different-sized animal prey. To reiterate an essential point, archaeologically-

identifiable variables such as ecological context, technology, cooking methods, prey anatomy, and prey size all impact zooarchaeological interpretations. These variables should not be underestimated, especially in the course of archaeological research, when we don't have the ethnoarchaeological benefits of direct behavioral observations and thorough knowledge of context. To paraphrase Binford (2001), the theme of ethnoarchaeological research is the growth of knowledge about the human past, but the contextual variability it reveals sustains archaeological inquiry as an open-ended endeavor.

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APPENDIX A: CUT AND CHOP CODE DESCRIPTIONS AND ILLUSTRATIONS

Faunal Coding System (Gifford and Crader 1977)Body Part

CRA	Cranial indet. or cranium complete	DENT	Dentary with teeth
BCS	Braincase	ANG	Angle or angular
PMX	Premaxilla	SAN	Surangular
PMXT	Premaxilla with teeth	RAM	Ramus
MAX	Maxilla	CRN	Coronoid process
MAXT	Maxilla with teeth	ART	Articular condyle or articular
PAL	Palatine	PRT	Prearticular
VOM	Vomer	TTH	Tooth indet.
NAS	Nasal	I	Incisor indet. upper or lower indet.
SPH	Sphenoid	DI	Deciduous incisor indet. upper or lower indet.
ETH	Ethmoid	C	Canine upper or lower indet.
LAC	Lacrimal	DC	Deciduous canine upper or lower indet.
FRN [FRO]	Frontal	P	Premolar indet. upper or lower indet.
HCO	Horn core	DP	Deciduous premolar indet. upper or lower indet.
HSH	Horn sheath	M	Molar indet. upper or lower indet.
JUG	Jugal	CTH	Cheektooth indet. upper or lower indet.
ZYG	Zygomatic arch	THR	Toothrow upper or lower indet.
ORB	Orbital region	DTHR	Deciduous toothrow upper or lower indet.
TEM	Temporal	UI0	Upper incisor indet.
SQA	Squamosal	UI1	Upper incisor 1
PAR	Parietal	UI2	Upper incisor 2
OCC	Occipital	UI3	Upper incisor 3
BOC	Basioccipital	UI4	Upper incisor 4
OCN	Occipital condyle	DUI0	Deciduous upper incisor indet.
MAS	Mastoid process	DUI1	Deciduous upper incisor 1
PET	Petrosal	DUI2	Deciduous upper incisor 2
BUL	Bulla	DUI3	Deciduous upper incisor 3
PAS	Parasphenoid	DUI4	Deciduous upper incisor 4
ALS	Alisphenoid	UC	Upper canine
DET	Dermethmoid	DUC	Deciduous upper canine
LET	Lateral ethmoid	UP0	Upper premolar indet.
PRT	Parethmoid	UP1	Upper premolar 1
PFR	Prefrontal	UP2	Upper premolar 2
SPO	Sphenotic	UP3	Upper premolar 3
PRO	Prootic	UP4	Upper premolar 4
PTO	Pterotic	UP34	Upper premolar 3 or 4
EPO	Epiotic	DUP0	Deciduous upper premolar indet.
SOC	Supraoccipital	DUP1	Deciduous upper premolar 1
XOC	Exoccipital	DUP2	Deciduous upper premolar 2
COB	Circumorbital	DUP3	Deciduous upper premolar 3
HYQ	Unit HYM SYP MPT QUA	DUP4	Deciduous upper premolar 4
HYM	Hyomandibular	UM0	Upper molar indet.
SYP	Symplectic	UM1	Upper molar 1
MPT	Metapterygoid	UM2	Upper molar 2
QUA	Quadrate	UM3	Upper molar 3
PTG	Pterygoid	UM12	Upper molar 1 or 2
EPT	Entopterygoid	UM23	Upper molar 2 or 3
SMX	Supramaxilla	UCH	Upper cheektooth indet.
OPS	Unit OPR POP IOP SOP	UTHR	Upper toothrow
OPR	Operculum	DUTR	Deciduous upper toothrow
POP	Preoperculum	LI0	Lower incisor indet.
IOP	Interoperculum	LI1	Lower incisor 1
SOP	Suboperculum	LI2	Lower incisor 2
HYA	Unit BHY CHY EHY	LI3	Lower incisor 3
BHY	Basihyal	LI4	Lower incisor 4
CHY	Ceratohyal	DLI0	Deciduous lower incisor indet.
EHY	Epihyal	DLI1	Deciduous lower incisor 1
UHY	Urohyal	DLI2	Deciduous lower incisor 2
BRN	Branchiostegal	DLI3	Deciduous lower incisor 3
QJU	Quadratojugal	DLI4	Deciduous lower incisor 4
SOR	Supraorbital	LC	Lower canine
OTO	Otolith	DLC	Deciduous lower canine
MAN	Mandible indet. or complete	LP0	Lower premolar indet.
MANT	Mandible with teeth	LP1	Lower premolar 1
SYM	Symphysis	LP2	Lower premolar 2
SYMT	Symphysis with teeth	LP3	Lower premolar 3
DEN	Dentary or corpus	LP4	Lower premolar 4

LP34	Lower premolar 3 or 4	SAC3	Sacral vertebra 3
DLP0	Deciduous lower premolar indet.	SAC4	Sacral vertebra 4
DLP1	Deciduous lower premolar 1	SAC5	Sacral vertebra 5
DLP2	Deciduous lower premolar 2	SACL	Last sacral vertebra
DLP3	Deciduous lower premolar 3	SACC	Sacral centrum
DLP4	Deciduous lower premolar 4	SACE	Sacral centrum epiphysis
LM0	Lower molar indet.	CAU	Caudal vertebra
LM1	Lower molar 1	CAUR	Caudal row articulated
LM2	Lower molar 2	SYN	Synsacrum
LM3	Lower molar 3	RIB	Rib indet.
LM12	Lower molar 1 or 2	RIB1	First rib
LM23	Lower molar 2 or 3	RIBP	Posterior rib
LCH	Lower cheektooth indet.	COS	Costal cartilage
LTHR	Lower toothrow	STE	Sternum or sternabrae
DLTR	Deciduous lower toothrow	MNB	Manubrium
HYO	Hyoid	FUR	Furculum
AXL	Axial indet.	BAC	Baculum
VRT	Vertebra indet.	GIR	Girdle bone indet.
VRTR	Vertebral row articulated indet. or mixed	PEC	Pectoral girdle bone indet.
CEN	Centrum indet.	SCP	Scapula indet. or complete
CENE	Centrum epiphysis indet.	SCPG	Glenoid of scapula
CER	Cervical vertebra indet.	SCPA	Acromion of scapula
ATL	Atlas cervical vertebra 1	SCPS	Spine of scapula
AXI	Axis cervical vertebra 2	SCPB	Blade of scapula
CER3	Cervical vertebra 3	CLV	Clavicle
CER4	Cervical vertebra 4	ICL	Interclavicle
CER5	Cervical vertebra 5	ACR	Acromion bone
CER6	Cervical vertebra 6	CLE	Cleithrum
CER7	Cervical vertebra 7	SCL	Supracleithrum
CERR	Cervical row articulated	PCL	Postcleithrum
CERC	Cervical centrum	ACO	Anterior coracoid
CERE	Cervical centrum epiphysis	PEL	Pelvis indet. or complete
THO	Thoracic vertebra indet.	ILI	Ilium
THO1	Thoracic vertebra 1	ISC	Ischium
THO2	Thoracic vertebra 2	PUB	Pubis
THO3	Thoracic vertebra 3	ILIS	Ilium plus ischium
THO4	Thoracic vertebra 4	ILPB	Ilium plus pubis
THO5	Thoracic vertebra 5	ISPB	Ischium plus pubis
THO6	Thoracic vertebra 6	ACE	Acetabulum
THO7	Thoracic vertebra 7	AILI	Acetabulum ilium only
THO8	Thoracic vertebra 8	AISC	Acetabulum ischium only
THO9	Thoracic vertebra 9	APUB	Acetabulum pubis only
TH10	Thoracic vertebra 10	AISI	Acetabulum ischium and ilium only
TH11	Thoracic vertebra 11	APIL	Acetabulum pubis and ilium only
TH12	Thoracic vertebra 12	APIS	Acetabulum pubis and ischium only
TH13	Thoracic vertebra 13	PPUB	Prepubis
TH14	Thoracic vertebra 14	LBN	Long bone indet.
TH15	Thoracic vertebra 15	FLB	Forelimb indet. or articulated unit
TH16	Thoracic vertebra 16	HUM	Humerus
TH17	Thoracic vertebra 17	RAD	Radius
TH18	Thoracic vertebra 18	ULN	Ulna
THOL	Last thoracic vertebra	ULC	Ulna olecranon with sigmoid notch
THOR	Thoracic row articulated	ULS	Ulna sigmoid notch only
THOC	Thoracic centrum epiphysis	RUL	Radioulna
THEC	Thoracic centrum epiphysis	MET	Metapodial indet.
LUM	Lumbar vertebra indet.	MC0	Metacarpal digit indet.
LUM1	Lumbar vertebra 1	MC1	Metacarpal first digit
LUM2	Lumbar vertebra 2	MC2	Metacarpal second digit
LUM3	Lumbar vertebra 3	MC3	Metacarpal third digit
LUM4	Lumbar vertebra 4	MC4	Metacarpal fourth digit
LUM5	Lumbar vertebra 5	MC5	Metacarpal fifth digit
LUM6	Lumbar vertebra 6	MCM	Main metacarpal
LUM7	Lumbar vertebra 7	MCA	Accessory metacarpal
LUML	Last lumbar vertebra	CMC	Carpometacarpus
LUMR	Lumbar row articulated	HLB	Hindlimb indet. or articulated unit
LUMC	Lumbar centrum	FEM	Femur
LUME	Lumbar centrum epiphysis	TIB	Tibia
SAC	Sacrum complete or sacral vertebra indet.	FIB	Fibula or lateral malleolus
SAC1	Sacral vertebra 1	TBT	Tibiotarsus
SAC2	Sacral vertebra 2	MT0	Metatarsal digit indet.

MT1	Metatarsal first digit	HDSM	Hind distal sesamoid medial
MT2	Metatarsal second digit	HDSL	Hind distal sesamoid lateral
MT3	Metatarsal third digit	PHA	Phalanx indet.
MT4	Metatarsal fourth digit	PHA1	First phalanx digit indet. front or hind indet.
MT5	Metatarsal fifth digit	PH11	First phalanx first digit front or hind indet.
MTM	Main metatarsal cannon bone	PH12	First phalanx second digit front or hind indet.
MTA	Accessory metatarsal	PH13	First phalanx third digit front or hind indet.
TMT	Tarsometatarsus	PH14	First phalanx fourth digit front or hind indet.
PAT	Patella	PH15	First phalanx fifth digit front or hind indet.
POD	Podial indet.	PHA2	Second phalanx digit indet.
CAR	Carpal or manus bone indet.	PH21	Second phalanx first digit front or hind indet.
SCA	Scaphoid	PH22	Second phalanx second digit front or hind indet.
LUN	Lunate	PH23	Second phalanx third digit front or hind indet.
CUN	Cuneiform	PH24	Second phalanx fourth digit front or hind indet.
MAG	Magnum	PH25	Second phalanx fifth digit front or hind indet.
UNC	Unciform	PHA3	Third phalanx digit indet.
PIS	Pisiform	PH33	Third phalanx third digit front or hind indet.
TZD	Trapezoid	PH34	Third phalanx fourth digit front or hind indet.
TZM	Trapezium	PH35	Third phalanx fifth digit front or hind indet.
SCL	Scapholunar	PH32	Third phalanx second digit front or hind indet.
RDL	Radiale	PHA4	Fourth phalanx fourth digit front or hind indet.
INTC	Intermedium carpal	PHA5	Fifth phalanx fourth digit front or hind indet.
ULR	Ulnare	FP10	Front first phalanx digit indet.
CNC1	Centrale carpal 1	FP11	Front first phalanx first digit
CNC2	Centrale carpal 2	FP12	Front first phalanx second digit
DC1	Distal carpal 1	FP13	Front first phalanx third digit
DC2	Distal carpal 2	FP14	Front first phalanx fourth digit
DC3	Distal carpal 3	FP15	Front first phalanx fifth digit
DC4	Distal carpal 4	FP20	Front second phalanx digit indet.
NAVI	Navicular of the carpus	FP21	Front second phalanx first digit
TRI	Triquetal	FP22	Front second phalanx second digit
CAP	Capitate	FP23	Front second phalanx third digit
HAM	Hamate	FP24	Front second phalanx fourth digit
GMLT	Greater multangle	FP25	Front second phalanx fifth digit
LMLT	Lesser multangle	FP30	Front third phalanx digit indet.
TAR	Tarsal or pes bone indet.	FP32	Front third phalanx second digit
AST	Astragalus	FP33	Front third phalanx third digit
CAL	Calcaneum	FP34	Front third phalanx fourth digit
NAV	Navicular of the tarsus	FP35	Front third phalanx fifth digit
CUB	Cuboid	FP40	Front fourth phalanx digit indet.
NVC	Naviculocuboid	FP43	Front fourth phalanx third digit
CU1	Medial cuneiform	FP44	Front fourth phalanx fourth digit
CU2	Intermediate cuneiform	FP54	Front fifth phalanx fourth digit
CU3	Lateral cuneiform	HP10	Hind first phalanx digit indet.
TBL	Tibiale	HP11	Hind first phalanx first digit
INTT	Intermedium tarsal	HP12	Hind first phalanx second digit
FBR	Fibulare	HP13	Hind first phalanx third digit
CNT	Centrale tarsal	HP14	Hind first phalanx fourth digit
DT1	Distal tarsal 1	HP15	Hind first phalanx fifth digit
DT2	Distal tarsal 2	HP20	Second phalanx digit indet.
DT3	Distal tarsal 3	HP21	Second phalanx first digit
DT4	Distal tarsal 4	HP22	Second phalanx second digit
TAL	Talus of primates	HP23	Second phalanx third digit
SES	Sesamoid indet.	HP24	Second phalanx fourth digit
PSS	Proximal sesamoid medial lateral front hind indet.	HP25	Second phalanx fifth digit
PSM	Proximal sesamoid medial front or hind indet.	HP30	Hind third phalanx digit indet.
PSL	Proximal sesamoid lateral front or hind indet.	HP32	Hind third phalanx second digit
DSS	Distal sesamoid medial lateral front or hind indet.	HP33	Hind third phalanx third digit
DSM	Distal sesamoid medial front or hind indet.	HP34	Hind third phalanx fourth digit
DSL	Distal sesamoid lateral front or hind indet.	HP35	Hind third phalanx fifth digit
FPSS	Front proximal sesamoid medial or lateral indet.	HP40	Hind fourth phalanx digit indet.
FPSM	Front proximal sesamoid medial	HP43	Hind fourth phalanx third digit
FPSL	Front proximal sesamoid lateral	HP44	Hind fourth phalanx fourth digit
FDSS	Front distal sesamoid medial or lateral indet.	HP45	Hind fourth phalanx fifth digit
FDSM	Front distal sesamoid medial	HP50	Hind fifth phalanx digit indet.
FDSL	Front distal sesamoid lateral	HP51	Hind fifth phalanx first digit
HPSS	Hind proximal sesamoid medial or lateral indet.	HP52	Hind fifth phalanx second digit
HPSM	Hind proximal sesamoid medial	HP53	Hind fifth phalanx third digit
HPSL	Hind proximal sesamoid lateral	HP54	Hind fifth phalanx fourth digit
HDSS	Hind distal sesamoid medial or lateral indet.	HOOF	Hoof cover

DER	Dermal bones
RAY	Fin ray
SCU	Scute
CRP	Carapace
PLA	Plastron
SKIN	Skin
SCL	Scale
SPI	Pectoral spine
NID	Totally nonidentifiable bone

Portion

CO	Complete bone
[~CO	Nearly complete]
FR	Fragment not otherwise specified
PX	Proximal articulation or end [$< 25\%$ of bone]
PSH	Proximal articulation plus shaft [$\geq 25\%$ of bone]
SH	Shaft
DS	Distal articulation or end [$< 25\%$ of bone]
DSH	Distal articulation plus shaft [$\geq 25\%$ of bone]
ANT	Anterior
POS	Posterior
HFL	Entire bone split longitudinally in half
MID	Middle or central portion
AMI	Anterior plus middle portion
PMI	Posterior plus middle portion

Segment

LT	Lateral segment of portion
MD	Medial section of portion
AN	Anterior segment of portion
PO	Posterior segment of portion
AL	Anterolateral segment of portion
PL	Posterolateral segment of portion
AM	Anteromedial segment of portion
PO [PM]	Posteromedial segment of portion
[PD	Posterior dorsal]
HF	Half seg. lateral medial anterior posterior indet.
FR	Unspecified fragment of portion
CS	Complete shaft tubular

Skull

FRO-1

Description: A complete transverse chop through the frontals at the orbits. Comparable to Lupo's (1993) Sk-6, but passes through the frontals, not the nasals. Note location in relation to Binford's (1981) S-3 and S-7. Figure A.1.

Frequency: Blue duiker 1 (1), medium duiker 1 (1).

Function: Food preparation, consumption. Comparable marks are classified as "food preparation" (Lupo 1993:334) and "consumption" (Binford 1981:136).

FRO-2

Description: Transverse or oblique cuts across the dorsal surface of the frontals. Similar to Lupo's (1993) Sk-1 and Sk-7, but occur on the frontals, not the nasals. Figure A.2.

Frequency: Blue duiker 4 (7), medium duiker 1 (1).

Function: Unknown. Comparable marks are classified as "skinning" (Lupo 1993:334) and that is a possible function of FRO-2.

FRO-3

Description: Deep, long sagittal cuts in frontals. Figure A.8.

Frequency: Yellow-backed duiker 1 (4).

Function: Unknown. Possibly food preparation or skinning.

FRO-4

Description: Long, relatively deep transverse cuts that run parallel to Binford's (1981) S-3 chop. Figure A.2.

Frequency: Blue duiker 2 (3).

Function: Unknown. Binford's (1981:136) S-3 chop is classified as "Dismembering, consumption." However, the FRO-4 cut is the result of pressure, not percussion, and does not penetrate the braincase.

FRO-5

Description: Sagittal cuts on the dorsal surface of the frontals. Location comparable to FRO-3, but shorter and shallower. Figure A.3.

Frequency: Blue duiker 2 (6), medium duiker 2 (7).

Function: Unknown. Possibly skinning, but more likely a result of food preparation.

FRO-6

Description: Transverse cuts just distal of the coronal suture. Location comparable to FRO-4, but FRO-6 marks are shorter and closer to the coronal suture. Figure A.3.

Frequency: Blue duiker 1 (3).

Function: Unknown. Possibly skinning, but more likely a result of food preparation.

HCO-1

Description: A complete chop through one or both horn cores. Figure A.1.

Frequency: Blue duiker 21 (21), medium duiker 7 (7), yellow-backed duiker 1 (1).

Function: Dismemberment, horn removal. The keratinous outer coverings of duiker horns are valuable as medicinal and ritual items (Lupo, personal communication 2008).

HCO-2

Description: A partial chop in one or both horn cores. Figure A.3.

Frequency: Blue duiker 5 (6), medium duiker 3 (4), yellow-backed duiker 1 (2).

Function: Dismemberment, horn removal. Binford (1984:100) identifies a similar mark on medium-large bovids (size class III; Klein 1976) from Klasies River Mouth, and attributes the mark to horn removal.

HCO-3

Description: Transverse cuts on one or both horn cores. Figure A.2.

Frequency: Blue duiker 3 (8), medium duiker 2 (3).

Function: Dismemberment, horn removal.

MAXT-1

Description: Marks that run parallel to and just above the maxillary toothrow. Comparable in form and probable function to Binford's (1981) S-6 cut, but does not occur specifically above the third molar. Figure A.4.

Frequency: Blue duiker 5 (8), medium duiker 3 (5), yellow-backed duiker 1 (9).

Function: Dismemberment. MAXT-1 likely results from the same tool stroke that produces the common MANT-2 cut in the process of severing the masseter muscle.

OCC-1

Description: Partial sagittal chops in dorsal-posterior edge of occipital. Figure A.9.

Frequency: Blue duiker 2 (4), yellow-backed duiker 1 (5).

Function: Unknown. In the case of the large duiker, may be a result of death blows to the animal's skull from a machete.

OCC-2

Description: Sagittal cuts on dorsal-posterior edge of occipital. Figure A.9.

Frequency: Blue duiker 2 (2), medium duiker 1 (3), yellow-backed duiker 1 (1).

Function: Unknown. Possibly food preparation or skinning.

OCC-3

Description: Transverse cut on the ventral occipital just anterior of the foramen magnum. Figure A.7.

Frequency: Blue duiker 2 (2), medium duiker 2 (3).

Function: Unknown. Possibly food preparation or skinning.

OCN-1

Description: Comparable to Binford's (1981) S-1 in location and function, OCN-1 is a complete transverse chop through the occipital condyles that results from removal of the head. Figure A.9.

Frequency: Giant pouched rat 1 (1), brush-tailed porcupine 1 (1), blue duiker 11 (11), medium duiker 8 (8), yellow-backed duiker 1 (1).

Function: Dismemberment, food preparation. The beheading of duiker carcasses during primary field butchery may result in a complete transverse chop through the occipital condyles. Since field observations indicate that duiker skulls and the first few cervical vertebrae are removed as a unit, it is possible that skulls are later chopped apart from attached cervical vertebrae during food preparation.

OCN-2

Description: Comparable to Binford's (1981) S-1 in location and function, OCN-2 is a partial transverse chop in the occipital condyles that results from removal of the head. Figure A.6.

Frequency: Blue duiker 2 (2), yellow-backed duiker 1 (2).

Function: Dismemberment, food preparation.

ORB-1

Description: A partial chop in the rim of the orbit. Figure A.3.

Frequency: Blue duiker 2 (9), yellow-backed duiker 1 (1).

Function: Unknown.

ORB-2

Description: A cut or nick in the edge of the orbit rim. Figure A.2.

Frequency: Blue duiker 3 (9), medium duiker 3 (5), yellow-backed duiker 1 (3).

Function: Unknown. Possibly food preparation or skinning.

PAR-1

Description: Longitudinal cuts on the lateral surface of the parietal. Figure A.4.

Frequency: Blue duiker 6 (13), medium duiker 3 (8).

Function: Unknown. Possibly food preparation or skinning.

PAR-2

Description: Transverse cuts on the lateral face of the parietal/frontal. Figure A.4.

Frequency: Blue duiker 6 (17), medium duiker 4 (24), yellow-backed duiker 1 (4).

Function: Unknown. Possibly food preparation or skinning.

PAR-3

Description: Partial transverse chop at the location of PAR-2. Figure A.4.

Frequency: Blue duiker 3 (5), yellow-backed duiker 1 (2).

Function: Unknown.

PMX-1

Description: Marks on the premaxilla and maxilla that run perpendicular to the maxillary toothrow. Figure A.5.

Frequency: Blue duiker 4 (5), medium duiker 5 (9).

Function: Unknown. Possibly food preparation or skinning.

S-1

Description: “Transverse cut on occipital condyle” (Binford 1981:136). Binford also cites Guilday et al. (1962). OCN-1 and OCN-2 represent chop variations of this mark. Figure A.7.

Frequency: Brush-tailed porcupine 1 (1), blue duiker 2 (3), medium duiker 1 (1).

Function: Dismemberment. “Marks from cutting off the head” (Binford 1981:102).

S-3

Description: “Transverse chops across cranium above and below the antlers or horns” (Binford 1981:136). Binford also cites Guilday et al. (1962). With blue duikers a chop at the location of S-3 usually passes completely through the skull. Figure A.1.

Frequency: Blue duiker 2 (2), medium duiker 4 (4), river hog 1 (2).

Function: Dismemberment, consumption. Among caribou, this chop is produced during antler removal (Binford 1981:108). Guilday et al. (1962:76) identify this mark on white-tailed deer (*Odocoileus virginianus*) and elk (*Cervus canadensis*) crania and relate it to brain removal.

S-7

Description: “Nose cut off” (Binford 1981:136). Figure A.1.

Frequency: Blue duiker 2 (2), medium duiker 1 (1), river hog 1 (1).

Function: Consumption (Binford 1981:136).

Sk-1

Description: “One or more transverse and oblique cutmarks across the nasals, similar to [Binford’s] S-7 but more proximal in location and penetrate the bone” (Lupo 1993:314). Used here to designate a cut at this location. Figure A.2.

Frequency: Medium duiker 2 (5).

Function: Nose removal (consumption) (Lupo 1993:314).

Sk-2

Description: “Two or more transverse parallel cutmarks on ventral border of the nasals” (Lupo 1993:334). As used here, may apply to one or more marks at this location. Figure A.5.

Frequency: Blue duiker 1 (2).

Function: Unknown. Comparable marks are classified as “skinning” (Lupo 1993:334) and that is a possible function of Sk-2 in this context.

Sk-8

Description: “Cluster of transverse parallel cutmarks on the occipital protuberance” (Lupo 1993:335). As used here, may apply to one or more marks at this location. Figure A.6.

