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An Initial Zooarchaeological Analysis of Magubike and Mlambalasi: Two Archaeological Sites from the Iringa Region of Southern Tanzania

by

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Abstract

The current study consists of a preliminary analysis of the faunal materials recovered from test pit excavations at Magubike (HxJf-01) and Mlambalasi (HwJf-02), two archaeological sites in the Iringa district of Tanzania. Both sites contain faunal materials from the Iron Age, Later Stone Age and Middle Stone Age, which is unique for this region and causes them to be particularly germane to the behavioural modernity debate. The analysis of the faunal materials employed a combined zooarchaeological and taphonomic approach designed to elucidate each site's formational history and human behavioural component. Through the construction of a sound taphonomic framework, an initial understanding of the formational processes at both sites was achieved and insight into Iron Age human subsistence strategies was attained. The poor preservation of the Later Stone Age and Middle Stone Age faunal materials precluded an understanding of the human subsistence strategies employed during these periods.

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Chapter 1 – Introduction

Behavioural modernity is a concept that has generated much debate within the past 20 years in paleoanthropological and archaeological circles (Klein, 1999; Henshilwood and Marean, 2003; McBrearty and Brooks, 2000; Mellars, 1989; 2005; 2006; Willoughby, 2007). The debate centers on the apparent dichotomy represented by the appearance of anatomically modern humans during the African Middle Stone Age (MSA, 200,000 to 40,000 years ago), while "modern" behaviour only becomes archaeologically visible with the onset of the African Later Stone Age (LSA) and the European and Middle Eastern Upper Palaeolithic sometime around 40,000 years ago (McDougall, *et al*., 2004; Klein, 1999; 2008; Willoughby, 2007). This perceived temporal disjunction between modern human anatomy and modern human behaviour has been questioned through recent archaeological excavations in Southern and Eastern Africa (Marean, *et al.*, 2007; Brooks, *et al*., 1995; Henshilwood, *et al.*, 2001). Zooarchaeological studies have figured prominently in the behavioural modernity debate, being used by both proponents of a disjunction between modern anatomy and behaviour; and those that argue for a gradual co-evolution between the two (Marean, *et al.*, 2007; Henshilwood and Marean, 2003; McBrearty and Brooks, 2000; Klein, 1992; 2001).

Recent fieldwork conducted in the Iringa region of southern Tanzania has uncovered two new rockshelter sites, Magubike and Mlambalasi, which may offer further insight into the behavioural modernity debate. Both sites contain an abundance of lithic artefacts, as well as preserved faunal remains belonging to the Iron Age, LSA and MSA (Biittner, *et al*., 2006; Willoughby, 2006). The faunal remains from Magubike and Mlambalasi represent the first instance of such material being recovered from LSA and MSA contexts in the Iringa region specifically and more generally within southern and central Tanzania. Magubike and Mlambalasi's temporal continuity and depth, coupled with their comparatively rich archaeological record, offers a unique opportunity for examining human behavioural evolution and variation over the past 100,000 years.

The current study focuses on the faunal materials recovered from Magubike and Mlambalasi during initial test excavations in 2006. This thesis will use these materials to address the following questions. What are the formational histories of the faunal assemblages? How can these be used to infer site formational history? What human subsistence behaviours can be identified from the faunal assemblages? Finally, what insight can the faunal assemblages provide with regard to the behavioural modernity debate?

The current study incorporates a complementary taphonomic and zooarchaeological approach, in order to best answer the questions posed above. When these approaches are combined, information derived from one can be used to greatly enhance the interpretative scope of the other and vice versa. Taphonomic and zooarchaeological methods will be used to generate data from the faunal assemblages and for the data's subsequent analysis. In order to practice a more holistic approach and generate inferences with the greatest insight, the results will be interpreted within zooarchaeological and taphonomic theoretical frameworks, as well as behavioural modernity and behavioural ecology contexts were possible.

This thesis is organised in a manner sought to guide the reader through the background and process of this study. Chapter 2 introduces the behavioural modernity debate by first providing a brief history and subsequently outlining the current positions. This chapter also focuses on the zooarchaeological aspects of the behavioural modernity debate, as they are most pertinent for the context of the current study.

Chapter 3 reviews the three theoretical fields employed in this research. These fields are zooarchaeology, taphonomy and to a lesser extent, behavioural ecology. As these fields are theoretically quite broad and diverse, a general description of each field's main elements is presented, followed by a more thorough discussion of the particular aspects of theory most applicable to this study.

The context of the current study is the focus of Chapter 4. This chapter includes a discussion of the sites' locations, characteristics and the excavation methods used for the recovery of the faunal remains. A section of this chapter focuses on the region's cultural history, in order to provide an interpretative background. Discussion of the current and past environmental conditions is also included within this chapter. The goal of this chapter is to give the reader an informed, extensive background of the sites and to provide a context for the interpretation of their faunal assemblages.

Chapter 5 encompasses a discussion of the techniques and methods used within the current study. This discussion explicitly details the methodology used for the identification and quantification of the faunal assemblages, as it is this crucial step in which the data are generated. Through explicitly outlining the methodology and concurrently providing sound theoretical and practical grounds for its institution, it is hoped that the chances of error, confusion and misinterpretation are significantly lessened. The same is true for the explicit detailing of the analytical and statistical methods used to examine the data, as this area also offers fertile ground for misunderstanding.

Chapter 6 presents the results of the identification and quantification of the faunal assemblages, as well as the results of the analyses. Chapter 7 comprises an interpretation of the results, focusing on the sites' respective formational histories; and their human behavioural components. The relevance of this information with regard to the behavioural modernity debate will also be considered.

Chapter 8 offers a reflection on the results obtained, and some of the problems and issues encountered. Possible solutions are suggested for these problems, and questions that have arisen out of this study are presented. Future research directions are also postulated, which will hopefully be considered with the onset of further excavations at Magubike and Mlambalasi.

Chapter 2 – The Modern Human Origins Debate

2.1 – *Introduction*

The origin of modern humans has been the subject of profuse and intense debate within paleoanthropological and archaeological circles since both fields' inceptions (Brace, 1967; Howells, 1976; Clark, 1981; Wolpoff, *et al.*, 1984; Stringer and Andrews, 1988; Aiello, 1993; Conroy, 2005; Willoughby, 2007). The ferocity of this debate may be amply summarised by Desmond Clark's (1981:164) statement that, "the appearance of modern man is the most significant event in the whole long record of mankind's biological and cultural evolution." The debate surrounding modern human origins focuses on how, where and when people like us (fully modern humans) first evolved. Each of these questions is interconnected and all have been addressed through examining the fossil, archaeological and paleoenvironmental records of the Old World. The results of this research can be broadly characterised by three models for the evolution of modern humans: the multiregional model, the complete replacement model and the hybridization model (Wolpoff, *et al.*, 1984; Stringer and Andrews, 1988; Bräuer, 1984; 1989; Conroy, 2005; Willoughby, 2007). These models focus on the physical, rather than the behavioural evolution of modern humans, but will be briefly discussed below, as they have laid the foundation for the current climate of the modern human origins debate.

With the results of much focused archaeological, paleoanthropological and genetic research, it has become evident that anatomically modern humans, people displaying the physical characteristics of *Homo sapiens*, evolved only in Africa and then emigrated to the rest of the world (Stringer, 2002; Ingman, 2000; Carroll, 2003; Conroy, 2005; Willoughby, 2007; Klein, 2008). The debate has recently shifted to focus more on the origins of modern human behaviour, broadly considered to be complex abstract behaviours associated only with *Homo sapiens*, with two camps emerging (Klein, 1999; 2008; McBrearty and Brooks, 2000; Henshilwood and Marean, 2003). One position argues that modern human anatomy evolved independent of, and before modern human behaviour. Modern human behaviour is argued to have only been possible with the appearance of a genetic mutation that altered brain function and allowed human minds to achieve their current cognitive state. This position is championed by Richard Klein (1992; 1995; 1999; 2001; 2008) and has been termed the Human Revolution Model, following McBrearty and Brooks (2000).

Opposing the Human Revolution Model is a model that posits that modern human behaviour developed in tandem with modern anatomy. This model will be termed the Co-Evolution Model and is vocally supported by many Africanist archaeologists (McBrearty and Brooks, 2000; Henshilwood and Marean, 2003; Henshilwood *et al.*, 2002; 2004; Willoughby, 2005; 2007). Both the Human Revolution Model's and Co-Evolution Model's positions will be discussed in greater depth below, with an emphasis placed on the zooarchaeological record and the role it plays within the debate.

2.2 – *Models of Human Evolution*

Franz Weidenreich (1937) first noted similarities between the skeletons (particularly the crania) of Chinese and Javanese *Homo erectus* (at the time *Sinanthropus* and *Pithecanthropus*) and modern humans from the same region. This led Weidenreich (1937; 1947) to postulate that parallel evolutionary lineages existed, leading to the independent evolution of modern humans in different parts of the world and provided the foundation for the Multiregional Continuity Model. Subsequently the model was championed most notably by Brace (1967) and Wolpoff and Thorne (Wolpoff, *et al.*, 1984; Thorne and Wolpoff, 1981; 1992; Wolpoff, 1989; Wolpoff, *et al.*, 2000).

The current version of the Multiregional Continuity Model posits that modern humans gradually evolved from regionally specific precursor hominids, allowing for the maintenance of regional characteristic traits that are argued to have developed during the course of the initial hominid migration from Africa. The problem of speciation is circumvented with the suggestion of gene flow between the different regions, enabling the maintenance of a worldwide species, as well as specific regional morphologies (Wolpoff, 1989; Wolpoff, *et al.*, 1984; Conroy, 2005; Willoughby, 2007). Evidentially, the Multiregional Continuity Model places a heavy reliance on the fossil record and the argument that one can trace specific regional characteristics through time. Multiregionalists have also used some of the genetic data to support their model, claiming that it does not exclude the possibility of multiple parallel evolutionary events in distinct geographical regions. These claims are based on the variations found in timing of genetic speciation for *Homo sapiens*, as well as finding great genetic diversity in several geographically distant parts of the world (such as China and Africa). Large amounts of genetic diversity are associated with long periods of time required for their accumulation and therefore if present in many parts of the world suggest several ancient populations of *Homo sapiens* (Wolpoff and Thorne, 1991; Wolpoff, *et al.*, 2000; Templeton, 1994).

In contrast to the Multiregional Continuity Model, the Complete Replacement Model posits that there was only one geographically isolated evolutionary event that led to the genesis of modern humans (Stringer and Andrews, 1988; Stringer, 2002). The Complete Replacement Model was championed by Stringer and Andrews (1988) shortly after the first mtDNA study was published by Cann and colleagues (1987). In their study, Cann and colleagues (1987) analysed mitochondrial DNA from 145 ethnically diverse modern humans. The authors found the most parsimonious genetic tree to display one African ancestral population, indicating an African origin for modern humans sometime between 100kya and 200kya. Cann and colleagues (1987) also found modern human mitochondrial DNA to lack significant diversity, leading them to argue for no intermixing between *Homo sapiens* and other hominid species. Expanding on this evidence, Stringer and Andrews (1988) argued that after modern humans evolved in Africa, they emigrated to the rest of the world and outcompeted and replaced other hominids (Stringer, 2002).

The Complete Replacement Model relies on support from the archaeological, genetic and fossil records. The archaeological record is argued to display the gradual spread of new technologies associated with the appearance of modern humans, with this technology (LSA or Upper Palaeolithic) being found earliest in Africa (Ambrose, 1998a; Klein, 1999; Willoughby, 2007). Genetic research into both humans and Neandertals has provided overwhelmingly one-sided evidence for a single origin for modern humans, due to the lack of genetic diversity in current human populations and the dissimilarities between the human and Neandertal genomes (Cann, *et al.*, 1987; Krings, *et al.*, 1997; Cavalli-Sforza and Feldman, 2003; Weaver and Roseman, 2005). An African origin is supported by the significantly increased genetic diversity displayed in some sub-Saharan African populations (such as the !San). This diversity is interpreted as the result of great time depth since the formation of a lineage (Ingman, *et al.* 2000; Hammer and Zegura, 2002).

Supporters of the Complete Replacement Model also argue that the fossil record does not display regionally specific traits characterised by great time depth, which is contrary to the Multiregionalist position. Rather it is argued that these regional characteristics emerged with the emigration and expansion of modern humans (Lahr and Foley, 1994; Aiello, 1993; Willoughby, 2005; 2007). The fossil record also demonstrates that the oldest anatomically modern skeleton (dated by ^{39}Ar-^{40}Ar to approximately 195,000 years ago (195kya)) and all other anatomically modern skeletal remains older than 100kya are only to be found in Africa and the Levant, reinforcing a single African origin for modern humans (McDougall, *et al.*, 2004; Klein, 1999; Conroy, 2005; Willoughby, 2005; 2007).

The Replacement with Hybridization Model was initially forwarded by Bräuer (1984; 1989) as the Afro-European *sapiens* model, and can be considered a middle ground between the Multiregional and Complete Replacement Models. Following the Complete Replacement Model, Bräuer (1984; 1989) contended that modern humans evolved only in Africa, but upon emigrating, they were able to, and did, intermix with other hominid populations. Bräuer (1984; 1989) based his argument largely on the Eastern European fossil record, which contains several skeletons that appear to display both Neandertal and modern human morphologies (specifically Mladeč and Vindija). More recent excavations in Lagar Velho, Portugal, also claim to have uncovered a 24,500 year old Gravettian skeleton that displays a mixture of Neandertal and modern human characteristics (Duarte, *et al.*, 1999).

Smith (1992a; 1992b) proposed a variation to the Hybridization Model, the Assimilation Model. This model asservates that modern humans originated in Africa, but denies replacement and an African emigration. Instead, the Assimilation Model contends that gene flow, admixture and changing selective pressures are the means and processes through which the new genetic material spread throughout the Old World. These mechanisms are argued to have enabled the evolution of modern humans, while maintaining each regional population's respective characteristics (Smith, 1992*a*; Stringer, 2002). Smith's (1992a; 1992b) model was based on the Multiregionalist interpretation of the fossil record and incorporated elements of the early genetic research. From the genetic perspective, Smith (1992a; 1992b) argued that the greater number of Africans as opposed to non-Africans resulted in African genes being preserved in significantly higher frequencies than expected.

As noted above, the vast majority of the archaeological, genetic and fossil evidence supports a single African origin for modern humans, leading to the rejection of the Multiregional Continuity Model. Ensuing genetic research has also ruled out the possibility of significant intermixing between modern humans and other contemporary hominids, particularly Neandertals (Green, *et al.*, 2006; Noonan, *et al.*, 2006). Such evidence does not rule out the possibility of Neandertals and modern humans interbreeding and producing viable offspring, rather it argues against any significant contribution by Neandertals (and other hominids) to the modern human gene pool. Therefore both manifestations of the Hybridization Model can be refuted and the Complete Replacement Model can be accepted with the caveat that there may have been productive interbreeding between modern humans and other hominids, but it was not significant. It is in this climate that the behavioural modernity debate takes place.

2.3 – *The Behavioural Modernity Debate*

With the publication of ^{39}Ar-^{40}Ar dates for the levels sandwiching the Ethiopian Omo 1 and Omo 2 skeletons, the presence of anatomically modern humans was pushed back to 195kya (McDougall, *et al.*, 2004). This date places the appearance of modern humans in the MSA, which has been technologically and behaviourally associated more with the immediate precursors to modern humans, than with modern humans themselves. Modern human behaviour has been classically associated with the onset of the LSA in Africa and the Upper Palaeolithic in Europe and the Levant, around 40kya, which fit nicely with earlier estimates of the appearance of modern anatomy, especially in Europe (Klein, 1999; 2008; McBrearty and Brooks, 2000; Henshilwood and Marean, 2003).

The revised time-depth of anatomically modern humans therefore created a discordance between modern human anatomy and modern human behaviour, leading to two positions, the Human Revolution Model and the Co-Evolution Model. The Human Revolution Model argues for a genetic mutation enabling modern cognition and precipitating the MSA-LSA and Middle Palaeolithic-Upper Palaeolithic transitions, whilst the Co-Evolution Model argues that modern behaviour evolved in tandem with modern anatomy during the MSA (Klein, 1992; 1999; 2008; McBrearty and Brooks, 2000; Henshilwood and Marean, 2003; Willoughby, 2007). Both models will be discussed in greater depth further below, as will what constitutes modern subsistence behaviour and how it has been interpreted in the archaeological record.

Klein (1992; 1995; 1999; 2008) is the current major proponent of the Human Revolution Model. He argues for behavioural modernity appearing as a punctuated event, being expressed in the archaeological record with the MSA-LSA and Middle Palaeolithic-Upper Palaeolithic technological innovations. Klein (1992; 2008) bases his argument on an archaeological and behavioural trait-list that is posited to reflect the cognitive abilities of fully modern humans only. There have been many iterations and refinements of this trait-list approach, but for the most part these trait-lists variously consist of complex burials, art, ornamentation, decoration, symbolic use of ochre, worked bone and antler, blade technology, standardization of artefact types, artefact diversity, complex hearth construction, organized use of domestic space, expanded exchange networks, effective large mammal exploitation, seasonally focused mobility strategies, use of harsh environments, fishing, fowling, microliths and grindstones (Klein, 1992; 1995; 1999; 2008; Ambrose, 1998a; Thackeray, 1992; Mellars, 1989; 2005; Willoughby, 2001b; 2007; D'Errico, 2003; Henshilwood and Marean, 2003; McBrearty and Brooks, 2000) (for some useful examples of trait-list tables see Henshilwood and Marean (2003:628), McBrearty and Brooks (2000:491-493) and most recently Klein (2008:270)). The Human Revolution Model argues that once some combination of these traits becomes a regular and visible part of the archaeological record, behaviourally modern humans are present.

The Human Revolution Model draws the majority of its evidence from the European archaeological record, where there appears to be a dramatic and abrupt shift from the Middle Palaeolithic (associated with Neandertals) to the Upper Palaeolithic (associated with modern humans). This shift is manifested by many of the traits mentioned above, such as the introduction of blade technology, worked bone, complex art, burials, ornamentation and artefact diversity. These traits are contrasted with the more simplistic lithic technologies, subsistence strategies and absence of symbolic behaviour interpreted from Middle Palaeolithic archaeological sites (Henshilwood and Marean, 2003; Mellars, 1989; 2005; McBrearty and Brooks, 2000; Willoughby, 2007). A similar argument has been made with respect to the African archaeological record, focusing again on the appearance of blade technology, worked bone, and art, as well as the use of ochre, spatial organisation, the introduction of grindstones and changes in subsistence behaviour (Ambrose, 1998a; Ambrose and Lorenz, 1990; Klein, 1992; 2001; 2008; Klein and Cruz-Uribe, 1996; McBrearty and Brooks, 2000; Henshilwood and Marean, 2003; Willoughby, 2005; 2007; Thackeray, 1992).

To account for the chronological discrepancy between the appearance of modern anatomy and modern behaviour, Klein (1992; 2008) has argued that a genetic mutation or series of mutations accompanied and facilitated these new more complex behaviours. Unfortunately, this is currently an untestable assumption, with the complexities associated with genetic research and accurately calibrating the timing of past genetic mutations (Wall and Kim, 2007; Carroll, 2003; Willerslev and Cooper, 2005). Nonetheless, there have been some interesting developments, in particular regarding research into the FOXP2 gene, which plays a role in speech production. Enard and colleagues (2002) estimated that this mutation occurred fairly recently in human evolutionary history, most likely within the past 120ky, theoretically placing it within the crucial time interval specified by the Human Revolution Model (Lai, *et al.*, 2001). More recent research into Neandertal genetics however, has shown that Neandertals also have the FOXP2 mutation and therefore the mutation is argued to be much older (300-400kya instead of within the last 200ky) than first thought (Krause, *et al.*, 2007).

Contrary to the Human Revolution Model, which argues for a rapid transition or “revolution” from the MSA-LSA and Middle Palaeolithic-Upper

Palaeolithic, the Co-Evolution Model proffers a more gradualist perspective. The Co-Evolution Model proposes that modern behaviour evolved with modern anatomy during the MSA and is not the result of a genetic mutation (or series thereof) that promptly resulted in a change in brain function around 50kya. In opposition to the Human Revolution Model, the Co-Evolution Model rejects a specific trait-list approach to defining modern human behaviour, as it is cogently argued that previous trait-lists display a marked Eurocentric bias and produce an ambiguous rubric for confirming the presence of modern human behaviour (how many traits must a behaviourally modern human display in order to be considered a behaviourally modern human?) (Henshilwood and Marean, 2003; McBrearty and Brooks, 2000; Willoughby, 2007; Wadley, 2001; D'Errico, 2003).

Proponents of the Co-Evolution Model instead opt for a more flexible definition of modern behaviour, based more on cultural context and cognitive research. Broadly speaking, modern human behaviour is argued to be manifested in external symbolic storage, which represents the capacity for complicated, abstract thought and the ability for significant planning depth. These characteristics are argued to be expressed archaeologically through artistic and symbolic artefacts and complex subsistence strategies (Henshilwood and Marean, 2003:635; McBrearty and Brooks, 2000:492; Wadley, 2001:210). This interpretation of modern human behaviour complements current and previous research in cognitive science, where various models of cognitive evolution all argue for complex, abstract, symbolic thought processes as being exclusively modern human characteristics (Barnard, *et al.*, 2007; Amati and Shallice, 2007;

Donald, 1991; Noble and Davidson, 1996; Wynn and Coolidge, 2004; Mithen, 2001).

The archaeological record of the African MSA and to some extent that from the Middle Palaeolithic of the Levant and Europe, is used to support the Co-Evolution Model. Recent research in southern and eastern Africa has demonstrated the presence of complex, abstract behaviours such as the use of ochre, artistic engravings on ochre, worked shell beads interpreted as personal adornments (Blombos Cave, Henshilwood, *et al.*, 2001; 2002; 2004; D'Errico, 2003; D'Errico, *et al.*, 2003; 2005; Henshilwood and Marean, 2003), complex subsistence strategies (including fishing and fowling) (Pinnacle Point, Marean, *et al.*, 2007 and Blombos Cave, Henshilwood and Marean, 2003) and worked bone tools (Katanda, Brooks, *et al*, 1995; Yellen, *et al.*, 1995). This research has helped to demonstrate that the capacity for abstract, symbolic cognition was present in the African MSA (McBrearty and Brooks, 2000; Willoughby, 2007).

The Co-Evolution Model also offers the flexibility of not tying cultural evolution together with biological evolution (Willoughby, 2001b). This is an important point, as during the later part of the MSA, there was a significant amount of paleoenvironmental turmoil, resulting in the spread of unpredictable and marginal environments (best exemplified by the Mt. Toba eruption approximately 71kya, argued to be the largest volcanic eruption in the past 450 million years) (Ambrose, 1998b; Scholz, *et al.*, 2007; Conroy, 2005; Willoughby, 2007). This period also bears witness to the driest conditions exhibited during the past 200ky, with Scholz and colleagues (2007) using the term "mega-droughts" to reflect the specific climatic severity observed from 135-75kya. Immediately following this arid period was one of the wettest periods seen within the past 100ky, illustrating the drastic nature of the climatic shifts (Carto, *et al.*, 2009). Related to these dramatic environmental conditions is the genetic evidence supporting repeated population bottlenecks and expansions within the past 100ky (Manica, *et al.*, 2007; Ambrose, 1998b; Stringer, 2002; Harpending *et al.*, 1993; 1998). The increased stress on human populations as indicated by the population bottlenecks would have likely provided a fecund landscape for cultural change and increasingly complex ways of surviving within harsh, competitive environments.