Frequency: Blue duiker 3 (7), medium duiker 4 (10).

Function: Dismemberment (Lupo 1993:335).

Sk-10

Description: “Two or more cutmarks on the canine eminence” (Lupo 1993:335). As used here, may apply to one or more marks at this location. Figure A.7.

Frequency: Medium duiker 1 (4).

Function: Unknown. Comparable marks are classified as “skinning” (Lupo 1993:335) and that is a possible function of Sk-10 in this context.

Sk-11

Description: “Occipital chopped sagittally” (Lupo 1993:335). Used here to indicate a partial chop at this location. Figure A.7.

Frequency: Blue duiker 1 (1), yellow-backed duiker 1 (2).

Function: Food preparation (Lupo 1993:335).

Sk-12

Description: “Cluster of transverse cutmarks on the zygomatic arch” (Lupo 1993:335). Lupo notes that similar marks are reported by Gifford-Gonzalez (1989:205). As used here, may apply to one or more marks at this location. Figure A.5.

Frequency: Medium duiker 2 (2).

Function: Dismemberment, fillet (Lupo 1993:335).

Sk-13

Description: “Single cutmark behind M3, shorter and oriented at a different angle than [Binford’s 1981] S-6” (Lupo 1993:335). As used here, may apply to one or more marks at this location. Figure A.4.

Frequency: Yellow-backed duiker 1 (3).

Function: Dismemberment (Lupo 1993:335).

Sk-14

Description: “Zygomatic arches are chopped off” (Lupo 1993:335). Figure A.8.

Frequency: Yellow-backed duiker 1 (1).

Function: Food preparation (Lupo 1993:335).

ZYG-1

Description: Partial transverse chop to the zygomatic arch. Figure A.5.

Frequency: Blue duiker 1 (1), medium duiker 1 (1), yellow-backed duiker 1 (4), river hog 1 (2).

Function: Dismemberment. Location similar to Lupo's (1993) Sk-12 cut, which is categorized as a "dismemberment, fillet" mark.

ZYG-2

Description: Sagittal cuts on ventral surface of zygomatic arch. Figure A.7.

Frequency: Medium duiker 1 (2).

Function: Unknown. Possibly food preparation or skinning.

Mandible

ANG-1

Description: A diagonal nick in the ventral edge of the gonial. Comparable to Lupo's (1993) Man-4, but oriented in the opposite direction. Figure A.10.

Frequency: Blue duiker 3 (3).

Function: Dismemberment. Mandible marks are dominated by cuts and chops to the gonial and ascending ramus.

Man-3

Description: "Chop on the ventral border of the angle of the mandible" (Lupo 1993:336). Lupo notes that a similar mark is reported by Gifford-Gonzalez (1989). Figure A.11.

Frequency: River hog 1 (1).

Function: Dismemberment, fillet (Lupo 1993:336).

MANT-1

Description: A complete diagonal chop through the ascending ramus. Figure A.11.

Frequency: Blue duiker 5 (5).

Function: Dismemberment.

MANT-2

Description: Long transverse cuts on the buccal face of the ascending ramus at or above the level of the toothrow. Nicholson (2005:88) documents a similar mark on white-lipped peccary (*Tayassu pecari*) bones processed by Aché foragers. Figure A.10.

Frequency: Murid rats and mice 1 (1), giant pouched rat 2 (3), brush-tailed porcupine 7 (10), monkey 2 (5), blue duiker 64 (132), medium duiker 35 (74), yellow-backed duiker 2 (4), river hog 1 (3).

Function: Dismemberment. This mark is associated with the severing of the masseter muscle to facilitate mandible removal (Frison 1971; Schmitt et al. 2001). Hudson notes that Aka foragers in her study area “cut along [duiker mandibles] on either side through the cheek muscle” (1990:117). Binford (1984:110) identifies this mark on bovid mandibles recovered from Klasies River Mouth and argues that the orientation of the mark is a consequence of dismemberment while the animal’s jaw is closed (Open-jaw dismemberment results in a mark comparable to MANT-12). Guilday et al. (1962:68) identify similar marks (Cuts 2A and 2B) on black bear (*Ursus americanus*) mandibles and associate it with removing the lower jaw.

MANT-3

Description: A complete chop that removes the postero-ventral tip of the gonial. Figure A.14.

Frequency: Blue duiker 2 (2), river hog 1 (1).

Function: Dismemberment.

MANT-4

Description: Partial chop in the posterior edge of the ascending ramus. Figure A.11.

Frequency: Blue duiker 7 (10).

Function: Dismemberment.

MANT-5

Description: Transverse cuts on the posterior edge of the ascending ramus. Figure A.12.

Frequency: Brush-tailed porcupine 1 (1), blue duiker 17 (28), medium duiker 8 (18).

Function: Dismemberment.

MANT-6

Description: Complete diagonal chop through ascending ramus. Similar to, but oriented differently than, MANT-1. Figure A.13.

Frequency: Yellow-backed duiker 2 (2).

Function: Dismemberment.

MANT-7

Description: Complete transverse chop through the ascending ramus. Figure A.12.

Frequency: Monkey 3 (3), blue duiker 13 (14), medium duiker 34 (34), yellow-backed duiker 3 (3).

Function: Dismemberment.

MANT-8

Description: Longitudinal or oblique cuts along the horizontal ramus. Most occur on rodent mandibles. Fernández-Jalvo et al. (1999) report a similar mark on a 1.76 million-year-old fossil hedgehog (*Erinaceous broomei*) mandible from Olduvai Gorge and relate it to skinning activities since the location is far from any muscle attachments. Figure A.15.

Frequency: Giant pouched rat 9 (16), brush-tailed porcupine 3 (5), blue duiker 4 (6).

Function: Unknown. Possibly skinning.

MANT-9

Description: Partial chops in the anterior edge of the ascending ramus. Figure A.13.

Frequency: Blue duiker 2 (3).

Function: Dismemberment.

MANT-10

Description: Transverse cuts on the anterior edge of the ascending ramus. Figure A.12.

Frequency: Blue duiker 2 (3), medium duiker 2 (8).

Function: Dismemberment.

MANT-11

Description: Transverse cuts on posterior edge of coronoid process. Figure A.10.

Frequency: Medium duiker 1 (3).

Function: Dismemberment.

MANT-12

Description: Long diagonal cuts on the buccal face of horizontal ramus. Comparable to Lupo's (1993) Man-4 in location and orientation, but longer. Figure A.12.

Frequency: Blue duiker 2 (4).

Function: Dismemberment. Binford (1984:110) identifies this mark on bovid mandibles recovered from Klasies River Mouth and argues that the orientation of the mark is a consequence of dismemberment while the animal's jaw is open (Closed-jaw dismemberment results in a mark comparable to MANT-2).

MANT-13

Description: Long transverse cuts on the lingual face of the ascending ramus at or above the level of the tooththrow. Figure A.14.

Frequency: Blue duiker 2 (3), medium duiker 3 (7).

Function: Dismemberment. Far less common than marks on the buccal face (MANT-2), but likely serving the same function.

MANT-14

Description: A partial diagonal chop to the gonial following the orientation of MANT-1. Figure A.11.

Frequency: Blue duiker 1 (1).

Function: Dismemberment.

MANT-15

Description: Short transverse cuts on the buccal face of the horizontal ramus. Figure A.10.

Frequency: Blue duiker 1 (1), medium duiker 1 (2).

Function: Unknown.

MANT-16

Description: An oblique cut on the lingual face of the mandibular symphysis. Figure A.14.

Frequency: Medium duiker 1 (1).

Function: Unknown.

Atlas

ATL-1

Description: A partial transverse chop through the atlas. Comparable to Lupo's (1993) Atl-11, but not limited to the dorsal surface of the atlas. Figure A.16.

Frequency: Blue duiker 15 (21), medium duiker 5 (5).

Function: Dismemberment, head removal.

ATL-2

Description: A transverse cut on the lateral edge of the atlas. Figure A.16.

Frequency: Blue duiker 5 (8).

Function: Dismemberment.

ATL-3

Description: A complete transverse chop through the atlas. Figure A.16.

Frequency: Brush-tailed porcupine 1 (1), blue duiker 3 (3).

Function: Dismemberment, head removal.

ATL-4

Description: A sagittal cut on the anterior edge of the atlas. Figure A.17.

Frequency: Blue duiker 1 (1).

Function: Unknown

ATL-5

Description: Partial sagittal chop in the anterior atlas. Figure A.17.

Frequency: Blue duiker 1 (2), medium duiker 3 (5).

Function: Dismemberment, food preparation. Lupo (1993:337) classifies a complete chop with this orientation (Atl-10) as “food preparation.”

ATL-6

Description: Binford distinguishes between CV-1 “Transverse cuts across the proximal ventral surface of the atlas” (1981:137) and CV-2 “transverse cuts across posterior ventral surface of atlas” (1981:137). Since these locations are less than 2 cm apart on a blue duiker atlas, all transverse cuts on the ventral surface of the atlas are classified as ATL-6. Binford also cites Guilday et al. (1962), Martin (1907-1910) and Parmalee (1965) as references for these marks. Figure A.19.

Frequency: Blue duiker 2 (3).

Function: Dismemberment. Guilday et al. (1962:68) identify this mark (Cut 4) on black bear (*Ursus americanus*) atlas vertebrae and associate it with removing the head from the neck.

Atl-10

Description: “Atlas is chopped in half sagittally” (Lupo 1993:337). Figure A.18.

Frequency: Medium duiker 8 (8).

Function: Dismemberment, food preparation. Lupo (1993:337) identifies this as a food preparation mark. Among duikers, it may occur during sagittal bisection of the carcass.

Axis

Axi-1

Description: “Single transverse cutmark on the spinous process above the posterior articulation” (Lupo 1993:337). Figure A.21.

Frequency: Blue duiker 1 (1).

Function: Unknown. Lupo (1993:337) identifies this as a filleting mark, although it probably does not reflect this function on the single blue duiker specimen on which it occurs.

AXI-2

Description: Transverse cut on lateral face of axis. Figure A.21.

Frequency: Blue duiker 5 (7).

Function: Dismemberment.

AXI-3

Description: Transverse cut on ventral axis. Figure A.23.

Frequency: Giant pouched rat 1 (1), blue duiker 4 (5).

Function: Dismemberment.

AXI-4

Description: Transverse cut on dorsal surface of anterior articular facet. Compare to AXI-6. Figure A.20.

Frequency: Blue duiker 3 (6).

Function: Dismemberment.

AXI-5

Description: A complete transverse chop through the axis. Figure A.20.

Frequency: Blue duiker 8 (8), medium duiker 2 (2).

Function: Dismemberment, head removal.

AXI-6

Description: Transverse cut on the ventral surface of anterior articular facet. Cut is comparable to, but with a more specific location than, Binford's (1981) CV-3. Also see Frison (1971) and Parmalee (1965). Figure A.23.

Frequency: Medium duiker 2 (2).

Function: Dismemberment.

AXI-7

Description: Complete sagittal chop through the axis. Figure A.22.

Frequency: Blue duiker 1 (1), medium duiker 3 (3).

Function: Dismemberment, food preparation.

AXI-8

Description: Partial sagittal chop through the axis. Figure A.20.

Frequency: Medium duiker 2 (2).

Function: Dismemberment, food preparation.

CV-5

Description: “Transverse chopping of axis” (Binford 1981:137). Used here to indicate a partial transverse chop to the axis. A transverse chop passing completely through the axis is coded as AXI-5. Figure A.21.

Frequency: Blue duiker 8 (10), medium duiker 3 (7).

Function: Dismemberment, head removal.

Cervical (CER3 +)

CER-1

Description: A partial transverse chop to a cervical vertebra. Chop passes midway through the cervical. Figure A.27.

Frequency: Blue duiker 32 (37), medium duiker 2 (2).

Function: Dismemberment.

CER-2

Description: Transverse cut on the ventral surface of cervical. Figure A.30.

Frequency: Giant pouched rat 1 (1), blue duiker 6 (6).

Function: Dismemberment.

CER-3

Description: Complete transverse chop through cervical. Figure A.27.

Frequency: Blue duiker 36 (36), medium duiker 23 (24).

Function: Dismemberment, head removal, food preparation (function varies depending on the specific cervical vertebra).

CER-4

Description: Transverse cuts on dorsal surface of cervical. Comparable to Lupo's (1993) Cer-11, but not necessarily two marks or limited to the mid-section. Nicholson (2005:67) documents a similar mark on red brocket deer (*Mazama americana*) bones processed by Aché foragers. Figure A.26.

Frequency: Blue duiker 9 (16).

Function: Dismemberment.

CER-5

Description: Transverse cuts on lateral surface of cervical. Nicholson (2005:67) documents a similar mark on red brocket deer (*Mazama americana*) bones processed by Aché foragers. Figure A.28.

Frequency: Giant pouched rat 1 (1), blue duiker 10 (19), medium duiker 4 (9).

Function: Dismemberment.

CER-6

Description: Longitudinal cut on anterior face of cervical centrum. Figure A.24.

Frequency: Blue duiker 1 (1).

Function: Unknown.

CER-7

Description: A partial sagittal chop to a cervical vertebra. Figure A.25.

Frequency: Blue duiker 1 (1), medium duiker 5 (7).

Function: Dismemberment, food preparation.

CER-8

Description: Small off-center sagittal cut on ventral surface of cervical centrum. Figure A.31.

Frequency: Giant pouched rat 2 (2), blue duiker 1 (1).

Function: Unknown.

CER-9

Description: Small sagittal nick on dorsal-anterior edge of anterior. Figure A.26.

Frequency: Medium duiker 2 (3).

Function: Unknown.

CER-10

Description: Longitudinal cuts on the posterior edge of the cervical arch. Comparable to THO-7, but occurs on cervical vertebrae. Figure A.29.

Frequency: Medium duiker 1 (2).

Function: Unknown.

CER-11

Description: Longitudinal cuts inside neural canal. Not illustrated.

Frequency: Medium duiker 2 (4).

Function: Unknown.

CER-12

Description: Partial dorsal/ventral chop. This is a partial version of complete chop Cer-13. Figure A.24.

Frequency: Medium duiker 1 (1).

Function: Dismemberment, food preparation.

Cer-13

Description: “Dorsal half chopped from centrum, transverse shear fracture at the arch, similar to [Binford’s 1981] Cv-6, but not restricted to the 6th cervical” (Lupo 1993:316). Based on the directional terminology used here, this would be categorized as a longitudinal chop (see Figure A.29).

Frequency: Blue duiker 7 (8), medium duiker 7 (7).

Function: Dismemberment, food preparation (Lupo 1993:316).

Cer-15

Description: “Centrum is chopped in half sagittally” (Lupo 1993:339). Used here to refer to a complete sagittal chop through cervical vertebrae. This chop is sometimes off-center or slightly diagonal. Figure A.25.

Frequency: Giant pouched rat 2 (2), brush-tailed porcupine 5 (5), blue duiker 16 (16), medium duiker 32 (34).

Function: Dismemberment, food preparation. Lupo (1993:339) identifies this as a food preparation mark, but it may also occur during the sagittal splitting of duiker carcasses.

CER-16

Description: Identical to THO-2, but occur on the dorsal spines of cervical vertebrae. Not illustrated (see THO-2 in Figure A.34).

Frequency: Medium duiker 1 (2).

Function: Fillet (Binford 1981:137).

Thoracic**THO-1**

Description: A sagittal or slightly diagonal cut on the ventral surface of thoracic centrum. Figure A.37.

Frequency: Giant pouched rat 2 (3), blue duiker 2 (2).

Function: Unknown.

THO-2

Description: Longitudinal cut on the lateral surface of dorsal spine. Comparable to Binford's (1981) TV-2, but not limited to "base and lower portion of the dorsal spine" (1981:137). Figure A.34.

Frequency: Brush-tailed porcupine 1 (1), blue duiker 9 (23), medium duiker 14 (30).

Function: Fillet (Binford 1981:137).

Tho-3

Description: "Centrum is chopped in half sagittally" (Lupo 1993:339). Figure A.32.

Frequency: Giant pouched rat 12 (12), tree pangolin 7 (7), brush-tailed porcupine 11 (11), monkey 8 (8), blue duiker 221 (223), medium duiker 75 (76).

Function: Dismemberment. Lupo (1993) classifies this as a food preparation mark. Among duikers it is produced during the initial dismemberment (see page X).

THO-4

Description: Partial transverse chop through thoracic vertebra. Figure A.35.

Frequency: Giant pouched rat 2 (2), blue duiker 5 (6), medium duiker 5 (6).

Function: Dismemberment, food preparation.

THO-5

Description: Partial sagittal chop in thoracic vertebra. Figure A.33.

Frequency: Blue duiker 3 (4), medium duiker 1 (1).

Function: Dismemberment.

Tho-6

Description: "Dorsal half of spinous process is cut off" (Lupo 1993:317). Figure A.34.

Frequency: Blue duiker 5 (5), medium duiker 9 (10).

Function: Dismemberment, preparation (Lupo 1993:317).

Tho-7

Description: “Dorsal half is chopped off, transverse chop at or near the arch” (Lupo 1993:340). Based on the directional terminology used here, this would be categorized as a longitudinal chop (see Figure A.32).

Frequency: Medium duiker 2 (2).

Function: Dismemberment, food preparation (Lupo 1993:317).

THO-8

Description: Sagittal cuts inside neural canal on underside of dorsal spine. Not illustrated.

Frequency: Blue duiker 2 (4), medium duiker 1 (2).

Function: Unknown.

THO-9

Description: Transverse cut on lateral face of thoracic centrum. Figure A.35.

Frequency: Brush-tailed porcupine 1 (1), medium duiker 2 (2).

Function: Dismemberment.

THO-10

Description: Transverse cut on dorsal/lateral anterior spine. Figure A.35.

Frequency: Blue duiker 1 (1), medium duiker 4 (5).

Function: Dismemberment.

Tho-11

Description: “Centrum is chopped longitudinally” (Lupo 1993:341). This code is used to refer to a complete chop through a thoracic vertebra. Based on the directional terminology used here, this would be categorized as a transverse chop (see Figure A.34).

Frequency: Giant pouched rat 1 (1), brush-tailed porcupine 2 (2), monkey 2 (2), blue duiker 32 (33), medium duiker 26 (27).

Function: Dismemberment, food preparation (Lupo 1993:341).

THO-12

Description: Transverse cuts on dorsal surface of thoracic centrum (within neural canal). Not illustrated.

Frequency: Medium duiker 1 (3).

Function: Unknown.

THO-13

Description: Longitudinal cut across the posterior face of caudal articular process. Comparable to Lupo's (1993) Tho-5, but on posterior, not lateral. Figure A.36.

Frequency: Blue duiker 1 (1).

Function: Unknown.

THO-14

Description: Sagittal cut on anterior centrum. Figure A.33.

Frequency: Giant pouched rat 1 (1), blue duiker 1 (1).

Function: Unknown.

THO-15

Description: Longitudinal cuts on posterior edge of neural arch. Figure A.36.

Frequency: Blue duiker 1 (2).

Function: Unknown.

TV-3

Description: "Transverse cut across the inferior surface of the centrum" (Binford 1981:137). Binford also cites Guilday et al. (1962) and Wheat (1979) as references for this mark. Figure A.36.

Frequency: Giant pouched rat 2 (3), brush-tailed porcupine 1 (1), blue duiker 15 (22), medium duiker 3 (3).

Function: Dismemberment (Binford 1981:137).

Lumbar

LUM-1

Description: Sagittally-oriented cuts on the ventral surface of the transverse process. Identical to Lupo's (1993) Lum-5, but on the ventral, not dorsal, surface. Figure A.40.

Frequency: Giant pouched rat 4 (6), blue duiker 42 (82), medium duiker 5 (8).

Function: Dismemberment, food preparation.

Lum-2

Description: "Dorsal half chopped off, transverse chop at or near the arch" (Lupo 1993:341). Based on the directional terminology used here, this would be categorized as a longitudinal chop (see Figure A.39).

Frequency: Giant pouched rat 1 (1), medium duiker 1 (1).

Function: Food preparation (Lupo 1993:341).

LUM-3

Description: Transverse cut on the ventral lumbar centrum. Figure A.40.

Frequency: Giant pouched rat 2 (2), tree pangolin 2 (2), blue duiker 2 (2), civet 1 (4), medium duiker 4 (9).

Function: Dismemberment.

LUM-4

Description: Transverse partial chop in ventral lumbar centrum. Figure A.40.

Frequency: Giant pouched rat 1 (1), blue duiker 5 (5), medium duiker 1 (1).

Function: Dismemberment.

Lum-5

Description: "Single or multiple cutmarks dispersed on the dorsal side of the transverse process" (Lupo 1993:341). Figure A.38.

Frequency: Giant pouched rat 1 (1), blue duiker 1 (1), medium duiker 2 (5).

Function: Fillet (1993:341). Similar to, but far less common than, the LUM-1 cut on ventral transverse process.

LUM-6

Description: Sagittal cut on the ventral lumbar centrum. Figure A.40.

Frequency: Giant pouched rat 3 (5), tree pangolin 1 (1).

Function: Unknown.

Lum-7

Description: “Single longitudinal cutmark on the centrum lateral side in the mid-section” (Lupo 1993:341). Based on the directional terminology used here, this would be categorized as a transverse cut (see Figure A.39).

Frequency: Giant pouched rat 2 (2), tree pangolin 1 (1), brush-tailed porcupine 1 (1), blue duiker 7 (10).

Function: Fillet (Lupo 1993:341).

LUM-8

Description: Longitudinal cut on the lumbar dorsal spine. Figure A.39.

Frequency: Giant pouched rat 1 (1).

Function: Unknown.

Lum-9

Description: “Centrum chopped in half sagittally” (Lupo 1993:341). Used here to refer to any complete sagittally-oriented chop through a lumbar. Figure A.40.

Frequency: Giant pouched rat 13 (13), tree pangolin 11 (13), brush-tailed porcupine 27 (27), monkey 3 (3), blue duiker 164 (167), medium duiker 21 (25).

Function: Dismemberment. Lupo (1993) classifies this as a food preparation mark. Among duikers it is produced during the initial dismemberment (see page X).

Lum-10

Description: “Centrum chopped in half longitudinally” (Lupo 1993:342). Based on the directional terminology used here, this would be categorized as a transverse chop (see Figure A.39).

Frequency: Giant pouched rat 6 (6), tree pangolin 1 (1), brush-tailed porcupine 5 (5), monkey 1 (1), blue duiker 26 (26), medium duiker 11 (13).

Function: Dismemberment, food preparation (Lupo 1993:342).

LUM-11

Description: A partial transverse chop through the lumbar. Figure A.39.

Frequency: Giant pouched rat 2 (2), blue duiker 4 (5), medium duiker 1 (1).

Function: Dismemberment, food preparation.

LUM-12

Description: Sagittal cut on anterior centrum. Not illustrated (see THO-14).

Frequency: Brush-tailed porcupine 1 (1), medium duiker 1 (1).

Function: Unknown.

LUM-13

Description: Transverse cut across dorsal surface of anterior and/or posterior articulating facets. Figure A.38.

Frequency: Giant pouched rat 2 (2), blue duiker 2 (2), medium duiker 1 (1).

Function: Dismemberment.

LUM-14

Description: Nick in posterior edge of lumbar transverse process. Figure A.38.

Frequency: Medium duiker 3 (4).

Function: Dismemberment, food preparation.

LUM-15

Description: Nick in anterior edge of lumbar transverse process. Figure A.38.

Frequency: Giant pouched rat 1 (1), brush-tailed porcupine 1 (1), medium duiker 1 (1).

Function: Dismemberment, food preparation.

LUM-16

Description: Partial chop version of Lupo's (1993) Lum-2. Not illustrated (See figure A.39).

Frequency: Medium duiker 1 (1).

Function: Unknown.

Sacrum**SAC-1**

Description: Complete sagittally-oriented chop through sacrum. Figure A.41.

Frequency: Giant pouched rat 3 (3), tree pangolin 2 (2), brush-tailed porcupine 8 (8), monkey 1 (1), blue duiker 25 (25), medium duiker 5 (6).

Function: Dismemberment. This mark is a continuation of the complete-carcass sagittal chop that passes through the vertebrae.

SAC-2

Description: Complete transverse chop through sacrum. Figure A.41.

Frequency: Giant pouched rat 1 (1), blue duiker 6 (7), medium duiker 2 (2).

Function: Dismemberment, food preparation.

SAC-3

Description: Transverse cut on ventral surface of sacrum toward cranial end (underside of sacrum wings). Not illustrated.

Frequency: Giant pouched rat 1 (2), blue duiker 2 (2).

Function: Dismemberment.

SAC-4

Description: Sagittal cut on ventral surface of sacrum. Not illustrated.

Frequency: Giant pouched rat 2 (3), tree pangolin 1 (2), blue duiker 1 (1).

Function: Unknown.

SAC-5

Description: Transverse cut midway along length of dorsal sacrum. Figure A.41.

Frequency: Blue duiker 1 (1), civet 1 (1).

Function: Dismemberment.

SAC-6

Description: Sagittal cut on anterior centrum. Not illustrated (see THO-14).

Frequency: Blue duiker 2 (2).

Function: Unknown.

SAC-7

Description: Sagittally-oriented cut on dorsal sacrum toward caudal end. Not illustrated.

Frequency: Medium duiker 1 (1).

Function: Unknown.

Caudal**CAU-1**

Description: Complete transverse chop through caudal. Not illustrated.

Frequency: Giant pouched rat 1 (1), brush-tailed porcupine 1 (1), medium duiker 2 (2).

Function: Dismemberment, food preparation.

CAU-2

Description: Transverse nicks on lateral edge of caudal. Not illustrated.

Frequency: Giant pouched rat 1 (2).

Function: Dismemberment.

CAU-3

Description: Complete sagittal chop through caudal. Not illustrated.

Frequency: Monkey 1 (1), medium duiker 1 (1).

Function: Dismemberment.

CAU-4

Description: Transverse cut on dorsal caudal. Not illustrated.

Frequency: Giant pouched rat 1 (1).

Function: Dismemberment.

Rib

RIB-1

Description: Transverse cut on medial mid-shaft of rib. Figure A.44.

Frequency: Giant pouched rat 1 (2), tree pangolin 1 (2), brush-tailed porcupine 2 (2), blue duiker 51 (72), medium duiker 31 (59), river hog 2 (5).

Function: Unknown.

RIB-2

Description: Transverse cut on medial proximal shaft. Figure A.44.

Frequency: Giant pouched rat 2 (2), monkey 5 (5), blue duiker 29 (40), medium duiker 8 (10).

Function: Unknown.

Rib-3

Description: "Rib head cut off between head and tubercle" (Lupo 1993:289). Figure A.42.

Frequency: Giant pouched rat 3 (3), tree pangolin 1 (1), brush-tailed porcupine 11 (11), blue duiker 10 (11), medium duiker 2 (2).

Function: Dismemberment.

Rib-4

Description: “Rib shaft cut off at or just below angle” (Lupo 1993:289). Used here to designate a complete chop through the proximal rib shaft. Figure A.42.

Frequency: Blue duiker 17 (17), medium duiker 26 (26).

Function: Dismemberment.

RIB-5

Description: Transverse nick on anterior (cranial) edge of mid-shaft. Figure A.43.

Frequency: Blue duiker 8 (11), medium duiker 5 (5).

Function: Unknown.

RIB-6

Description: Transverse cut on lateral mid-shaft. Figure A.44.

Frequency: Blue duiker 26 (37), medium duiker 12 (15).

Function: Unknown. Possibly fillet and/or food preparation.

RIB-7

Description: Transverse or oblique nick on anterior (cranial) edge of distal shaft. Figure A.43.

Frequency: Blue duiker 20 (28), medium duiker 1 (2).

Function: Unknown.

RIB-8

Description: Transverse nick on postero-medial edge at mid-shaft. Figure A.45.

Frequency: Blue duiker 5 (6), medium duiker 1 (1).

Function: Unknown.

RIB-9

Description: Transverse nick on anterior (cranial) edge of proximal rib shaft. Figure A.43.

Frequency: Giant pouched rat 5 (6), blue duiker 8 (11), medium duiker 6 (7).

Function: Unknown.

RIB-10

Description: Transverse nick on posterior (caudal) edge of proximal rib shaft. Figure A.45.

Frequency: Blue duiker 3 (4), medium duiker 2 (2).

Function: Unknown.

RIB-11

Description: Transverse or oblique nick on posterior (caudal) edge of distal shaft. Figure A.45.

Frequency: Blue duiker 2 (4), medium duiker 1 (1).

Function: Unknown.

RIB-12

Description: Transverse cut on posterior (caudal) rib neck. Figure A.45.

Frequency: Medium duiker 1 (1).

Function: Unknown.

Rib-14

Description: "Single transverse or oblique cutmarks or scrapes at the shaft mid-section just below the angle on the lateral side" (Lupo 1993:318). Used here to refer to transverse cut on lateral proximal shaft. Figure A.44.

Frequency: Blue duiker 3 (4), medium duiker 4 (6).

Function: Fillet (Lupo 1993:318).

Rib-16

Description: “Cluster of transverse or oblique cutmarks on the lateral surface near the distal end of the rib” (Lupo 1993:319). As used here, may apply to one or more cuts at this location. Figure A.44.

Frequency: Blue duiker 33 (50), medium duiker 14 (27).

Function: Fillet (Lupo 1993:319).

Rib-17

Description: “Single cutmark on the distal end of the rib on the medial surface” (Lupo 1993:319). Used here to categorize a transverse or oblique cut on medial face of distal rib shaft. Figure A.44.

Frequency: Giant pouched rat 1 (1), brush-tailed porcupine 2 (2), blue duiker 14 (25), medium duiker 10 (15), river hog 3 (5).

Function: Fillet (Lupo 1993:319).

Rib-19

Description: “Rib shaft cut or chopped in half at the mid-section” (Lupo 1993:343). Figure A.42.

Frequency: Giant pouched rat 1 (1), tree pangolin 1 (1), brush-tailed porcupine 1 (1), blue duiker 220 (223), medium duiker 33 (36), river hog 3 (3).

Function: Dismemberment (Lupo 1993:343).

Rs-2

Description: Based on Binford’s (1981) RS-2. “Distal ends of the ribs are cut or chopped off” (Lupo 1993:318). Lupo notes that a similar mark is reported by Frison (1971). Figure A.42.

Frequency: Giant pouched rat 2 (2), blue duiker 118 (118), medium duiker 23 (23).

Function: Dismemberment. Mark consistent with removal of the sternum portion.

Sternum

STE-1

Description: Transverse cuts along medial/lateral edge of sternum. Not illustrated.

Frequency: Blue duiker 1 (3).

Function: Dismemberment.

STE-2

Description: Complete transverse chop through sternum. Not illustrated.

Frequency: Medium duiker 1 (2).

Function: Dismemberment.

STE-3

Description: Complete sagittal chop through sternum. Guilday et al. (1962:76) identify this mark (Cut 19) on white-tailed deer (*Odocoileus virginianus*) and elk (*Cervus canadensis*) sternabrae. Not illustrated.

Frequency: Blue duiker 6 (6).

Function: Dismemberment.

STE-4

Description: Transverse cut on dorsal surface of sternum. Not illustrated.

Frequency: Blue duiker 3 (3).

Function: Unknown.

STE-5

Description: Transverse cut on ventral surface of sternum. Binford (1981) codes marks on the ventral sternum as RS-4, but does not specify the orientation of these marks. Not illustrated.

Frequency: Blue duiker 1 (2).

Function: Unknown.

STE-6

Description: Sagittally-oriented cut on the dorsal sternum. Not illustrated.

Frequency: Blue duiker 2 (3).

Function: Unknown.

Scapula

SCP-1

Description: Transverse cuts on the posterior neck of the scapula. Binford (1981) codes all cuts on the scapula neck (regardless of side) as S-2. Figure A.48.

Frequency: Giant pouched rat 1 (2), brush-tailed porcupine 1 (2), blue duiker 17 (35), medium duiker 1 (1).

Function: Dismemberment.

SCP-2

Description: Transverse cuts on the medial scapula neck. Binford (1981) codes all cuts on the scapula neck (regardless of side) as S-2. Figure A.47.

Frequency: Blue duiker 8 (10).

Function: Dismemberment. Guilday et al. (1962:76) identify a similar mark (Cut 5) on white-tailed deer (*Odocoileus virginianus*) and elk (*Cervus canadensis*) scapulae and relate it to shoulder dismemberment.

SCP-3

Description: Complete transverse chop through scapula neck. Figure A.46.

Frequency: Blue duiker 15 (15), medium duiker 1 (1).

Function: Dismemberment.

SCP-4

Description: Complete transverse chop through scapula blade. Figure A.46.

Frequency: Giant pouched rat 1 (1), blue duiker 4 (4), medium duiker 1 (1), river hog 3 (3).

Function: Dismemberment.

SCP-5

Description: Transverse nicks in anterior edge of scapula blade. Figure A.46.

Frequency: Giant pouched rat 2 (4), tree pangolin 1 (1), brush-tailed porcupine 1 (1).

Function: Unknown.

SCP-6

Description: Complete longitudinal chop through anterior portion of glenoid. Figure A.46.

Frequency: Giant pouched rat 1 (1), blue duiker 1 (1).

Function: Dismemberment.

SCP-7

Description: Partial transverse chop in scapula neck. Figure A.47.

Frequency: Blue duiker 4 (4), medium duiker 1 (1).

Function: Dismemberment.

SCP-8

Description: Transverse cuts on posterior scapula blade. Figure A.48.

Frequency: Blue duiker 1 (2), river hog 1 (1).

Function: Dismemberment.

SCP-9

Description: Small longitudinal nick in lateral edge of glenoid. Figure A.46.

Frequency: Blue duiker 1 (1).

Function: Unknown.

SCP-10

Description: Partial transverse chop in scapula blade. Figure A.47.

Frequency: Blue duiker 2 (2), river hog 2 (5).

Function: Dismemberment.

Humerus**Hd-1**

Description: “Transverse marks across anterior articulator face” (Binford 1981:140). Binford also cites Guilday et al. (1962) and David (1972) as references for this mark. Figure A.49.

Frequency: Blue duiker 3 (4).

Function: Dismemberment (Binford 1981:140). Guilday et al. (1962:68, 70, 76) identify similar marks (Cuts 8, 2, and 6) on black bear (*Ursus americanus*), mountain lion (*Felis concolor*), white-tailed deer (*Odocoileus virginianus*), and elk (*Cervus canadensis*) humeri and associate them with elbow dismemberment.

Hd-2

Description: “Transverse marks across medial surface” (Binford 1981:140). Binford illustrates this mark in multiple locations. Used here to designate cuts as illustrated in Binford’s Figure 4.30 (f) (1981:123). Also see Marshall (1986). Figure A.51.

Frequency: Blue duiker 10 (15).

Function: Dismemberment (Binford 1981:140).

Hd-3

Description: “Marks on the upper margins of the olecranon fossa” (Binford 1981:141). Binford also cites Wheat (1979) and David (1972) as references for this mark. Nicholson documents a similar mark on brown capuchin monkey (*Cebus apella*) and white-lipped peccary (*Tayassu pecari*) bones processed by Aché foragers. Figure A.52.

Frequency: Giant pouched rat 1 (1), blue duiker 6 (13).

Function: Dismemberment (Binford 1981:141).

Hp-1

Description: “Marks along the border of the ‘lip’ of ball, concentrated on the posterior edge” (Binford 1981:140). Binford also cites Martin (1907-1910) and Guilday et al. (1962) as references for this mark. Figure A.52.

Frequency: Blue duiker 2 (3).

Function: Dismemberment (Binford 1981:140).

Hp-2

Description: “Marks on the apex of the lateral tuberosity” (Binford 1981:140). Binford also cites Parmalee (1965) as a reference for this mark. Figure A.51.

Frequency: Civet 1 (2).

Function: Dismemberment (Binford 1981:140).

HUM-1

Description: Transverse cut on postero-lateral face of proximal shaft. Figure A.52.

Frequency: Blue duiker 2 (2).

Function: Unknown.

HUM-2

Description: Complete transverse chop through or slightly below humeral head. Figure A.49.

Frequency: Tortoise 3 (3), tree pangolin 2 (2), blue duiker 23 (23), medium duiker 1 (1).

Function: Dismemberment.

HUM-3

Description: Complete transverse chop through or slightly above distal condyle. Figure A.49.

Frequency: Giant pouched rat 1 (1), brush-tailed porcupine 1 (1), blue duiker 16 (16), medium duiker 1 (1).

Function: Dismemberment.

HUM-4

Description: Transverse cut on medial mid-shaft. Figure A.51.

Frequency: Giant pouched rat 1 (3), brush-tailed porcupine 1 (1), blue duiker 3 (7).

Function: Unknown. Possibly fillet and/or food preparation.

HUM-5

Description: Transverse cut on anterior proximal shaft. Figure A.49.

Frequency: Blue duiker 3 (5).

Function: Unknown. Possibly fillet and/or food preparation.

HUM-6

Description: Partial chop in humerus mid-shaft. Figure A.52.

Frequency: Blue duiker 1 (2), medium duiker 1 (2).

Function: Dismemberment.

Hum-7

Description: “Multiple fine striae oblique and parallel on the neck below the proximal articulation on posterior surface similar to [Binford’s 1981] Hp-5” (Lupo 1993:295). Used here to refer to one or more transverse or oblique cuts on posterior humerus neck. Figure A.52.

Frequency: Giant pouched rat 2 (3), civet 1 (1), blue duiker 11 (17).

Function: Fillet (Lupo 1993:344).

HUM-8

Description: Partial chop in or just below humeral head. Figure A.53.

Frequency: Blue duiker 2 (3).

Function: Dismemberment.

Hum-9

Description: “Two transverse cutmarks on the anterior surface of the lateral tuberosity” (Lupo 1993:295). May apply to one or more marks at this location. Figure A.49.

Frequency: Giant pouched rat 1 (1), blue duiker 2 (3).

Function: Dismemberment. Lupo identifies this as a “fillet, dismemberment” mark (1993:295). It is most likely associated with dismemberment in this context.

HUM-10

Description: Deep transverse cut on medial face, just above distal condyle. Figure A.51.

Frequency: Blue duiker 1 (1).

Function: Dismemberment.

Hum-11

Description: “A single transverse cutmark on the medial proximal shaft below the neck” (Lupo 1993:296). Figure A.51.

Frequency: Blue duiker 1 (1).

Function: Fillet (Lupo 1993:296).

HUM-12

Description: Partial chop just above the distal condyle. Figure A.53.

Frequency: Blue duiker 5 (5).

Function: Dismemberment.

Hum-13

Description: “A single transverse or oblique cutmark on the posterior side at the mid-section of the shaft” (Lupo 1993:296). May refer to one or more marks at this location. Figure A.52.

Frequency: Blue duiker 2 (9).

Function: Fillet (Lupo 1993:296).

Hum-14

Description: "A single oblique cutmark on medial distal shaft" (Lupo 1993:296). Used here to indicate one or more transverse or oblique cuts at this location. Figure A.51.

Frequency: Brush-tailed porcupine 1 (3).

Function: Unknown. Lupo (1993:296) classifies this as a fillet mark, but this function is unlikely for small prey like porcupines.

HUM-15

Description: Transverse cut on anterior distal shaft. Figure A.49.

Frequency: Blue duiker 3 (5), medium duiker 1 (2).

Function: Unknown. Possibly fillet and/or food preparation.

HUM-16

Description: Transverse cut on lateral face of lateral tuberosity. Figure A.50.

Frequency: Blue duiker 1 (1).

Function: Dismemberment.

HUM-17

Description: Longitudinal cut on the anterior proximal humerus between tuberosities. Figure A.49.

Frequency: Brush-tailed porcupine 1 (2).

Function: Unknown.

HUM-18

Description: Transverse cuts across the medial face of proximal humerus. Figure A.51.

Frequency: Tortoise 1 (2), blue duiker 1 (4), medium duiker 1 (4).

Function: Dismemberment.

HUM-19

Description: Transverse cut on the lateral mid-shaft. Figure A.50.

Frequency: Medium duiker 1 (1).

Function: Unknown. Possibly fillet and/or food preparation.

Radius

RAD-1

Description: Transverse or oblique cut on the medial mid-shaft. Figure A.57.

Frequency: Blue duiker 9 (15), medium duiker 1 (1).

Function: Unknown. Possibly fillet and/or food preparation.

RAD-2

Description: Transverse cut on anterior proximal shaft. Figure A.54.

Frequency: Blue duiker 2 (2).

Function: Unknown.

RAD-3

Description: Transverse cut on postero-medial edge of distal shaft. Figure A.57.

Frequency: Blue duiker 1 (1).

Function: Unknown.

RAD-4

Description: Complete transverse chop through radius mid-shaft. Figure A.54.

Frequency: Blue duiker 1 (1), medium duiker 2 (2).

Function: Dismemberment.

RAD-5

Description: Partial chop in anterior distal shaft. Figure A.55.

Frequency: Blue duiker 1 (1).

Function: Dismemberment.

RAD-6

Description: Transverse or oblique cut on lateral face just below proximal articulation. Figure A.56.

Frequency: Blue duiker 1 (1).

Function: Dismemberment.

RAD-7

Description: Complete transverse chop through proximal radius. Figure A.54.

Frequency: Blue duiker 1 (1).

Function: Dismemberment.

RAD-8

Description: Partial chop in medial face of radius just below proximal articulation. Figure A.57.

Frequency: Blue duiker 1 (1).

Function: Dismemberment.

RAD-9

Description: Transverse cut on posterior radius just below proximal end. Figure A.58.

Frequency: Medium duiker 1 (2).

Function: Dismemberment. Guilday et al. (1962:68, 76) identify similar marks (Cuts 10 and 7) on black bear (*Ursus americanus*), white-tailed deer (*Odocoileus virginianus*), and elk (*Cervus canadensis*) radii and associate them with elbow dismemberment.

RAD-10

Description: Complete chop through proximal shaft of radius. Figure A.54.

Frequency: Blue duiker 1 (1), medium duiker 1 (1).

Function: Dismemberment.

RAD-11

Description: Complete chop through distal shaft of radius. Figure A.54.

Frequency: Giant pouched rat 1 (1), blue duiker 2 (2).

Function: Dismemberment.

RAD-12

Description: Transverse cut on medial face just below proximal articulation. Figure A.57.

Frequency: Giant pouched rat 1 (1), blue duiker 1 (2).

Function: Dismemberment.

RCd-3

Description: “Transverse marks on the inferior articulator surface” (Binford 1981:141). Figure A.55.

Frequency: Blue duiker 1 (2).

Function: Dismemberment (Binford 1981:141).

RCp-5

Description: “Transverse marks on anterior margin of radial tuberosities” (Binford 1981:141). Binford also cites Frison (1970), David (1972), Parmalee (1965), and Wheat (1979) as references for this mark. Figure A.55.

Frequency: Medium duiker 1 (1).

Function: Dismemberment (Binford 1981:141).

Ulna**RCp-1**

Description: “Transverse mark inside semi-lunar notch” (Binford 1981:141). Figure A.59.

Frequency: Blue duiker 2 (2).

Function: Dismemberment (Binford 1981:141). Guilday et al. (1962:68, 76) identify similar marks (Cuts 9 and 8) on black bear (*Ursus americanus*), white-tailed deer (*Odocoileus virginianus*), and elk (*Cervus canadensis*) ulnae and associate it with elbow dismemberment.

ULN-1

Description: Complete diagonal chop through olecranon. Figure A.59.

Frequency: Blue duiker 8 (8).

Function: Dismemberment.

ULN-2

Description: Transverse cuts along posterior edge of proximal ulna. Figure A.59.

Frequency: Blue duiker 5 (7).

Function: Dismemberment.

ULN-3

Description: Transverse cut on anterior edge of ulna mid-shaft. Figure A.59.

Frequency: Civet 1 (1).

Function: Unknown.

ULN-4

Description: Complete chop through distal shaft of ulna. Figure A.59.

Frequency: Giant pouched rat 1 (1), blue duiker 2 (2), medium duiker 1 (1).

Function: Dismemberment.

ULN-5

Description: Complete chop through ulna just below semi-lunar notch. Figure A.59.

Frequency: Blue duiker 1 (1), medium duiker 1 (1).

Function: Dismemberment.

ULN-6

Description: Transverse cuts on medial or lateral surface of distal ulna. Figure A.59.

Frequency: Blue duiker 3 (6), medium duiker 1 (5).

Function: Unknown.

Metacarpal**MCM-1**

Description: Complete transverse chop through mid-shaft. Figure A.61.

Frequency: Blue duiker 4 (4).

Function: Dismemberment.

MCM-2

Description: Transverse cut on medial mid-shaft. Figure A.60.

Frequency: Blue duiker 1 (1).

Function: Unknown.

MCM-3

Description: Partial chop removing one distal condyle. Figure A.61.

Frequency: Blue duiker 1 (1).

Function: Dismemberment.

MCM-4

Description: Partial transverse chop in posterior just below proximal articulation. Figure A.61.

Frequency: Blue duiker 1 (1).

Function: Dismemberment.

MCM-5

Description: Transverse cuts just above distal condyles on anterior surface. Figure A.60.

Frequency: Medium duiker 1 (2).

Function: Dismemberment.

MCM-6

Description: Transverse cuts on anterior surface just below proximal articulation. Figure A.60.

Frequency: Medium duiker 1 (3).

Function: Dismemberment.

Mc-7

Description: "Single transverse cutmark on the anterior distal shaft" (Lupo 1993:347). As used here, may apply to one or more marks at this location. Figure A.60.

Frequency: Medium duiker 1 (5).

Function: Skinning (Lupo 1993:347).

MCM-8

Description: Transverse cut on medial proximal shaft. Comparable to MTM-9, but occurs on the metacarpal. Not illustrated (See MTM-9, Figure A.81).

Frequency: Blue duiker 1 (2).

Function: Unknown.

Innominate**ACE-1**

Description: Partial chop through the acetabulum. Comparable to Lupo's (1993) Pel-3, but does not pass completely through the acetabulum. Figure A.64.

Frequency: Monkey 1 (1), blue duiker 3 (3).

Function: Dismemberment.

ACE-2

Description: Transverse cut across acetabulum. Figure A.65.

Frequency: Giant pouched rat 1 (1), blue duiker 3 (4).

Function: Dismemberment.

APUB-1

Description: Small transverse cut on dorsal-medial pubis near acetabulum. Figure A.62.

Frequency: Giant pouched rat 1 (1), brush-tailed porcupine 1 (1), blue duiker 2 (2).

Function: Unknown.

ILI-1

Description: Complete transverse chop through the ilium blade. Figure A.63.

Frequency: Giant pouched rat 9 (10), brush-tailed porcupine 2 (2), monkey 1 (1), blue duiker 6 (6), medium duiker 2 (2).

Function: Dismemberment.

ILI-2

Description: Partial transverse chop in lateral face of ilium blade. Figure A.64.

Frequency: Blue duiker 1 (1).

Function: Dismemberment.

ILI-3

Description: Partial transverse chop in lateral face of ilium neck. Figure A.64.

Frequency: Blue duiker 1 (1).

Function: Dismemberment.

ILI-4

Description: Transverse cut on the medial ilium neck. Figure A.66.

Frequency: Giant pouched rat 1 (1), brush-tailed porcupine 1 (1), blue duiker 3 (4), medium duiker 3 (6).

Function: Unknown.

ILI-5

Description: Transverse cut on lateral ilium mid-neck. Comparable to Lupo's (1993) Pel-1, but less dispersed along the length of the ilium neck and blade. Figure A.65.

Frequency: Giant pouched rat 1 (1), blue duiker 4 (10), medium duiker 3 (3).

Function: Unknown.

ILI-6

Description: Transverse cut on the ventral edge of the ilium neck. Figure A.67.

Frequency: Giant pouched rat 1 (1), tortoise 1 (3), brush-tailed porcupine 1 (2), blue duiker 7 (11).

Function: Unknown. Possibly related to dismemberment.

ILI-7

Description: Partial chop at the location of Binford's (1981) PS-7. Figure A.68.

Frequency: Blue duiker 1 (1).

Function: Dismemberment.

ILI-8

Description: Partial chop on ventral edge of ilium neck. Figure A.68.

Frequency: Giant pouched rat 1 (1), brush-tailed porcupine 2 (2), blue duiker 1 (1).

Function: Dismemberment.

ILI-9

Description: Transverse cut on lateral ilium blade. Comparable to the uppermost of Lupo's (1993) Pel-1 marks. This mark often occurs parallel to a shear fracture through the ilium blade. Figure A.65.

Frequency: Giant pouched rat 4 (4), blue duiker 2 (3), civet 1 (3).

Function: Dismemberment.

ILI-10

Description: Partial chop in the dorsal edge of the ilium neck just above the acetabulum. Figure A.62.

Frequency: Giant pouched rat 1 (1), blue duiker 1 (1).

Function: Dismemberment.

ILI-11

Description: Transverse cut on ventral edge of ilium blade. Nicholson (2005:68) documents a similar mark on red brocket deer (*Mazama americana*) bones processed by Aché foragers. Figure A.67.

Frequency: Giant pouched rat 4 (8), brush-tailed porcupine 2 (4), blue duiker 3 (5).

Function: Dismemberment.

ILI-12

Description: Transverse cut on medial face of ilium blade. Figure A.66.

Frequency: Blue duiker 2 (4).

Function: Unknown.

ILI-13

Description: Partial chop in the medial ilium blade. Figure A.66.

Frequency: Monkey 1 (2), blue duiker 1 (1).

Function: Dismemberment.

ILI-14

Description: Partial chop in medial ilium neck. Figure A.66.

Frequency: Giant pouched rat 1 (1), medium duiker 1 (2).

Function: Dismemberment.

ILI-15

Description: Transverse nick in dorsal edge of ilium blade. Figure A.62.

Frequency: Giant pouched rat 2 (2).

Function: Unknown.