These cultural changes need not have any biological background and instead may be an expression of latent modern cognitive abilities that were already present, but expressed in different, less archaeologically visible forms. The varied expression of modern cognition in the MSA archaeological record appears to be most parsimoniously explained by a gradual development of the suite of modern behavioural characteristics based on cultural and environmental contexts (Henshilwood and Marean, 2003; McBrearty and Brooks, 2000; Willoughby, 2007; D'Errico, *et al.*, 2003).

2.4 – *Modern Subsistence Behaviour*

Subsistence behaviour has proven to play a significant role throughout the course of the behavioural modernity debate, starting with Binford's (1985) polemic assertion that MSA and Middle Palaeolithic peoples were obligate scavengers, obtaining meat through scavenging only. The ability to regularly acquire high-quality foods through complicated procurement strategies is argued to reflect the complicated cognitive processes that characterise modern human behaviour. Following this line of thought, modern, historic and LSA hunter-gatherers should all share similar patterns of subsistence procurement and this should be reflected in the zooarchaeological record (Kusimba, 2005; Marean and Assefa, 1999; Klein, 2001). While the Human Revolution Model and the Co-Evolution Model both broadly agree to this definition of modern human subsistence behaviour, they differ in its application.

The Human Revolution Model produces a trait-list for modern subsistence behaviour that is founded largely on the interpreted differences between South African MSA and LSA hunter-gatherers. This trait-list approach argues that modern subsistence behaviour is only apparent in LSA hunter-gatherers based on their ability to regularly and intentionally exploit, as opposed to opportunistically scavenge:

1. Seasonally-focused resources, such as fur seals.
2. Large and dangerous animals, such as buffalo and bushpigs, instead of smaller and more docile ungulates, such as eland.
3. Aquatic and marine resources, represented by both birds and fish.
4. Intensive exploitation of animals that are relatively easy to acquire, such as tortoises and shellfish (Klein, 2001:10-11; Klein and Cruz-Uribe, 1996).

Klein’s (2001; Klein and Cruz-Uribe, 1996) trait-list approach is hampered by two major oversights. As mentioned above, the Co-Evolution Model provides more flexibility in dealing with cultural changes that result from fluctuations in population pressure. Henshilwood and Marean (2003:632-633) argue that the characteristics espoused in the trait-list can also be explained (perhaps more parsimoniously) by labour and resource intensification, associated with increased population pressures in the LSA. There is also much evidence for several of these modern subsistence traits (particularly the exploitation of aquatic and marine resources, and the hunting of large dangerous animals) being unambiguously present in South African MSA sites, such as Blombos Cave, Pinnacle Point, Die Kelder’s Cave and Klasies River (Marean, *et al.*, 2007; Milo, 1998; Henshilwood, *et al.*, 2002; Henshilwood and Marean, 2003; McBrearty and Brooks, 2000; Marean, 1998; Marean, *et al.*, 2000).

A second issue with the Human Revolution Model’s position is that it does not accurately take into account modern human foraging behaviour. Klein (2001:10) and others persistently argue that modern subsistence behaviour does not entail scavenging or that a significant amount of the food is not acquired through scavenging (Binford, 1985; Stiner, 1991; Stiner and Kuhn, 1992). This assertion is in opposition to ethnoarchaeological research that has documented not only the huge variability and adaptability of modern hunter-gatherer subsistence practices, but also evidence from one Hadza group that attained roughly 20 percent of its large and medium-sized mammal carcasses from scavenging (Lupo, 2007; Kelly, 2007; O’Connell, *et al.*, 1988:356-357; Bunn, *et al.*, 1988; O’Connell and Hawkes, 1988).

In keeping with their interpretation of modern behaviour in general, supporters of the Co-Evolution Model subscribe to a more generalised concept of modern subsistence behaviour. Here modern subsistence behaviour is considered to represent subsistence strategies that are comparable to and fully compatible with modern, historic, LSA and Upper Palaeolithic hunter-gatherers. These strategies are argued to demonstrate significant planning depth and abstract symbolic behaviour, necessary in accomplishing the complex tasks exhibited by behaviourally modern foragers (Kusimba, 2005; Marean and Assefa, 1999; 2005; Yeshurun, *et al.*, 2007; McBrearty and Brooks, 2000; Henshilwood and Marean, 2003). These tasks include planning and carrying out the exploitation of seasonal resources, exploiting large, dangerous resources, and by having plastic, flexible subsistence strategies that ensure survival during times of stress and intense resource pressure (Marean and Assefa, 1999; 2005).

This broad definition of modern subsistence behaviour has been recently applied to several MSA zooarchaeological contexts with interesting results. Assefa (2006) assessed the faunal remains from the Ethiopian MSA site of Porc-Epic. The results of his analysis strongly suggest that Porc-Epic was a campsite and that its MSA occupants were effectively exploiting the wide range of bovids present on the palaeolandscape. This interpretation is supported by the predominance of high-utility elements and the wide range of taxa present, all displaying evidence of primary access by humans. Assefa’s (2006) results indicate that the MSA peoples were practicing a sophisticated, yet flexible subsistence strategy and were engaged in effectively exploiting their landscape, which is concordant with modern subsistence behaviour.

Faith's (2008) study comparing 51 MSA sites and 98 LSA sites from southern Africa offers another insightful look into the MSA zooarchaeological record. This study allowed Faith (2008) to directly test if there were significant behavioural differences between MSA and LSA hunter-gatherers and if so, whether these were related to cognition. Faith's (2008) results indicate that at the minimum, MSA hunter-gatherers had equal success in competently and fully exploiting the same diversity of environments as their LSA counterparts. More specifically, the MSA hunter-gatherers were interpreted as procuring greater meat yields than their LSA counterparts, due to increased encounter rates with large prey, indicating that MSA hunter-gatherers may have enjoyed greater foraging success than some of their LSA counterparts (Faith, 2008:24). Both Faith's (2008) and Assefa's (2006) studies demonstrate the feasibility of reconciling the Co-Evolution Model's interpretation of modern subsistence behaviour with the zooarchaeological record. Both studies also yield interesting results, complementing the zooarchaeological research at the other African sites mentioned above.

The major flaw in the Co-Evolution Model's interpretation of modern subsistence behaviour is that it is not limited to just *Homo sapiens*. Much recent zooarchaeological research has put forth a strong argument for Middle Palaeolithic Neandertals also engaging in modern subsistence behaviour throughout Europe and the Levant (D'Errico, 2003; Grayson and Delpech, 2003; Tyler-Faith, 2007; Gaudzinski and Roebroeks, 2000; Patou-Mathis, 2000; Marean, 1998; Davies and Underdown, 2006; Yeshurun, *et al.*, 2007; Marean 1998; Marean and Kim, 1998, Burke, 2000 and contributions therein; Burke, 2006).

A prime example can be found in Grayson and Delpech's (2003) study of ungulate accumulations from the Middle Palaeolithic to the Magdalenian at Grotte XVI, France. The authors found there to be no significant differences between the accumulation and use of ungulates between the Middle and Upper Palaeolithic levels and were able to soundly relate the small variations found to climatic and environmental changes occurring during this period (Grayson and Delpech, 2003:1644-1645). Their research was later corroborated by Faith (2007), who showed that central-place foraging theory (founded on ethnographic research of modern hunter-gatherers) was equally valid in explaining both Middle and Upper Palaeolithic ungulate accumulations (Faith, 2007:2010).

Other examples can be seen in the findings of Yeshurun and colleagues (2007) research at Misliya Cave, Israel and the research of Gaudzinski and Roebroeks (2000) at Salzgitter-Lebenstadt, Germany. Both studies found convincing evidence for Neandertals focusing on prime-aged individuals, deer and gazelles in the former and reindeer in the latter. Prime-aged individuals are argued to be the most desirable age group, as they offer the greatest amounts of meat and nutrition, but they are also the hardest and most dangerous to hunt. As modern humans have the ability to focus on prime-aged individuals, zooarchaeological assemblages that also display this pattern are attributed to modern subsistence behaviour (Marean and Assefa, 1999; 2005; Stiner, 1990).

While there appears to be ample evidence in support of Neandertals practicing modern subsistence behaviour, they are, as mentioned above, a genetically separate species (Krings, *et al.*, 1997; Green, *et al.*, 2006; Noonan, *et al.*, 2006). This forces the question that if Neandertals were engaging in the same subsistence behaviours as modern humans, does that negate the Co-Evolution Model's interpretation of modern subsistence behaviour? Although it may appear that Neandertals engaged in modern subsistence behaviour, this is something that can only be inferred from the zooarchaeological record and not established through first-hand observation.

Ethnographic research into human hunting behaviours has demonstrated a strong symbolic component, evinced through animism, transference of personhood to prey and concepts of unique hunter-gatherer socialities that establish strong, symbolic and ritualistic relationships between hunters and their prey (Ingold, 2000; Willerslev, 2007; Binford, 1978; Bird-David, 1999; Brightman, 2002). If Neandertal subsistence behaviours included similar social and symbolic aspects, then they could be more strongly linked with the practice of modern subsistence behaviour. Unfortunately the zooarchaeological record lacks the acuity required to establish what, if any, social and symbolic interactions were taking place between Neandertals and their prey. The same is also true of MSA zooarchaeological assemblages. However, this problem reinforces the need to explore the behavioural modernity question from a holistic viewpoint and not limit oneself to one particular aspect of the debate.

Chapter 3 - Theoretical Review

3.1 – *Zooarchaeological Theory*

The field of zooarchaeology focuses on studying, analysing and interpreting past peoples' relationships with their environment, specifically their cultural and economic interactions with the faunal aspect of their environment. These studies are accomplished by analysing the faunal component of an archaeological assemblage, which entails identification of the bones to element and taxon; and the subsequent quantification and interpretation of the faunal assemblage within its archaeological context (Reitz and Wing, 1999:1). Zooarchaeology is a broad field, characterised by a multidisciplinary bent, with many of its practioners specialising in one particular aspect of zooarchaeological study, such as a particular animal or geographical/cultural area. Being such a diverse field, zooarchaeology is built upon a large and varied theoretical foundation necessary to accommodate its multidisciplinary nature.

The complete scope of zooarchaeological theory will not be discussed here, only the aspects that are deemed relevant. This will include a broad outline of what constitutes subsistence strategies and how they can be identified from the zooarchaeological record; practical limitations of the zooarchaeological record; interpreting the zooarchaeological record (with a focus on the limb-shaft debate) and taphonomic theory. The latter plays an extremely significant role in the interpretation of the zooarchaeological record and will be accorded due consideration, especially with respect to the roles of human and non-human agents in site formation.

Subsistence strategies are the means by which people go about acquiring their food. These strategies play a significant role in shaping and are shaped by the social and economic institutions of a particular cultural group (Reitz and Wing, 1999:7). A comprehensive analysis of subsistence strategies entails examining not only the faunal aspect, but also the floral and ecological aspects, as these help to clearly identify the total environmental context of a particular group's mode of subsistence and lead to more accurate inferences regarding the interpretation of their subsistence strategies (Reitz and Wing, 1999; Marean and Assefa, 2005). Unfortunately, due to preservational bias against the floral component, most MSA and early LSA sites lack insight into this aspect of subsistence, so rely heavily on the faunal and paleoenvironmental components (Lyman, 1994; Marean and Assefa, 1999; Reitz and Wing, 1999; Renfrew and Bahn, 2000:282-286).

Interpretations of subsistence strategies have been largely influenced and characterised by the forager-collector continuum model initially introduced by Binford (1978; 1980). Binford (1980) compared the foraging strategies of the Nunamiut and San peoples and found them to be quite different, which he interpreted as being the result of differential resource distributions in two extremely different environments. Based on these two hunter-gatherer groups, Binford created a continuum, with foragers (represented by the subsistence strategies of the San) at one end and collectors (represented by the subsistence strategies of the Nunamiut) at the other.

The foraging subsistence pattern is characterised by extensive (especially seasonal) mobility, the use of encounter strategies for hunting and gathering and infrequent food storage. Foragers are also characterised by living in environments that have temporally and spatially homogenous resource distributions. When the resources within a given patch are exploited, foragers move on to another more abundant patch, hence their highly mobile lifestyle (Binford, 1980; 1982). Binford (1980) identifies foragers as engaging in residential mobility, whereby the entire residence is relocated to a new, fecund area, once the current area has been exploited. In this respect, foragers are described as "moving consumers to goods" (Binford, 1980:15).

The collector subsistence pattern is described as an adaptation to environments where resource distribution is temporally and spatially heterogeneous. Consequent of this resource heterogeneity, collectors engage in a logistical mobility strategy, whereby specialised task groups are assembled that target specific resources for high bulk extraction and storage. Heterogeneous resource distributions also necessitate fewer residential moves, but result in the establishment of field stations, hunting camps and caches within several days walking distance of the main campsite (Binford, 1978; 1980; 1982). In contrast to foragers, Binford (1980:15) characterises collectors as "moving goods to consumers".

As noted above, this model was introduced as and is to be considered a continuum along which all hunter-gatherer groups may be placed. The substantial variety expressed by modern and archaeological hunter-gatherers and the environments in which they inhabit, necessitates much caution before oversimplifying and reducing their subsistence strategies to either pole (Kelly, 2007). Binford (1980:17-19) himself noted that different strategies may be employed depending on the different environmental and social contexts, such as seasonal variations, and increases and decreases in population pressure and resource abundance. Binford's (1980) original model has provided a background setting for the human behavioural ecology approach in archaeology, which will be discussed later.

In their summary article discussing Middle Palaeolithic and MSA zooarchaeological assemblages of the Old World, Marean and Assefa (1999:24-26) explicate the three data sets most commonly used in interpreting subsistence strategies: skeletal element abundances, bone surface modifications and mortality profiles. Unfortunately the data acquired in this study do not facilitate the construction of mortality profiles, so they will only be briefly discussed. In addition to these three data sets, seasonality studies can also play a prominent role; however, as seasonality data were also not obtainable for the current study, this topic also does not warrant further discussion. Both skeletal element abundances and bone surface modifications will be soundly outlined within this section, but as each also consists of a significant taphonomic component, they will be further discussed in the taphonomic theory section.

Skeletal element abundances are fundamental quantitative measures of any zooarchaeological assemblage (Lyman, 2008; Reitz and Wing, 1999). In order to determine the skeletal element abundance for a given zooarchaeological assemblage, those bones that can be identified are so, and then sorted into skeletal units (elements) based on the taxa to which they are attributed (Reitz and Wing, 1999; Lyman, 2008; Marean and Assefa, 1999). Relative abundances are established by comparing the counts of each element, using Number of Identifiable Specimens (NISP, the number of specimens that can be identified from a faunal assemblage), Minimum Number of Elements (MNE the minimum number of elements needed to account for the specimens under study) and/or Minimum Number of Individuals (MNI, the minimum number of individuals needed to account for the elements in an assemblage), depending on the questions being asked and the nature of the data (see Chapter 5 for further discussion of NISP, MNE and MNI) (Lyman, 2008:214-249).

Skeletal element abundances are most commonly used to interpret foraging and food transportation strategies. These kinds of analyses are conducted by examining the relative abundances of skeletal elements within an assemblage and comparing them with each element's associated nutritional value (Marean and Assefa, 1999; Reitz and Wing, 1999). There are several utility indices within the literature that relate each element of a particular taxon to a set of nutritional values. The two most common and well-know are Binford's (1978) Modified General Utility Index (MGUI) and Metcalfe and Jones' (1988) Food Utility Index (FUI). Binford's (1978:72-75) MGUI incorporates actualistic nutritional data based on meat, marrow and bone grease and was created for caribou and sheep. The MGUI was preferred by Binford and others over Binford's (1978) General Utility Index (GUI), because the MGUI accounts for riders, bones with little nutritional value that are attached to bones with high nutritional value (Reitz and Wing, 1999:215).

Metcalfe and Jones' (1988) FUI is extremely similar to the MGUI, but is argued to possess two advantages over it. The first is that it is more simply derived, and as Metcalfe and Jones (1988:490-491) point out, this allows for easier calculations of FUI for species other than sheep and caribou. Second, and also due to the FUI's simplified derivation, it can be applied to the anatomical data from which it was calculated, allowing changes in the variables (such as the nutritional values of marrow, grease and meat) to be scrutinised (Metcalfe and Jones, 1988:493).

When skeletal element abundances are calculated and analysed in tandem with an economic utility index (such as MGUI or FUI), several characteristics of the faunal assemblage can be discerned. These include whether or not the assemblage was created through human or non-human agency, was scavenging being practiced, what sort of transport decisions where being made, the type of occupation (kill or campsite) and taphonomic bias (such as carnivore-ravaging). This non-exhaustive list illustrates the importance of skeletal element abundance data in the interpretation of past subsistence strategies (Marean and Assefa, 1999; Egeland and Byerly, 2005; Cleghorn and Marean, 2004; Bunn and Kroll, 1986;

Stiner, 1991; Yravedra and Dominguez-Rodrigo, 2009; Dominguez-Rodrigo, *et al*, 2007).

Bone surface modification refers to marks that have been created through either human or non-human agency on the surface of bones. These modifications can be used to infer the presence and extent of both human and non-human agency in the creation of the faunal assemblage (Fisher, 1995; Marean and Assefa, 1999). Human-induced marks typically result from processes and techniques that are used to extract the meat, marrow and other nutritional elements from a carcass. These are best represented by cut-marks and percussion marks, with the former relating to the skinning, defleshing and dismemberment of the carcass and the latter to the extraction of marrow (Marean and Assefa, 1999; Binford, 1981; Dominguez-Rodrigo, *et al.*, 2007; Fisher, 1995; Blumenschine and Selvaggio, 1988; Pickering and Egeland, 2006; Lyman, 1994:294-353; Galan, *et al.*, 2009).

Non-human induced bone surface modifications may reflect either natural or carnivore agency (Fisher, 1995). The majority of natural agents make marks during bone weathering, described by Behrensmeyer (1978:153) as, “the process by which the original microscopic organic and inorganic composition of a bone are separated from each other and destroyed by physical and chemical agents operating on the bone in situ, either on the surface or within the soil zone.” These processes include, but are not limited to trampling, physical compaction, geochemical alteration and biochemical marks (Behrensmeyer, 1978; Lyman, 1994:354-403; Dominguez-Rodrigo and Barba, 2006).

Carnivore agency is manifested primarily by tooth marks (see Chapter 5 and Binford, 1981:44-49 for an in depth description of carnivore tooth marks), but carnivores can also be a source of trampling and carnivore-ingested bone may possess pitting or decay from gastric acid (Marean and Assefa, 1999; Behrensmeyer, 1978; Lyman, 1994:205-216; Marean and Spencer, 1991; Blumeschine and Marean, 1993; Dominguez-Rodrigo, *et al.*, 2007; Fisher, 1995; Njau and Blumenschine, 2005).

The ability to be able to correctly identify the presence of bone surface modification and the causal agent/agents is of utmost importance for understanding how a faunal assemblage was formed. Once a sufficient understanding of the role of human and non-human agency can be established, reliable inferences regarding subsistence strategies can be drawn (Marean and Assefa, 1999; Fisher, 1995; Dominguez-Rodrigo, *et al*, 2007; Gifford-Gonzalez, 1991; Marean and Spencer, 1991; Capaldo and Blumenschine, 1994; Pickering and Egeland, 2006).

Mortality profiles describe the relative frequencies of different age and sex classes of a given taxa within a faunal assemblage. The information from this data set can be used to assess the prey-selection choices of the accumulating agent, given that the taphonomic conditions of the site facilitate the necessary levels of acuity (Marean and Assefa, 1999:25; Stiner, 1990:306-308). Stiner (1990:308-309) discusses the three types of mortality profiles: the living-structure profile (also known as the catastrophic model), the u-shaped profile (also known as the attritional model) and the prime-dominated profile (Marean and Assefa, 1999:25).

The living structure or catastrophic profile represents a faunal assemblage that contains a ratio of adults to juveniles to senescents that is said to reflect the age structure of the living population. Such models are argued to be produced by catastrophic events that eliminate the animals in an unbiased manner (Stiner, 1990:308; Marean and Assefa, 1999:25).

U-shaped or attritional profiles are represented by faunal assemblages containing elevated frequencies of juveniles and senescents and depressed frequencies of prime-aged adults. These profiles are argued to reflect natural death patterns and have been used to infer scavenging behaviour (Marean and Assefa, 1999:25; Stiner, 1990:308).

Prime-dominated mortality profiles are characterised by an abundance of prime-aged adults in comparison to juveniles and senescents. This type of profile is argued to be contrary to any natural mortality phenomena and is frequently related in the literature to sophisticated hunting practices (Marean and Assefa, 1999:25; 2005; Stiner, 1990:309; Yeshurun, *et al.*, 2007; Klein, 2001; Klein and Cruz-Uribe, 1996; Milo, 1998; Gaudzinski and Roebroeks, 2000; Marean 1998).

There are several challenges in being able to securely establish mortality patterns within a faunal assemblage. The prerequisite for the construction of any mortality profile is the ability to discern different age-groups within the faunal remains. Given that each archaeological site has a unique life history, this will be largely context dependent, and will also rely on the skill of the analyst.

Unfortunately this was not feasible for the current study and hence precludes mortality profiles from the analysis.

The taphonomic conditions must also be appropriate for mortality profiles to be constructed. Equifinality in the archaeological record necessitates that the site's formational history be well understood and the roles of the various accumulating agents be accounted for (Lyman, 2004; Munro and Bar-Oz, 2004b). Only in cases where human agency can be reliably inferred should mortality profiles be constructed.

Over the past 25 years there has been much debate regarding the most precise analytical methodology to be used in studying faunal assemblages, particularly those from the Early Stone Age, MSA, LSA, Middle Palaeolithic and Upper Palaeolithic (Binford, 1981; 1984; 1985; Bunn and Kroll, 1986; Stiner, 1991; Marean and Frey, 1997; Marean, 1998; Stiner, 2002; Pickering, *et al.*, 2003; Marean, *et al.*, 2004; Yravedra and Dominguez-Rodrigo, 2009). This debate has focused on the methodologies used to construct counts of Minimum Numbers of Elements (MNE) for the interpretation of skeletal part profiles.

There are two methods that have been and are currently employed in zooarchaeological constructions of MNE, one method largely disregards using limb shafts (also referred to as the Anatomical Regions Profiling Technique, or ARP (Stiner, 2002)) and the other emphasises the importance of including limb shafts in the construction of MNE values (recently referred to as the "shaft critique" (Marean, *et al.*, 2004:76)). Depending on which method is used, the resulting MNE values may (and do) vary quite significantly, as evinced in both archaeological and experimental settings (Marean, 1998; Marean and Frey, 1997; Marean and Kim, 1998; Marean and Spencer, 1991; Bunn and Kroll, 1986; Marean, *et al.*, 2004 and references therein; Pickering, *et al.*, 2003 and references therein). Such variation based on analytical technique provides a significant obstacle in interpreting a site's faunal assemblage and in drawing accurate inferences about the occupants' subsistence strategies. Both the ARP and shaft methods will be discussed in more depth below.

Utility curves were initially constructed by Binford (1978) as a means to compare skeletal element abundances within a zooarchaeological context using a given element's utility. Element utility was initially described according to Binford's (1978:72-75) MGUI and utility curves were constructed as scatter plots of skeletal element abundance (generally represented by %MAU, or percent Minimum Animal Units) versus utility (initially represented by MGUI, subsequently represented by Metcalfe and Jones' (1988) FUI) (Marean and Frey, 1997; Marean and Assefa, 1999). Construction of utility curves gives the analyst insight into the butchery and transport decisions that have been made at the site (Marean and Frey, 1997:699). For example, Binford (1978:81) discussed three main types of strategies, bulk, gourmet and unbiased. Bulk strategies are indicative of selection for skeletal elements representing high and moderate utility and the abandonment of low utility elements. Gourmet strategies display a specific selection for the highest utility elements, with consequent abandonment of low and moderate utility elements. Unbiased strategies fall in the middle and are represented by a positive linear correlation between element frequency and element utility.

The main issue that has arisen with utility curves as methodological tools, is that many assemblages (spanning all archaeological time periods) have produced reverse utility curves (Marean and Frey, 1997; Marean, *et al.*, 2004). Reverse utility curves are formed when there is a high frequency of low utility elements (such as head and foot bones) within a faunal assemblage. These patterns (typically called head-and-foot dominated assemblages) are counter-intuitive to sophisticated hunting and subsistence practices and have been used by some zooarchaeologists to infer scavenging or less complex hunting behaviours (Binford, 1984; 1985; Stiner, 1991; Stiner and Kuhn, 1992).

Low utility elements, such as head and foot bones, typically have the highest density values (along with limb shafts) and have been experimentally shown to survive carnivore ravaging and other destructive taphonomic processes better than less dense, higher utility elements (such as ribs, long bone epiphyses and axial bones) (Marean and Spencer, 1991; Pickering, *et al*, 2003 and references therein; Marean, *et al.*, 2004 and references therein; Lam, *et al.*, 1999; Lam and Pearson, 2005; Marean, 1991; Marean, *et al.*, 1992; Blumenschine, 1988). Therefore the method for constructing utility curves must be able to take such taphonomic processes into account or specious inferences about a past group's subsistence practices may be drawn. Regarding this issue, two competing analytical methodologies have arisen, ARP and the shaft method.

The Anatomical Regions Profiling technique (ARP) is the current incarnation of a method generally used before the shaft critique movement of the late 1990's. Historically, MNEs were calculated by focusing on the epiphyses of long bones, as they are argued to contain the easiest, most identifiable landmarks. Limb shafts were largely discarded from analyses, as their incorporation was (and is) time-consuming. The analysis of limb shaft fragments was considered to not be worth the effort, as they were thought to contribute little further analytical information in the construction of MNEs and skeletal abundance profiles (Klein and Cruz-Uribe, 1984; Stiner, 1991; Klein, 1989).

Stiner (1991; 2002:981) champions the ARP approach and argues that it circumvents the issues of comparing different skeletal regions of differing densities by focusing on compact bones. Stiner (1991; 2002) divides up the animal carcass into nine anatomical regions (horn/antler, head, neck, axial, upper front, lower front, upper hind, lower hind and feet), with each region argued to have broadly the same average density values based on Lyman's (1994:234-250) photon densitometry scan sites. Stiner (2002:981-982) argues that this division into density-related anatomical regions allows one to get around issues of differential preservation induced by density-mediated attrition.

For limb portions, Stiner (1991; 2002) advocates the calculation of MNEs based on recognisable features that are found in the more resistant parts of the anatomical region. Because of the averred density evenness in limb shafts and epiphyses, Stiner (1991; 2002) focuses on epiphyses, as they are argued to contain a greater number of identifiable landmarks than limb shafts and therefore, all things being equal, give a better estimation of MNE.

Stiner (2002:988) advocates the ARP approach over the shaft method for one reason: it is simpler. She follows Occam's razor, where the simplest explanation is often the best, as it requires fewer assumptions and a shorter chain of inferences. In this context, by dividing an animal carcass up into nine portions that are on average equally dense, one is not required to make as many assumptions or inferences with regard to density-related variation and portion identifiability. The fewer assumptions and the broader anatomical regions allow the analyst to focus on the part of the assemblage that is most easily identified and therefore most likely to be correct. According to proponents of the ARP method, this results in the most accurate estimations of MNE (Stiner, 1991; 2002).

The recent catalyst of the shaft critique can be in part found in Brain's (1981) work, criticising and refuting Dart's (1957) claim of an australopithecine osteodontokeratic culture. Brain (1981) was able to show, using actualistic and experimental studies, that the limb shafts, head bones and foot bones better survived carnivore ravaging and other attritional taphonomic processes. Using this inferential framework, Brain (1981) found firm footing with which to refute Dart's claim that these over-represented elements were selected and fashioned as tools by australopithecines (Marean, *et al.*, 2004).

The shaft critique argues that interpretations of head-dominated and head-and-foot-dominated faunal assemblages interpreted by the ARP method are largely fallacious. Instead they contend that the pattern is a methodological artefact, brought about by not including limb shafts in the faunal analysis. Limb shafts are argued to play a significant role in accurate constructions of MNEs and for giving accurate accounts of human and carnivore-induced marks (Marean and Frey, 1997; Marean and Kim, 1998; Marean *et al.*, 2004; Marean, 1998; Pickering, *et al.*, 2003; Bunn and Kroll, 1986). Marean and colleagues (2004:70) have recently termed methodologically produced head-dominated and head-and-foot-dominated assemblages Type II patterns, based on their, "failure to reject the false hypothesis that the pattern results from the behaviour of the bone accumulator."

To circumvent Type II patterns, supporters of the shaft critique argue for the inclusion of limb shafts in faunal analyses, such as the calculation of MNEs and the identification of human and carnivore marks (Marean *et al.*, 2004; Marean and Frey, 1997; Pickering, *et al.*, 2003). This argument is supported through multiple experimental and archaeological studies that demonstrate not only the greater survivability of limb shafts, as opposed to epiphyses, but also that the inclusion of shafts in MNE counts turns reverse-utility curves produced by Type II patterns into positive utility-curves. Needless to say, the interpretation of a group's subsistence behaviour in particular, and behavioural capabilities in general, is significantly affected by such contrary data (Marean and Kim, 1998; Marean, 1998; Marean and Frey, 1997; Marean, *et al.*, 2004; Bartram and Marean, 1999; Yravedra and Dominguez-Rodrigo, 2009).

Stiner (1991; 2002) has argued that the differences in density between limb epiphyses and shafts are neglible, especially with regard to survivability.

Lam and Pearson (2005) have explicitly dealt with this issue and shown that by using computed tomography, as opposed to photon densitometry, one can more accurately assess density. The results of computed tomography density studies have conclusively demonstrated that limb shaft portions are denser than the epiphyses (Lam and Pearson, 2005; Lam *et al.*, 1999). Limb shafts, therefore survive density-mediated attrition better than limb epiphyses and will be more prevalent in faunal assemblages that have been subjected to such attrition.

Apart from being denser than limb epiphyses, limb shafts have also been demonstrated to better survive the effects of carnivore ravaging (Marean and Spencer, 1991; Blumenschine and Marean, 1993; Brain, 1981; Marean, *et al.*, 1992; Marean *et al.*, 2004, and references therein; Pickering, 2002; Binford, 1978). This is in large part due to the cancellous or spongy bone that is in the epiphyses and presents a greasy, highly appealing food source for scavenging carnivores. Some carnivores, such as the spotted hyena (*Crocuta crocuta*) appear to be specifically adapted for such behaviours, as they have extremely powerful jaws that have the ability to gnaw and work their way through epiphyses and into the distal and proximal ends of shafts (see figures 3.46 and 3.49 in Binford (1981:74-75) for a good example of wolf-ravaged remains). Even when limb bones have been broken for marrow and then subjected to carnivore ravaging, the shaft portion has been demonstrated to survive better than the epiphyses (Blumenschine, 1988; Bunn and Kroll, 1986; Capaldo and Blumenschine, 1994).

Experimental and actualistic research has confirmed the higher survivability of limb shafts as opposed to limb epiphyses. The results of these studies necessitate the consideration of limb shafts when analysing faunal assemblages, as by not doing so, one introduces unneeded methodological bias and raises the potential for a Type II pattern (Marean, *et al.*, 2004; Marean and Frey, 1997; Marean and Kim; 1998).

In addition to their high survivability, limb shafts also provide the majority of human-affected defleshing cut marks, as much of an animal's meat is distributed along the shaft (Marean, *et al*, 2004; Marean and Assefa, 1999). The same is true of percussion marks, as they are created when the shaft is being opened for marrow acquisition. There is also the potential for carnivore marks and non-human affected marks that can yield highly important taphonomic information (Marean and Assefa, 1999; Marean, *et al.*, 2000; Binford, 1981; Pickering and Egeland, 2005; Blumenschine, 1988; Blumenschine and Selvaggio, 1988; Dominguez-Rodrigo, *et al.*, 2007; Dominguez-Rodrigo and Barba, 2006). By not including limb shafts in the faunal analysis, one misses these crucial data and may come to draw spurious inferences and conclusions regarding the site's taphonomic history and occupants.

As mentioned above, other researchers had, for the most part, excluded limb shaft fragments from their studies, as they were argued to be too time consuming to identify and quantify, despite representing parts of the animal carcass that are associated with the highest utility (Stiner, 1991; 2002; Klein, 1989; Klein and Cruz-Uribe, 1984). Marean and Frey (1997) demonstrated that through refitting and careful examination, limb shafts could be quantified and identified. Recent work from Barba and Dominguez-Rodrigo (2005) demonstrates the distance the discipline has come in this respect, with their excellent rubric for identifying limb shaft fragments to element and portion. Therefore, while time-consuming, once the methodology for identifying limb shafts has been learned and incorporated, it can be used to generate data that are much more accurate and specific, leading to better estimations of MNE and bone surface modifications (Marean *et al.*; Yravedra and Dominguez-Rodrigo, 2009; Dominguez-Rodrigo, *et al.*, 2007).

To emphasise the importance of including shafts in faunal analyses, two pertinent examples from the literature will be discussed, Bunn and Kroll's (1986) analysis of the approximately 1.8mya FLK *Zinjanthropus* site from Olduvai Gorge, Tanzania and Marean's (1998; Marean and Kim, 1998) study of Kobeh and Die Kelder's Caves from the Middle Palaeolithic of Iran and MSA of South Africa respectively.

Bunn and Kroll (1986) provide an exemplary example of the importance of including limb shafts in faunal analyses. The authors' study of FLK *Zinjanthropus* came at a time when there were three competing models describing the subsistence strategies engaged in by the australopithecine occupants of the site. Binford (1984) claimed that the hominids were practicing a scavenging only subsistence strategy, based on skeletal element profiles, cut marks and the simplicity of the Oldowan tool tradition. Potts and Shipman (1981) argued that based on the placement and distribution of cut marks, the hominids were not processing the carcasses primarily for meat, rather they were engaged in procuring materials, such as skin and tendons, for technological purposes. Bunn and Kroll (1986) argued in favour of the FLK *Zinjanthropus* hominids engaging in a complex subsistence strategy involving the hunting and processing of small animals and possibly the hunting or aggressive scavenging of large animals. This argument was supported by the authors' analysis of cut marks and skeletal element profiles.

Bunn and Kroll (1986:435-436) argued vehemently for the inclusion of limb shafts in both the construction of skeletal element profiles and MNEs; and for analysing cut marks. Their argument arises from Binford's (1984) study, which did not include limb shafts, and provided the data from which Binford made his assertions. Bunn and Kroll (1986:435-436) firmly demonstrate that the inclusion of limb shafts in MNE estimates results not in the head-and-foot-dominated pattern (Type II) espoused by Binford (1984), but rather a pattern demonstrating a high frequency of high utility limb elements relative to axial and low utility elements. These data led Bunn and Kroll (1986:436) to surmise that the hominids were practicing a selective transportation strategy.

Bunn and Kroll (1986:436-437) were also able to discern that the majority of identifiable cut marks appeared on the shaft, not on the epiphyseal portions of the limb elements. By including shafts in their cut mark analysis, the authors were able to identify not only more cut marks, but also interpret the behaviours associated with the placement and creation of those marks. Based on the frequencies, placement and type of marks, Bunn and Kroll (1986:437-438) concluded that the hominids had primary access to both small and large animal carcasses present at the site.

The results of Bunn and Kroll's (1986) study provided a powerful example of the utility of incorporating limb shafts into faunal analyses. Their results contradicted two models of early hominid subsistence behaviour and favoured hominids engaging in a hunting subsistence strategy. This conclusion, although still debated thereafter, was founded on a strong inferential framework and solid zooarchaeological methodology, resulting in the continued relevance of their results in today's academic world (Dominguez-Rodrigo, *et al.*, 2007).

In a study designed to demonstrate the utility of including limb shafts in faunal analyses, Marean (1998) examined the faunal remains from two sites, Kobeh Cave, a Middle Palaeolithic site from Iran, and Die Kelders Cave 1, an MSA site from South Africa. Marean (1998) explicitly set out to compare the ARP technique to the shaft method by using both methodologies to construct skeletal element profiles and abundances for the faunal assemblages from Kobeh and Die Kelders. The results indicated that when the ARP technique was used, head-and-foot-dominated profiles were created, resulting in reverse-utility curves. However, when shafts were incorporated into the analysis, limb bone abundance increased and positive utility curves were constructed.

Marean's (1998) results from these two Upper Pleistocene contexts emphasise the importance of accuracy and precision in faunal analyses, as the two contrary results are indicative of vastly different subsistence behaviours. The use of the ARP method only would have led to incorrect inferences regarding the cognitive capacities of the Neandertals responsible for the Kobeh assemblage and the MSA peoples responsible for the Die Kelders assemblage.

Marean (1998) also focused on bone surface modifications and the differing interpretations that one can arrive at when limb shafts are and are not included in the study. Of particular relevance is Marean's (1998) discussion of carnivore tooth marking on long bone limb shafts. Building on actualistic and experimental research, the frequencies of carnivore tooth marks on limb shafts can be used to infer whether humans or carnivores had primary access to the bone (Blumenschine and Selvaggio, 1988; Blumenschine, 1988; Capaldo and Blumenschine, 1994; Marean *et al.*, 1992).

In the carnivore-first model, limb shaft fragments display a high incidence of carnivore tooth marking, as the carnivore must break through the bone to get at the marrow. The hominid-first model predicts that there will be lower frequencies of carnivore tooth marking on limb shafts, as the hominids have already processed the bone for marrow and therefore there is no need for the carnivore to break through the bone. These secondary remains also lack the same amount of marrow and therefore will not be of as much interest to the carnivore (Blumenschine, 1988; Marean, 1998).

Through incorporating limb shafts into his analysis of bone surface modifications and skeletal element abundances, Marean (1998) was able to demonstrate the methodological basis for Type II patterns and the inaccurate behavioural interpretations they manufactured. Marean's (1998) work, like Bunn and Kroll's (1986) was built upon a sound methodological foundation, steeped in actualistic, experimental and taphonomic research and proved to be another strong catalyst for the current state of the shaft critique.

Based on the extensive research of the past twenty-plus years, the shaft critique makes a forceful argument for the analytical utility of including limb shafts in faunal analyses. This research is based on actualistic, experimental and zooarchaeological studies that continually find support for the shaft critique. The inclusion of limb shaft fragments, based on their higher survivability than epiphyses, can help mediate Type II patterns of skeletal element abundance and yield information pertaining to human and non-human affected marks. In this respect, the analytical insight offered by limb shafts has relevance to a site's taphonomic and behavioural interpretation (Marean, *et al*., 2004; Dominguez-Rodrigo, *et al.*, 2007; Marean and Assefa, 1999). Supporters of the shaft critique argue that these benefits outweigh the extra time and training required of zooarchaeologists to properly analyse shafts (Marean *et al.*, 2004; Pickering, *et al.,* 2003; Yravedra and Dominguez-Rodrigo, 2009).

3.2 - *Taphonomic Theory*

Taphonomy is broadly described by Enloe (2004:148) as the "identification of the sources of bias in the accumulation, preservation, collection and identification of the faunal material that is studied from archaeological sites." This definition builds on Efremov's (1940:85) pioneering work in outlining taphonomy as the study of the transition of animal remains from the biosphere to the lithosphere. Taphonomists seek to understand site formational histories, the processes that have combined to produce the zooarchaeological assemblage that is being studied, in order to be able to distinguish the different agents involved

(Lyman, 1994:1-9; Dominguez-Rodrigo, *et al.*, 2007:23-32; Enloe, 2004; Bar-Oz and Munro, 2004). The ability to relate specific agents to traces manifested within zooarchaeological assemblages facilitates informed inferences regarding the extent (if any) of the human behavioural contribution to the site; and the paleoecological landscape. In turn, reliable inferences of the human behavioural component yields insight into past subsistence strategies; and accurate reconstructions of past ecologies generates a context for these strategies (Dominguez-Rodrigo, *et al.*, 2007; Enloe, 2004; Lyman, 1994; Dominguez-Rodrigo, 2008).

Identification of past agents and their traces is based on actualistic, experimental and ethnoarchaeological research designed to provide strong analogies from which accurate inferential frameworks can be constructed (Dominguez-Rodrigo, 2008; Dominguez-Rodrigo, *et al.*, 2007; Lyman, 1994; Gifford-Gonzalez, 1991). Taphonomy can therefore be thought of as “middle range theory”, which is described by Reitz and Wing (1999:23) as, “empirical observations of the processes and principles responsible for the formation of the archaeological record in order to interpret human behaviour in the past.” Middle-range theory was largely popularised and introduced into mainstream archaeology by Binford especially in his ethnoarchaeological account of the Nunamiut (1978) and in his monograph discussing bone modification (1981).

The importance of creating solid referential frameworks through strong, informed actualistic, experimental and ethnographic studies is integral to middle-range theory and therefore taphonomy (Gifford-Gonzalez, 1991; Binford, 1978;

1981; Dominguez-Rodrigo, 2008). In regard to a discussion of taphonomic theory, this must take the primary position and will be followed by a brief discussion of both the human and non-human actors and their respective traces.

Before discussing the role of actualistic research in taphonomy, it is necessary to identify the terminology that will be employed. This discussion follows Gifford-Gonzalez's (1991:228-229) use of the terms actor, trace, effector, behavioural context and ecological context. Actors are the causal agents of a trace. Traces are the marks or residues of past behaviours created by an object that modifies the material being studied. The object that effects the modification is considered the effector. Behavioural contexts indicate the behavioural patterns that are the focus of the research and ecological contexts are the environmental and ecological conditions in which the behavioural context takes place. For example, if a hominid were to use a stone tool to cut some meat from an animal carcass in the open savannah, the actor would be the hominid, the trace would be the cut marks, the effector would be the stone tool, the behavioural context would be defleshing/carcass processing and the ecological context would be the open savannah.

The importance of actualistic, experimental and ethnoarchaeological research for taphonomists lies in the creation of strong analogic frames of reference that can be used to discern past effectors, actors and contexts from previously ambiguous traces (Gifford-Gonzalez, 1991; Dominguez-Rodrigo, 2008; Lyman, 1994). Ambiguity with regard to effector and actor can be thought of as synonymous with equifinality in the zooarchaeological record. Strong actualistic research resulting in solid analogies attempts to circumvent such equifinality and provide a window into discerning past behavioural and ecological contexts (Lyman, 1994; 2004; Munro and Bar-Oz, 2004a and contributions therein; Gifford-Gonzalez, 1991; Dominguez-Rodrigo, 2008; Dominguez-Rodrigo, *et al.*, 2007).

Actualistic research relies upon uniformitarian principles, which assume there are regularities in the functioning of the world that are unbounded by time and can therefore be observed in the present (Dominguez-Rodrigo, 2008). In its modern incarnation, uniformitarianism acknowledges that the rates of change are not necessarily constant and that the agents of change cannot be empirically verified. Following Shea (1982), methodological uniformitarianism provides an approach to understanding nature, instead of being able to directly inform upon it. Methodological uniformitarianism therefore assumes that natural laws are unchanging throughout time and space and can result in explaining observed past results through modern processes (Dominguez-Rodrigo, 2008:69; Shea, 1982; Gould, 1965; Gifford-Gonzalez, 1991). This theoretical foundation results in the creation of analogies that are constructed in order to link modern processes with past observed events.

Actualistic studies focus on configurational processes (*sensu* Simpson, 1970, processes that are dependent on specific interactions at particular times and places) and thus require special attention be paid to the context within which the research is conducted. Dominguez-Rodrigo (2008:70) outlines three criteria fundamental for the construction and use of analogies within the taphonomic referential framework:

1. The ability to differentiate whether the analogy is case-specific or general.
2. With regard to case-specific analogies; a list of assumptions must be created from the data collected from the assemblage where the hypothesis testing will take place.
3. The experimental premises must be validly shown to match the set of assumptions associated with the construction of the hypothesis.

Meeting these three criteria provides for a strong analogical foundation for actualistic, experimental and ethnoarchaeological studies that have relevance to past behavioural contexts. Not meeting these three criteria will lead to misinformed associations between actors, effectors, traces and contexts (Dominguez-Rodrigo, 2008; Dominguez-Rodrigo, *et al.*, 2007; Gifford-Gonzalez, 1991; Lyman, 2004).

Interpreting behavioural and ecological contexts from archaeological and specifically zooarchaeological remains is one of the stated goals of taphonomy (Lyman, 1994; Enloe, 2004). In order to accomplish this goal, equifinality in the relationships between actor, effector and trace must be negated through actualistic, experimental and ethnoarchaeological studies founded on sound analogical reasoning (see above, Dominguez-Rodrigo, 2008; Gifford-Gonzalez, 1991). Such studies have resulted in the identification of both human-induced and non-human-induced behaviours that have taphonomic relevance. The ability to reliably distinguish between human and non-human actors and their traces results in strong inferential arguments for particular behavioural and ecological contexts (Lyman, 1994; 2004; Dominguez-Rodrigo, *et al.*, 2007; Munro and Bar-Oz, 2004a and references therein).

The majority of human-induced traces are the by-product of intentional human interactions with the biotic component of an ecosystem. These traces are generally produced in the acquisition, processing and consumption of animals (Lyman, 1994; Binford, 1978; 1981). There are two main groups of traces that have been attributed to human actors: cut marks and percussion marks (Gifford-Gonzalez, 1991; Binford, 1981).

Cut marks pertain to marks made by metal or stone effectors (an object that effects the mark or trace) and are the result of carcass processing (such as defleshing, disarticulation and skinning) (Binford, 1978; 1981; Potts and Shipman, 1981). Percussion marks are created through bone breakage, generally for the purposes of marrow extraction (Binford, 1978; 1981; Blumenschine and Selvaggio, 1988). Both cut marks and percussion marks have been the subject of on-going, extensive actualistic and experimental research, aimed at establishing reliable criteria for their identification (Galan, *et al*., 2009; Dominguez-Rodrigo and Yravedra, 2009; Dominguez-Rodrigo, *et al.*, 2007; Pickering and Egeland, 2006). This important research seeks to rule-out problems of equifinality that have plagued taphonomists in correctly ascribing behavioural contexts to zooarchaeological assemblages (Lyman, 2004; Dominguez-Rodrigo and Yravedra, 2009; see especially Dominguez-Rodrigo, *et al.*, 2007).

Human-induced traces can also be reflected in the skeletal element abundances found within a zooarchaeological assemblage (see above). When skeletal element abundances are used in tandem with human-induced traces (cut marks and percussion marks) and informative ethnoarchaeological research, strong inferences can be drawn regarding the type of site that is being studied and the decisions that were made regarding carcass processing and transportation (Binford, 1978; Egeland and Byerly, 2005; Lupo, 2007; Lupo and Schmitt, 2005; Stiner and Munro, 2002). These inferences, however, require the addition of a behavioural ecology framework, which introduces further assumptions and caveats that will be discussed in the next section.