ILI-16

Description: Longitudinal chop through anterior-dorsal corner of ilium blade. Figure A.63.

Frequency: Medium duiker 1 (1).

Function: Dismemberment.

ILI-17

Description: Transverse chop through anterior-ventral corner of ilium blade. Figure A.63.

Frequency: Medium duiker 1 (1).

Function: Dismemberment.

ISC-1

Description: Partial transverse chop in the ischium below the acetabulum. This is a partial version of Lupo's (1993) Pel-4. Figure A.64.

Frequency: Blue duiker 2 (2).

Function: Dismemberment.

ISC-2

Description: Transverse cut across dorsal edge of ischium just below acetabulum. Figure A.62.

Frequency: Giant pouched rat 1 (1), brush-tailed porcupine 1 (1), blue duiker 2 (3).

Function: Unknown.

ISC-3

Description: Oblique cut on medial ischium. Figure A.66.

Frequency: Blue duiker 1 (1), medium duiker 1 (1).

Function: Unknown.

ISC-4

Description: Complete transverse chop through the caudal end of the pelvis. Figure A.63.

Frequency: Blue duiker 2 (2).

Function: Dismemberment.

Pel-2

Description: "Ilium chopped off above the acetabulum" (Lupo 1993:347). Figure A.63.

Frequency: Giant pouched rat 2 (2), tortoise 3 (3), brush-tailed porcupine 5 (5), monkey 2 (2), blue duiker 28 (28), medium duiker 7 (7).

Function: Dismemberment (Lupo 1993:347). Guilday et al. (1962:76) identify this mark (Cut 12) on white-tailed deer (*Odocoileus virginianus*) and elk (*Cervus canadensis*) innominates and relate it to dismemberment.

Pel-3

Description: "Chop through acetabulum" (Lupo 1993:347). Figure A.63.

Frequency: Giant pouched rat 1 (1), tree pangolin 1 (1), brush-tailed porcupine 9 (9), monkey 1 (1), blue duiker 10 (10), medium duiker 4 (4).

Function: Food preparation (Lupo 1993:347).

Pel-4

Description: "Ischium chopped off below the acetabulum" (Lupo 1993:347). Figure A.63.

Frequency: Giant pouched rat 5 (5), blue duiker 13 (13), medium duiker 3 (3).

Function: Food preparation (Lupo 1993:347).

PS-6

Description: “Cut across deep fossa in front of acetabulum” (Binford 1981:138). Binford also cites Guilday et al. (1962) as a reference for this mark. Hockett (1994:111) reports a similar mark on a *Lepus* sp. innominate recovered from Hogup Cave. Figure A.67.

Frequency: Blue duiker 3 (7).

Function: Filleting (Binford 1981:138).

PS-7

Description: “Marks above the acetabulum on arm of ilium” (Binford 1981:138). Binford also cites Wheat (1979) as a reference for this mark. Binford specifically illustrates this mark on the ventral edge (see Figure A.67).

Frequency: Giant pouched rat 6 (9), brush-tailed porcupine 4 (4), blue duiker 8 (15), medium duiker 1 (1).

Function: Dismemberment (Binford 1981:138).

PS-8

Description: “Marks below acetabulum on arm of ischium” (Binford 1981:138). Binford illustrates a range of locations for this mark, all on the lateral-ventral edge (see Figure A.67).

Frequency: Giant pouched rat 4 (8), monkey 1 (2), blue duiker 5 (7).

Function: Dismemberment (Binford 1981:138).

PS-10

Description: “Marks below acetabulum on arm of pelvis” (Binford 1981:138). Used here to specifically code transverse cuts on the anterior/ventral pubis. Figure A.67.

Frequency: Murid rats and mice 1 (2), giant pouched rat 2 (4), tree pangolin 1 (1), blue duiker 12 (18), medium duiker 1 (1).

Function: Dismemberment (Binford 1981:138). Guilday et al. (1962:68) identify a similar mark (Cut 13) on black bear (*Ursus americanus*) innominates and associate it with hipsocket dismemberment.

PUB-1

Description: Complete sagittal or slightly diagonal chop through the acetabulum/pubis. Figure A.68.

Frequency: Giant pouched rat 2 (2), tree pangolin 1 (1), blue duiker 27 (29), medium duiker 3 (3).

Function: Dismemberment. This mark results from the sagittal splitting of the carcass.

PUB-2

Description: Partial chop version of PUB-1. Not illustrated.

Frequency: Tortoise 1 (1), blue duiker 1 (1).

Function: Dismemberment.

Femur

Fd-1

Description: “Transverse cut across posterior surface just above condyles” (Binford 1981:138). Binford also cites Guilday et al. (1962) as a reference for this mark. Nicholson (2005:127) documents a similar mark on brown capuchin monkey (*Cebus apella*) bones processed by Aché foragers. Figure A.74.

Frequency: Brush-tailed porcupine 3 (3), blue duiker 16 (36), medium duiker 2 (4).

Function: Dismemberment (Binford 1981:138). Guilday et al. (1962:68) identify a similar mark (Cut 15) on black bear (*Ursus americanus*) femora and associate it with knee joint dismemberment.

FEM-1

Description: Transverse cut on posterior distal shaft. Figure A.74.

Frequency: Blue duiker 4 (9).

Function: Unknown. Possibly fillet and/or food preparation.

FEM-2

Description: Transverse cut on anterior mid-shaft. Figure A.69.

Frequency: Tree pangolin 1 (1), brush-tailed porcupine 1 (1), blue duiker 2 (7).

Function: Unknown. Possibly fillet and/or food preparation.

Fem-3

Description: “A single transverse cutmark on the posterior side at the mid-section of the shaft” (Lupo 1993:299). Figure A.74.

Frequency: Giant pouched rat 10 (13), brush-tailed porcupine 1 (3), blue duiker 4 (6), medium duiker 1 (2).

Function: Fillet (Lupo 1993:299).

FEM-4

Description: Transverse cut on lateral mid-shaft. Figure A.72.

Frequency: Blue duiker 6 (8).

Function: Unknown. Possibly fillet and/or food preparation.

FEM-5

Description: Transverse or oblique cut on medial mid-shaft. Figure A.73.

Frequency: Murid rats and mice 1 (1), giant pouched rat 3 (8), brush-tailed porcupine 1 (2), blue duiker 4 (4).

Function: Unknown. Possibly fillet and/or food preparation.

FEM-6

Description: Deep hacks in the posterior distal condyles. Figure A.75.

Frequency: Blue duiker 3 (6).

Function: Dismemberment.

FEM-7

Description: Transverse or oblique cut on the medial distal shaft. Figure A.73.

Frequency: Giant pouched rat 2 (2), tree pangolin 1 (1), blue duiker 1 (2).

Function: Unknown. Possibly fillet and/or food preparation.

FEM-8

Description: Partial chop in the posterior distal shaft. Figure A.75.

Frequency: Blue duiker 6 (8).

Function: Dismemberment.

FEM-9

Description: Complete transverse chop through shaft just below proximal end. Figure A.75.

Frequency: Giant pouched rat 6 (6), monkey 1 (1), blue duiker 17 (17), medium duiker 5 (5).

Function: Dismemberment.

FEM-10

Description: Transverse or oblique cut on medial proximal shaft. Figure A.73.

Frequency: Giant pouched rat 1 (1), tree pangolin 1 (2), monkey 1 (1), blue duiker 5 (7).

Function: Unknown. Possibly fillet and/or food preparation.

FEM-11

Description: Complete transverse chop through or just above distal condyles. Nicholson (2005:86) documents a similar mark on white-lipped peccary (*Tayassu pecari*) bones processed by Aché foragers. Figure A.70.

Frequency: Giant pouched rat 5 (5), brush-tailed porcupine 1 (1), blue duiker 13 (13), medium duiker 3 (3).

Function: Dismemberment.

FEM-12

Description: Complete transverse chop through mid-shaft. Figure A.72.

Frequency: Giant pouched rat 2 (2), blue duiker 16 (16), medium duiker 5 (5).

Function: Dismemberment.

FEM-13

Description: Complete longitudinal chop through femoral head. Figure A.73.

Frequency: Brush-tailed porcupine 1 (1), blue duiker 1 (1), medium duiker 1 (1).

Function: Dismemberment.

FEM-14

Description: Partial chop in posterior mid-shaft. Figure A.75.

Frequency: Blue duiker 1 (1), medium duiker 1 (1).

Function: Dismemberment.

Fem-15

Description: "Distal end is chopped sagittally" (Lupo 1993:349). Lupo also cites Yellen (1977b) as a reference for this mark. Figure A.71.

Frequency: Blue duiker 3 (3).

Function: Food preparation (Lupo 1993:349).

FEM-16

Description: Complete transverse chop through femoral head. Figure A.75.

Frequency: Giant pouched rat 1 (1), tree pangolin 1 (2), brush-tailed porcupine 1 (1).

Function: Dismemberment.

FEM-17

Description: Transverse marks on the posterior femoral neck and greater trochanter. Figure A.74.

Frequency: Brush-tailed porcupine 2 (2), blue duiker 1 (2), medium duiker 2 (5).

Function: Unknown. Possibly fillet and/or food preparation.

FEM-18

Description: Transverse cuts on medial greater trochanter. Figure A.73.

Frequency: Giant pouched rat 1 (2).

Function: Dismemberment.

FEM-19

Description: Transverse cut on the anterior distal shaft. Nicholson (2005:71) documents a similar mark on brown capuchin monkey (*Cephus apella*) bones processed by Aché foragers. Figure A.69.

Frequency: Blue duiker 1 (4).

Function: Unknown. Possibly fillet and/or food preparation.

FEM-20

Description: Transverse or oblique cut on anterior proximal shaft. Figure A.69.

Frequency: Blue duiker 3 (3).

Function: Unknown. Possibly fillet and/or food preparation.

FEM-21

Description: Transverse cuts encircling complete mid-shaft cylinder. Figure A.70.

Frequency: Medium duiker 2 (8).

Function: Unknown. Possibly fillet and/or food preparation.

FEM-22

Description: Longitudinal cut on the posterior distal shaft. Figure A.74.

Frequency: Blue duiker 1 (1).

Function: Unknown.

FEM-23

Description: Partial transverse chop in femoral head. Figure A.75.

Frequency: Blue duiker 2 (2), medium duiker 1 (1).

Function: Dismemberment.

FEM-24

Description: Transverse cut on the lateral proximal shaft. Figure A.72.

Frequency: Blue duiker 1 (2).

Function: Unknown. Possibly fillet and/or food preparation.

FEM-25

Description: Transverse cut on the posterior proximal shaft. Figure A.74.

Frequency: Monkey 1 (1), blue duiker 3 (3).

Function: Unknown. Possibly fillet and/or food preparation.

FEM-26

Description: Partial longitudinal chop in femoral head. Figure A.73.

Frequency: Monkey 1 (1).

Function: Dismemberment.

FEM-27

Description: Longitudinal cut on medial mid-shaft. Figure A.73.

Frequency: Blue duiker 1 (1).

Function: Unknown.

Fp-1

Description: “Marks on the neck of the femur” (Binford 1981:138). Binford also cites Guilday et al. (1962) and Martin (1907-1910) as references for this mark. Nicholson (2005:54) documents similar cuts and cleave marks on red brocket deer (*Mazama americana*) bones processed by Aché foragers. Figure A.69.

Frequency: Giant pouched rat 4 (5), blue duiker 3 (3).

Function: Dismemberment (Binford 1981:138). Guilday et al. (1962:68) identify a similar mark (Cut 14) on black bear (*Ursus americanus*) femora and associate it with hipsocket dismemberment.

Fp-3

Description: “Marks circling the margin of the femur head” (Binford 1981:138). Figure A.69.

Frequency: Giant pouched rat 2 (4), blue duiker 1 (1), medium duiker 1 (2).

Function: Dismemberment (Binford 1981:138).

Fp-4

Description: “Transverse marks on lesser trochanter” (Binford 1981:138). Figure A.74.

Frequency: Giant pouched rat 2 (2), blue duiker 7 (11).

Function: Filleting (Binford 1981:138).

Fp-5

Description: “Transverse marks on lateral surface of greater trochanter” (Binford 1981:138). Figure A.72.

Frequency: Brush-tailed porcupine 1 (1), blue duiker 3 (4).

Function: Dismemberment (Binford 1981:138).

Fp-7

Description: “Short marks on the neck of greater trochanter, anterior face” (Binford 1981:138). Binford also cites Wheat (1979) as a reference for this mark. Figure A.69.

Frequency: Giant pouched rat 3 (5), brush-tailed porcupine 1 (3), blue duiker 6 (19).

Function: Filleting (Binford 1981:138).

Patella**PAT-1**

Description: Transverse cut on anterior patella. Not illustrated.

Frequency: Medium duiker 1 (2).

Function: Dismemberment.

Tibia

Td-1

Description: “Transverse marks across medial malleolus and just above on distal tibia” (Binford 1981:139). Binford also cites Guilday et al. (1962) as a reference for this mark. Figure A.77.

Frequency: Medium duiker 1 (1).

Function: Dismemberment (Binford 1981:139).

Td-3

Description: “Transverse cut across anterior face between the dorsal projection and the medial malleolus” (Binford 1981:139). As illustrated by Binford, this cut may occur on the medial surface (see Figure A.78).

Frequency: Blue duiker 3 (5), medium duiker 2 (3).

Function: Dismemberment (Binford 1981:139). Guilday et al. (1962:76) identify a similar mark on white-tailed deer (*Odocoileus virginianus*) and elk (*Cervus canadensis*) tibiae and associate it with dismemberment.

TIB-1

Description: Transverse or oblique cut on the posterior proximal shaft. Figure A.79.

Frequency: Brush-tailed porcupine 1 (3), blue duiker 6 (9), medium duiker 1 (1).

Function: Unknown. Possibly fillet and/or food preparation.

TIB-2

Description: Complete transverse chop through mid-shaft. Figure A.77.

Frequency: Giant pouched rat 1 (1), blue duiker 5 (5).

Function: Dismemberment.

TIB-3

Description: Transverse or oblique cut on the posterior mid-shaft. Figure A.79.

Frequency: Giant pouched rat 1 (1), brush-tailed porcupine 1 (1), blue duiker 8 (15), medium duiker 2 (4).

Function: Unknown. Possibly fillet and/or food preparation.

TIB-4

Description: Complete transverse chop through distal shaft. Figure A.77.

Frequency: Blue duiker 8 (8).

Function: Dismemberment.

TIB-5

Description: Transverse or diagonal partial chop in posterior surface of proximal tibia. Figure A.79.

Frequency: Blue duiker 4 (5), medium duiker 1 (1).

Function: Dismemberment.

TIB-6

Description: Partial transverse chop in medial mid-shaft. Figure A.78.

Frequency: Blue duiker 1 (1).

Function: Dismemberment.

TIB-7

Description: Complete transverse chop through proximal shaft. Figure A.77.

Frequency: Blue duiker 3 (3), medium duiker 1 (1).

Function: Dismemberment.

Tib-8

Description: "Single transverse or oblique cutmark on the posterior distal shaft" (Lupo 1993:300). Figure A.79.

Frequency: Giant pouched rat 1 (6), blue duiker 1 (2).

Function: Fillet (Lupo 1993:300).

TIB-9

Description: Transverse or oblique cut on medial proximal shaft. Figure A.78.

Frequency: Blue duiker 2 (2), civet 1 (2).

Function: Unknown. Possibly fillet and/or food preparation.

TIB-10

Description: Transverse cut on lateral mid-shaft. Figure A.77.

Frequency: Blue duiker 1 (2), medium duiker 1 (1).

Function: Unknown. Possibly fillet and/or food preparation.

Tib-11

Description: "A single transverse cutmark on the medial distal shaft" (Lupo 1993:300). Figure A.78.

Frequency: Giant pouched rat 3 (4), brush-tailed porcupine 1 (5), blue duiker 2 (6).

Function: Fillet (Lupo 1993:300).

Tib-12

Description: "Single transverse cutmark on the antero-lateral proximal shaft, inferior to the tibial tuberosity and tibial crest" (Lupo 1993:300). Figure A.76.

Frequency: Blue duiker 4 (5), medium duiker 1 (1).

Function: Fillet (Lupo 1993:300).

TIB-13

Description: Longitudinal nick on dorsal-lateral edge of proximal articulation. Figure A.77.

Frequency: Blue duiker 1 (1).

Function: Unknown.

TIB-14

Description: Transverse cut on lateral distal shaft. Figure A.77.

Frequency: Blue duiker 3 (4), medium duiker 1 (2).

Function: Unknown. Possibly fillet and/or food preparation.

TIB-15

Description: Transverse cuts on antero-medial edge of proximal shaft. Figure A.76.

Frequency: Blue duiker 3 (6).

Function: Unknown. Possibly fillet and/or food preparation.

TIB-16

Description: Transverse cut on medial mid-shaft. Figure A.78.

Frequency: Brush-tailed porcupine 1 (1), blue duiker 3 (4).

Function: Unknown. Possibly fillet and/or food preparation.

TIB-17

Description: Transverse cut on anterior proximal tibia. Figure A.76.

Frequency: Brush-tailed porcupine 2 (2), medium duiker 1 (2).

Function: Unknown. Possibly fillet and/or food preparation.

TIB-18

Description: Transverse cut on posterior proximal tibia. Nicholson (2005:55) documents a similar mark on red brocket deer (*Mazama americana*) bones processed by Aché foragers. Figure A.79.

Frequency: Blue duiker 2 (2), medium duiker 1 (2).

Function: Unknown.

TIB-19

Description: Partial chop in antero-lateral mid-shaft. Figure A.76.

Frequency: Medium duiker 1 (1).

Function: Dismemberment.

TIB-20

Description: Partial chop in postero-lateral proximal shaft. Figure A.79.

Frequency: Brush-tailed porcupine 1 (1), blue duiker 1 (1).

Function: Dismemberment.

Tib-21

Description: “Two transverse cutmarks on the anterior distal shaft” (Lupo 1993:350). Used here to indicate one or more cuts at this location. Figure A.76.

Frequency: Blue duiker 2 (2), medium duiker 2 (2).

Function: Fillet (Lupo 1993:350).

TIB-22

Description: Complete transverse chop through tibia just below proximal articulation. Figure A.77.

Frequency: Brush-tailed porcupine 2 (2), blue duiker 5 (5), medium duiker 1 (1).

Function: Dismemberment.

TIB-23

Description: Transverse or oblique partial chop in lateral mid-shaft. Figure A.77.

Frequency: Brush-tailed porcupine 1 (1), blue duiker 1 (1).

Function: Dismemberment.

TIB-24

Description: Partial transverse chop in lateral distal shaft. Figure A.77.

Frequency: Medium duiker 2 (2).

Function: Dismemberment.

TIB-25

Description: Transverse cut on medial surface just below proximal articulation. Figure A.78.

Frequency: Giant pouched rat 1 (1).

Function: Dismemberment. Guilday et al. (1962:76) identify a similar mark (E1) on elk (*Cervus canadensis*) tibiae and relate it to dismemberment.

TIB-26

Description: Transverse nick on postero-medial edge just below proximal articulation. Figure A.80.

Frequency: Blue duiker 1 (1).

Function: Dismemberment.

TIB-27

Description: Long nearly longitudinal cuts on posterior mid-shaft. Figure A.80.

Frequency: Medium duiker 1 (2).

Function: Unknown.

TIB-28

Description: Complete diagonal chop through medial distal tibia. Figure A.76.

Frequency: Giant pouched rat 2 (2).

Function: Dismemberment.

Fibula**FIB-1**

Description: Transverse cut on posterior edge of proximal fibula. Not illustrated.

Frequency: Giant pouched rat 2 (2).

Function: Unknown.

FIB-2

Description: Transverse cut on the posterior edge of distal fibula. Not illustrated.

Frequency: Giant pouched rat 1 (1).

Function: Unknown.

Calcaneus**CAL-1**

Description: Complete transverse chop through calcaneus below tuber calcis. Not illustrated.

Frequency: Blue duiker 1 (1).

Function: Dismemberment.

Cal-2

Description: "Single transverse or oblique cutmark on the lateral side of proximal shaft below tuber calcis" (Lupo 1993:302). Not illustrated.

Frequency: Medium duiker 1 (4).

Function: Dismemberment (Lupo 1993:302).

CAL-3

Description: Transverse cut on posterior surface of calcaneus midway between the tuber calcis and coracoid process. Not illustrated.

Frequency: Giant pouched rat 1 (1), medium duiker 1 (2).

Function: Dismemberment.

CAL-4

Description: Partial longitudinal chop in proximal articular surface. Not illustrated.

Frequency: Blue duiker 1 (1).

Function: Dismemberment.

TC-3

Description: “Marks on the dorsal chest midway between tuber calcis and the articulator surface” (Binford 1981:139). Not illustrated.

Frequency: Medium duiker 1 (6).

Function: Unknown. Binford identifies the function of this mark as “fillet, hanging carcass” (Binford 1981:139).

Astragalus**AST-1**

Description: Partial transverse or diagonal chop in medial astragalus. Not illustrated.

Frequency: Blue duiker 3 (4).

Function: Dismemberment.

AST-2

Description: Complete transverse chop through astragalus. Not illustrated.

Frequency: Blue duiker 3 (3).

Function: Dismemberment.

TA-1

Description: “Transverse mark at margins of the anterior face, midway on the bone” (Binford 1981:139). Binford also cites Frison (1970) and Guilday et al. (1962) as references for this mark. Not illustrated.

Frequency: Blue duiker 1 (1), medium duiker 1 (2).

Function: Dismemberment (Binford 1981:139).

TA-2

Description: “Marks across medial face midway on the bone” (Binford 1981:139). Not illustrated.

Frequency: Blue duiker 1 (1).

Function: Dismemberment (1981:139).

Naviculocuboid

NVC-1

Description: Transverse cut across medial surface. Figure A.81.

Frequency: Blue duiker 1 (2).

Function: Dismemberment.

Metatarsal

MTd-1

Description: “Transverse mark across posterior face of both condyles” (Binford 1981:140). Binford also cites Wheat (1979) as a reference for this mark. Figure A.84.

Frequency: Medium duiker 1 (2).

Function: Dismemberment (Binford 1981:140).

MTM-1

Description: Partial chop in medial surface of proximal end. Figure A.82.

Frequency: Blue duiker 1 (1).

Function: Dismemberment.

MTM-2

Description: Transverse cut on the lateral mid-shaft. Figure A.83.

Frequency: Blue duiker 2 (3).

Function: Unknown. Possibly skinning.

MTM-3

Description: Complete transverse chop through shaft. Figure A.82.

Frequency: Blue duiker 5 (6), medium duiker 1 (1).

Function: Dismemberment.

MTM-4

Description: Transverse cut on medial mid-shaft. Figure A.81.

Frequency: Blue duiker 6 (9).

Function: Unknown. Possibly skinning.

MTM-5

Description: Transverse cut on lateral surface just below proximal articulation. Figure A.83.

Frequency: Blue duiker 1 (1).

Function: Dismemberment.

MTM-6

Description: Complete transverse chop through distal end just above condyles. Figure A.82.

Frequency: Blue duiker 1 (1).

Function: Dismemberment.

MTM-7

Description: Partial chop removing one distal condyle. Figure A.82.

Frequency: Blue duiker 1 (1).

Function: Dismemberment.

MTM-8

Description: Transverse cut on medial surface just below proximal articulation. Figure A.81.

Frequency: Blue duiker 1 (2).

Function: Dismemberment.

MTM-9

Description: Transverse cut on medial proximal shaft. Comparable to MCM-8, but occurs on the metatarsal. Figure A.81.

Frequency: Blue duiker 1 (3).

Function: Unknown. Possibly skinning.

MTM-10

Description: Partial chop on posterior mid-shaft. Figure A.84.

Frequency: Blue duiker 5 (5).

Function: Dismemberment.

MTM-11

Description: Partial chop on medial mid-shaft. Figure A.81.

Frequency: Blue duiker 1 (1).

Function: Dismemberment.

MTM-12

Description: Transverse cut on posterior mid-shaft. Figure A.84.

Frequency: Blue duiker 1 (1).

Function: Unknown. Possibly skinning.

MTM-13

Description: Transverse cut on posterior just below proximal articulation. Figure A.84.

Frequency: Medium duiker 1 (4).

Function: Dismemberment.

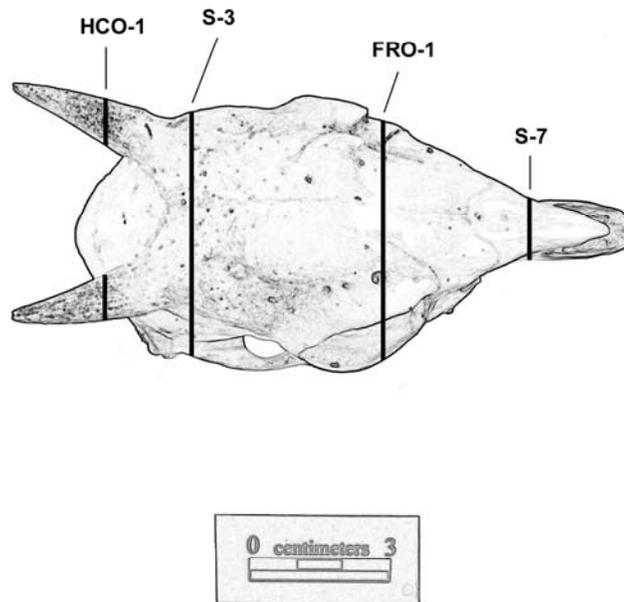


Figure A.1. Dorsal view of blue duiker cranium

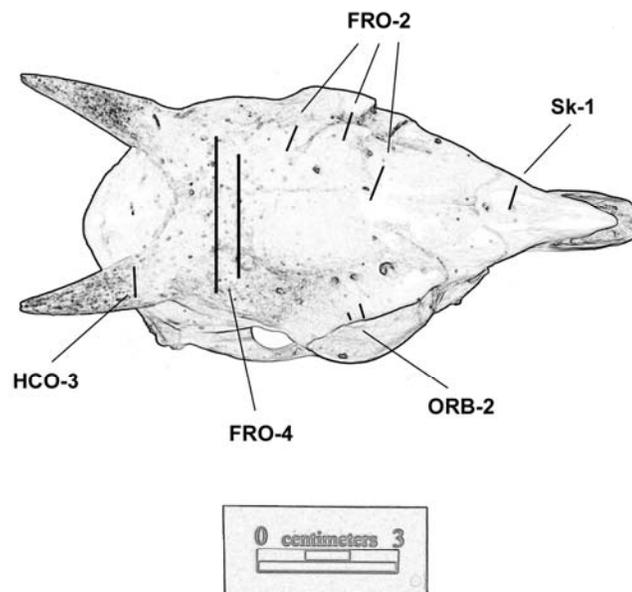


Figure A.2. Dorsal view of blue duiker cranium

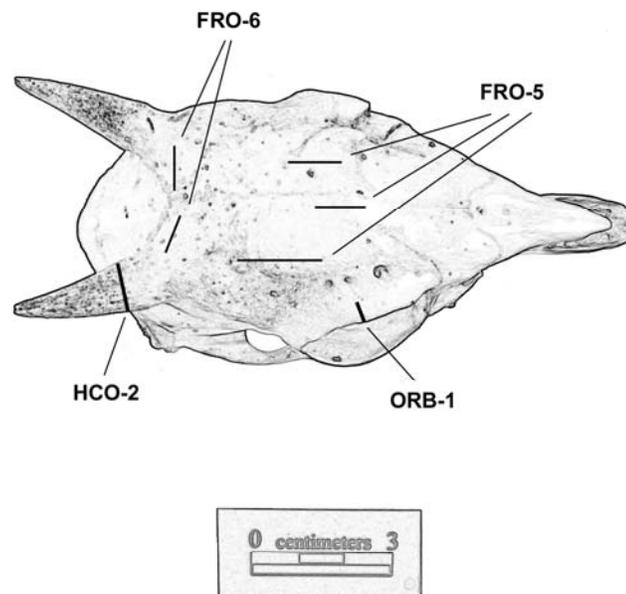


Figure A.3. Dorsal view of blue duiker cranium

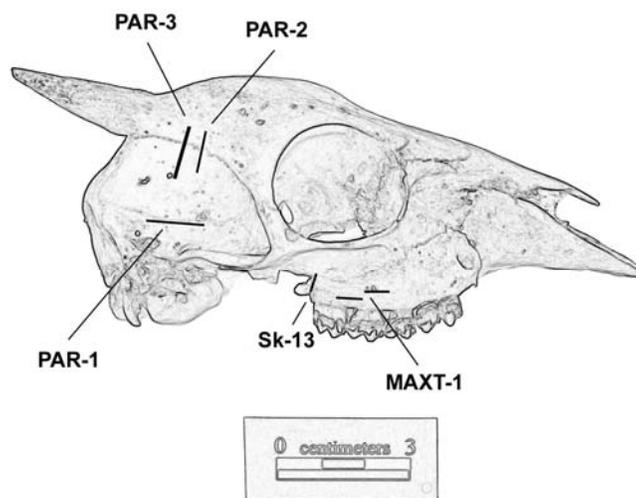


Figure A.4. Lateral view of blue duiker cranium

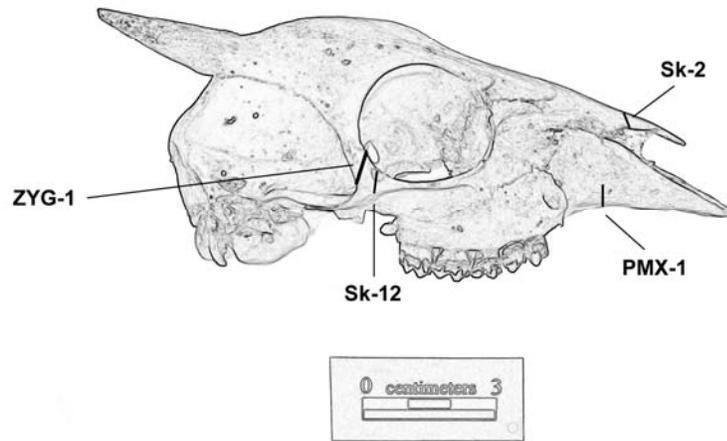


Figure A.5. Lateral view of blue duiker cranium

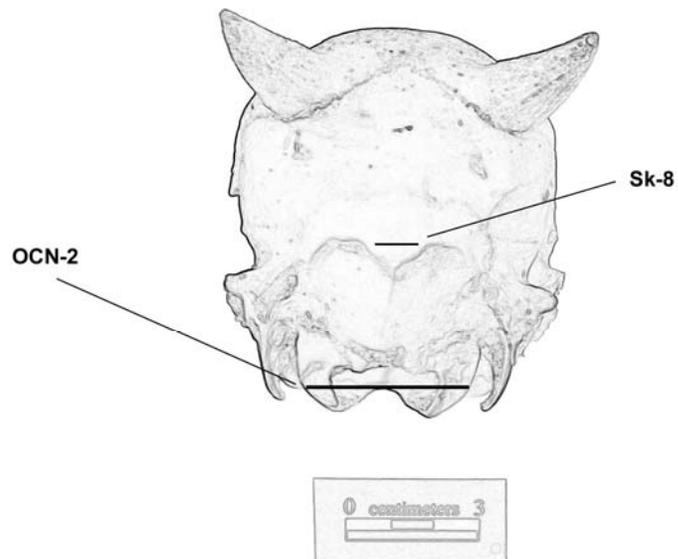


Figure A.6. Posterior view of blue duiker cranium

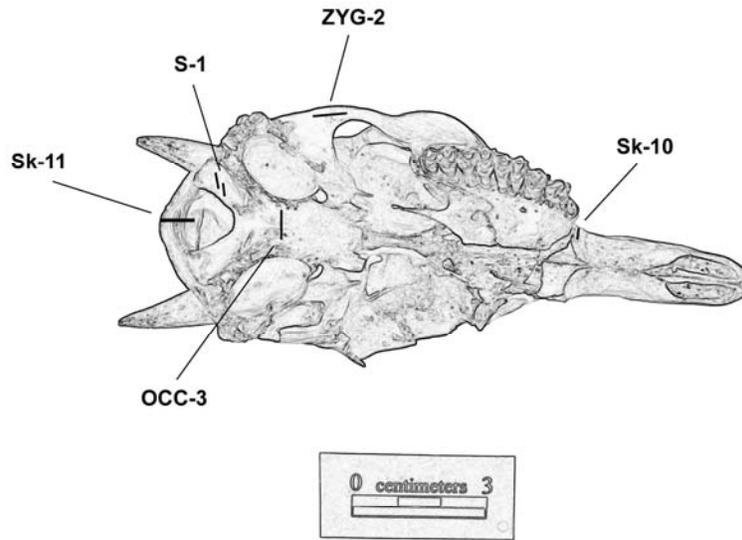


Figure A.7. Ventral view of blue duiker cranium

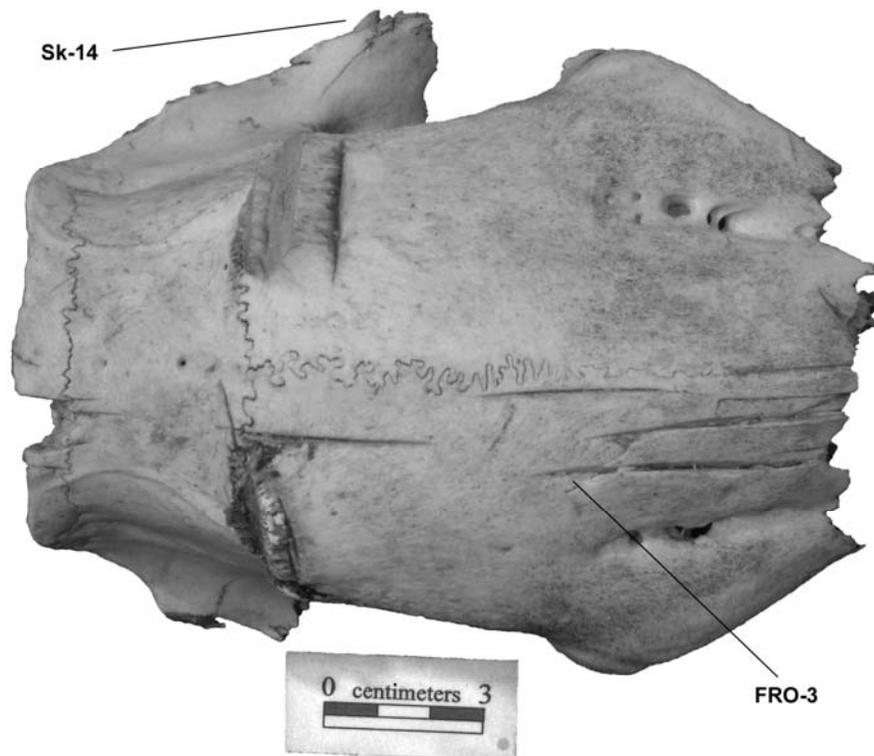


Figure A.8. Dorsal view of yellow-backed duiker cranium

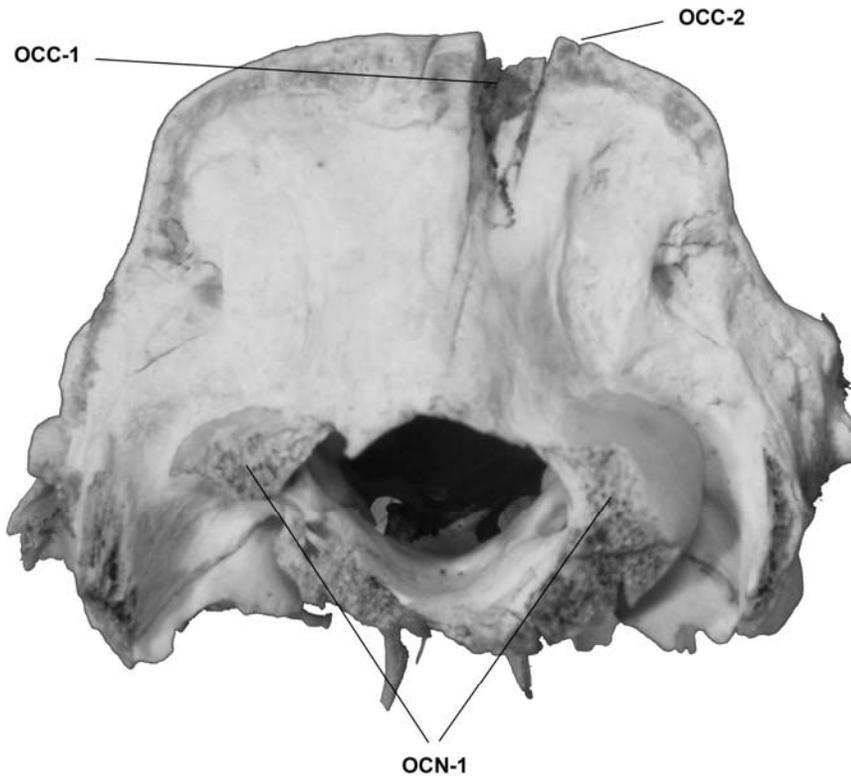


Figure A.9. Posterior view of yellow-backed duiker cranium

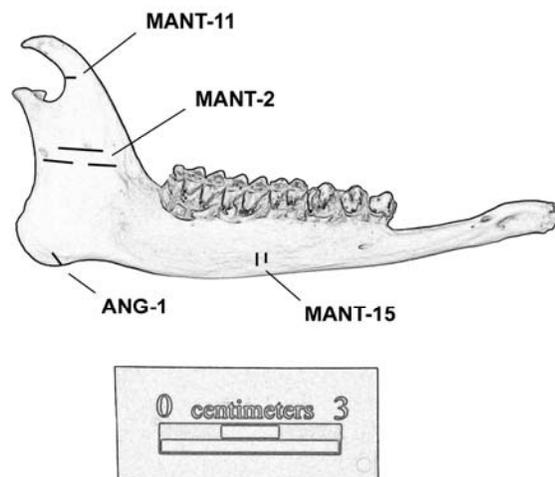


Figure A.10. Lateral view of blue duiker mandible

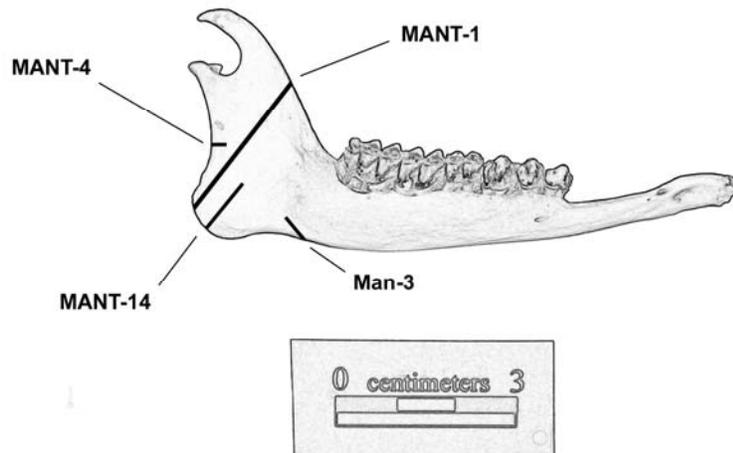


Figure A.11. Lateral view of blue duiker mandible

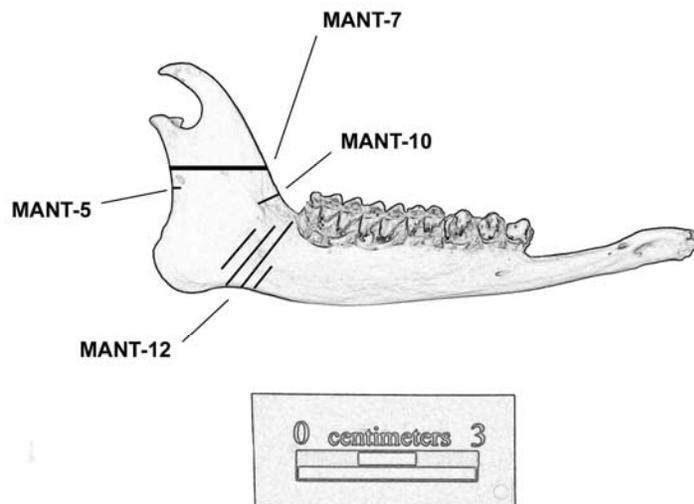


Figure A.12. Lateral view of blue duiker mandible

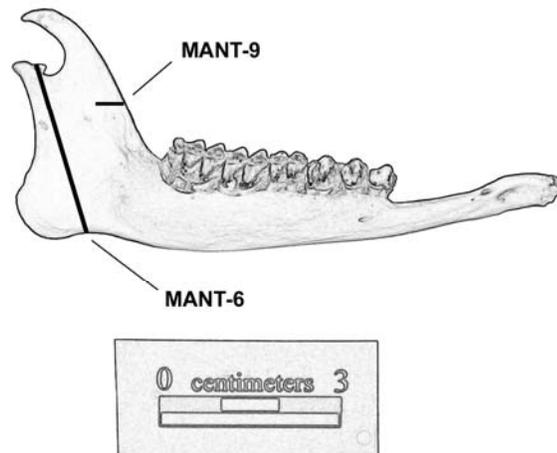


Figure A.13. Lateral view of blue duiker mandible

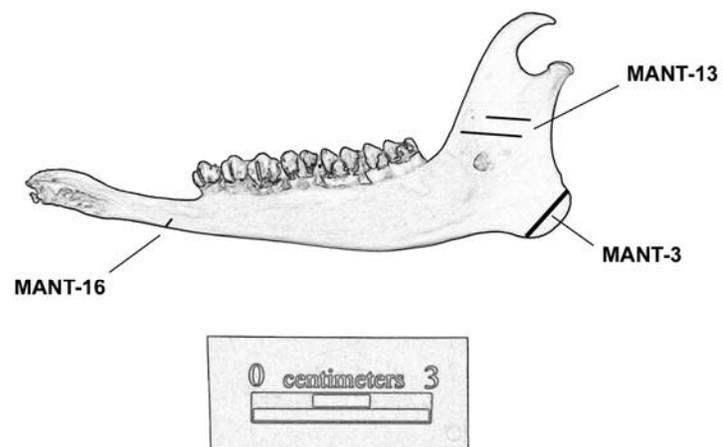


Figure A.14. Medial view of blue duiker mandible

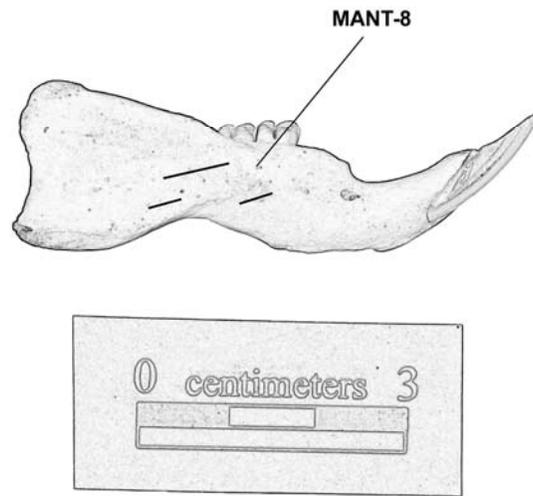


Figure A.15. Lateral view of brush-tailed porcupine mandible

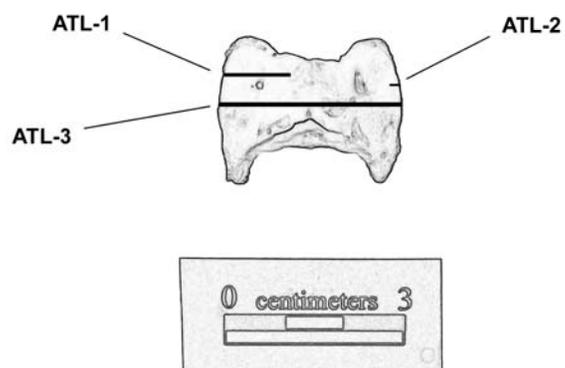


Figure A.16. Dorsal view of blue duiker atlas vertebra

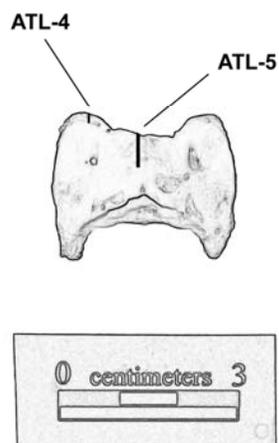


Figure A.17. Dorsal view of blue duiker atlas vertebra

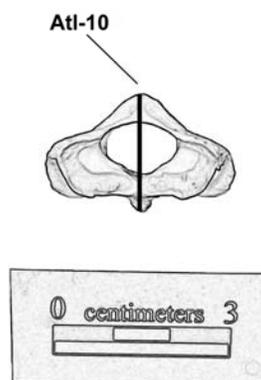


Figure A.18. Anterior view of blue duiker atlas vertebra

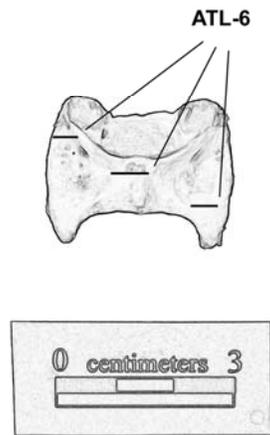


Figure A.19. Ventral view of blue duiker atlas vertebra

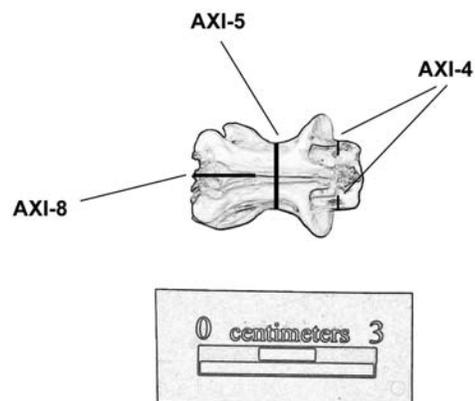


Figure A.20. Dorsal view of blue duiker axis vertebra

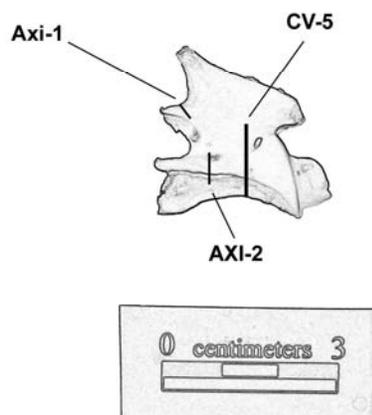


Figure A.21. Lateral view of blue duiker axis vertebra