As mentioned above, utility curves, combined with cut marks and percussion marks can lead to informative inferences regarding human subsistence behaviour. Both positive and negative utility curves are of heuristic value, especially in indicating the degree of post-depositional attrition suffered by the assemblage (Marean and Assefa, 1999; Marean, *et al.*, 2004). More specifically, skeletal element abundances combined with observations of density-mediated attrition and human-induced traces have led to informed inferences regarding differential transportation strategies. For example, Yeshurun and colleagues (2007:669) were able to discern different transportation patterns between gazelles and fallow deer at the Middle Palaeolithic site of Misliya Cave, Israel. Smaller gazelles are interpreted as being transported completely and butchered on site, as opposed to the bigger fallow deer, which were field butchered, resulting in only the high-utility and low-bulk elements being transported back to the site.

The ability to identify human-induced traces from the zooarchaeological record and use them in conjunction with behavioural ecology frameworks to infer behavioural contexts is founded on strong actualistic research. This research has allowed analysts to dispense with equivocal perspectives of some zooarchaeological contexts and differentiate human from non-human taphonomic processes.

Non-human induced traces can be divided into two broad categories, carnivore-induced traces and other biotic and abiotic-induced traces. Carnivore-induced traces have been briefly discussed above and entail various kinds of tooth marks and ingestion marks produced when carnivores process bone (Brain, 1981; Binford, 1981; Marean and Spencer, 1991; Marean, *et al.*, 1992; Dominguez-Rodrigo, *et al.*, 2007). As with human-induced traces, carnivore traces can be identified in zooarchaeological assemblages through analogical referential frameworks that have been constructed through experimental and actualistic studies (see in particular Binford, 1981). The majority of this research focuses on isolating carnivore behaviour from other taphonomic processes in order to ascertain the specific traces they leave.

An interesting example comes from Marean and Spencer's (1991) experiments with spotted hyenas (*Crocuta crocuta*). The authors' fed different sized groups of captive hyenas a variety of limb bones and monitored the results in an effort to observe the effects of hyena ravaging. Their results indicated a preferential destruction of limb ends and also provided further information regarding the types of marks left on bones ravaged by hyenas. As noted above, their important work helped to establish the foundation for the shaft critique.

Another example illustrates the strength of combining actualistic research of both human and carnivore-induced traces. Blumenschine (1988) conducted an experimental study that examined the effects of carnivore tooth marks on hammerstone broken and unmodified limb bones. The author was able to conclude that the unmodified bones produced frequencies of tooth marks that were significantly greater than those found on hammerstone broken bones. These results led to the formation of the hominid-first and carnivore-first models that were productively used in Marean's (1998) analysis of Kobeh Cave mentioned above.

Other non-human induced traces are created through weathering, diagenetic (such as sediment abrasion, compaction and chemical attrition), and biostratinomic processes (such as trampling), as well as other biotic agents (such as rodent gnawing). Lyman (1994) provides an excellent review of the majority of these processes and the traces they leave. Behrensmeyer (1978) also provides an excellent account of weathering and its traces with her diachronic actualistic study in the Amboseli Basin in southern Kenya. Her research produced a five stage weathering scale that allows the zooarchaeologist to roughly gauge both the extent of time before burial and the paleoecological conditions of the burial environment, albeit within a specific environmental context of the Amboseli Basin.

An interesting recent development has been the establishment of biochemical marks on faunal remains (Dominguez-Rodrigo and Barba, 2006). These marks are produced by fungi and colonies of bacteria and mimic aspects of tooth marks. This information was used in a recent reanalysis of the FLK Zinj site, in accordance with other lines of evidence to strengthen the argument for early hominid access to fleshed carcasses (Dominguez-Rodrigo, *et al.*, 2007; Dominguez-Rodrigo and Barba, 2006; contra Blumenschine, 1995).

There are many different agents that contribute to the formation and patterning of archaeological sites and hence zooarchaeological assemblages. Taphonomy attempts to identify each of the agents and their traces, allowing the researcher to draw valid inferences about the site's behavioural and ecological contexts (Lyman, 1994; Gifford-Gonzalez, 1991; Dominguez-Rodrigo, 2008). These attempts are complicated by the equifinality of traces that, in order to be understood, require extensive, accurate actualistic, experimental and ethnoarchaeological research that can be used to create an informative taphonomic framework (Lyman, 2004; Munro and Bar-Oz, 2004a and references therein; Dominguez-Rodrigo, 2008; Binford, 1981).

More recently multi-agent patterning within archaeological sites has been the subject of extensive research and model-making (see Fernandez-Lopez (2006) and Bar-Oz and Munro (2004) for examples). This research takes into account not only one particular trace, but multiple human and non-human induced traces, making such models more realistic, complicated and applicable to the archaeological record (Dominguez-Rodrigo *et al.*, 2007:13-14; Cleghorn and Marean, 2004; Bartram and Marean, 1999; Pickering, 2002; Galan, *et al*., 2009).

Creating models and referential frameworks based on strong analogical reasoning that can simultaneously address multiple traces facilitates stronger arguments and inferences about past contexts (Fogelin, 2007:620). This in turn leads to more accurate reconstructions of archaeological sites and the behaviours that patterned their formation; and gives the archaeologist greater insight into the research questions they are addressing (Gifford-Gonzalez, 1991; Binford, 1981; Dominguez-Rodrigo, 2008). Taphonomic analysis is therefore an integral part of any archaeological inquiry and especially relevant to zooarchaeology where issues with equifinality can distort an actor's contribution and impinge on drawing accurate inferences about the subsistence behaviours of past peoples.

3.3 – *Behavioural Ecology Theory*

Behavioural ecology can be broadly defined as the study of how human behavioural decisions are affected by their environmental contexts, where the environmental context encompasses the ecological, biological, social and cultural spheres. These decisions are analysed from an evolutionary perspective that is derived from Darwinian concepts of adaptation, natural selection and fitness (Lupo, 2007:146; Winterhalder and Smith, 2000:51-52; Bird and O'Connell, 2006:146-147).

Behavioural ecology (BE) originally developed within the biological sciences, but was incorporated into anthropological and archaeological research beginning in the mid-1970’s in an effort to deal with problems arising from cultural ecology’s insistence on group selection and homeostasis (Kelly, 2007:49-50). By incorporating a Neo-Darwinian-evolutionary approach, BE is able to look at variation in decision-making at both the intra- and inter-group levels, while still focusing on the broad environmental context as discussed above (Kelly, 2007:50-51; Winterhalder and Smith, 2000; Bird and O’Connell, 2006). The underlying assumption of the BE approach is that individuals will engage in rational choices/decision-making designed to optimise their reproductive success within their environmental context. These choices, considered to be the individual’s phenotype, are the subject of natural selection and are argued to have both a genetic and cultural component (Lupo, 2007; Kelly, 2007; Winterhalder and Smith, 2000; O’Connell and Bird, 2006).

With respect to archaeology and anthropology, BE has been most commonly used to study foraging strategies amongst modern hunter-gatherers, with the results being employed to offer further insight into the archaeological record (Lupo, 2006; 2007; Kelly, 2007; Winterhalder and Smith, 2000). Some of the more ubiquitous and well-known examples in the literature are the studies of the Nunamiut, Ache, Hadza, San, Bofi and Aka (see Binford, 1978; Hawkes, *et al.*, 1982; Bunn *et al.*, 1988; O’Connell, *et al.*, 1988; Bartram, 1993; Lee, 1968; Lupo and Schmitt, 2005; Kelly; 2007 and references therein). These studies have resulted in the formation of a body of theory known as foraging theory.

Foraging theory, or optimal foraging theory, is composed of several models that assess the costs and benefits of a particular set of foraging strategies or decisions against the environmental background, to determine which represents the most rational/optimal/selectively advantageous choice (Kelly, 2007; Lupo, 2007; Winterhalder and Smith, 2000; Bamforth, 2002). Optimal foraging models all consists of four main features (Kelly, 2007:73; Lupo, 2007:146):

1. A goal, which is generally presumed to be, but not always, the maximisation of foraging efficiency.
2. A currency, which is used to evaluate choices and is generally measured in calories.
3. A set of constraints, which consist of extrinsic and intrinsic factors that limit the returns of different choices.
4. A set of options which are available to a particular individual.

There are three optimal foraging models that have been frequently used within archaeological contexts: the Diet-Breadth Model, the Patch-Choice Model and the Central-Place Foraging Model. The Diet-Breadth and Patch-Choice models will be briefly summarised, as the exploratory nature of the data and the difficulty in identifying and quantifying the taxa present in the faunal assemblages precludes their use in the current study. The Central-Place Foraging model will be more thoroughly outlined as it is used in tandem with other zooarchaeological analyses to garner behavioural insight for this research. In addition the limitations of applying BE will be discussed, as its application to the archaeological record relies on ethnographic and ethnoarchaeological analogies, which, as mentioned above, must meet certain criteria in order to provide a methodologically sound referential framework (Binford, 1981; Gifford-Gonzalez, 1991; Dominguez-Rodrigo, 2008).

Both the Diet-Breadth and Patch-Choice models examine the range of resources found within an environment, with the Diet-Breadth model using this information to calculate an estimate of what resources should be present in the diet based on how much net energy they provide. Changes in diet-breadth may be indicative of resource intensification precipitated by environmental and/or social changes (Lupo, 2007; Kelly, 2007; Winterhalder and Smith, 2000). Similarly, the Patch-Choice model examines resource abundances within particular foraging areas or “patches” and using the Marginal Value Theorem, predicts which patches a forager should use and when a forager should move on to another patch (Lupo, 2007; Kelly, 2007; Winterhalder and Smith, 2000).

Central-Place Foraging models (CPF) are used to examine the behavioural choices and decisions of predators when they transport their prey from a kill site to a central place. Within anthropological and archaeological contexts, this involves consideration of the costs involved in transporting prey, with regard to resource choice, load size, foraging party size and the distance between foraging patches and the central place (Lupo, 2007:151-152; 2006:25-26; Kaspari, 1990; 1991; Kelly, 2007). The key problem addressed by CPF models is the question of how much time and effort should be exerted in processing the resource before transporting it back to the camp. Increased resource processing results in lighter load weights and increases both the maximum distance a forager can go from the camp and the overall nutritional utility of the load. However, increased processing requires increased inputs of both time and energy, which may be more fruitfully spent pursuing other resources or activities (Lupo, 2006; 2007; Metcalfe and Barlow, 1992; Kelly, 2007).

CPF models identify the goal of the forager as maximising the rate of nutrient return to the residential camp. Lupo (2007:152) identifies the following assumptions made by CPF models: that there is an inverse relationship between improving load utility and the minimum distance at which it becomes efficient to process a load; and that processing resources at the central place has negligible costs (Metcalfe and Barlow, 1992).

Lupo (2006; 2007) also notes two important issues associated with the use of CPF models in zooarchaeological contexts. First, because the data required for the use of CPF models comes from faunal remains, any assemblage interpreted using CPF models must have a secure taphonomic footing. The actors involved in site formation and their corresponding influences must be securely identified, so that the human behavioural element can be analysed within a secure context. This is critical for CPF models, as they use skeletal element abundances to infer differential transportation strategies (Egeland and Byerly, 2005; Grayson and Delpech, 1998; Faith, 2007).

Lupo (2006:26-27), building on Metcalfe and Barlow (1992), also discusses the importance of differentiating different resources types, specifically large animal carcasses (of particular relevance to this discussion). Large animal carcasses are argued to be most parsimoniously considered as a discrete, non-renewable, time-limited events and not as patches. Lupo (2006) argues this because they require prompt utilisation in the form of consumption and/or transportation and the carcass itself represents a diverse array of resources, each attached to their own return rates (as indicated by utility indices) (Lupo, 2006; 2007).

Several ethnographic studies have been used to examine modern hunter-gatherer transport decisions and have led to some interesting conclusions on the utility of CPF models. Egeland and Byerely (2005) used ethnographic data acquired from previous studies of the Hadza and the Kua, as well as experimentally derived data in order to create an estimation of post-encounter return rates for Size Class 2-4 bovids. The authors then used their return rates to create a predictive CPF model and compared it with the ethnographic data derived from the Hadza and Kua San. The Hadza are a group of modern hunter-gatherers found near Lake Eyasi in northern Tanzania, while the Kua San, also previously known as the Kalahari Bushmen, are modern hunter-gatherers from southern Africa. No relationship between the model's predictions of the frequency of bone transport with respect to the calculated return rates and the behaviour of the modern hunter-gatherers was found (Egeland and Byerly, 2005:154).

In a similar study with the Hadza, Lupo (2006) also found there to be no correlation between her predictive CPF models and actual Hadza transportation decisions. Both Egeland and Byerly (2005) and Lupo (2006) comment on how their indices were too simplistic (or reductionist) and fail to fully take into account the different contexts associated with each butchering event. Egeland and Byerely (2005:154) in particular note that there are differences between zooarchaeologically meaningful and behaviourally meaningful units and this is emphasised by Lupo's (2006:52-53) discussion of the importance of biltong, a culturally meaningful food item, as well as her identification of social and political motivations also playing a significant role in the forager's decision making.

Despite these issues, there remains optimism that future, more comprehensive studies, building on the pioneering ethnographic work of O'Connell and colleagues (1988) and Bunn and colleagues (1988) can produce more accurate CPF models. It is also hoped that these models will prove to be useful within taphonomically secure zooarchaeological contexts, as they will be able to further inform on past peoples' subsistence and residential strategies by specifically focusing on processing and transportation.

The majority of the criticism against the BE framework comes from problems that are derived from the assumptions made by the optimal foraging models. One of the major problems is the consistent violation of these models' fundamental assumptions when tested against ethnographic and zooarchaeological data. Ethnographic studies of a large sample of modern hunter-gatherer groups have shown that they do not always forage optimally or randomly, as predicted by the Diet-Breadth, Patch-Choice and Central-Place Foraging models (Bunn, *et al.*, 1988; O'Connell, *et al.*, 1988; Hawkes, *et al.*, 1982; Lupo, 2006; Egeland and Byerly, 2005; Lupo and Schmitt, 2005; Kelly, 2007).

A second fundamental issue is discussed by Sih and Christensen (2001), who researched 134 studies of optimal diet theory (the Diet-Breadth model) and found there to be a general failure of the theory to predict the diets of predators engaging mobile prey. The failure of optimal diet theory was concluded to be the result of a predator-mobile prey relationship that was too complex and involved too many parameters. Their conclusion has relevant repercussions, as none of the authors' 134 studies included humans, who arguably exhibit an even greater diversity and complexity of subsistence behaviours. Sih and Christensen (2001) also emphasised that another major reason for the failure of optimal diet theory was the choice of currency used, a chronic criticism of optimal foraging models (Brightman, 2002; Kelly, 2007; Lupo, 2007; Winterhalder and Smith, 2000).

Within BE there has been a general tendency to construct models that use currencies based on energy only (Kelly, 2007; Lupo, 2007). The main argument against using energy as the sole measure of currency for optimal foraging models is that it largely ignores the social, political, historical and cultural context of the situated forager, and is therefore too simplistic (Brightman, 2002:339-340; Lupo, 2007:174-175; Gremillion, 2002). Brightman (2002:343) argues against etic-only suppositions of what is optimal and instead for a more nuanced, interactive view, that constructs "currency" not just as a Western measure of caloric content, but also takes into consideration the forager's conception of what makes a resource optimal and desirable. This approach allows for currencies to be more holistically constructed and, as Lupo (2007:174) posits, helps to situate the forager within a "state and context" that will elucidate a better understanding of their particular goals.

Another important issue discussed here is BE's applicability to archaeological contexts. Grayson and Delpech (1998:1119) highlight the crux of this issue:

> "In these applications (of foraging theory to archaeology), concepts that are meant to apply in ecological time must be translated to archaeological time, and variables that are readily measured when they can be observed directly must now be estimated from very different kinds of information."

Gremillion (2002:143-144) reinforces the previous statement by stressing how optimal foraging models were created, tested and refined on the basis of real-time ethnographic observations. The advantage of good ethnographic data is that it yields accurate information regarding the people and their social and political contexts; and the environmental and ecological variables of the habitats in which they forage. These data are, for the overwhelming majority of archaeological sites, impossible to acquire with the same degree of acuity. The lower the degree of resolution, the necessarily broader any resulting interpretations become, as the effects of time and space-averaging serve to hide variability and homogenise the archaeological record (Lupo, 2001; 2007; Lyman, 2003; see also Binford's (1980; 1982) discussion of the palimpsest effect).

Lack of acuity in the archaeological record also leads to questions of equifinality when trying to ascertain the behavioural context of a specific archaeological event. Binford (1982) for example, notes that the Nunamiut would often use the same campsite for different purposes, thus creating a palimpsest. This palimpsest, representing different behaviours, would obscure any attempts to use CPF models and as noted above would homogenise the assemblage, blurring changes in diet-breadth and patch-choice that may have had temporal, behavioural and cultural significance (see also Lyman (2003) for an excellent example).

BE and optimal foraging theory, like taphonomic theory, are founded on the genesis of a solid analogical framework, which is used to determine relationships between patterns in the archaeological record and the behavioural processes that produce them. Optimal foraging models are then subject to the same rigorous testing of their analogical frameworks as taphonomic models and therefore, following the criteria of Dominguez-Rodrigo (2008:70) mentioned above, their analogies must exhibit:

1. The ability to differentiate whether the analogy is case-specific or general.
2. With regard to case-specific analogies; a list of assumptions must be created from the data collected from the assemblage where the hypothesis testing will take place.
3. The experimental premises must be validly shown to match the set of assumptions associated with the construction of the hypothesis.

While the first criterion can be said to be met, the second appears to be largely dependent on the archaeological context. However, if consideration is given to the critique of energy as the sole currency in use, then the second criterion may be said to be lacking from archaeological applications of optimal foraging models

(Lupo, 2007; Brightman, 2002; Egeland and Byerly, 2005). The third criterion is largely unmet, as the experimental premises are often too simplistic or reductionist to be validly associated with the hypothesis (see above, Lupo, 2007; Winterhalder and Smith, 2000). With the absence of these criteria in the generation of referential frameworks for optimal foraging models, it is not unexpected that they lack a certain amount predictive power, as evinced by the discussion of Lupo's (2006) and Egeland and Byerly's (2005) studies above.

Despite these issues, optimal foraging models (specifically the Diet-Breadth and Patch-Choice models) have been used profitably within archaeological contexts (see Stiner and Munro 2002; Faith, 2007; 2008; Grayson and Delpech, 1998; 2003). The current issues with the construction of a referential framework for optimal foraging models best serve to highlight where future research needs to take place. Already these areas (such as delving further into the situated context of the forager and taking a more holistic view of currency) are being discussed within the literature and are figuring prominently in fresh research. These new studies offer much encouragement for future, more accurate applications of BE and optimal foraging models to the archaeological record (Winterhalder and Smith, 2000; Lupo, 2007; Bliege Bird and Smith, 2005).

Chapter 4 – The Iringa Sites and Setting

4.1 – *Introduction*

Recent surveys within the south-central Iringa region of Tanzania have yielded two sites that are the focus of the current study. These sites are Magubike and Mlambalasi and a description of both will be given below. This description will include where the sites are located; what the sites have produced; an overview of the region's culture history; and an overview of the past and present environmental settings. The purpose of this section is to provide a background to the sites and allow for the creation of a context within which the current research has taken place.

Magubike and Mlambalasi are both granitic rockshelters located within the Iringa region of Tanzania, which is in the eastern part of the African continent (see Figure 4.1). Both were first shown to Dr. Pamela Willoughby during a visit in 2005 and both were subsequently surveyed and test-excavated in July and August of 2006 (Willoughby, 2006; 2007; Biittner, *et al.*, 2006).

4.2 – *Magubike (HxJw-01)*

Magubike is a rockshelter complex located within the village of the same name (see Figure 4.2). It is positioned on the top of a butte at 7º45.790'S, 35º38.399'E, with an elevation of 1541m above sea level and has been designated the SASES (Standardised African Site Enumeration System) number HxJf-01 in accordance with the system developed by Nelson (1971).

Magubike consists of two main chambers that exhibit surface scatters of Iron Age materials (metal tools and ceramics) and possible Later Stone Age (LSA) lithics. During the 2006 field season, three 1m^2 test pits were excavated in 10cm arbitrary levels within the two main chambers. Test pit 1 was excavated in a side chamber to a depth of 180cm, where bedrock was reached. This test pit revealed a cultural sequence of Iron Age (0-50cm), LSA (50-70cm), possibly mixed LSA and MSA (70-100cm) and MSA (110-180cm) (see Figure 4.3). The determination of the cultural sequence for this test pit and all subsequent test pits was based on the lithic technology, following Mehlman (1989). There were no faunal remains recovered below 70cm, but there are distinct differences that can be noted between the LSA and MSA lithics. The LSA lithics are small white quartz, typical of the region, in contrast with the larger, more materially diverse array associated with the MSA, which includes volcanics, quartz and quartzite that are mostly lightly coloured (Biittner, *et al.*, 2006; Willoughby, 2006; Willoughby and Sipe, 2002).

Test pit 2 was excavated in the other chamber and produced a cultural sequence of Iron Age (0-50cm) and MSA (50-60cm), before the excavation had to be suspended due to the presence of a large rock. Test pit 3 was then initiated adjacent to test pit 2 and excavated to bedrock, producing a sequence of Iron Age (0-60cm) and MSA (60-210cm), with no intervening LSA levels (see Figure 4.4). Test pit 3 proved to be extremely rich with thousands of MSA lithic artefacts, a wealth of faunal material, shells, seven isolated fossil human teeth and a single shell bead (Biittner, *et al.*, 2006; Willoughby, 2006).

Recent excavations undertaken in October 2008 have produced a third sequence of Iron Age, LSA and MSA from a new test pit excavated below the modern rockshelter (Willoughby, pers. comm., April, 2009).

Of particular interest is the complete lack of an LSA in test pits 2 and 3, as well as the difference in raw materials found in the MSA levels between the two chambers. In contrast the most recent test pit, excavated in October 2008, displays a large LSA component. Test pit 1 comprises an MSA lithic component dominated by light–coloured materials, which contrasts with test pits 2 and 3, where the lithic materials consist of dark volcanic and siliceous rocks and possible metamorphic rocks (Biittner, *et al.*, 2006). Personal observations by the author and Katie Biittner (pers. comm, August 2008) indicated that the site, particularly test pit 1, appears to have been affected by an ephemeral stream. This ephemeral stream and possibly water percolating up through the sediment may be responsible for the significant amount of carbonate adherence observed on the MSA materials. Identifying the nature of the fluvial activity with regard to the site's formational history is a goal of future research.

4.3 – *Mlambalasi*

Mlambalasi is located approximately 50km west of the city of Iringa at 7º35.458'S, 35º30.142'E, with an elevation of approximately 1029m (see Figure 4.5). This site is particularly well known within the region as it is situated in a rockshelter above the burials monuments of the 19th century Wahehe Chief, Mkwawa and one of his servants. Mkwawa is noted throughout the region for his ultimately unsuccessful rebellion against the German colonialists (Willoughby, 2007). Mkwawa's burial place was acknowledged as an archaeological site by Dr. Willoughby and her research team in 2006 and designated the SASES number HwJf-01. The rockshelter at Mlambalasi has been designated the SASES number HwJf-02 (Biittner, *et al.*, 2006; Willoughby, 2006).

The Mlambalasi archaeological site (HwJf-02) consists of a rockshelter with two chambers situated at the top of a slope. Initial surface examination by Dr. P. Willoughby in 2005 revealed an extensive scatter of Iron Age and historical materials (including iron, slag, grindstones and ceramics), as well as LSA white quartz lithics and possible MSA lithics. In 2006, two 1m^2 test pits were excavated, one test pit in one of the rockshelter's two main chambers and the other on the slope in front of the rockshelter. Further surface collections were also undertaken (Biittner, *et al.*, 2006; Willoughby, 2006).

Test pit 1 was excavated in 5 or10cm arbitrary levels, due to the extremely fine-grained sediment (Willoughby, pers. comm., April 2009) and produced the following sequence: Iron Age (0-45cm) and LSA (45-120cm). The LSA levels were comprised of a microlithic (Holocene) LSA component, followed by a partial human burial, followed by a macrolithic LSA component. Test pit 1 had to be suspended at 120cm due to the presence of many large rocks (see Figure 4.6) (Biittner, *et al.*, 2006; Willoughby, 2006).

The human remains have undergone a preliminary analysis conducted by Elizabeth Sawchuk (2008), who was able to determine that they mostly belonged to a single individual. However, some juvenile bones were also recovered and future excavations will be focused on determining the extent and context of the human remains. The remains themselves have been indirectly dated, with radiocarbon dates from shells above the burial yielding an uncalibrated date of 12,940 ±90 BP (TO-13417) and shells below giving a date of 11,710 ± 90 BP (TO-13418) (Biittner, *et al.,* 2006). Katie Biittner (pers. comm., 2008) has discussed the possibility that these snails are active bioturbation agents, resulting in the mixing of levels and the reversed radiocarbon dates. The radiocarbon dates, however, fit with the lithic typology ascribed to these levels and are therefore considered to be a good estimate of the age of the burial. There are currently plans to continue excavations at Mlambalasi in 2010, to further explore the burial, or burials.

Test pit 2 was excavated in 10cm arbitrary levels on the top of the slope in front of the rockshelter proper. The following sequence was obtained: Iron Age (0-70cm), mixed LSA and Iron Age (70-110cm) and LSA transitioning to MSA (110-160cm). As this test pit was excavated on a slope, there are significant concerns about the stratigraphic context, especially below the Iron Age levels. Willoughby (2006:2) notes a lack of clear stratigraphic layers and Biittner (pers. comm., August 2008) identifies the presence of large snails and a termite mound as bioturbation agents. The slope also acts as a prime catchment area for wash-out from the rockshelter and slump accumulation with most of the upper level materials being affected. The MSA materials, however, appear to be largely intact (Gillieson, 1996; White, 1988; Biittner, *et al.*, 2006; Willoughby, 2006, pers. comm., April 2009).

4.4 – *A Brief Overview of the Culture History of Iringa*

In East Africa in general, and in Tanzania specifically, the Upper Pleistocene and Holocene periods have been divided into cultural units largely based on archaeological technocomplexes. This is in part due to the prevalence of lithic materials of different forms and styles within the archaeological record. Lithic materials have also been the predominant research focus for much of the southern and central Tanzanian archaeology, due to a relative paucity of fossil, faunal and other remains. This has lead to the construction of detailed typologies that have been used to create a relative cultural framework for East Africa, consisting of the Early Stone Age (represented in southern Tanzania by the Acheulian), MSA, LSA and Iron Age (see Table 4.1) (Mehlman, 1989; Willoughby, 1993; 2007; Willoughby and Sipe, 2002; Conroy, 2005).

The culture history of the Iringa region begins with the Acheulian, the second phase of the Early Stone Age. The Acheulian industry is characterised by large cutting and chopping tools, such as handaxes and cleavers and is first documented around 1.5mya at Olduvai Gorge and Peninj in northern Tanzania (Bower, 1977; Hublin, 2001). This industry is associated with both *Homo erectus* and *Homo heidelbegensis*, and is found in Africa, Europe and Asia.

In the Iringa region, the Acheulian is best represented at Isimila, an eroded gully located about 20km southwest of the city of Iringa (Willoughby, 2007:263-265). This site was excavated extensively during the late 1950's and has produced some breath-taking archaeological vistas, with its ubiquitous aggregates of Acheulian artefacts (Cole and Kleindienst, 1974; Hansen and Keller, 1971; Howell, 1961). The site of "Isimila 2" (HxJg-105) was found during the field season of 2008 and also contains a plethora of Acheulean, as well as possible MSA stone artefacts. Willoughby (2007:265) further notes the site of Mgongo on the outskirts of Iringa, which also contains Acheulian artefacts (Giichi, 1988).

The Acheulian transitions into the MSA between 300kya and 250kya, evinced by a change in lithic types and reduction strategies (Willoughby, 2007; Conroy, 2005). In the Acheulian, stone tools consisted mostly of a variety of large bifacial flakes, such as handaxes and cleavers (Hublin, 2001; Bower, 1977).

The MSA and later Acheulean (after 500kya) are, however, best represented by the use of prepared stone cores from which flake tools are produced (following Mehlman's (1989) typology). This is typically referred to as the Levallois reduction strategy and leads to standardised tools, such as points, flakes and blades. The Levallois strategy is associated in the MSA with scrapers, points and flakes that have been struck from radial or patterned platform cores and then retouched (Willoughby, 2001a; 2007). The presence of both retouched flakes and Levallois tools is what differentiates the MSA lithic industry from the Acheulean. The MSA is argued to have persisted until roughly 40kya and encompasses the temporal period when modern humans evolved.

Within Iringa there are few excavated MSA sites, which makes the excavation of Magubike and Mlambalasi both unique and pioneering, especially as they exhibit the first LSA and MSA faunal remains to be recovered in the Iringa region. In contrast, northern Tanzania exhibits numerous well-documented and excavated MSA sites, such as Lake Eyasi, Mumba-Höhle and Nasera in the Eyasi Basin (Mehlman, 1989; 1979; Mabulla, 2007; 1996).

Faunal remains are found from the Iron Age, LSA and MSA levels in several sites from the Eyasi Basin, with Mumba-Höhle having the best representation of MSA fauna. At Bed V in the Mumba sequence, dated to between 45 and 65kya, a diverse faunal assemblage is associated with a transitional MSA-LSA lithic industry. This bed also contains artefacts illustrative of symbolic behaviour, such as ochre and an object interpreted as a palette (Mabulla, 2007:17-20). As with the fauna in the current study that from the Eyasi Basin predominantly consists of bovids considered to be representative of modern species, with some extinct species also present. The faunal remains from the Eyasi Basin sites are also highly carbonate-affected, an effect that is ubiquitous within the faunal assemblages of Magubike and Mlamabalsi (Mehlman, 1989; 1979; Mabulla, 2007:21; 1996).

The Eyasi Basin sites, Mumba in particular, differ from the Magubike and Mlambalasi in demonstrating preserved plant remains (baobab) and several rockshelter images depicting hunting, as well as plant gathering and processing. Such complexity in the subsistence strategies of the MSA-LSA Eyasi Basin hunter-gatherers has led to comparisons with the modern Hadzabe or Hadza hunter-gatherers that currently inhabit the region (Mabulla, 2007).

Slightly to the south and west of the Iringa region is the region of Mbeya. Willoughby (1993; 1996; 2001a; Willoughby and Sipe, 2002) has documented numerous MSA, LSA and Iron Age sites within the Mbeya region, focused around the Songwe River Valley and Lake Rukwa Basin. The majority of the MSA sites are open-air accumulations found on river terraces. While no faunal analysis has yet been achieved at these sites, analysis of the MSA lithic component indicates heavy working and processing of the tools, as well as varied material use. The variability in lithic materials is suggestive of high-mobility strategies and/or exchange networks due to the absence of some of these materials within the immediate vicinity of the sites (Willoughby, 2001a; Willoughby and Sipe, 2002).

The LSA follows the MSA and is generally acknowledged to start around 40kya, but can range in appearance from 50kya to 20kya (Willoughby, 2007; Conroy, 2005). Technologically, the LSA is characterised by a predominance of microliths and blades, as well as geometrically backed tools, such as crescents, triangles and trapezes. These tools are generally struck from single direction, pyramidal, prismatic or bipolar cores (Willoughby, 2001a; 2007; Willoughby and Sipe, 2002; Conroy, 2005). The Pleistocene component of the LSA in southern Tanzania generally appears to be better characterised by a predominance of larger artefacts, as opposed to the Holocene portion of the LSA, which is better represented by microliths (Willoughby and Sipe, 2002; Willoughby, 2001a). This temporal shift also appears to be illustrated in the lithic assemblage from Enkapune Ya Muto in Kenya (Ambrose, 1998a).

As with the dearth of documented and excavated MSA sites in Iringa, there are also few recorded LSA sites. Again Magubike and Mlambalasi represent an important step in providing a more complete cultural history for this region. The lack of excavated LSA sites is not due to the scarcity of material, as surface scatters of typical white quartz LSA microliths are a frequent feature of the landscape. However, there are currently no archaeologists, apart from Dr. Willoughby and her students, who are actively engaging in active archaeological survey and excavation of Stone Age sites in this region. There are, however, several Tanzanian archaeologists currently studying the region's Iron Age and historic record.

There are many LSA sites recorded in other parts of Tanzania, with northern Tanzania again being comparatively well represented, especially by the archaeologically rich sites of Mumba-Höhle and Nasera Rockshelter (Mehlman, 1989; Mabulla, 2007; 1996) in the Eyasi Basin and the Naisiusiu Beds at Olduvai Gorge (Skinner, *et al.*, 2003). These sites all contain ostrich egg shell, LSA lithics and faunal materials, as well as indications of modern symbolic behaviour, such as rock art, ochre use and beads.

Willoughby's (1993; 2001a; Willoughby and Sipe, 2002) excavations in the Songwe River Valley and Lake Rukwa Basin again provide a number of comparable LSA sites in the southwestern region of Mbeya. The Mbeya LSA assemblages display a preference for white quartz microliths and less exotic materials, which is in contrast to the MSA lithic assemblages (Willoughby, 2001a; Willoughby and Sipe, 2002). This same pattern is indicated in the initial analysis of the Magubike and Mlambalasi sites, and although the Iringa sites contain more crypto-crystalline artefacts, these broad similarities could be taken to indicate wide-ranging cultural continuity during the course of the MSA and LSA within these areas of Tanzania (Biittner, *et al.*, 2006).

Within the Iringa region, as with the Mbeya region, the LSA appears to last up to approximately 3kya, when the area saw the arrival of Bantu-speaking Iron Age peoples. Therefore, unlike in northern Tanzania, there appears to be no indication of a Pastoral Neolithic in Iringa and Mbeya (Willoughby, 2001a; 2007). The onset of the Iron Age is indicated by the earliest presence of ceramics, grindstones and metal production (specifically iron slag and furnaces) and represents the arrival of Bantu-speaking farmers into this part of Tanzania. With regard to the faunal record, the Iron Age is associated with the introduction of domesticates, specifically domesticated cattle, sheep and goats (Kingdon, 1989; Robertshaw, 1990; Willoughby, 2001a; 2007; Marshall and Hildebrand, 2002).

The Iringa region displays numerous Iron Age artefacts found as surface scatters on farmer’s fields. As with the LSA sites, there has been a relative paucity of archaeological research in this area and therefore a lack of documented and recorded sites.

4.5 – *The Environmental Context of Iringa*

This section addresses both the present and past environmental contexts of the Iringa region where such information is available. It should be noted however, that the overwhelming majority of environmental information available discusses the broader sub-Saharan and East African contexts.

Discussion of the environmental context involves a description of the landscape, climate and faunal components in both the present and the past. Understanding the environmental context allows for the archaeology to be better interpreted and the behaviours of past peoples more accurately inferred. Therefore the importance of having at least a broad cognisance of any given site's environmental context can be considered an integral part of sound archaeological methodology (Schiffer, 1987).

The Iringa region is located in the southern highlands of the south central portion of Tanzania. Within this region, there are many farming villages in valleys interspersed between large, granitic outcrops, with sediments being cut through by rivers and streams. These granitic outcrops, or koppies, form particularly prominent landscape features on the sides of hills, as they appear to be the product of erosion, which leads to the formation of rockshelters. It is within these rockshelters that the majority of MSA and LSA sites are to be found (Willoughby, 2007; Biittner, *et al.*, 2006).

There are also a number of ephemeral streams, dried up stream beds and gullies from which artefacts of the Acheulean, MSA and LSA periods have been found. The site of Isimila, for example, is situated within an ephemeral, eroded stream bed context and contains deposits from all three cultural periods (Cole and Kleindienst, 1974; Hansen and Keller, 1971; Howell, 1961; Willoughby, 2007).

The current vegetation of this area can be characterised by Marean's (1990:131) description of dry montaine forest, consisting of lower woody trees interspersed with patches of savannah. The patches of savannah generally occur on the plains and have been exploited as farm land by the local population. Dry montaine forest however, tends to appear more on and around the hills that are prevalent within the Iringa region, where it is also described as *Brachystegia* or miombo woodland (Willoughby, pers. comm., March, 2009; Biittner, *et al.*, 2006).

Current climatic conditions of Iringa and East Africa can be thought of as largely resembling those of the Holocene in general. The Holocene commenced approximately 13kya with the end of the Last Glacial Maximum (LGM) and is referred to within the literature as Marine Isotope Stage (MIS) 1 (Pillans and Naish, 2004; Willoughby, 2007; Boggs, 2006). The initial, early Holocene period, represents an exception, as it exhibits conditions that were much wetter than today, evinced by the presence of vegetation in the Sahara during this time (Gasse, 2000).

Marean (1990:127) notes that the current East African rainfall regime appears to come in two distinct wet seasons, as opposed to the single rainfall peak exhibited in northern and southern Africa. In general, precipitation in sub-Saharan Africa is very seasonal, following the West African monsoon. The summer West African monsoon effect is partially moderated in East Africa by the presence of mountains producing a rainshadow effect, although this is augmented by the development of the summer Asian monsoon, which forms along the Somalian and Arabian coasts (deMenocal, 1995; Hamilton, 1982).

The timing of the rainy periods is based on the northward and southward movements of the Intertropical Convergence Zone (ITCZ), a low pressure zone that follows the sun across the equator. ITCZ migration results in a period of "short rains" in November associated with the southward movement and a period of "long rains" from March to May associated with the northward movement. June through October therefore lacks significant precipitation and is regarded as the dry season (Robertshaw, 1990:11; Marean, 1990; deMenocal, 1995; Scholz, *et al.*, 2007).

The current East African landscape is dominated by a wild faunal composition comprised of mostly ungulates (Kingdon, 1989). A broad description of the modern ungulate population can be found in Table 4.2. It is important to note that all of these ungulate groups are represented by one or more species within the East African context and that strong anatomical and morphological similarities are exhibited amongst each group. Carnivores and rodents are also present, including hyenas and lions, which are both important taphonomic agents (Brain, 1981; Blumenschine and Marean, 1993).

Of particular note is the diversity of bovids present in the East African landscape environment, as they encompass a large range of sizes and behaviours and are an important food source of both modern and past hunter-gatherers (Kingdon, 1989; Marean, 1990; O'Connell, *et al.*, 1988; Bartram, 1993).

Fortunately, their distinctive dental morphologies allows for identifications of tooth remains to be made at the tribe level (see Methodology below) (Gentry, 1978).

Marean and Gifford-Gonzalez (1991) note that the more northern part of East Africa, particularly the savannah regions of the Serengeti and Athi-Kapiti plains, is dominated by wildebeest and supplemented by zebra, topi, hartebeest, buffalo, eland and gazelles. This faunal community demonstrates the strong bovid component that is to be found within East African faunal communities in general. However, as these regions are quite far north of the Iringa region, they should not be viewed as an exact reflection of the specific Iringa faunal community.

Domesticated fauna were introduced into the Iringa area concomitant with the onset of the Iron Age and the expansion of Bantu farmers (Willoughby, 2001; 2007; Robertshaw, 1990; Kingdon, 1989). Domesticated fauna of particular relevance to this study include domesticated cattle and caprines. Domesticate cattle (*Bos taurus*) are prevalent within modern and historic farming communities and within Iron Age contexts. They are morphologically quite similar to African Buffalo (*Syncerus caffer*), especially with regard to their dentition. However, the relative size of their dentition can be used to distinguish between the two (see Methodology below) (Robertshaw, 1990).

The first domesticated caprines in the Iringa region are also associated with the onset of the Iron Age and the Bantu expansion (Robertshaw, 1990; Kingdon, 1989). Within the East African context, domesticated caprines include sheep (*Ovis aries*) and goats (*Capra hircus*) (Robertshaw, 1990; Kingdon, 1989). It has been well noted within the archaeological literature that sheep and goats are closely related and have extremely similar morphologies, making it difficult to distinguish between them (Reitz and Wing, 1999; Robertshaw, 1990). However, there has been a significant amount of research devoted to the study of caprine dental morphology, which facilitates both the identification of and discrimination between sheep and goats in zooarchaeological assemblages (see Methodology below) (Halstead, *et al.*, 2002; Prendergast, 2008; Payne, 1985).

The tribes and genera discussed here as constituting the present and Holocene faunal component of the Iringa region were also present during earlier temporal periods, with the important exception of domesticates. Domesticated cattle and caprines appear in the Iringa region only with the onset of the Iron Age, approximately 3kya, and thus provide a relative temporal indicator within the archaeological assemblages of Magubike and Mlambalasi. The presence of domesticates in association with LSA or MSA archaeological material can also be used to infer taphonomic processes that have resulted in stratigraphic mixing and disturbed contexts.

The discussion of Iringa's past climate will be based on the period of interest to this study. As mentioned above, archaeological materials from the MSA, LSA and Iron Age were recovered from Magubike and Mlambalasi, with no ESA or Acheulean artefacts being found. This limits the period of interest in Iringa's past environment to the onset of the MSA, which is roughly 250-300kya and focuses the discussion on the later Quaternary or Upper Pleistocene (Willoughby, 2007: Conroy, 2005; Pillans and Naish, 2004).

The Quaternary Epoch is generally acknowledged to begin roughly 2.6 million years ago (mya) and is defined by the initiation of the glacial-interglacial cycles that have come to dominate past and present environmental conditions (Pillans and Naish, 2004; Clague, 2005; Willoughby, 2007). Glacial-interglacial cycles are controlled by both orbital eccentricity and orbital obliquity (Milankovitch cycles); the former being the shift in the path of the earth's orbit around the sun, and the later being the shift in the tilt of the earth's axis. The earth's eccentricity cycles approximately every 100ky, while its obliquity cycles approximately every 41ky and precessional cycles occur every 19-23ky (Willoughby, 2007:68-69; Conroy, 2005:26-39).

Initially, from around 2.6mya to approximately 1mya, the glacial-interglacial cycles appear to have been dominated by the earth's 41ky orbital obliquity cycle. Following 1mya, the timing of the glacial-interglacial cycles seems to have become dominated by the earth's eccentricity, resulting in 100ky cycles. This later period also exhibits significantly increased glacial climatic extremes (deMenocal, 1995:53; Ruddiman, *et al.*, 1989; Willoughby, 2007; Conroy, 2005; McManus, 2004).

Current glacial-interglacial cycles are comprised of expansions and contractions of the glaciers at the earth's poles and result in an approximately 10ky period of warm temperatures and a 90ky period of much colder temperatures (deMenocal, 1995:53). Information regarding these cycles and general palaeoclimatic data are obtained predominantly from deep-sea ice cores and sediments, where the oxygen isotope ratios of O^{18} and O^{16} (indicated as δO^{18}) are compared. Higher values for δO^{18} in ocean sediments indicate colder, glacial conditions, while lower values for δO^{18} indicate warmer interglacials (deMenocal, 1995; Faure, 1998:309). Lacustrine or lake sediments have also proven to be valuable sources of palaeoclimatic data, generally providing shorter, more regionally specific information (Marean, 1990 and references therein for East Africa, Scholz, *et al.*, 2007; Conroy, 2005; Willoughby, 2007).

The cycling present in the δO^{18} has led to the creation of Marine Isotope Stages (MIS, formerly Oxygen Isotope Stages or OIS), which correlate with glacial and interglacial periods, as identified in both the marine record (based on sediments) and the ice cores from Greenland and Antarctica (Shackleton, 2000; Willoughby, 2007). Odd-numbered stages represent periods of warming, while even-numbered stages represent periods of cooling, with sub-stages represented by the addition of a letter. For example, MIS 5e has been identified as an extremely warm sub-stage of stage MIS 5, while MIS 5d is a cooler sub-stage within MIS 5. Table 4.3 describes all of the marine isotope stages and sub-stages, the broad climatic conditions and the associated cultures and hominids from the onset of the MSA to the present.

With the advent of marine isotope stages, some general comments can be made about East African climate and environment during the past 300ky. Glacial phases typically result in dryer, more arid conditions throughout the world and this is true of East Africa and the Iringa region. During arid phases, the Iringa region would have been cooler than it currently is today, with suggestions of a drop by about 7º Celsius in the average global temperatures during glacial phases and between 12-13º Celsius during the previous ice age (Johnsen, *et al.*, 1992; Conroy, 2005).

The East African landscape would have changed significantly concomitant with increased aridity and cooler temperatures. There would have been a transition from closed, wooded environments associated with warmer, wetter conditions, to open savannahs and dry grasslands that prevail in arid, cool settings. In contrast, interglacials would have produced environments and landscapes very similar to those that are currently present (see description above) (Marean, 1990:166-167).

Two periods in particular have been identified as having extremely significant impacts on the East African environment. The first, identified by Scholz and colleagues (2007) from lake cores, occurred between roughly 135kya and 75kya and consisted of "mega-droughts" or conditions of hyper-aridity (Itambi, *et al.*, 2009). The authors contend that this was the driest period in the early late Pleistocene and one of the most arid periods during the Quaternary. Their data indicates that after about 70kya, much wetter, more stable conditions were reached.

Carto and colleagues (2009) have drawn the same conclusions with their use of sophisticated paleoenvironmental simulations created with an Earth System Climate Model. Their data indicate that a Heinrich event (periodic iceberg surges into the North Atlantic) around 100kya produced drastic changes in the environments of North and East Africa, concurrent with significant increases in aridity (Heinrich, 1988). These researchers have linked this particular paleoenvironmental shift to the migration of modern humans out of Africa.

The other major climatic event severely impacting East African environments was the Last Glacial Maximum (LGM), which itself produced extremely arid conditions (Willoughby, 2007; Conory, 2005; Marean, 1990). During this phase, open savannah has been documented for much of East Africa, with a major decrease in woodlands and an expansion of desert. Some regions, such as Northern Africa, are suggested as being completely abandoned at this time, as well as several sites in South Africa, such as Blombos Cave and Pinnacle Point (Henshilwood, *et al.*, 2002; Marean, *et al.*, 2007; Willoughby, 2007:72).

Both these extremely arid phases would have had a significant impact on human behaviour, as people would have had to contend with less productive environments, increased resource competition and generally harsher conditions. Such severe conditions have been linked to the development of modern behaviour as a means for survival, as well as population bottlenecks and subsequent expansions and emigrations concurrent with the change to more hospitable environmental conditions (Willoughby, 2007; Conroy, 2005; Ambrose, 1998b; Henshilwood and Marean, 2003; Stringer, 2002; Marean, 1997).