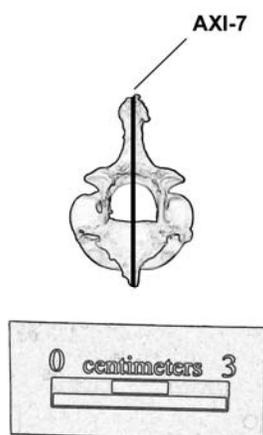


Figure A.22. Posterior view of blue duiker axis vertebra

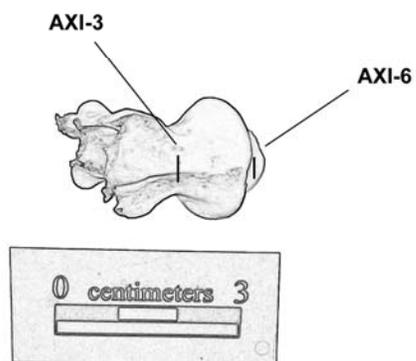


Figure A.23. Ventral view of blue duiker axis vertebra

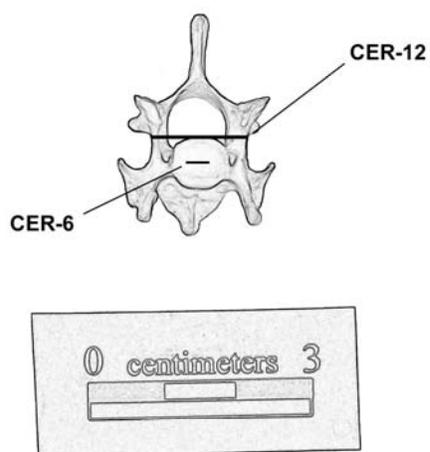


Figure A.24. Anterior view of blue duiker cervical vertebra

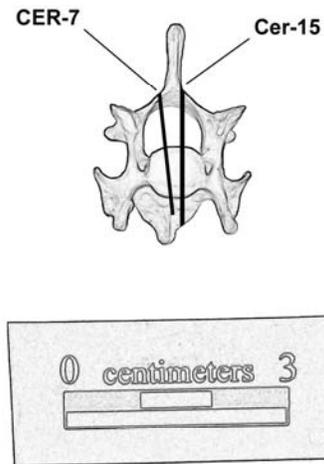


Figure A.25. Anterior view of blue duiker cervical vertebra

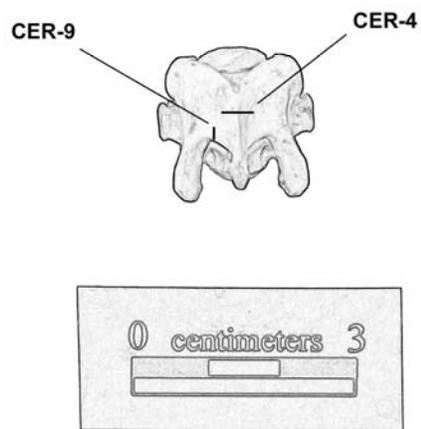


Figure A.26. Dorsal view of blue duiker cervical vertebra

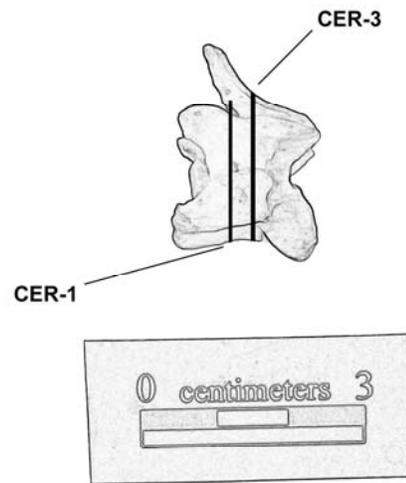


Figure A.27. Lateral view of blue duiker cervical vertebra

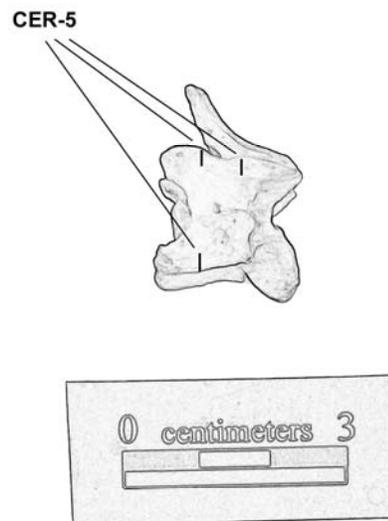


Figure A.28. Lateral view of blue duiker cervical vertebra

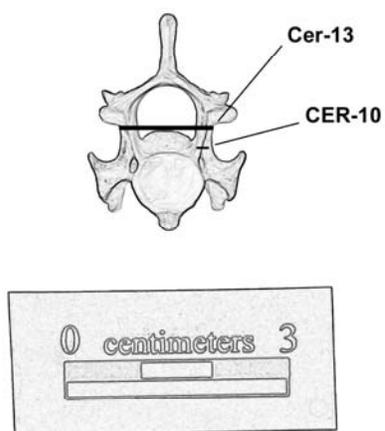


Figure A.29. Posterior view of blue duiker cervical vertebra

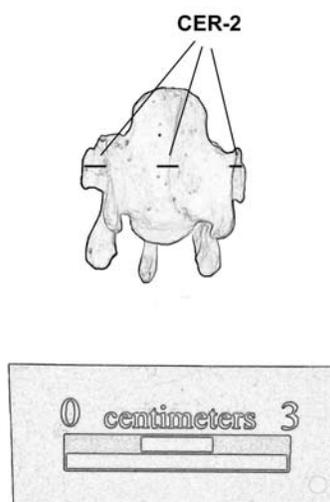


Figure A.30. Ventral view of blue duiker cervical vertebra

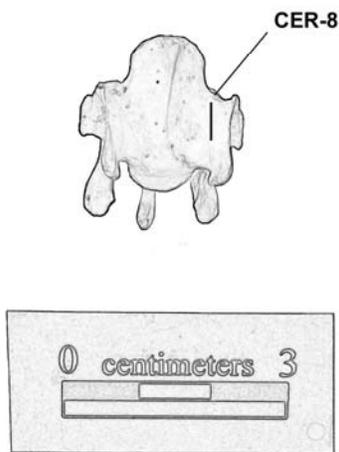


Figure A.31. Ventral view of blue duiker cervical vertebra

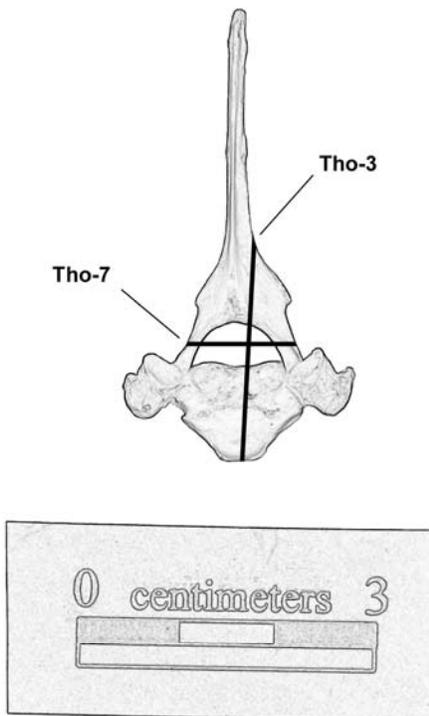


Figure A.32. Anterior view of blue duiker thoracic vertebra

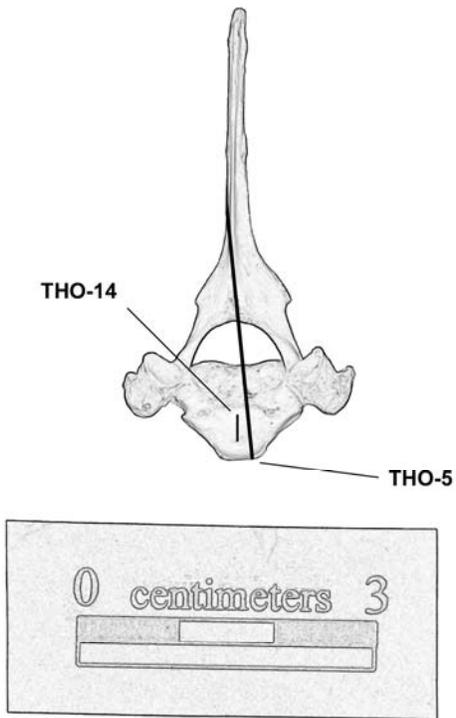


Figure A.33. Anterior view of blue duiker thoracic vertebra

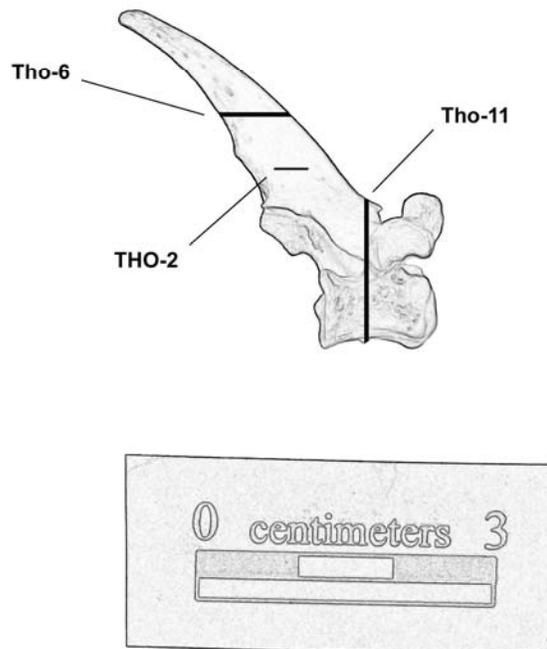


Figure A.34. Lateral view of blue duiker thoracic vertebra

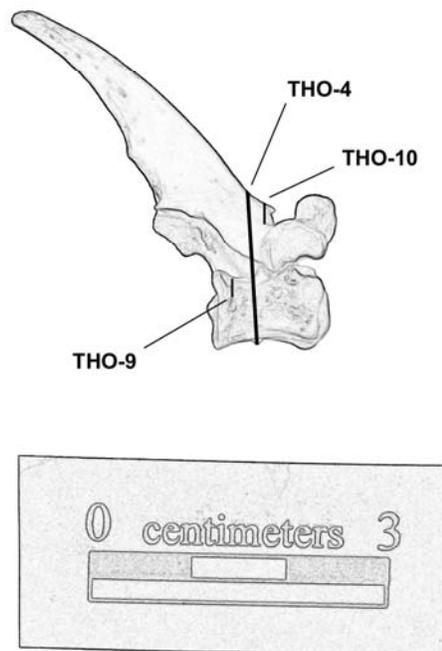


Figure A.35. Lateral view of blue duiker thoracic vertebra

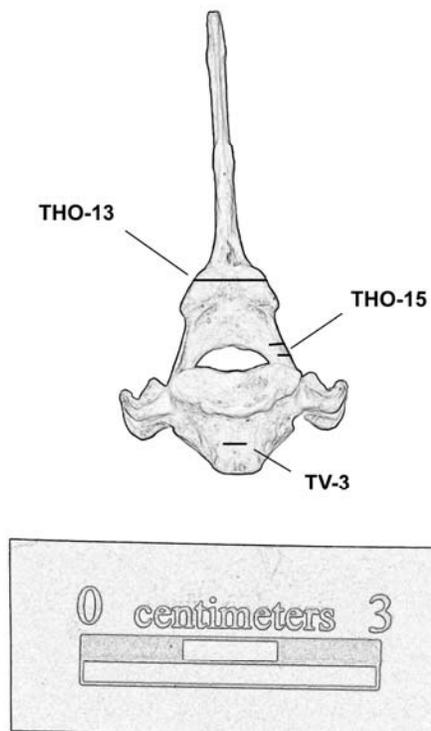


Figure A.36. Posterior view of blue duiker thoracic vertebra

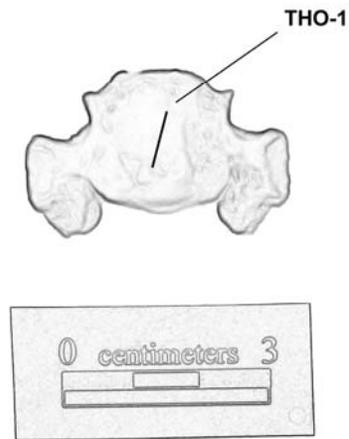


Figure A.37. Ventral view of blue duiker thoracic vertebra

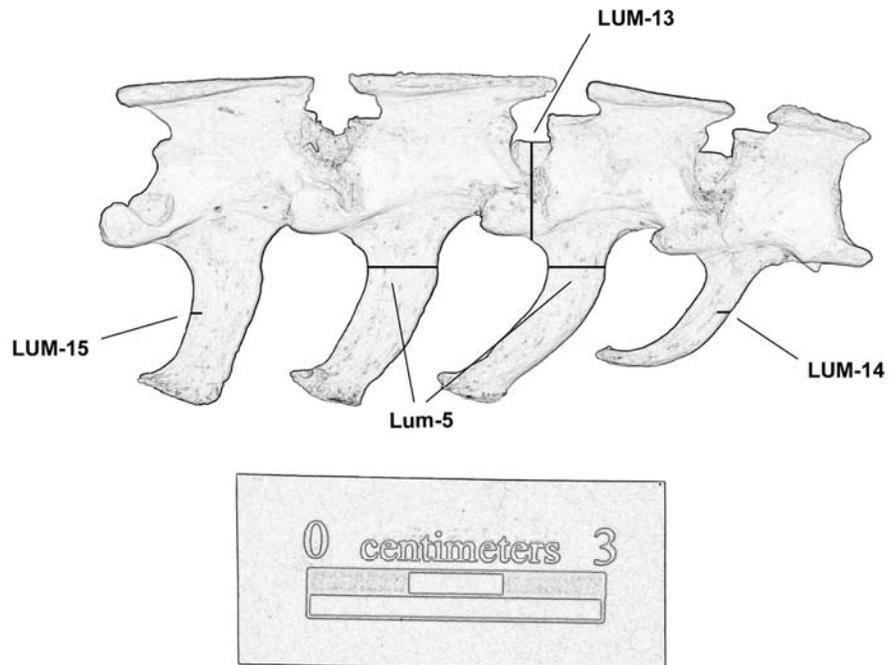


Figure A.38. Dorsal view of articulated sagittally-split blue duiker lumbar vertebrae

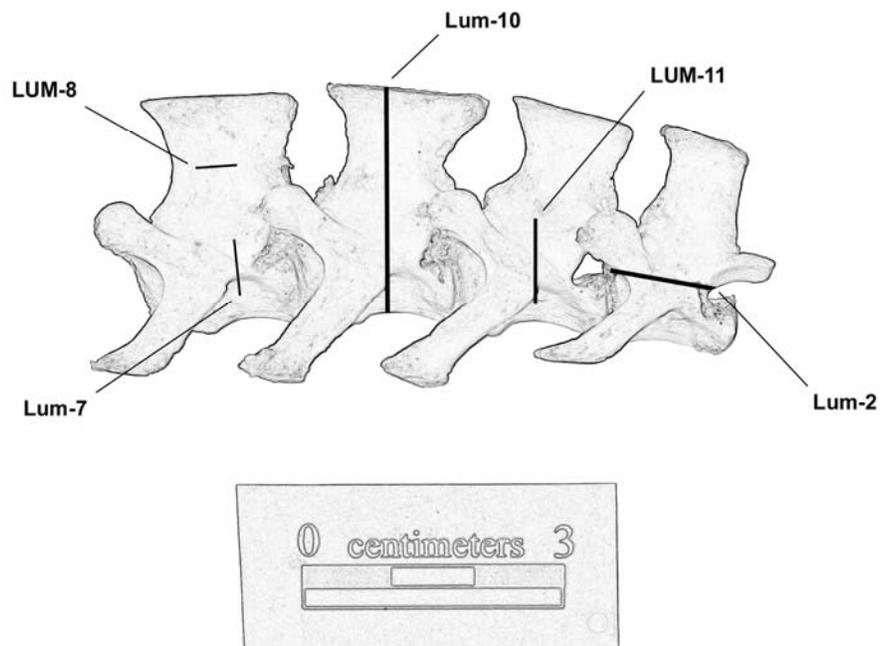


Figure A.39. Lateral view of articulated sagittally-split blue duiker lumbar vertebrae

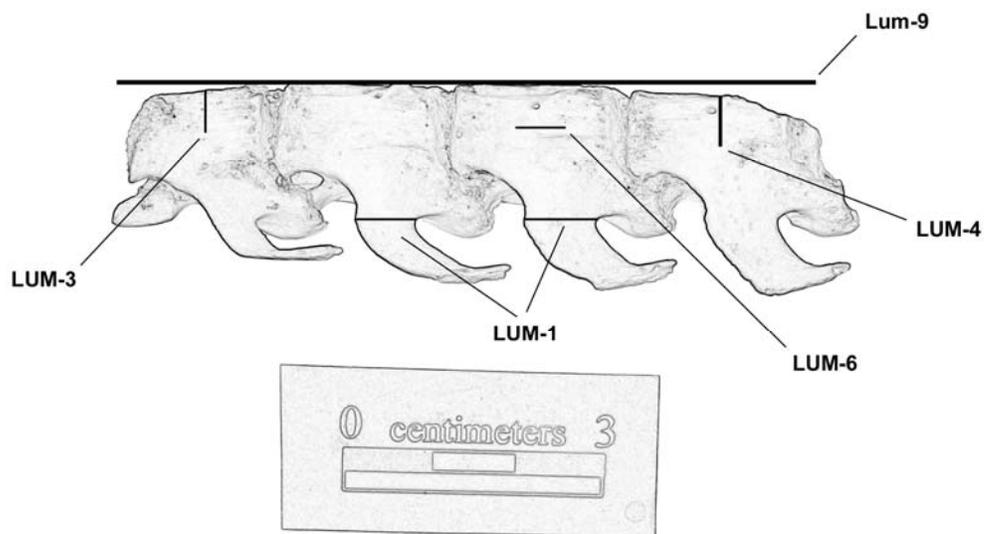


Figure A.40. Ventral view of articulated sagittally-split blue duiker lumbar vertebrae

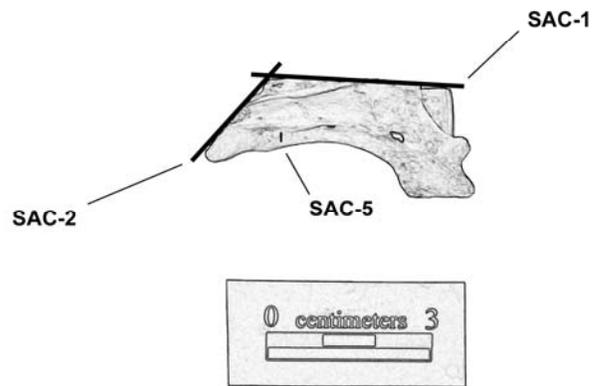


Figure A.41. Dorsal view of sagittally and transversely split blue duiker sacrum

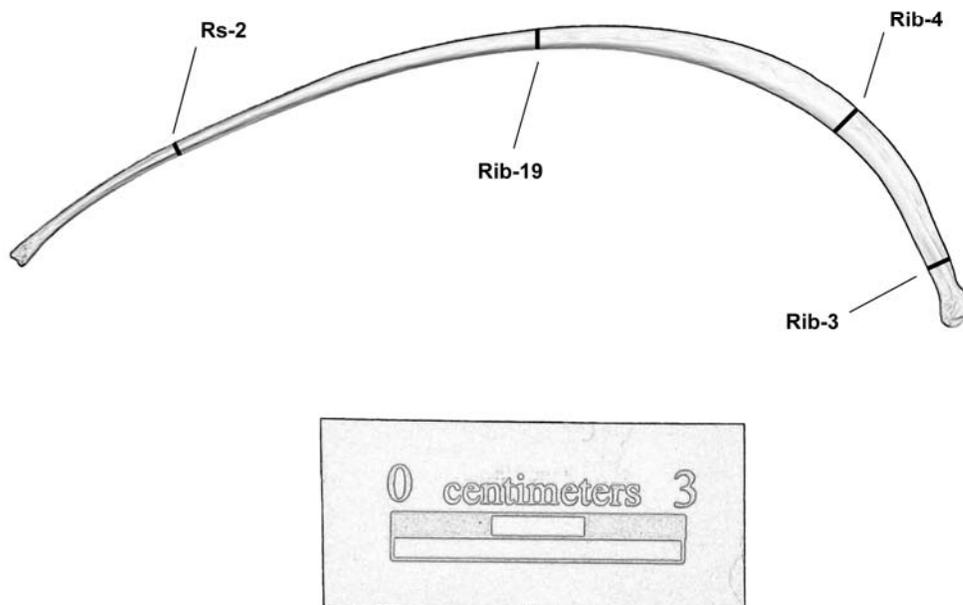


Figure A.42. Anterior view of blue duiker rib

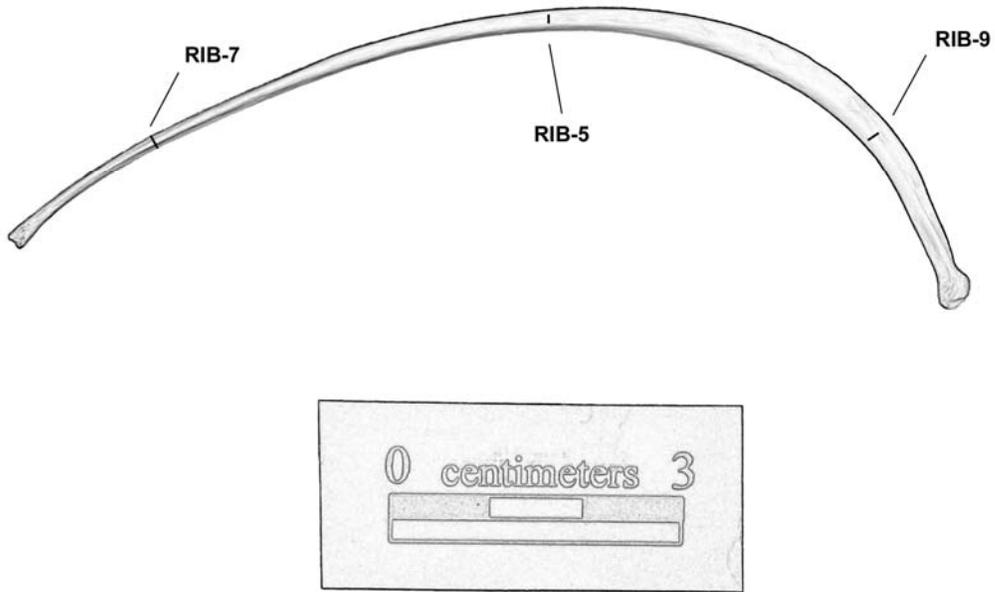


Figure A.43. Anterior view of blue duiker rib

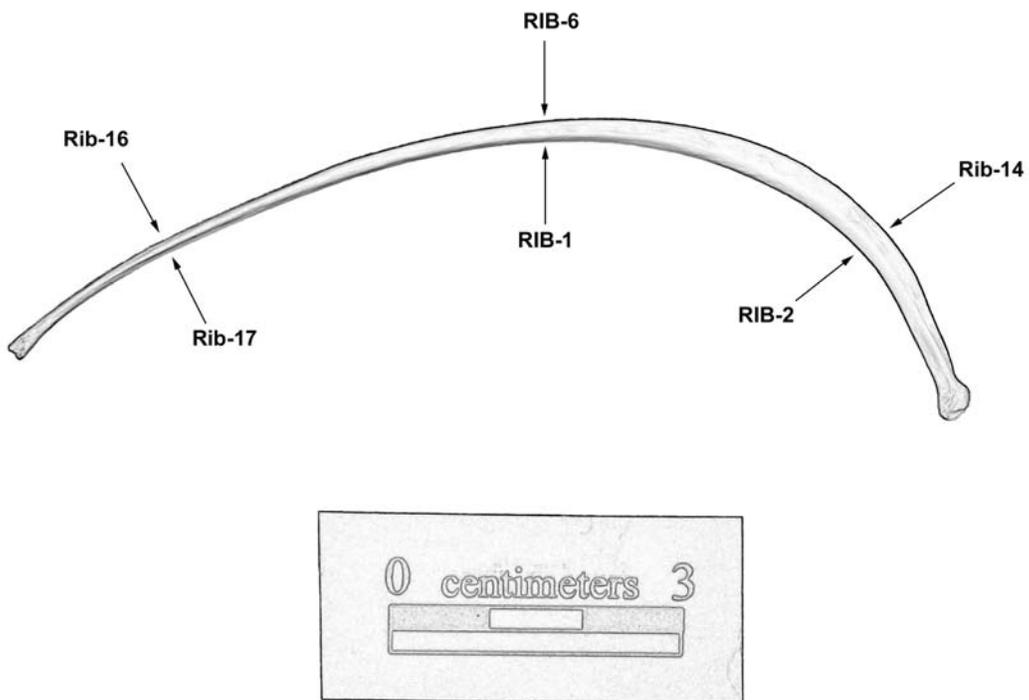


Figure A.44. Anterior view of blue duiker rib

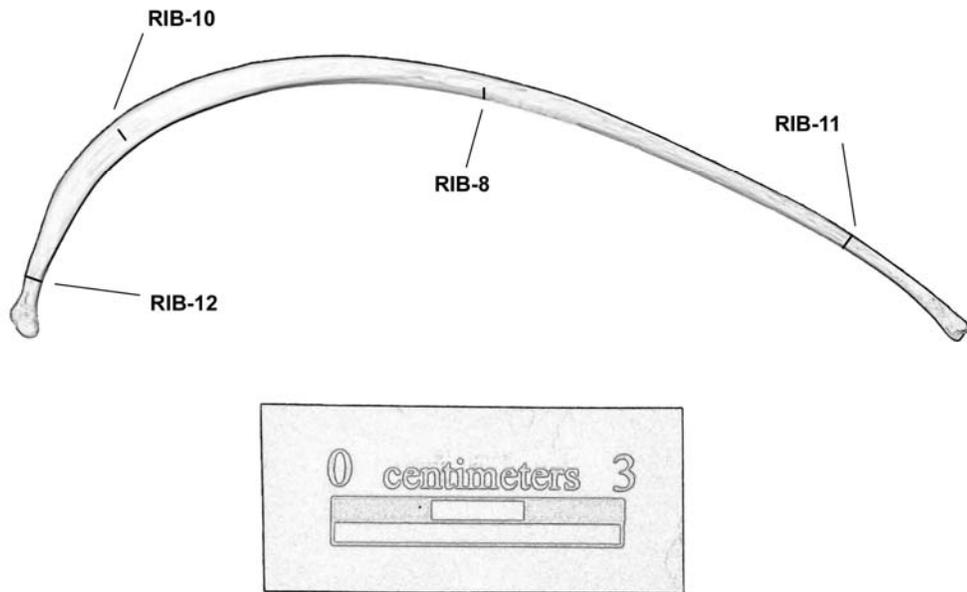


Figure A.45. Posterior view of blue duiker rib

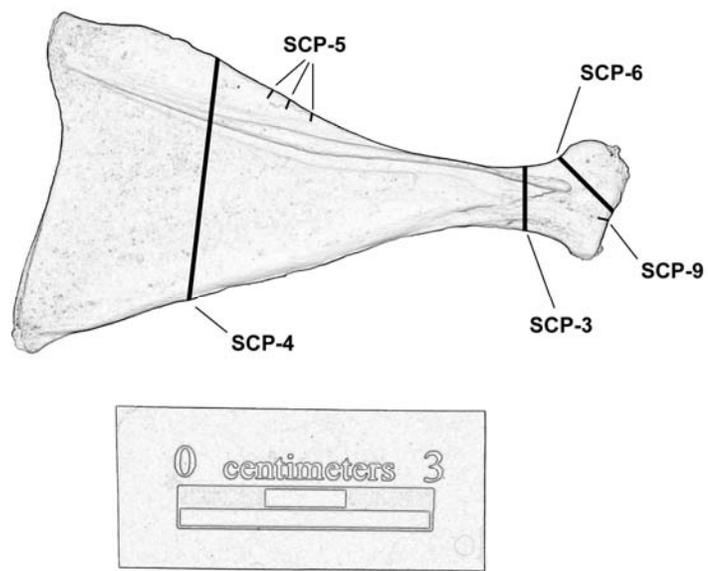


Figure A.46. Lateral view of blue duiker scapula

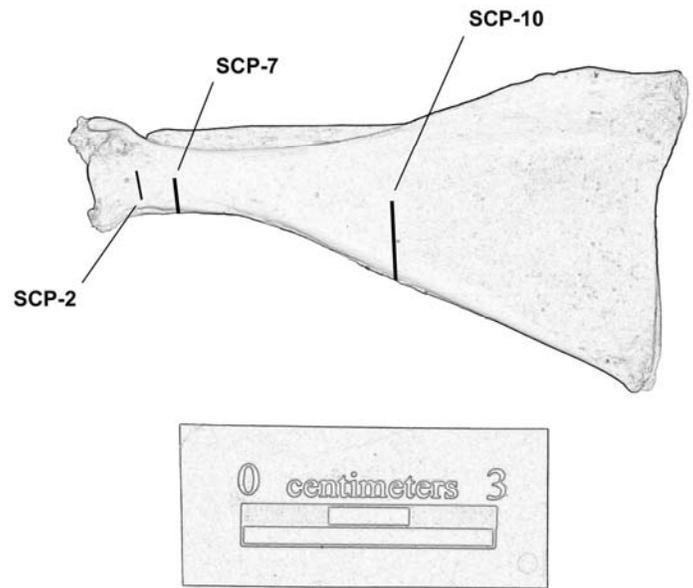


Figure A.47. Medial view of blue duiker scapula

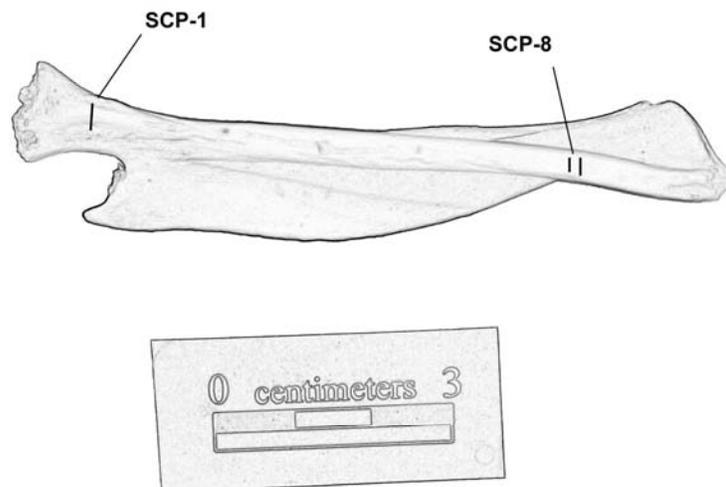


Figure A.48. Posterior view of blue duiker scapula

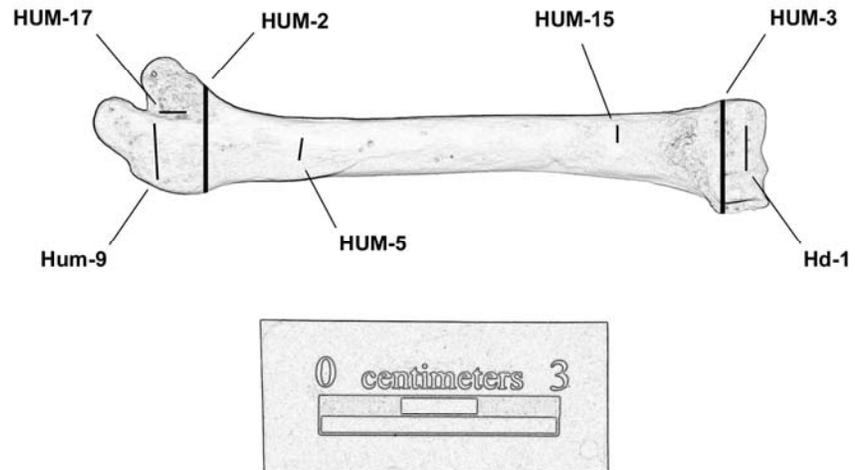


Figure A.49. Anterior view of blue duiker humerus

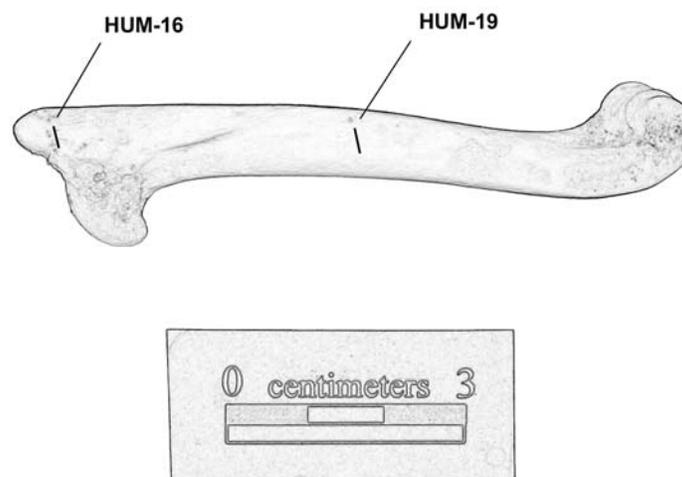


Figure A.50. Lateral view of blue duiker humerus

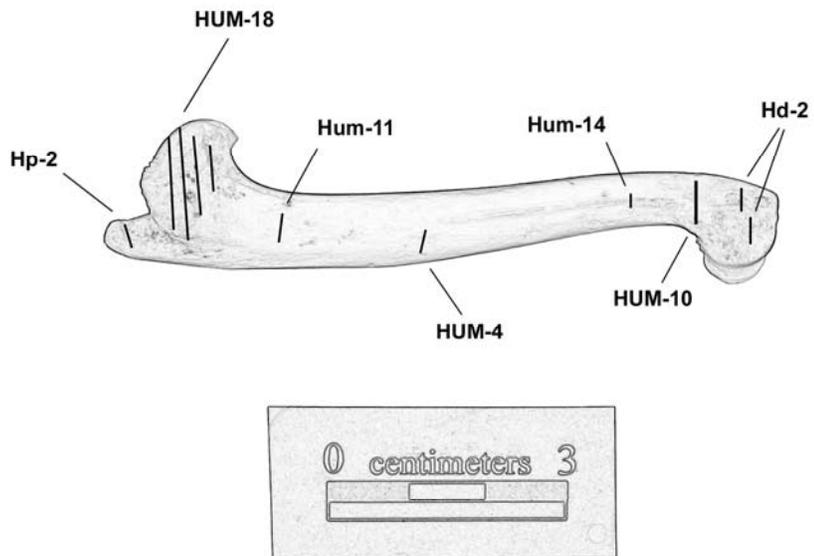


Figure A.51. Medial view of blue duiker humerus

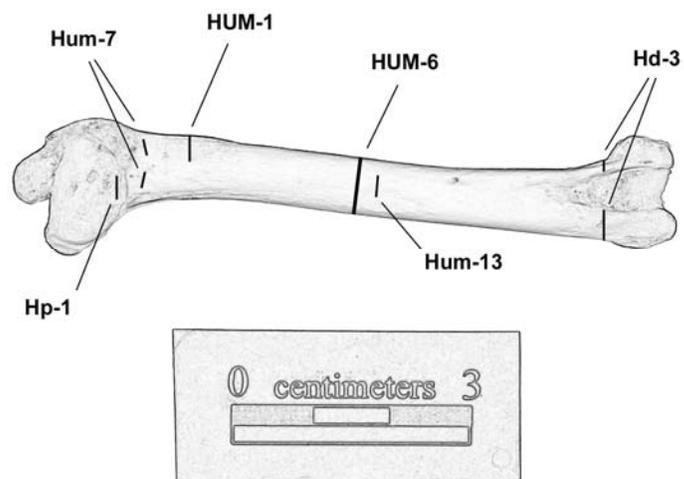


Figure A.52. Posterior view of blue duiker humerus

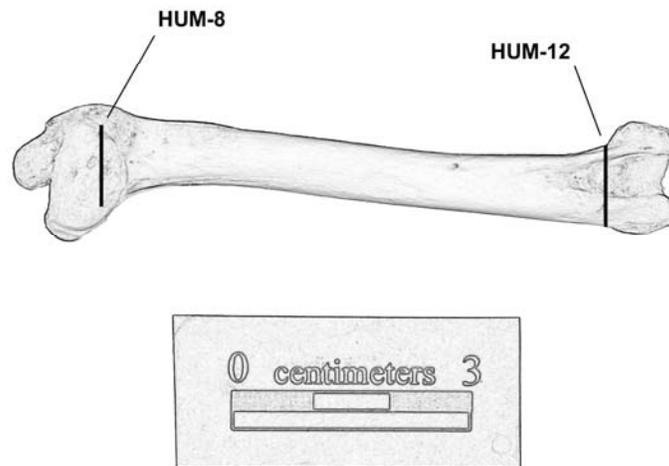


Figure A.53. Posterior view of blue duiker humerus

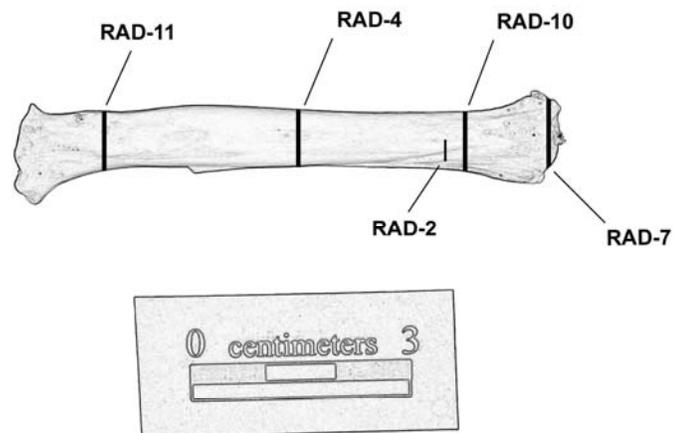


Figure A.54. Anterior view of blue duiker radius

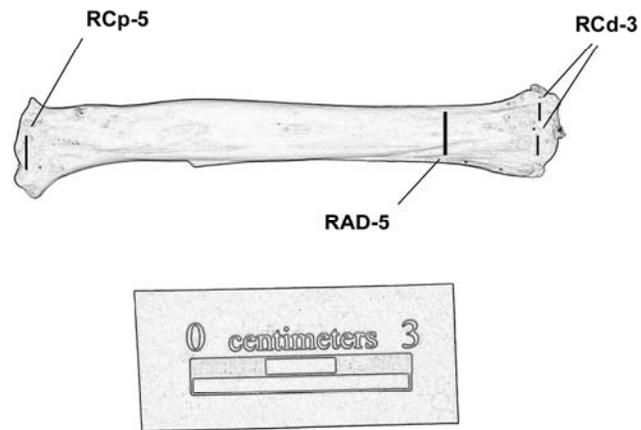


Figure A.55. Anterior view of blue duiker radius

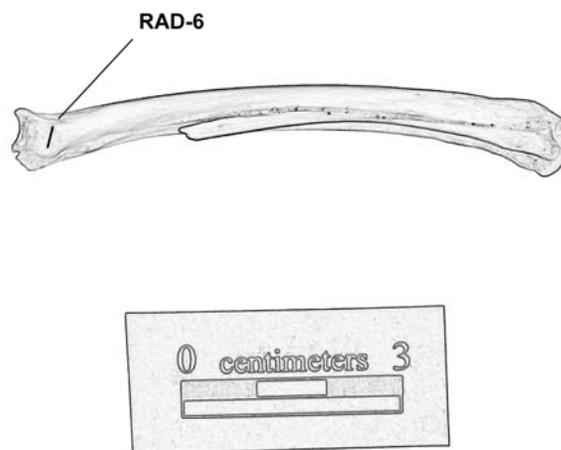


Figure A.56. Lateral view of blue duiker radius

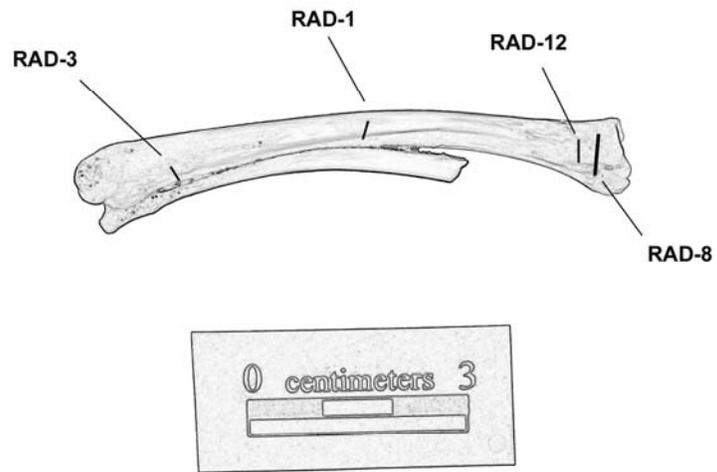


Figure A.57. Medial view of blue duiker radius

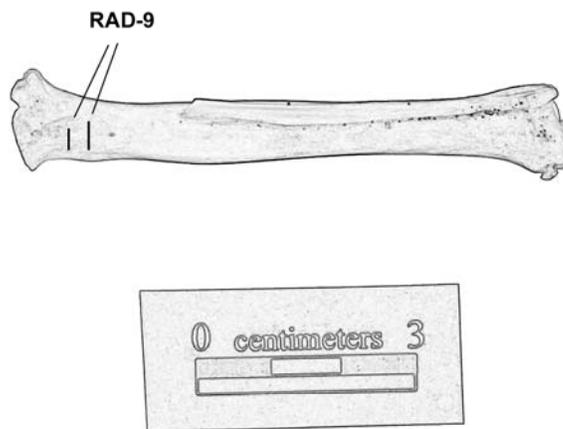


Figure A.58. Posterior view of blue duiker radius

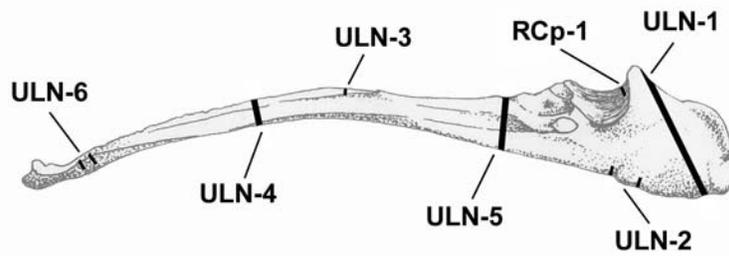


Figure A.59. Medial view of blue duiker ulna

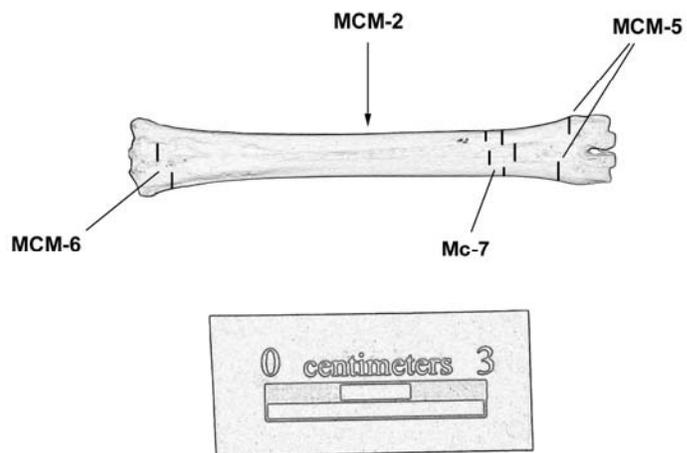


Figure A.60. Anterior view of blue duiker metacarpal

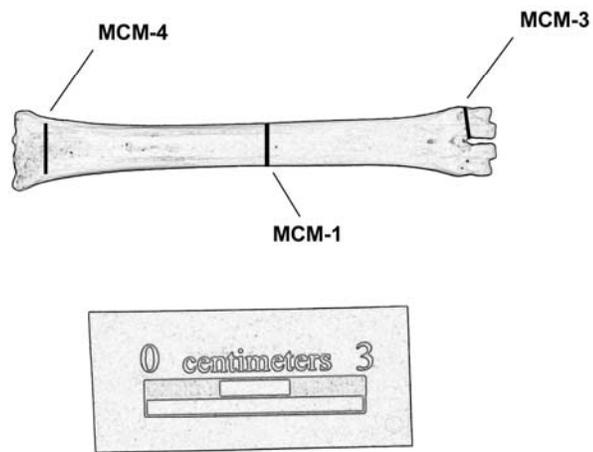


Figure A.61. Posterior view of blue duiker metacarpal

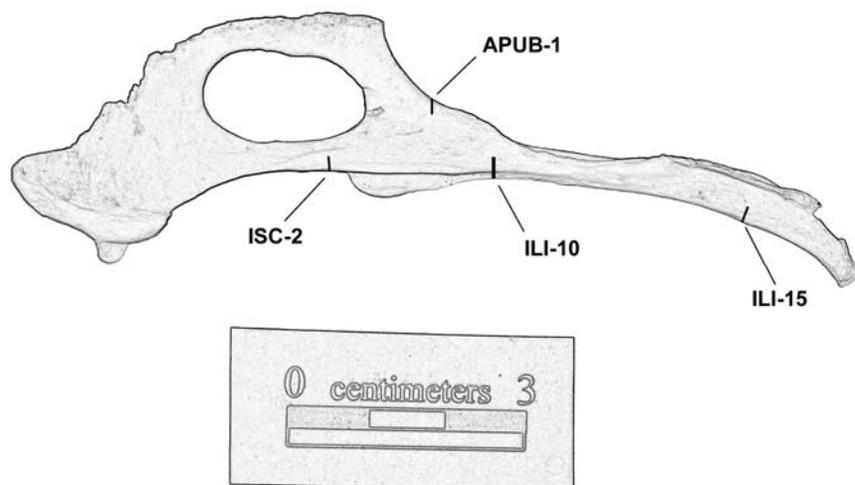


Figure A.62. Dorsal view of blue duiker innominate

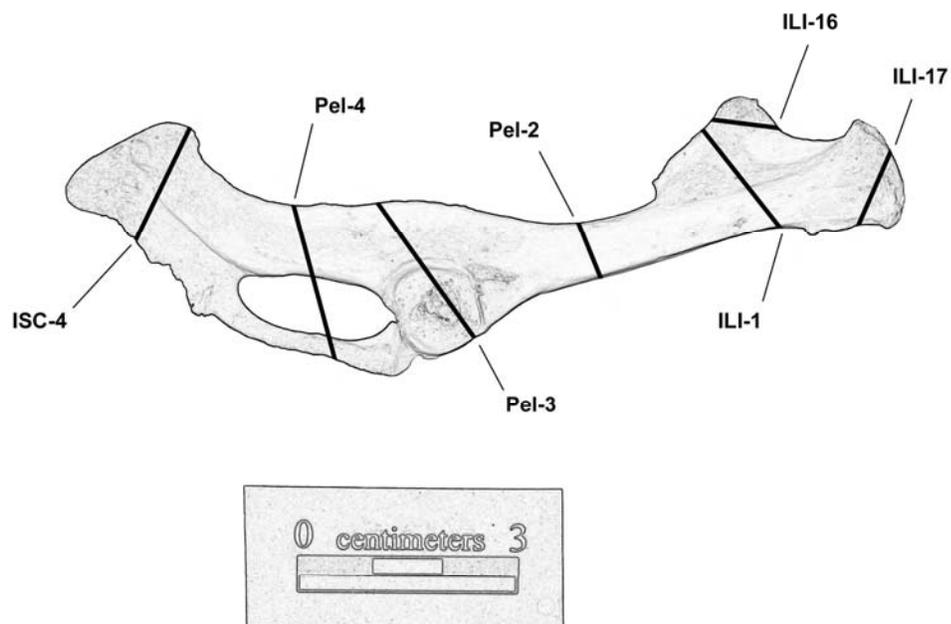