The faunal record of East Africa since the onset of the MSA is somewhat stable. Changes in the faunal composition are indicative of changes in ecozones and biozones associated with the cycling of the glacial and interglacial periods (Marean, 1990; Marean and Gifford-Gonzalez, 1991; Marean, 1997). Marean

(1990; Marean and Gifford-Gonzalez, 1991) notes that the faunal components associated with both the open glacial grasslands and more closed interglacial environments display a plethora of bovids as well as some equids. The overwhelming majority of bovids can be found within the current East African environment, with the exception of several extinct species, three of which are particularly noteworthy.

Each of the three extinct species appears to have lasted until approximately 12kya, when the East African environment shifted from the predominantly open grasslands associated with the LGM, to the more closed dry montaine forest environment exhibited today. All three of the extinct species display traits and features that indicate they were adapted for open arid grasslands and savannah environments. Marean (1990:167-181) notes several of these features, such as highly hypsodontic teeth, large body size, and limb morphologies designed for movement within open environments. These three extinct species are the giant buffalo (*Pelovoris antiquus*), the giant hartebeest (*Megalotragus priscus*) and an impala-sized alcelaphine antelope; and each is common within the pre-Holocene levels of Marean's (1990) analysis of the fauna from Lukenya Hills, Kenya (Marean and Gifford-Gonzalez, 1991). Several extinct species of gazelle were also present during the LGM and these species are also described as being arid adapted (Marean, 1990:167-169).

The past environments of the Iringa region in particular, and East Africa in general, are best described as having "no modern analogue" (Marean, 1990; 1991; Hamilton, 1982; Willoughby, 2007:94). However, with the ability to gauge past climates from deep sea cores, lake sediments and ice cores, as well as the preserved pollen and faunal records, past environmental contexts can be inferred with some degree of accuracy. The above is a brief description of the pertinent environmental contexts for the East African MSA, LSA and Iron Age, with a particular focus on the Iringa region. As discussed at the outset, it is designed to give a background and provide a context for the current zooarchaeological study only.

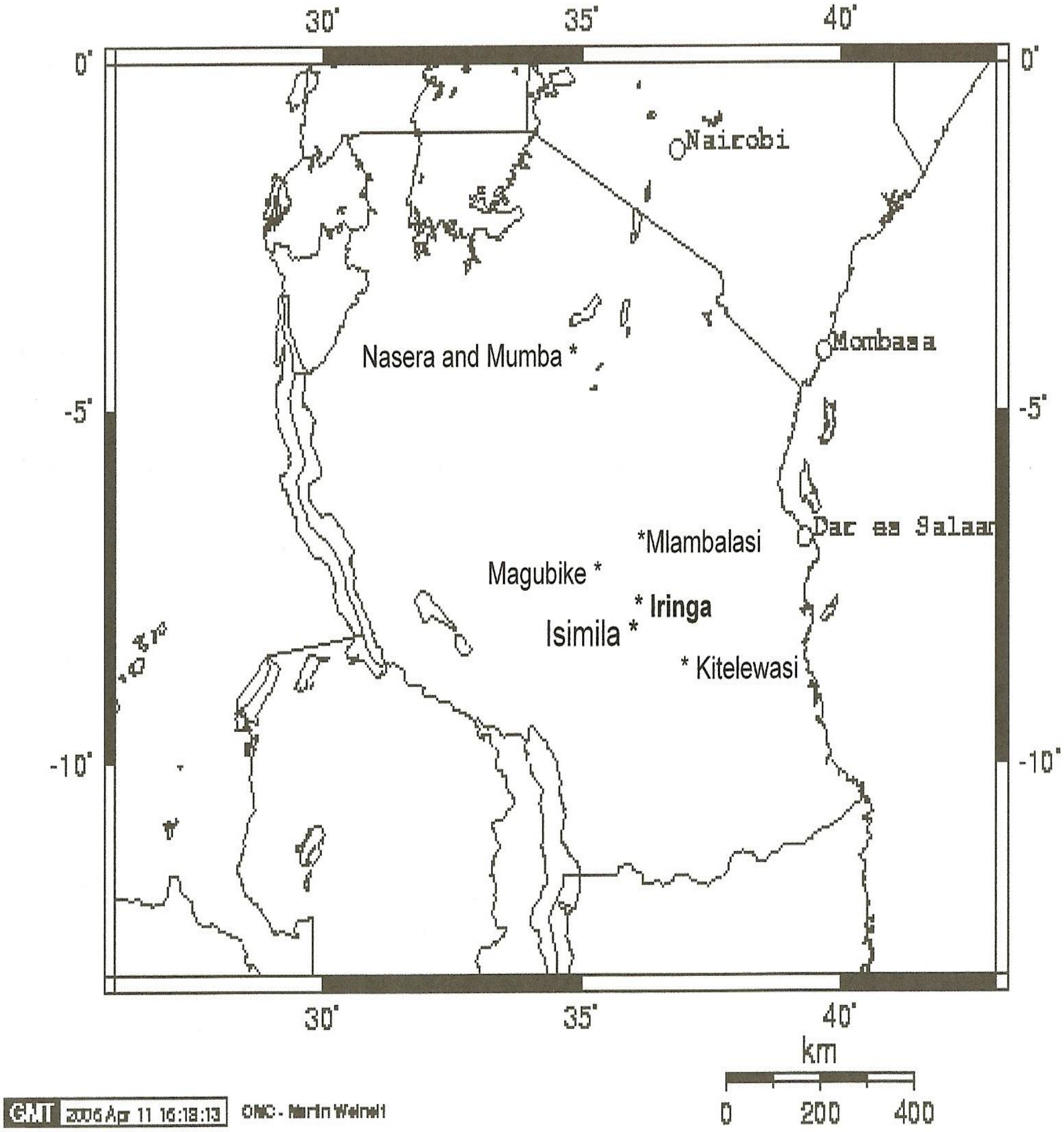
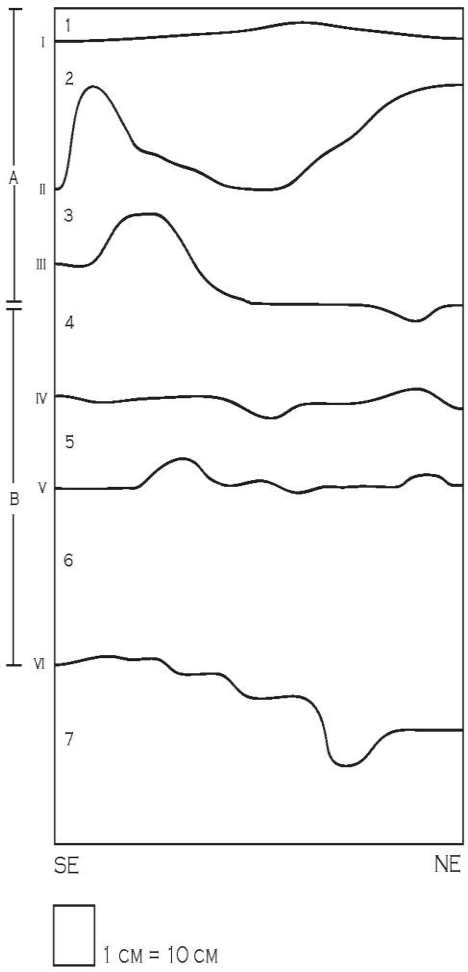


Figure 4.1 Map of Tanzania showing the locations of both sites (Biittner, *et al.*, 2006:63, Figure 1).

Figure 4.2 Photograph of Magubike rockshelter, taken by Dr. P. Willoughby.

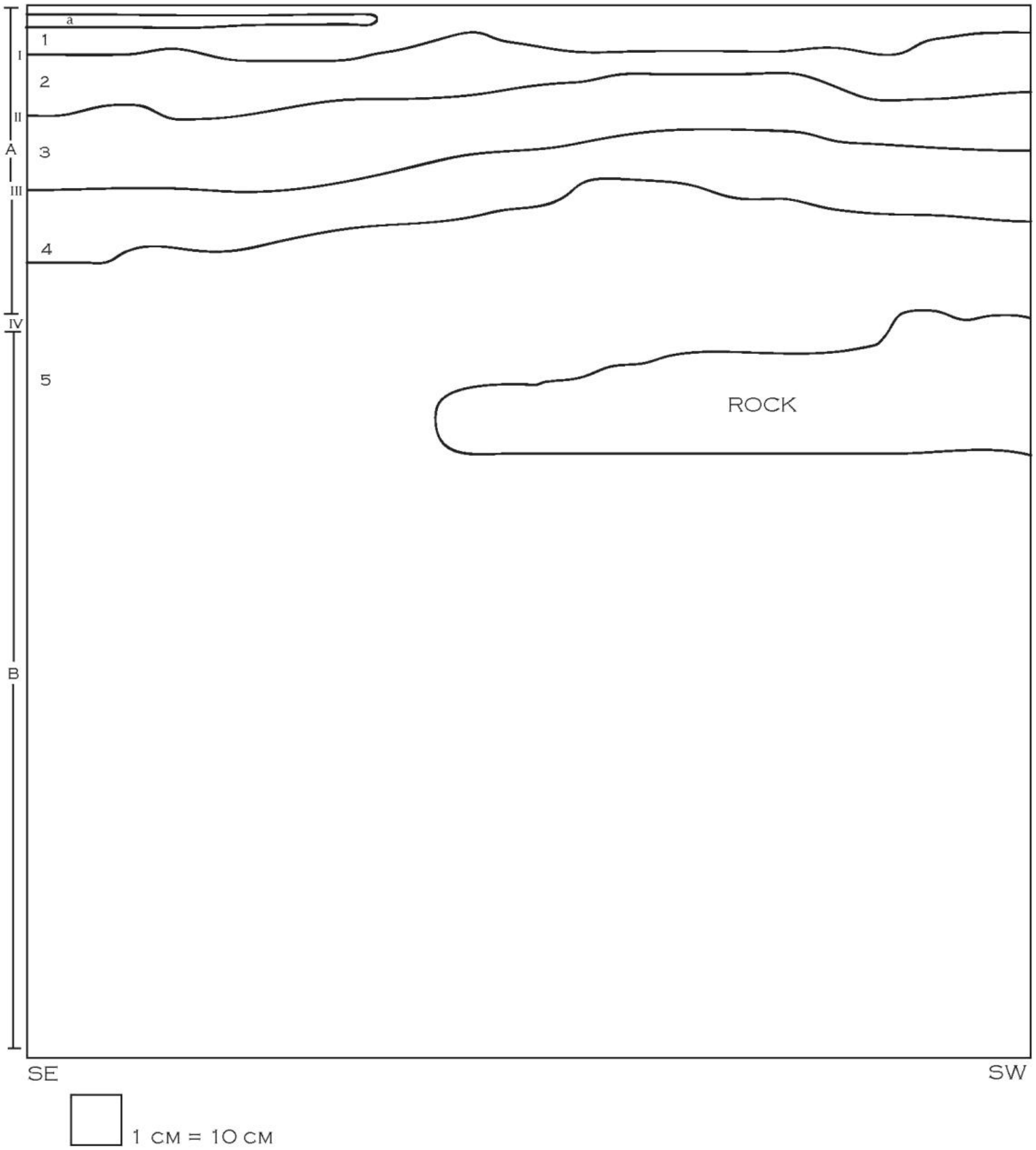
STRATIGRAPHIC PROFILE: MAGUBIKE (HXJF-01), TEST PIT #1, EAST WALL
16 AUGUST 2006

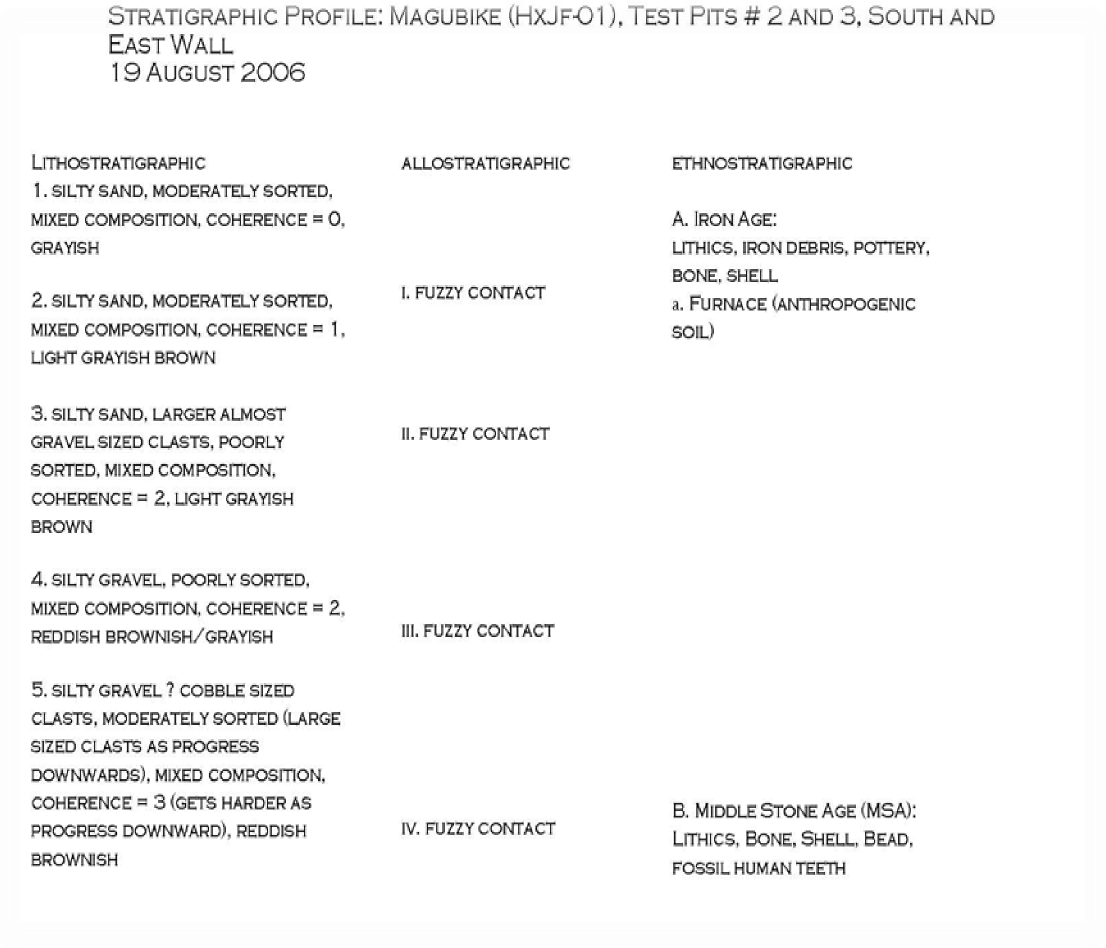


LITHOSTRATIGRAPHIC	ALLOSTRATIGRAPHIC	ETHNOSTRATIGRAPHIC
1. SILT AND SAND, MODERATELY SORTED, MIXED COMPOSITION, COHERENCE = 2, GREY	I. FUZZY CONTACT	A. IRON AGE: LITHICS, POTTERY, IRON SLAG, ASH, CHARCOAL, SHELL, BONE,
2. SILT AND SAND, (LESS SAND THAN 1), MODERATELY SORTED, MIXED COMPOSITION, COHERENCE = 1, DARKISH GREY	II. FUZZY CONTACT	
3. SILT AND SAND (GRITTY), MODERATELY SORTED, MIXED COMPOSITION, COHERENCE = 0, BROWNISH GREY	III. FUZZY CONTACT	
4. GRAVEL SIZED CLASTS WITH SILTY MATRIX, POORLY SORTED, MIXED COMPOSITION, COHERENCE = 1, REDDISH/ORANGE-ISH	IV. FUZZY CONTACT	
5. GRAVEL SIZED CLASTS WITH SILTY MATRIX, POORLY SORTED, MIXED COMPOSITION, COHERENCE = 1, DARK BROWN	V. FUZZY CONTACT	B. MIDDLE STONE AGE (MSA): LITHICS, BEADS, FAUNAL REMAINS
6. GRAVEL SIZED CLASTS WITH SILTY MATRIX (PREDOMINATELY GRAVEL), POORLY SORTED, MIXED COMPOSITION, COHERENCE = 1, REDDISH/ORANGE-ISH	VI. DISTINCT CONTACT	
7. BEDROCK		

Figure 4.3 Stratigraphic profile of Magubike, Test Pit 1. Drawn by Katie Biittner.

Stratigraphic Profile: Magubike (HxJf-01), Test Pits #2 & 3, South Wall
19 August 2006





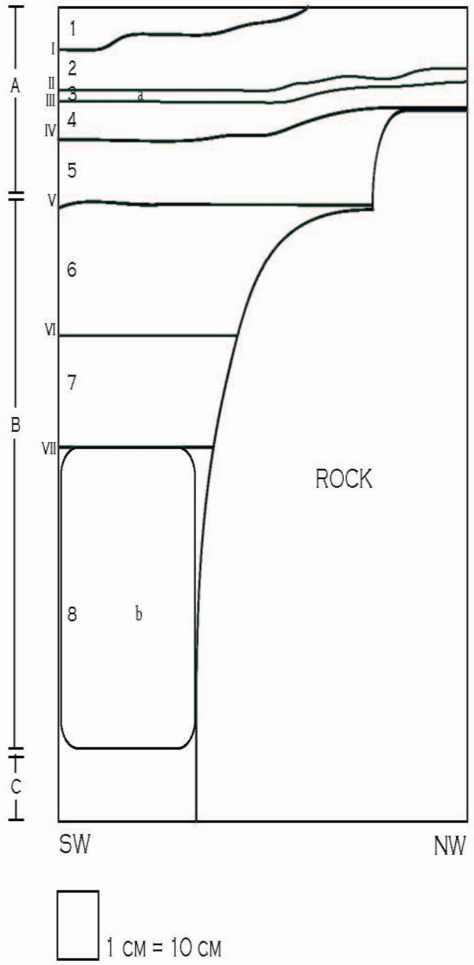
Stratigraphic Profile: Magubike (HxJf-01), Test Pits # 2 and 3, South and East Wall
19 August 2006

Lithostratigraphic	allostratigraphic	ethnostratigraphic
1. silty sand, moderately sorted, mixed composition, coherence = 0, grayish		A. Iron Age: lithics, iron debris, pottery, bone, shell a. Furnace (anthropogenic soil)
2. silty sand, moderately sorted, mixed composition, coherence = 1, light grayish brown	I. fuzzy contact	
3. silty sand, larger almost gravel sized clasts, poorly sorted, mixed composition, coherence = 2, light grayish brown	II. fuzzy contact	
4. silty gravel, poorly sorted, mixed composition, coherence = 2, reddish brownish/grayish	III. fuzzy contact	
5. silty gravel ? cobble sized clasts, moderately sorted (large sized clasts as progress downwards), mixed composition, coherence = 3 (gets harder as progress downward), reddish brownish	IV. fuzzy contact	B. Middle Stone Age (MSA): Lithics, Bone, Shell, Bead, fossil human teeth

Figure 4.4 Stratigraphic profile of Magubike, Test Pits 2 and 3. Drawn by Katie Biittner.

Figure 4.5 Photograph of Mlambalasi rockshelter, taken by Dr. P. Willoughby.

Stratigraphic Profile: Mlambalasi (HwJf-02), Test Pit #1, West Wall
08 August 2006



Lithostratigraphic

1. Silt and sand, poorly to moderately sorted, mixed composition, coherence = 2, dark brown

2. Silt and sand, ash and charcoal, mixed composition, poorly to moderately sorted, coherence = 2, black

3. Ash, coherence = 1, white

4. Silt and sand, moderately to well sorted, coherence = 2, pale orange

5. Coarse sand – silt, coherence = 2/3

6. Pebble – silt, coherence = 2

7. Cobble – silt

8. Boulder – cobble – silt

Allostratigraphic

I. Fuzzy contact

II. Sharp contact

III. Sharp contact

IV. Distinct contact

V. Fuzzy to distinct contact

VI. Fuzzy contact

VII. Fuzzy contact

Ethnostratigraphic

A. Iron Age:
Lithics, pottery, iron slag, ash, charcoal, shell, bone, beads
a. Ash layer (anthropogenic soil)

B. Late Stone Age (LSA):
Lithics, bone, shell,
b. Human remains, bead

C. Middle Stone Age (MSA):
Lithics

Figure 4.6 Stratigraphic profile of Mlambalasi, Test Pit 1. Drawn by Katie Biittner.

Table 4.1 The Palaeolithic Sequence, from Willoughby Table 3.1 (2007:14)

Palaeomagnetic Chrons and Subchrons	Geological Time Scale	Dates (In Years Before Present)	Archaeological Periods	Hominins
			Later Prehistory	
Bruhnes Normal Chron (C1n)	Holocene		Epipalaeolithic	
		10,000 BP		
	Upper Pleistocene		Upper Palaeolithic / Later Stone Age	*Homo sapiens* world wide
		30,000 to 40,000 BP		
		128,000 BP	Middle Palaeolithic / Middle Stone Age	*Homo sapiens* in Africa; *Homo neanderthalensis* in Europe
	Middle Pleistocene			
			Acheulian with Levallois flake tools	*Homo heidelbergensis*
Matuyama Reversed Chron (C1r)	Lower Pleistocene	780,000 BP		
Jaramillo Normal Subchron (C1r.1r)			Acheulian	*Homo ergaster*, *Homo erectus*
Matuyama Reversed Chron (C1r.1r)				
				Earliest *Homo* (*Homo habilis*, *Homo rudolfensis*)
Olduvai Normal Subchron (C2n)		1,600,000 BP	Oldowan	
		1,800,000 BP		
Matuyama Reversed Chron (C2r)	Pliocene			
Reunion Subchron (C2r.1n)				
Matuyama Reversed Chron (C2r.1r)		2,600,000 BP	Start of archaeological record	
Gauss Normal Chron (C2An.1n)				

Table 4.2 Description of the modern ungulate fauna found in East Africa (Kingdon, 1989).

East African Ungulates and Sub-Ungulates	
Taxa	**Common Names**
Procavidae	Hyraxes
Elephantidae	Elephants
Equidae	Horses, Zebras
Rhinocerotidae	Rhinoceroses
Hippopotamidae	Hippopotamuses
Suidae	Pigs and Warthogs
Giraffidae	Giraffes, Okapis
Bovini	Buffalo
Tragelophini	Sprial-horned bovines (eg. Eland, Kudu)
Cephalophini	Duikers
Neotragini	Dwarf antelopes (eg. Grysbok)
Madoqua	Dikdiks
Reduncini	Reduncines, Kobs
Antilopini	Gazelles
Alcelaphini	Alcephalines, Topis (eg. Hartebeest, Wildebeest, Impala)
Hippotragini	Horse-like antelopes (eg. Gemsbok, Orynx)
Caprini	Caprids (eg. Sheep and goats)

Table 4.3 Marine Isotope Stages (MIS) for the last 300,000 years, from Table 3.1 in Willoughby (2007:73-74)

Marine Isotope Stages and Sub-stages	Approximate Time Range (in years BP= before present)	Environmental context in Africa	Hominin origins and dispersals	Cultural Phases
1	13,000 BP to present	Holocene; warm conditions similar to present; sometimes wetter than present producing large lakes, such as Mega Chad		Epipalaeolithic, Mesolithic, and all later cultural periods
2	32,000 to 13,000 BP	Last glacial maximum (LGM); extremely cold and dry; expansion of Sahara and Kalahari deserts; loss of rainforest; vegetation zones compressed towards equator	Modern humans worldwide; last Neanderthals in Europe	Western Europe: Solutrean North Africa: no occupation? Sub-Saharan Africa: Middle/Later Stone Age transition in some localities?
3	64,000 to 32,000 BP	Interstadial; unstable climate that fluctuated on short time span; sea level about 70 m lower than present	Out of Africa II: modern humans enter Middle East, East and South Asia and Europe; displace (replace?) Neanderthals	European Middle/Upper Palaeolithic transition Sub-Saharan Africa: Middle/Later Stone Age transition?
4	75,000 to 64,000 BP	Stadial; intense cold; vegetation in Africa similar to LGM; expanded North African desert; sea level about 75 m below present level	Neanderthals in Middle East, modern humans in Africa	Middle Palaeolithic in North Africa/ Middle Stone Age in sub-Saharan Africa
5a	85,000 to 75,000 BP	warmer		Middle Palaeolithic/ Middle Stone Age

5b	95,000 to 85,000 BP	cooler		Middle Palaeolithic/ Middle Stone Age
5c	105,000 to 95,000 BP	warmer		Middle Palaeolithic/ Middle Stone Age
5d	116,000 to 105,000 BP	cooler		Middle Palaeolithic/ Middle Stone Age
5e	130,000 to 116,000 BP	Last interglacial = Riss/Wurm or Eemian Interglacial in Europe; rainforest expanded; rainfall higher in North Africa; African environments spread into Middle East	Modern humans (“Proto Cro-Magnons”) at Skhūl and Qafzeh in Israel	Middle Palaeolithic/ Middle Stone Age
6	195,000 to 130,000 BP	Glacial; drier than now; extended North African desert	For Foley and Lahr (1997), development of moderns in Africa, Neanderthals in Europe; other models already present in OIS 7	Middle Palaeolithic/ Middle Stone Age
7	251,000 to 195,000 BP	Temperate or cool	Foley and Lahr (1997): mode 3 expansion into Eurasia by *Homo helmei*; for others, time of first modern humans appearing in Africa, Neanderthals in Europe	Middle Palaeolithic/ Middle Stone Age
8	297,000 to 251,000 BP	Glacial	*Homo heidelbergensis* in Africa and Europe	End of the Acheulian; start of the Middle Palaeolithic/ Middle Stone Age

Chapter 5 – Materials and Methods

5.1 – *Introduction*

This chapter will consist of a comprehensive discussion of the materials that are the focus of this research and the methods by which they were studied. Where the materials come from and how they were acquired will be reviewed. In addition, the state of the materials, the methods used to analyse the materials, and how the materials were broken up into analytical units will be discussed. The aim of such a discussion is to provide not only the context for the analysis, but justification for the appropriateness of the methods employed.

The methodology section of this chapter will likewise provide a context for the kinds of analyses employed, by explicitly discussing the analytical methods incorporated and why they were chosen. Again, such transparency is argued to be necessary to demonstrate not only a sound methodological framework, but also to assist any future research that is conducted with this assemblage, as it allows both peers and future analysts to understand which methods where used and how they were incorporated.

5.2 – *Materials*

The materials section of this chapter will be divided into a description of the faunal remains that were excavated and those that were analysed. It should be noted that while the majority of the excavated and analysed materials are stone artefacts, the faunal component represents the first recovered LSA and MSA faunal remains from the Iringa region. This presents a unique opportunity for insight into the subsistence patterns of past peoples from Magubike and Mlambalasi and when combined with the lithic research, facilitates the potential for a comprehensive study of LSA and MSA hunter-gatherer lifeways (Bushozi, in prep.; Biittner, in prep., Alexander, in prep.; Biittner, *et al.*, 2006).

The current study is based on the materials collected during the 2006 field season, conducted by Dr. Pamela Willoughby and assisted by her two PhD students, Katie Biittner and Pastory Bushozi, as well as by her Tanzanian colleagues. Archaeological materials were collected from three sites; Mlambalasi (designated by the SASES number HwJf-2), Magubike (HxJf-1) and Kitelwasi (HxJh-1).

Surface collections were conducted at all three sites and faunal materials were recovered from each; however, test pitting was only undertaken at Mlambalasi and Magubike. Two 1m^2 test pits were excavated at Mlambalasi (Test Pit 1, TP1, and Test Pit 2, TP2), the first in 5-10cm arbitrary units, to a depth of 120cm, before being obstructed by large rocks. Test Pit 2 was excavated in 10cm arbitrary units to bedrock, reached at a depth of 160cm (see Figure 4.6 for the stratigraphic profile). Test Pit 2 is noted by Willoughby (2006; pers. comm., April, 2009) as displaying a highly disturbed context. Lithic and faunal remains were recovered from both test pits, and as mentioned above, the lithic component is much greater than the faunal component.

Unfortunately, the faunal component generally displays very poor surface preservation, especially in the materials that were recovered from the deeper levels. Carbonate-coating is ubiquitous in all levels, introducing difficulty into identifying diagnostic features and bone surface modifications. An additional complicating factor is the high degree of fragmentation exhibited in all levels, with the majority of specimens being less than 3cm in length. In addition, a large percentage of the recovered remains exhibit diagenetic breakage, indicative of post-burial attrition. Some of this breakage was clearly fresh and occurred recently, but the majority is not.

Magubike was excavated using three $1m^2$ test pits (Test Pit 1, TP1, Test Pit 2, TP2 and Test Pit 3, TP3), each in 10cm arbitrary levels. TP1 was excavated to bedrock, which was reached at a depth of 180cm. No faunal remains were recovered from TP1 after a depth of 70cm. TP2 was excavated to a depth of 60cm and included faunal remains. This test pit was concluded at 60cm due to a large rock, interpreted as roof fall (Willoughby, 2006). TP3 was excavated immediately next to TP2 and extended to bedrock, reached at 210cm (see Figures 4.3 and 4.4 for the stratigraphic profiles).

Magubike contains a greater number of identifiable specimens (NISP) than Mlambalasi (1168 as opposed 574) and can be generally described as better preserved. However, the faunal assemblage collected from Magubike is still less than optimal. As with Mlambalasi, the majority of the specimens from Magubike are less than 3cm and Magubike exhibits only a marginally lower percentage of poorly preserved specimens. The upper levels of Magubike are substantially less carbonate-affected than those at Mlambalasi, but once the MSA levels are reached, the percentage of carbonate affected specimens closely approaches that of the MSA for Mlambalasi. In addition, Magubike exhibits less diagenetic breakage than Mlambalasi, but substantially more green breakage. The author acknowledges, however, that some of this may be the result of insufficient experience to be able to accurately and consistently identify between green and diagenetic breakage.

Several decisions were made at the outset of this study as to what was going to be included within the analysis. It was decided that all surface collected faunal remains would be disregarded, as their context and provenance proved extremely difficult to interpret (is this specimen from the remains of someone’s barbecue from last week or has it eroded out of an LSA level, for example). Taking a conservative approach and excluding the surface collection from the present study was decided to be the most prudent and methodologically sound way to proceed. In turn, this eliminated Kitelwasi (HxJh-1) from the current study, as it was only subjected to a surface collection.

It was further decided that all of the faunal remains recovered from the test pits excavated at Mlambalasi and Magubike would comprise the faunal assemblage that constitutes the focus of this study. Shells were excluded, as the author does not have the background necessary with which to identify and analyse them.

Each site was then divided into three analytical units that corresponded to a particular cultural phase inferred from the lithic technology, following Mehlman (1989) (see Table 5.1). These units are roughly equivalent to the Historic and Iron Ages, LSA and MSA and it was hoped that a comparison between the cultural phases would be possible. One of the major issues with such a small sample size (total NISP of the entire faunal assemblage being 1736), is that one may lack the amount of data required to conduct nuanced statistical analyses that yield significant conclusions, especially when each site is divided into three analytical units, creating six analytical units altogether. However, there is no avoiding this issue at this point, and it should be noted that these are only test pits and future excavations will be more comprehensive and should hopefully generate an increased faunal assemblage.

Mlambalasi proved to be more complicated to divide into analytical units than Magubike, due to the mixing of lithic cultures found within some levels. Analytical Unit 1 from Mlambalasi (MB-A1) consists of the Iron Age only levels, 0-45cm in TP1 and 0-70cm in TP2. Analytical Unit 2 (MB-A2) consists of LSA only levels from TP1 (45-120cm) and mixed Iron Age and LSA levels from TP2 (70-120cm). Analytical Unit 3 (MB-A3) consists of the remaining levels from TP2 (120-160cm), which represent a combination of mixed MSA and LSA and MSA only artefacts. These analytical units were chosen in an attempt to both maximise sample sizes and maintain as much temporal control as possible. MB-A1 proved to be the richest unit with an NISP of 304, followed by MB-A2 with an NISP of 165 and MB-A3 with an NISP of 105.

Magubike was decidedly more straightforward to divide into analytical units, with the cultural boundaries proving to be much more distinct. Analytical Unit 1 from Magubike (MG-A1) consisted of the Iron Age from all three test pits (TP1: 0-50cm, TP2: 0-50cm, TP3: 0-60cm). Analytical Unit 2 (MG-A2) consisted of the LSA from TP1 only (50-70cm), as the LSA was absent in both TP2 and TP3. Analytical Unit 3 consisted of the MSA levels from TP2 and TP3 only (TP2: 50-60cm, TP3: 60-210cm), as there were no faunal remains associated with the MSA materials from TP1.

In contrast to Mlambalasi, MG-A3 proved to be the richest unit, with an NISP of 616, followed by MG-A1 with an NISP of 502. MG-A2 contains an NISP of only 46 specimens, which will introduce difficulties into the quantitative and statistical analyses, as it is clearly underrepresented in comparison with the all of the other analytical units (including those from Mlambalasi). That being said, both MG-A1 and MG-A3 are much larger than any single analytical unit from Mlambalasi and this will also restrict the complexity of any comparative statistical analyses that can be undertaken.

An important aside regarding carbonate coating should be made here. As mentioned above, carbonate-affected specimens are ubiquitous throughout the sample and although there are ways of removing the carbonate-coating (accomplished by the use of an acid bath, generally consisting of a weak solution of HCl), they were determined to not be applicable to this study. The use of an acid bath would have required a significant input of time to monitor the chemical process and remove the bones before the surface was damaged and the data wasted. Each bone fragment is unique and therefore requires a different amount of time, based on morphology, amount of carbonate coating and strength of acid. A test was performed using a weak solution of HCl and it was found that the length of time for the carbonate coating to be removed varied from five minutes to over thirty minutes. The conclusion was reached that such an investment of time would be better spent on analysing the sample in its current condition, as the possibility of gathering more data from such a highly fragmented assemblage was not considered to warrant the time investment that would be required.

5.3 – *Methodology*

The methodology section entails two parts, the first discusses the methods used in identifying and quantifying the faunal assemblage; and the second discusses the analytical procedures used to interpret the faunal assemblage. Both can be complex and unless clearly described, lead to confusion with regard to results and interpretations by one's peers. Therefore clear, detailed explanations of how a faunal assemblage has been identified and quantified are of the utmost importance and represent not only sound zooarchaeological method, but also sound academic method. Quantification includes both the measures used to quantify the faunal specimens themselves and the methodology used in discerning bone surface modifications, which provide crucial behavioural and taphonomic information. Explicit descriptions of analytical methods are necessary as well, as they can also be complex and subject to misinterpretation unless clearly enumerated (Lyman, 2008; Reitz and Wing, 2007; Dominguez-Rodrigo, *et al.*, 2007).

When presented with an unanalysed faunal assemblage, the first step undertaken is the identification of as much of the assemblage as possible. This step distinguishes the Number of Specimens (NSP) from the Number of

Identifiable Specimens (NISP) within a sample. Quantification or counts of NISP represent a fundamental zooarchaeological unit and primary data, from which many secondary quantification units are derived (Lyman, 2008:27-38; Reitz and Wing, 1999:191-194). NISP is determined by the ability of the analyst to identify a faunal specimen to element and taxon, generally with reference to a comparative faunal collection that contains skeletons of known species and is, ideally, representative of the fauna that are to be found within the assemblage.

The current study focused on identification to element and where warranted, to taxonomic distinctions beyond size level categories instituted by Bunn (1982) (see Table 5.2). The later proved to be especially difficult due to fragmentary nature of the faunal assemblage and the morphological similarities exhibited between African bovids. However, the analyst benefited from the use of the African mammal collection at Harvard University's Museum of Comparative Zoology for all units analysed, except for MG-A1. MG-A1 was analysed at the Universidad Complutense, where the author benefitted from the guidance of Dr. Manuel Dominguez-Rodrigo. The author also made use of the general taxonomic descriptions offered in Walker's (1985) monograph detailing the general morphology of African animal skeletons.

Attempting to identify the taxa present within the assemblage proved to be exceedingly difficult and therefore each specimen was assigned to a size class, following Bunn (1982) (see Table 5.2). Size classes 1 and 2 were lumped together, as were size classes 3 and 4, in order to provide a general dichotomy between small and large mammals and to produce data that could be manipulated in a statistically meaningful way (following Blumenschine, 1995:30; Dominguez-Rodrigo, *et al.*, 2007:76, Dominguez-Rodrigo, n.d.).

More specific taxonomic identifications were accomplished by analysing the dental remains, particularly molars and premolars. The identification was largely based on Gentry's (1978:544) morphological descriptions, which facilitate bovid identification to the tribe level and below. These identifications were made with the assistance of Dr. Dominguez-Rodrigo. Distinctions between domesticated cattle (*Bos taurus*) and African Buffalo (*Syncerus caffer*) were based upon the molar tooth measurement criteria outlined by Robertshaw (1990:248).

Identification of the specific domesticated caprines present in the sample followed the suggestion by Prendergast (2008:98-100) in focusing on the use of the criteria outlined in Halstead and colleagues (2002). Their criteria offer the most comprehensive methodology for distinguishing sheep from goats, based on differences in molar and premolar morphologies. These differences focus on the angle and shape of the tooth cusp and the occlusal surface.

The current study follows recent work that examines and interprets limb shaft fragment specimens. Using the criteria outlined in Barba and Dominguez-Rodrigo (2005), many limb shaft fragments were identifiable to long bone element. Those that were not able to be so specifically identified were maintained within the analysed sample and identified to the broader category of limb shaft. This approach was used because an overwhelming amount of literature has supported the diagnostic utility of limb shafts in preserving bone surface modifications produced by both human and non-human actors (Bunn and Kroll, 1986; Blumenschine, 1988; 1995; Marean and Assefa, 1999; Marean, *et al*., 2004; Dominguez-Rodrigo, *et al.*, 2007 and references above). Limb shafts not attributable to a specific element were retained for this purposed and then disregarded from the calculation of subsequent quantification units (such as Minimum Number of Elements, MNE, and Minimum Number of Individuals, MNI). This was done as indeterminate limb shafts do not display the morphological information necessary with which to reliably calculate these units.

The Minimum Number of Elements (MNE) is a derived measure, given by the number of redundant, or anatomically overlapping, skeletal parts for a specific skeletal element (Lyman, 2008:214). MNEs for this study were calculated by following the criteria noted above, with the analyst searching for anatomically overlapping portions amongst the entire set of elements from a particular analytical unit (the comparative method) (Bunn, 1982; Dominguez-Rodrigo, *et al*., 2007; Dominguez-Rodrigo and Yravedra, 2009; Dominguez-Rodrigo, nd). Unfortunately, due to the high degree of fragmentation of the assemblage, siding, ageing and sexing of elements was not possible and therefore the MNE estimates are for the element in general. This produces a coarser and more conservative MNE value, as the finer characteristics of the element cannot be distinguished from one another.

MNEs were calculated with inclusion of limb shafts identifiable to element, as there is a significant and persistent body of literature that supports this practice (see above) (Marean, *et al.*, 2004; Dominguez-Rodrigo and Yravedra, 2009; Marean and Frey, 1997; Bunn and Kroll, 1986). As discussed above, the sole use of epiphyses in the calculation of MNEs will bias the sample, especially against limb bones. Limb bone shafts are more resistant to carnivore-ravaging and density-mediated attrition than limb epiphyses and therefore exhibit higher survival rates in zooarchaeological assemblages (Marean, *et al.*, 2004; Marean and Assefa, 1999; Marean and Spencer, 1991; Pickering, *et al.*, 2003). Due to the strength of the "Shaft Critique" and the generally high rates of attrition demonstrated in this faunal assemblage, the inclusion of identifiable limb shafts is warranted over other approaches.

MNE is an important zooarchaeological measure, as it provides the basis for two other quantitative measures used within this study: Minimum Number of Individuals (MNI) and Minimum Animal Units (MAU). MNI counts represent the minimum number of individuals required to account for all of the elements present within a particular analytical unit (Lyman, 2008:38-41). In order to estimate MNI, one uses the value of the largest MNE estimation for a particular taxon. For this study, as taxa could not be identified, MNE estimates are based on size classes and therefore, so are MNI estimates. The specificity of the MNE estimate influences the MNI estimate, with greater specificity in MNE estimates (such as siding, ageing and sexing) accounting for higher MNI values (Lyman, 2008). As mentioned above, MNE estimates for this study are necessarily coarse and therefore yield conservative estimates of MNIs.

MAU is another derived value that is calculated by dividing the MNE value for a specific element by the number of elements that are to be found within a complete skeleton (Binford, 1978; 1981; Lyman, 2008). These values are typically standardised against the largest value and multiplied by 100 to give a %MAU. Normalising the values in this way allows for the graphical comparisons of MNE values that come from different sample sizes. As with MNEs, MAUs were derived using a conservative approach that did not take side, sex or age into account. MAU is a useful measure, as it was designed not to observe the individual frequencies of elements within an assemblage (such as NISP, MNE and MNI), but to compare the frequencies of different elements within the assemblage (Binford, 1978; Lyman, 2008).

NISP, MNE, MNI and MAU represent the quantitative measures that provide the basis of the subsequent analysis of this zooarchaeological assemblage. Each measure and the general identification procedure has been explicitly defined and thus should provide a firm framework against which the analysis can be conducted. Before moving on to discussing the analytical procedures that were undertaken, a discussion detailing the methodology involved in identifying bone surface modifications must take place.

Bone surface modifications include both human-effected and non-human-effected traces (see above). For the purposes of this study, both types of traces were analysed and these include cut marks (CM), percussion marks (PM), tooth marks (TM), trampling marks, biochemical marks and weathering. Before discussing the criteria that were used to assess and determine the presence of bone surface modifications, the methodology used for examining bone surfaces shall be made explicit.

All identifiable faunal specimens were observed using a 16X hand lens under strong light. This follows the criteria laid out by Bunn (1982:45-47) and is contrary to Potts and Shipman's (1981) assertion that a scanning electron microscope (SEM) is necessary for the correct identification of bone surface modifications. Several decades of research supports Bunn's (1982) initial assertions that SEM analysis does not significantly increase the number of bone surface modifications identified (see particularly Blumenschine and colleagues, 1996; Bunn and Kroll, 1986; Blumenschine, 1995; Dominguez-Rodrigo, *et al.*, 2007:25-26). The disadvantages of using a SEM include expense, restricted access and its time-consuming nature (Bunn, 1982; Blumenschine, 1995). Based on these constraints and with only slightly more accuracy being achieved, the author feels justified in using the hand lens method over the SEM method, as is prescribed in the majority of the recent literature (Blumenschine and Marean, 1993; Blumenschine, 1996; Dominguez-Rodrigo, *et al.*, 2007; Dominguez-Rodrigo, n.d.; Blumenschine, 1995; Pickering, *et al.*, 2006; Galan, *et al.*, 2009).

It should also be noted that the author had no significant practical experience in identifying bone surface modifications before undertaking this research. However, the author was given a period of intensive instruction by Dr. Dominguez-Rodrigo at the Universidad Complutense, in Madrid, Spain, over a period of approximately one month. This allowed the author to gain a satisfactory level of experience in the identification of the different kinds of bone surface modifications present within this faunal assemblage. MG-A1 was analysed under the guidance of Dr. Dominguez-Rodrigo, while the rest of the assemblage was analysed by the author alone. Experience is a crucial factor in being able to correctly identify and assign bone surface modifications. Although the author is still a relative novice within this area, Blumenschine and colleagues' (1996) study of training novices in the identification of bone surface modifications can be used to support that a suitable level of expertise has been acquired for the current study.

Cut marks were identified according to the criteria outlined by Potts and Shipman (1981:577). The authors describe cut marks as being, "elongated grooves with V-shaped cross-sections (and) many, fine parallel striations ... within each main groove". The key to identifying a cut mark as opposed to a tooth or trampling mark is the presence of microstriations within the groove and the more V-shaped groove itself (Bunn, 1982; Bunn and Kroll, 1986). Shoulder-effects, caused by the unevenness of the stone blade, when present are also an indicative of CM (Fisher, 1995:16).

Carnivore gnawing and sediment abrasion have also been shown to leave microstriations, but this is a rare feature and, particularly with carnivore gnawing, the microstriations appear to be generally conspicuous only at the SEM level (Fisher, 1995; Potts and Shipman, 1981; Blumenschine, 1995). Therefore the criteria discussed above yields a reliable indicator of what constitutes and can be correctly considered a CM. A conservative approach was taken and any marks that could not be confidently identified as CM were disregarded.

Percussion marks were identified according to the criteria outlined by Blumenschine and Selvaggio (1988), Blumenschine (1995) and Pickering and Egeland (2006). The authors are all in agreement that PM are comprised of pits, grooves and striae, which may or may not be associated with notches. Microstriation patches are generally to be found within or close to the pits or grooves, or alternatively, may be found in lieu of a pit or groove. These kinds of microstriations are densely packed and parallel, as opposed to microstriations produced by carnivore gnawing or other actors (Blumenschine and Selvaggio, 1988; Blumenschine, 1995). Microstriations are the key to correctly ascribing isolated pits as either PM or TM.

A recent publication by Galan and colleagues (2009) has demonstrated that PM are much more variable than previously thought. Their study used both modified and non-modified hammerstones to produce PM and found there to be considerable differences between the two, especially with regard to pit size, shape and conspicuousness. Modified hammerstones were found to produce greater numbers of pits associated with microstriations and pits that consisted of irregular shapes, while non-modified hammerstones produced a greater frequency of isolated pits without microstriations (and which are more inconspicuous, resembling TM) (Galan, *et al.*, 2009:782). Unfortunately these results have not been incorporated into the current study, but will be instituted during future faunal analyses.

This section shall discuss carnivore-effected tooth marks (TM), biochemical marks, trampling marks and weathering. These bone surface modifications all constitute important information regarding the taphonomy of the faunal assemblage in particular and the site in general.

Tooth marks have been most thoroughly described by Binford (1981:44-49), who notes four different types: punctures, furrows, pits and scores. Punctures are described by Binford (1981:44) as representing the imprint of a tooth or teeth that have collapsed part of the bone. Furrows are more linear and are generally associated with the epiphyses, as the carnivore attempts to access the cancellous bone (Blumenschine and Marean, 1993). Pits are considered as bowl-shaped or angular indentations resultant of static loading from the carnivore’s tooth on the surface of the bone. Scoring is represented by grooves that are u-shaped and typically lack microstriations (Binford, 1981:44; Blumenschine, 1995:29). Pits and scores are noted by Blumenschine (1995:29) as being the most ubiquitous kinds of TM.

Tooth pit size can be an important indicator of the carnivore agent involved in effecting the TM (Dominguez-Rodrigo and Piqueras, 2003). However, for this particular study, tooth pit size, while measured, was not analysed, as there were too few TM for a relevant analysis to be conducted.