Figure A.63. Latero-ventral view of blue duiker innominate

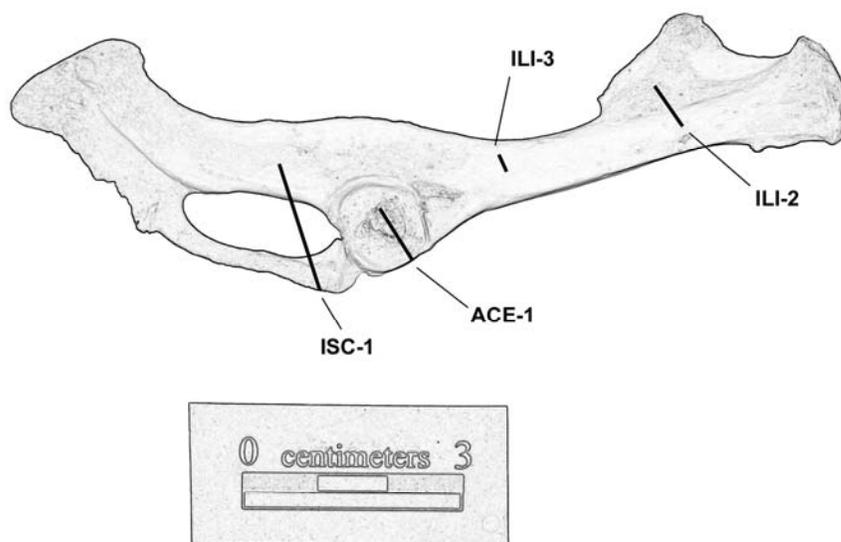


Figure A.64. Latero-ventral view of blue duiker innominate

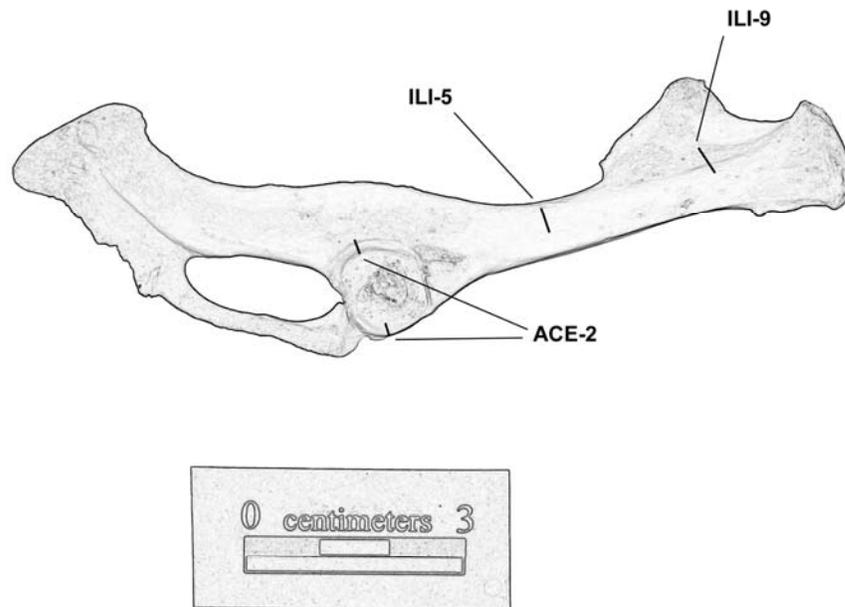


Figure A.65. Latero-ventral view of blue duiker innominate

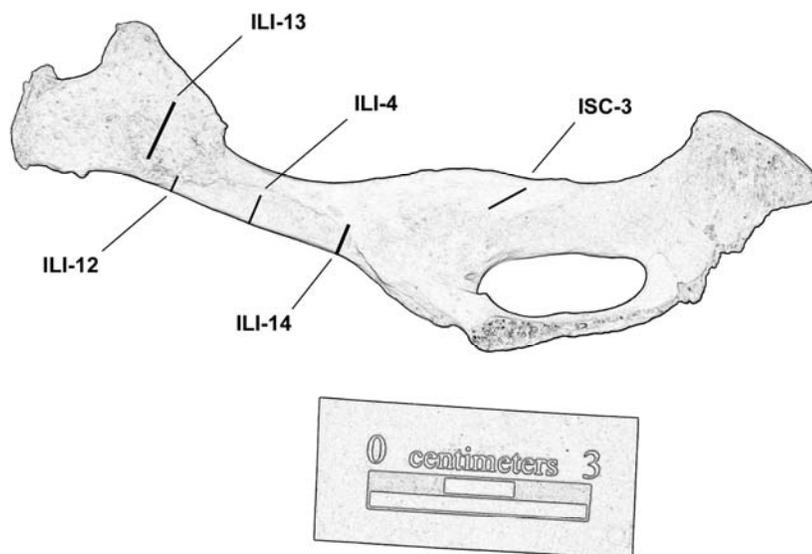


Figure A.66. Medial view of blue duiker innominate

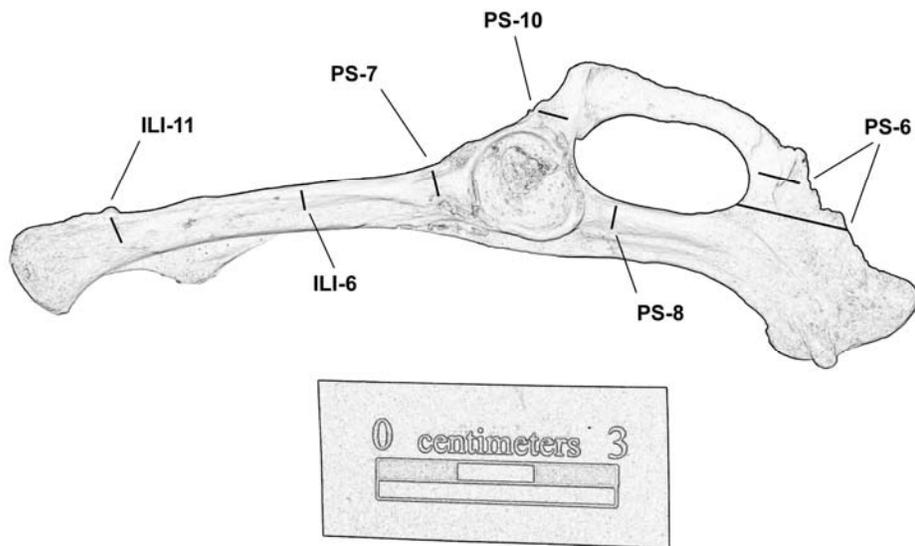


Figure A.67. Ventral view of blue duiker innominate

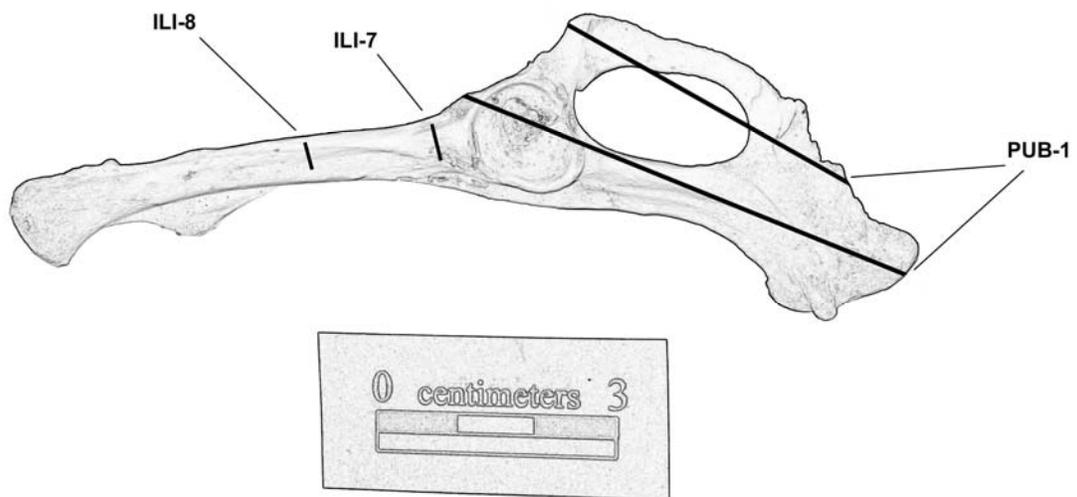


Figure A.68. Ventral view of blue duiker innominate

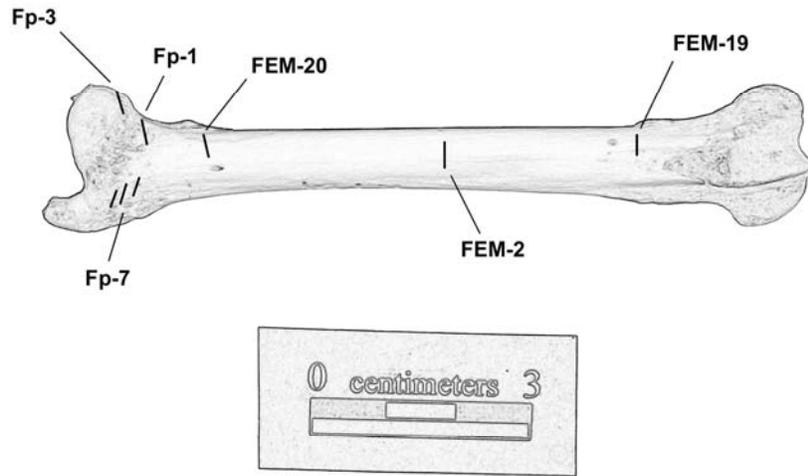


Figure A.69. Anterior view of blue duiker femur

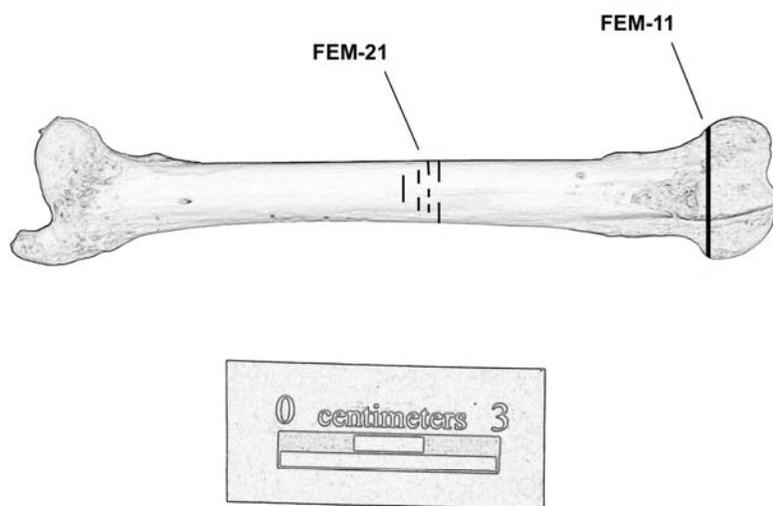


Figure A.70. Anterior view of blue duiker femur

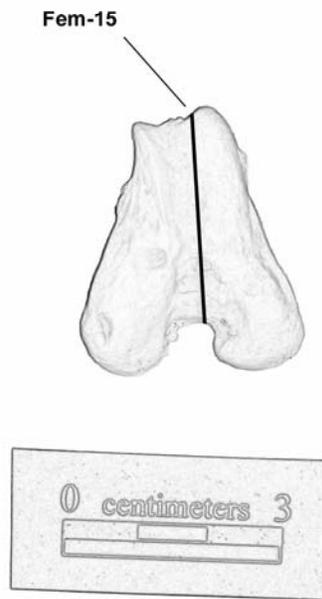


Figure A.71. Ventral view of blue duiker distal femur

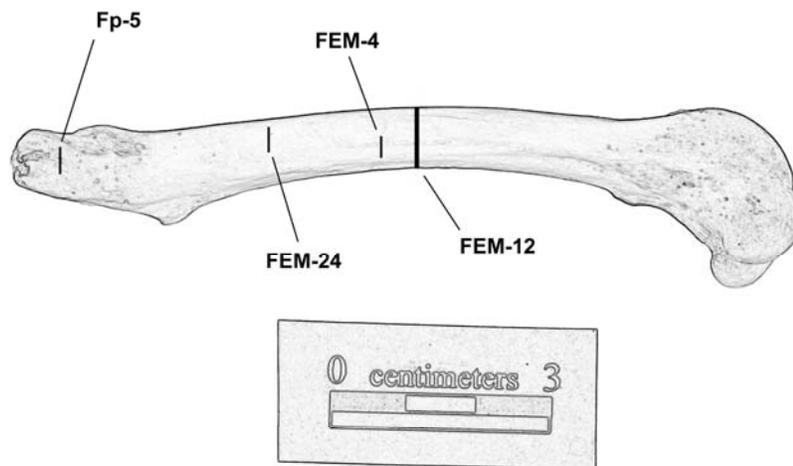


Figure A.72. Lateral view of blue duiker femur

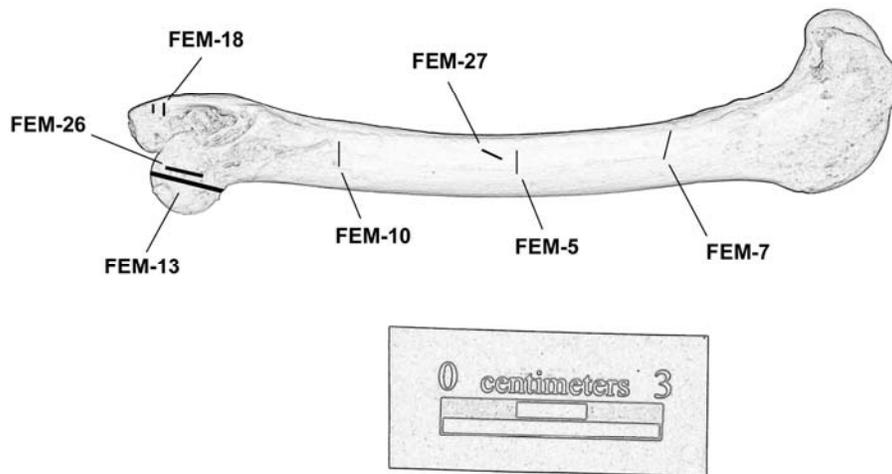


Figure A.73. Medial view of blue duiker femur

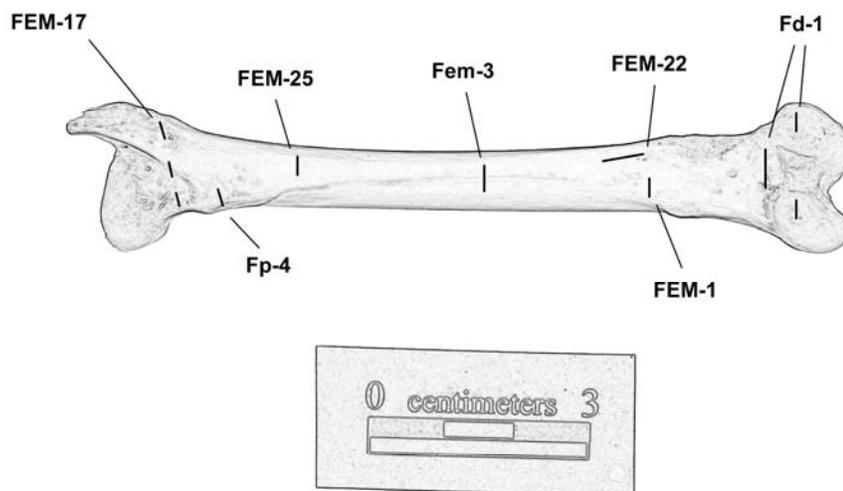


Figure A.74. Posterior view of blue duiker femur

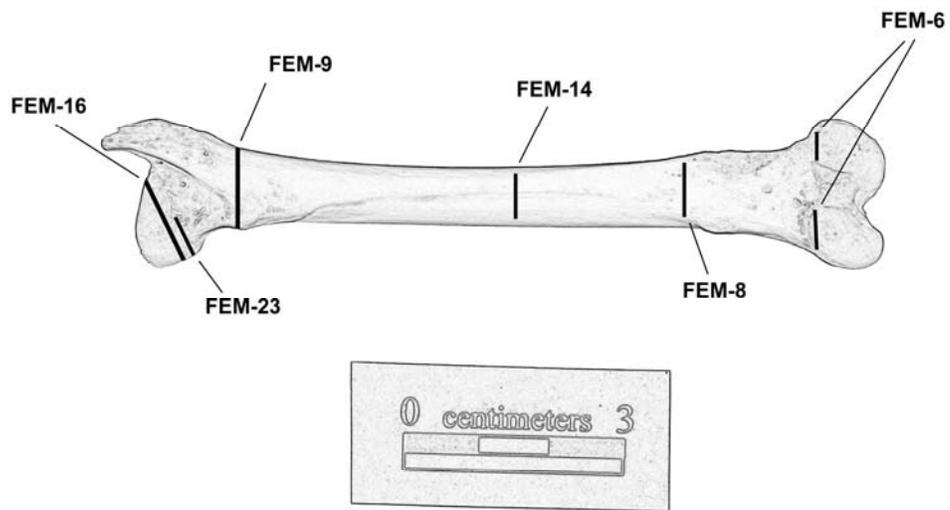


Figure A.75. Posterior view of blue duiker femur

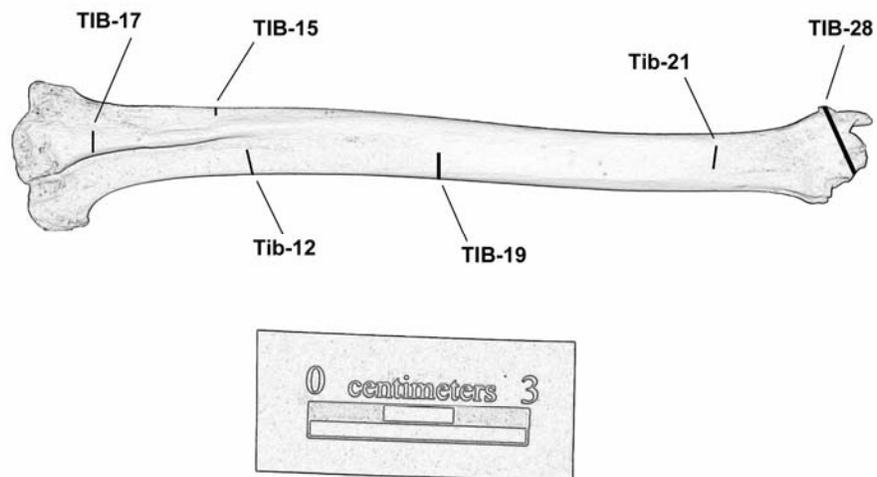


Figure A.76. Anterior view of blue duiker tibia

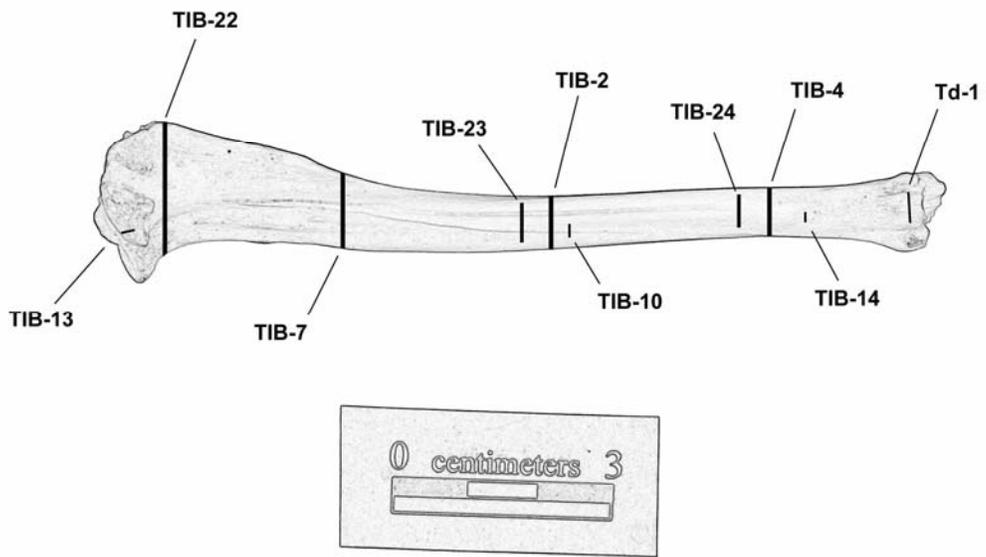


Figure A.77. Lateral view of blue duiker tibia

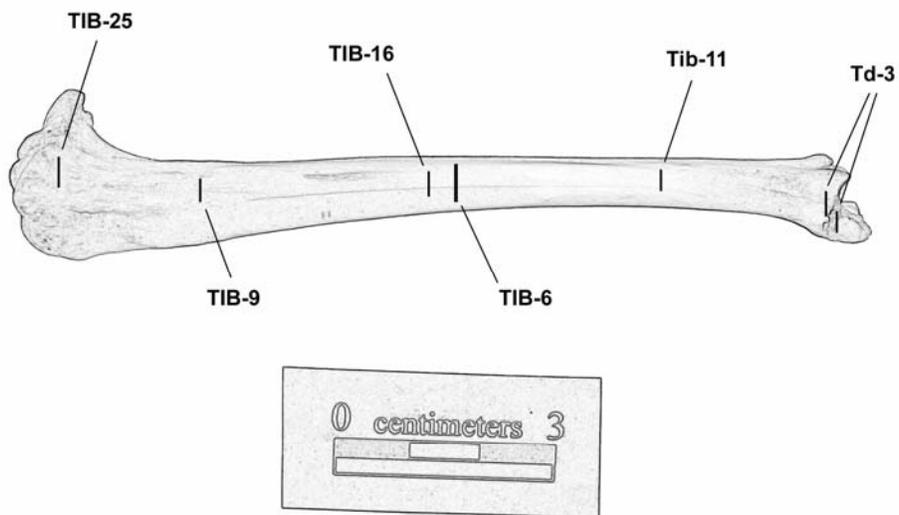


Figure A.78. Medial view of blue duiker tibia

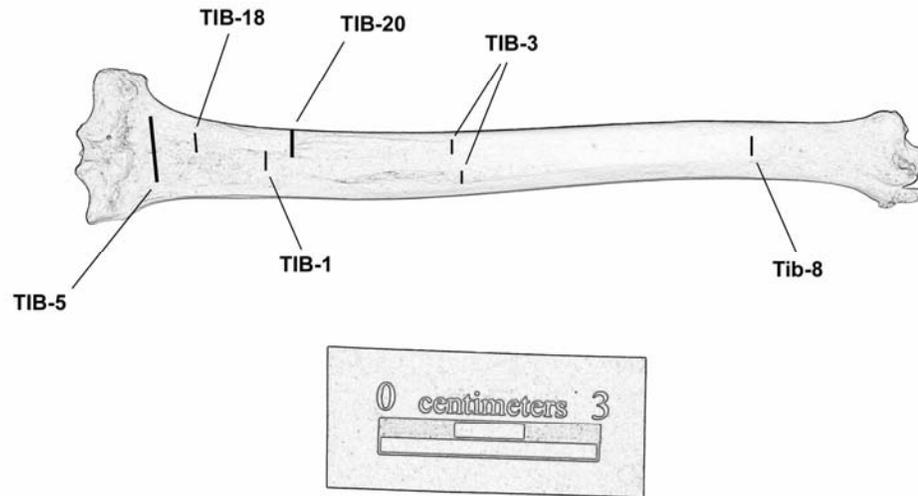


Figure A.79. Posterior view of blue duiker tibia

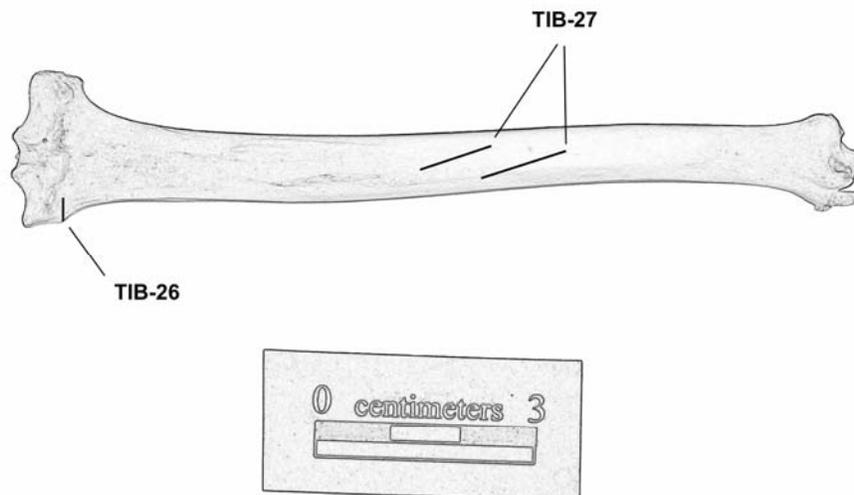


Figure A.80. Posterior view of blue duiker tibia

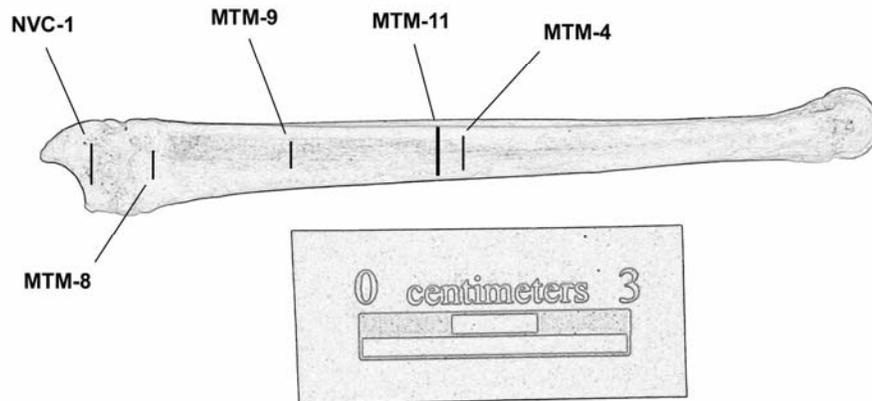


Figure A.81. Medial view of blue duiker metatarsal with articulating naviculocuboid

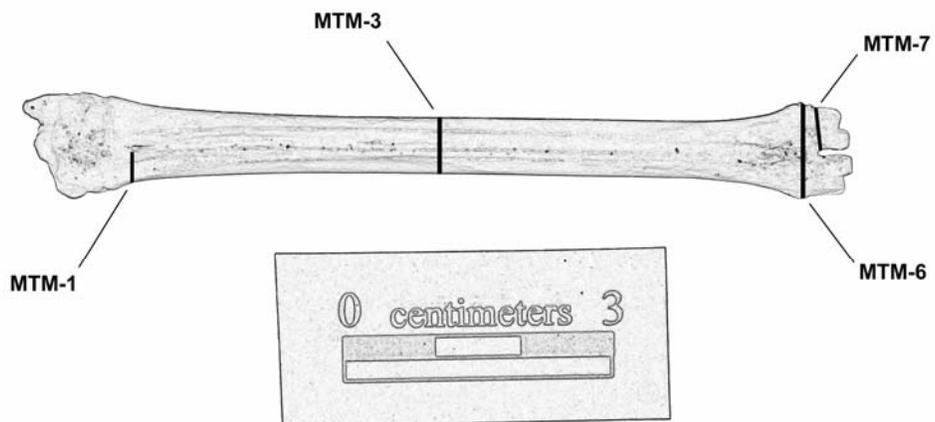


Figure A.82. Anterior view of blue duiker metatarsal

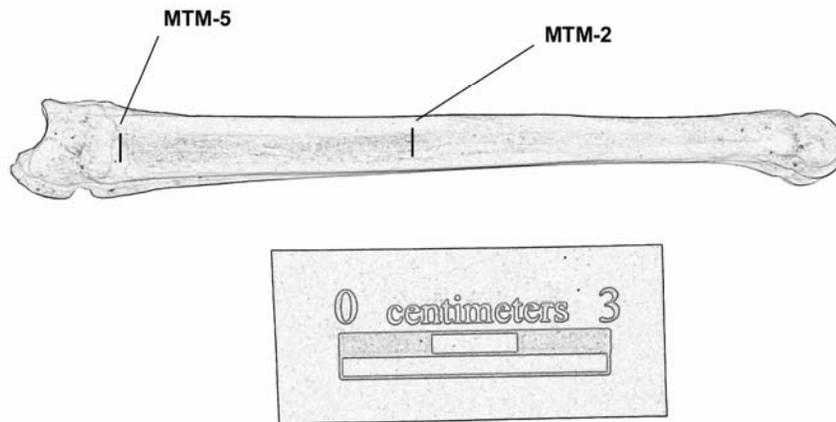


Figure A.83. Lateral view of blue duiker metatarsal

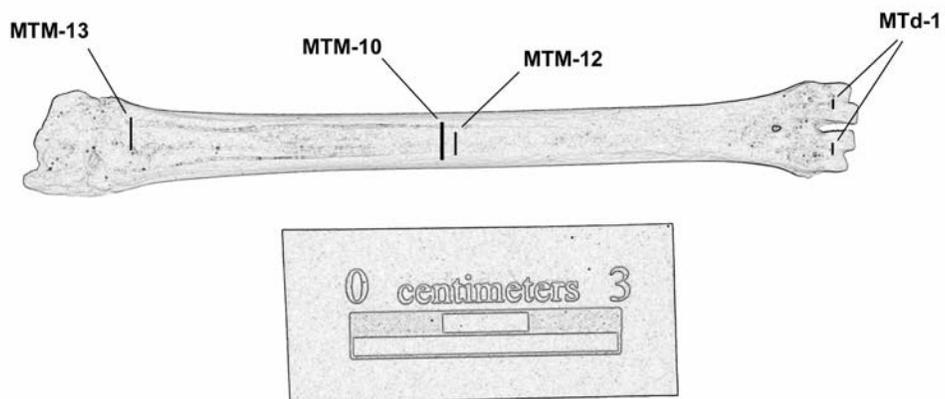


Figure A.84. Posterior view of blue duiker metatarsal