Binford (1981:49-50) was also prominent in discussing the presence of biochemical marks, particularly those caused by root-etching. Some biochemical marks have been speciously illustrated as being examples of elaborate human-effected art, as opposed to the more accurate observation that they are resultant of biochemical interactions between plant roots and bone surface (Binford, 1981:49-50). Biochemical marks are not always so distinctive however, as demonstrated by Dominguez-Rodrigo and Barba (2006). The authors note that biochemical marks are created by the fungal and bacterial colonies forming on the bone’s surface and that these colonies can leave marks that are reminiscent of TM. Biochemical marks can be distinguished from TM by their variable width and variable patterns of bone exfoliation (Dominguez-Rodrigo and Barba, 2006:178; Dominguez-Rodrigo, *et al.*, 2007).

The identification of biochemical marks was undertaken in this analysis, as their presence denotes an important taphonomic variable (Dominguez-Rodrigo and Barba, 2006). Not only do biochemical marks yield information about the burial history and environment from which the faunal assemblage was collected, but they also provide a confounding factor in determining TM and other bone surface modifications. Even if TM and other bone surface modifications are confused with biochemical marks, the acknowledgment that biochemical marks are present within the assemblage allows for this possibility to be taken into consideration, especially for future research.

Trampling marks are marks that have been made during the biostratinomic phase of the faunal assemblage's history and therefore give some indication of the pre-burial and possibly burial environments (Lyman, 1994). Trampling marks are caused when bones on the ground are walked on or disturbed in such a way as to come into forceful contact with abrasive sediment. The grains in the sediment then leave marks on the bone's surface. These marks are typically either broad v-shaped or u-shaped, lack microstriations, come individually or in groups and are generally orientated in a random fashion (Behrensmeyer, *et al.*, 1986; Andrews and Cook, 1985). They are most frequently confused with CM because of their v-shaped cross-section, but can be distinguished by their lack of microstriations and curved trajectories (the latter when present) (Behrensmeyer, *et al.*, 1986; Dominguez-Rodrigo, *et al.*, 2007).

Weathering was identified following the criteria laid out in Behrensmeyer's (1978) 5-stage system. However, due to the ubiquity of carbonate-coated specimens and other taphonomic factors, weathering was not found to be significant within this faunal assemblage. The lack of weathered bone may lead one to infer that the burial environment was fairly protected (as most cave and rockshelter environments tend to be), that burial took place rapidly or that there was a combination of both a protected burial environment and rapid burial (Behrensmeyer, 1978; Gilleson, 1996).

Bone breakage patterns are another important bone modification and bear some consideration. Fracture patterns are particularly important in determining whether the bone was green (recent occurrence of breakage) or dry (diagenetic occurrence of breakage) when the break took place (Villa and Mahieu, 1991; Brain, 1981). Several of the five criteria outlined by Villa and Mahieu (1991) were used in determining whether a break was green or diagenetic, these were the fracture outline and fracture angle. The other criteria could not be meaningfully applied to this assemblage, due to the poor preservational nature of the faunal specimens.

Shaft circumference measurements were also noted for all of the limb shaft specimens. Following Bunn (1982), shaft circumference of a particular specimen was assigned a value of 1 (less than half complete), 2 (more than half complete) or 3 (complete). The ratio of shafts with scores of 1 to shafts with scores of 2 and 3 is then calculated and can be used to generate useful information regarding carnivore and human involvement, as well as analyst bias (Marean, *et al.*, 2004; Dominguez-Rodrigo, *et al.*, 2007; Bunn, 1982).

In concluding this section, it should be noted that many of these bone surface modifications are best identified within a configurational context (Fisher, 1995). That is, all pertinent information should be taken into account when analysing bone surface modifications, such as the anatomical placement, how this placement is related to known human and non-human behaviours, the number and direction of bone surface modifications, and the taphonomic and burial contexts (was the assemblage subjected to carnivore ravaging, was it buried in a rocky sediment). Through instituting a configurational approach, one is able to fit the bone surface modifications into an interpretative context that allows for greater inferential depth and accuracy. This in turn allows for a better understanding of the taphonomic and behavioural contexts within which the faunal assemblage was formed (Fisher, 1995; Brain, 1981; Blumenschine and Marean, 1993; Blumenschine, 1995; Dominguez-Rodrigo, *et al.*, 2007).

Each analytical procedure will be further discussed in this section, in order to ensure that the analytical methodology used for this study can be easily followed. For the most part, the nature of the assemblages dictates an approach that is more qualitative than quantitative. In dealing with exploratory research, this is often the case, as both sample sizes and excavated areas are small.

The mixing of cultural phases within the Mlambalasi assemblage precluded a comprehensive comparison between the different analytical units, as well as between the two sites in general. Magubike also provokes issues when attempting to compare the different analytical units. Primarily, the LSA unit is composed of only two excavation levels, with a combined NISP of 46, compared with NISPs of 502 for the Iron Age levels and 616 for the MSA levels. This large discrepancy greatly impedes any quantitative comparative analysis and a solution is beyond the scope of the current study.

The present study incorporated three broad analytical measures: analysis of skeletal element abundances; analysis of bone surface modification; and the analysis of fracture patterns and fragmentation within the assemblage. Each will be discussed in turn.

Skeletal element abundance was quantified using a comprehensive MNE approach that incorporated both shafts and epiphyses, as mentioned above. These data were analysed first by examining the standardised proportions of MNE (%MNE) for small (Size 1 and 2) and large (Size 3 and 4) size animals from each analytical unit. These proportions were calculated by multiplying the number of elements found within a carcass by the MNI for the analytical unit, giving a maximum MNE estimate. The calculated MNE was then divided by the maximum MNE estimate for each element, giving a percentage indicating each element’s respective representation within the assemblage. This method of analysis follows Dominguez-Rodrigo and colleagues (2007:131-133; Dominguez-Rodrigo, n.d.) and emphasises any variation within skeletal element representation.

Subsequently, in order to further examine the skeletal element representation, %MAU values for selected elements were plotted against their corresponding %FUI values (also referred to as SFUI, as it is a Standardised Food Utility Index). Plots of %MAU against SFUI were conducted for both the small and large size animals for all analytical units. For this study, SFUI was calculated based on Metcalfe and Jones' (1988:498) whole element values, with the FUI values for vertebrae being a weighted average for the three specific types of vertebrae discussed in their article (cervical, thoracic and lumbar). A weighted average was used, as the majority of vertebrae within the assemblage could only be identified to a miscellaneous vertebrae category and not to a specific vertebral element.

The SFUI was calculated based on all elements that had been analysed to provide MNE estimates and hence excludes phalanges, tarsals and carpals. Therefore, the FUI for the femur, being the highest ranked element within this analytical context, was used to standardise the rest of the values.

Two statistical measures were instituted in order to examine the plots of %MAU versus SFUI. Firstly, as the data is rank-ordered, Spearman's rho was used to assess if there was any relationship between the variation in the two data sets. Peason's r was also used to determine whether a linear correlation was present and the co-efficient of determination (r^2) was determined to identify the degree to which the two variables vary in accordance with one another. Pearson's r was not originally intended to be used for ordinal-scale data; however it is an extremely robust measure. Following the conventions outlined in Dominguez-

Rodrigo (n.d.) and in a range of other statistically-orientated literature, Pearson's r has been demonstrated to provide useful insight for exploring trends in ordinal-scale data and is therefore incorporated into this study (O'Brien, 1979; Bollen and Barb, 1981). For all statistical measures, p-values were considered significant if they were calculated to be less than or equal to 0.05.

Both statistical measures offer important insight into interpreting the assemblage, with no significant relationship often signalling that there are taphonomic (likely density-mediated destruction) issues. When significant relationships are found, they can be interpreted according to the archaeological literature and proffer insight into carnivore-ravaging; and human butchery and transport decisions, especially when used in conjunction with Central-Place Foraging models (Dominguez-Rodrigo, *et al.*, 2007; Marean, *et al.*, 2004; Lyman, 1994; Lam and Pearson, 2005; Faith and Gordon, 2007).

Due to the complicated taphonomic nature of the two sites, %MAU was plotted against bone density (also described as Volume Density or VD, following Lam and colleagues (1999)) for a selection of elements. This selection was based on the bone density values available and by the analytical insight offered by the assemblage itself and consisted of the humerus, radius, ulna, metacarpals, femur, tibia, metatarsals, scapula and ribs. Bone density values were taken from Lam and colleagues (1999) BMD_2 data for four adult wildebeest (*Connachaetes taurinus*).

The measurements by Lam and colleagues (1999) were preferred, as they use computed tomography as opposed to photon densitometry methods, with the former having a greater demonstrated accuracy for estimating bone density values by taking both the internal and external shape into consideration (Lam, *et al*, 1998; 1999; Lam and Pearson, 2005). Lam and colleagues (1999) BMD_2 measurements were used; as they took into account the presence of internal cavities within specific bones (particularly limb bones) and thus do not artificially deflate density values. This contrasts with BMD_1 and photon densitometry measurements that do not take internal cavities into account. Only the midshaft value was used for long bones, as the overwhelming majority of long bones present within the assemblage are from the midshaft portion. The ubiquity of long bone midshafts, coupled with a lack of identification to particular shaft section required the use of midshaft values only, as lumping and averaging density values has been highly criticised for introducing error caused by overgeneralisations (Lam and Pearson, 2005; Lam, pers. comm., March, 2009).

The final measure of skeletal abundance used within this study is the calculation of an evenness index for selected skeletal elements. This measure follows Faith and Gordon (2007), who demonstrated that using Shannon's evenness index for high-survival elements in tandem with Central-Place Foraging models from Behavioural Ecology, garnered insight into both transport decisions made at the site and alerted the analyst to the presence of other taphonomic agents at work in the site's formation (primarily carnivore-ravaging and density-mediated attrition). The high-survival element set consists of long bones (humerus, radius, metacarpal, femur, tibia and metatarsal) and cranial elements (skull and mandible), which are demonstrably denser and experimentally shown to better survive the effects of carnivore ravaging (Cleghorn and Marean, 2004; Marean and Cleghorn, 2003). Therefore, following Faith and Gordon (2007:878), any significant variation present within the evenness of the distribution of high-survival elements should reflect hunter-gather transportation decisions.

The Shannon evenness index is calculated using the following formula:

$$E = -\sum p_i \ln p_i / \ln S \qquad (1)$$

where p_i represents the standardised proportion of specimens for the *i*-th element, or more simply put a standardised MNE proportion calculated by taking the MNE for a particular element and dividing by the total MNE for the high-survival set. S is simply the total number of elements present within the sample (the high-survival element set) and E is the evenness index value (Faith and Gordon, 2007:874).

Faith and Gordon (2007) were able to distinguish between four different transport strategies in their study by examining evenness values: gourmet, unbiased, bulk and unconstrained. Gourmet, unbiased and bulk strategies all correspond to Binford's (1978 and see Chapter 3.1) discussion of utility curves, whereas the unconstrained strategy refers to an instance where differential transport has not occurred, such as the transportation of an entire carcass (see Table 5.3).

Evenness index values can be broadly interpreted as indicating very even assemblages (equal frequencies of high and low-survival elements) when the value approaches 1 (>0.9) and uneven assemblages (preponderance of high-survival elements) when the value is less (<0.9) (Dominguez-Rodrigo, n.d.; pers. comm., August 2008). The calculation of Shannon's evenness index in tandem with the Central-Place Foraging model gives the potential for insight into transport decisions undertaken at Magubike and Mlambalasi.

The analysis of bone surface modifications focused on PM, TM, and CM, as these can be said to provide the greatest amount of insight into an assemblage's formational history and the human behavioural context (Dominguez-Rodrigo, *et al.*, 2007; Gifford-Gonzalez, 1991; Fisher, 1995). The total number of bone surface modifications identified within the assemblages was low and therefore necessitated an analysis that is more qualitative than quantitative in nature.

CM, PM and TM were quantified by summing the total number identified in each analytical unit to give a general impression of the different frequencies of each with respect to the others. A more specific quantification was also undertaken, in which CM, TM and PM were quantified for each element within the assemblage. These data were then compared to values and data sets in the literature.

Blumenschine's (1995) discussion of the relationship between PM and TM was used as a guide to interpreting the timing and nature of carnivore ravaging at the sites. Dominguez-Rodrigo's (1997; Dominguez-Rodrigo, *et al.*, 2007) discussion of CM frequencies was also incorporated, and was also used to gauge the carnivore role in assemblage formation and the order of nutritional acquisition (who had primary access to the carcass).

Through determining the relative proportions of CM, PM and TM, inferences can be made regarding the timing and formation of the faunal assemblage and the extent to which carnivores, scavengers and humans affected its composition.

Analysis of the fracture and fragmentation patterning within the assemblages broadly follows the same method used in the analysis of bone surface modifications. Examination of the fracture patterning involved quantifying the number of each class of limb shaft circumference (following Bunn, 1982, see above) and then comparing the ratios of Type 1 shafts to that of Type 2 and 3 shafts. The proportion given can be compared to published data and used to give an indication of whether the agent of carcass accumulation was human or non-human (Dominguez-Rodrigo, *et al*, 2007; Dominguez-Rodrigo, n.d.; Marean *et al.*, 2004; Villa and Mahieu, 1991).

The second method of analysing the fracture patterning is to examine the relationship between the amount of green and diagenetic breakage present within the assemblage. As mentioned above, green breakage occurs in fresh bone, while diagenetic breakage occurs in dry bone. Following Villa and Mahieu (1991) and Dominguez-Rodrigo and colleagues (2007), the ratio of green to diagenetic breaks can be calculated and compared to experimental data sets in order to compare and infer the roles of diagenetic destruction and human/carnivore activity (Dominguez-Rodrigo, n.d.).

Fragmentation analysis consisted of dividing the number of recorded specimens into length categories and calculating the percentage present in each category, as well as cumulative percents. This analysis was undertaken to elucidate the degree of fragmentation present within the assemblage and can be used in tandem with the fracture analyses to infer the amount of diagenetic attrition suffered by the assemblage (Bunn, 1982; Dominguez-Rodrigo, *et al.*, 2007; Villa and Mahieu, 1991; Dominguez-Rodrigo, n.d.). Fragmentation indices can also be used to discuss the relationship between NISP and MNE and any subsequent bias present within the assemblage (Lyman, 2008). The latter however, is beyond the scope of this study.

5.4 – *Summary*

The methodology involved for the identification, quantification and analysis of the faunal assemblages from Magubike and Mlambalasi has now been clearly outlined. This methodology follows published rubrics and practices that have been demonstrated to yield the most insight into faunal assemblage formation and the associated human behavioural component. It is important to reiterate that because of the small sizes and exploratory natures of the two faunal assemblages, a conservative approach was maintained at all times during the identification, quantification and analytical stages. Such an approach was undertaken to best ensure that the following results are as accurate and precise as possible and can therefore be of use to any subsequent faunal study of Magubike and Mlambalasi.

Table 5.1 Analytical units used in this study
*Based on associated lithic materials, as interpreted by Dr. P. Willoughby following Mehlman (1989)

Name	**Site**	**Test Pit**	**Archaeological Levels**	**Cultural Affiliation***
MG-A1	Magubike	1	0-50cm	Iron Age
		2	0-50cm	Iron Age
		3	0-60cm	Iron Age
MG-A2	Magubike	1	50-70cm	Later Stone Age
MG-A3	Magubike	2	50-60cm	Middle Stone Age
		3	60-210cm	Middle Stone Age
MB-A1	Mlambalasi	1	0-45cm	Iron Age
		2	0-70cm	Iron Age
MB-A2	Mlambalasi	1	45-120cm	Later Stone Age
		2	70-120cm	Mixed Iron Age and Later Stone Age
MB-A3	Mlambalasi	2	120-160cm	Mixed Later Stone Age and Middle Stone Age

Table 5.2 Animal size classes, following Bunn (1982:Table 2.3).

Size Class	**Weight**	**Example**
1	<50lbs/25kg	Gazelle
2	50-250lbs/25-115kg	Impala, Warthog
3	250-750lbs/115-340kg	Topi, Wildebeest, Zebra
4	750-2000lbs/340-900kg	Eland, African Buffalo
5	>2000lbs/900kg	Hippopotamus, Rhinoceros, Giraffe

Table 5.3 Shannon's evenness indices for different procurement strategies, following Table 2, in Faith and Gordon (2007:875). Gourmet strategies focus on high utility elements. Bulk strategies select for large quantities of high and moderate utility skeletal elements, while unbiased strategies fall in the middle (Binford, 1978). Unconstrained strategies represent complete carcass transport.

Transport Strategy	**Evenness Index Value**
Gourmet	0.369
Unbiased	0.842
Bulk	0.98
Unconstrained	1

Chapter 6 – Results

6.1 - *Introduction*

The following results have been generated by analysing the data using the methods and techniques discussed in Chapter 5. Chapter 6 has been organised so that the results from all analyses will be presented for each analytical unit. For each unit, the discussion will entail the results of the identification, focusing on the counts of NISP, MNE, MNI and taxa present. This will facilitate an impression of the skeletal element abundances that were found within each unit and generate information regarding the amount and quality of the data being discussed.

Subsequently, the results of the quantitative analyses of skeletal element abundances will be discussed, which will include the results of the application of Shannon's evenness index for skeletal element abundances; and the results of tests for relationships between %MAU and SFUI, and %MAU and bone density (VD). The results of these analyses will offer insight into the human behavioural component, as well as possible taphonomic bias suffered by the faunal assemblages.

Lastly, the results of the taphonomic analysis will be discussed. This discussion will focus on the presence and frequency of identified bone surface modifications; and the fragmentation and fracture patterns identified within each of the analytical units.

6.2 – *Results for MG-A1*

MG-A1 represents the Iron Age levels from Magubike. The total number of specimens for this unit (NSP) is 1212, from which the number of identifiable specimens (NISP) was 502 (see Table 1). This NISP value is the second highest amongst the units studied, less than only MG-A3. In examining Table 6.2, it can be seen that limb shaft fragments are the most ubiquitous element, comprising 171/502 (34%) of the identified specimens. Limb shaft fragments are followed by ribs, which predominantly consist of rib shaft fragments and comprise 88/502 (17.5%) of the identified specimens.

Small-size animals (Size 1 and 2) dominate the NISP count, comprising 347/502 (69%) of the identified specimens, while large-size animals (Size 3 and 4) account for only 84/502 (16.7%). The remaining NISP consist of indeterminate Size 2-3 animals and size indeterminate animals.

The MNE counts for small size animals from MG-A1 demonstrate that vertebra are the most ubiquitous element (MNE=7), followed by ribs (MNE=5) (see Table 6.3). When these MNE values are converted to %MNE (see Chapter 5), it can be seen that proportionally, the most abundant elements are equally the humerus, metacarpals and femur (see Figure 6.1). This presents an interesting assemblage from a taphonomic perspective, as the humerus, metacarpals and femur are all considered to be high-survival elements and the humerus and femur also have high FUI values. Such results necessitate further examination through comparisons of %MAU and SFUI and %MAU and VD, which are discussed below.

Unsurprisingly, the large size animals display a smaller MNE count, as the sample contains only 88 NISP. Again the ribs are the most prominent element in raw MNE counts, displaying 3 elements. When converted to %MNE, the skull is proportionally the most frequent element, but due to the small sample size these data are somewhat difficult to interpret (see Table 6.4 and Figure 6.2).

MNI counts based on the criteria discussed in Chapter 4 elicit a value for both small and large size animals in MG-A1 of 4 (see Table 6.5). The identifiable taxa present in MG-A1 consist of one bovid identified as *Bos taurus*, one indeterminate caprid and three goats (*Capra hircus*) (see Table 6.6). Microfaunal remains consist of one turtle, one reptile, one small carnivore and two birds.

The methodology and justification for applying Shannon's evenness index to the high-survival elements in each analytical unit has been discussed in Chapter 5 (Faith and Gordon, 2007; Dominguez-Rodrigo, n.d.). To reiterate, evenness values of >0.9 are indicative of an even assemblage, while evenness values of <0.9 are indicative of an uneven assemblage (Faith and Gordon, 2007; Dominguez-Rodrigo, n.d.; pers. comm., August 2008).

For MG-A1, the evenness index for small size animals is 0.88 (see Table 6.7). Therefore based on the criteria outlined above, there appears to be an almost even distribution of high and low-survival elements for the small size animals of this unit. The large size animals of MG-A1 display an evenness index of 0.83. This value represents a slightly uneven assemblage, with a slight propensity for high-survival elements. Both values fall around an unbiased transportation strategy, indicative of moderate transportation distances to the site (see Table 5.2).

The values are also indicative of the possibility of some taphonomic bias being associated with this level.

The current study tested for the presence of two relationships within the data: the relationship between %MAU and SFUI and the relationship between %MAU and VD (see Table 6.8 for values used). The presence of a relationship between %MAU and SFUI can be used to infer transportation and procurement strategies and thus complements the evenness index and provides the foundation for more secure inferences regarding the faunal assemblage and human subsistence strategies. When a negative or no relationship is evinced, taphonomic factors must then be considered.

Testing for a relationship between %MAU and VD allows for insight into the possibility that the assemblage was affected by density-mediated attrition. Both statistical analyses were conducted following the methodology outlined in Chapter 5, with all statistics being calculated using SPSS 17.0 and figures composed in Systat 10.2. As discussed in Chapter 5, the small size (Size Class 1 and 2) and large size (Size Class 3 and 4) animal data were analysed separately.

The results of the test for a relationship between %MAU and SFUI for small size animals in MG-A1 yielded a Spearman's rho of -0.14 (p=0.66) (Figure 6.3). This result, coupled with an r^2-value of 0.00 strongly suggests that a linear relationship is not warranted and that there is no covariance between the two variables.

For large size animals, Spearman's rho was calculated at 0.04 (p=0.9), again indicative of no relationship. An r^2-value of 0.06 supports the conclusion that there is no significant relationship between these two variables for large size animals.

The test for a relationship between %MAU and VD in small size animals yielded a Spearman's rho of 0.34 (p=0.37) (see Figure 6.4) and an r^2-value of 0.3. These values do not support the presence of a relationship between %MAU and VD.

Spearman's rho for large size animals is 0.78 (p=0.01). This indicates a significant positive correlation between the variance of the two variables and can be used to conclude that density-mediated attrition was a factor in the creation of this assemblage. An r^2-value of 0.59, also supports this interpretation. The presence of density-mediated effects in the large size animal assemblage lends some contextual support for the presence of density-mediated effects in the small size animal assemblage.

The taphonomic analysis consisted of identifying, quantifying and describing the state of the assemblage with regard to taphonomic factors. Taphonomic factors considered in the present study include bone preservation, bone surface modifications, diagenetic factors and fragmentation and fracture patterns.

MG-A1 displayed the second highest amount of good and good to moderately preserved bone within the units studied for both sites. In total, 31.8% of the specimens exhibited good to moderately-good preservation (considered well-preserved, see Table 6.9), yielding a large part of the sample that could be confidently examined for bone surface modifications.

The assemblage was not recorded as displaying any carbonate-effected bone; however this is most likely the result of an error in data recording by the author (see Table 6.9). Other diagenetic factors were present in the assemblage, with biochemical marks being identified on 7.2% of the assemblage and trampling marks on 2.2% of the assemblage.

Bone surface modifications were found to be present in MG-A1 (see Table 6.10). No TM were identified, although the presence of a small carnivore within the assemblage does not preclude carnivore ravaging as a source of taphonomic bias (Dominguez-Rodrigo, pers. comm., September 2008). The absence of TM, however, is indicative that carnivore-ravaging was a small to insignificant factor in site formation.

Human-affected bone surface modifications are present, with PM and CM both being exhibited within the assemblage. The small number of PM and CM prevents a quantitative analysis from being undertaken (such as that used by Dominguez-Rodrigo (n.d.; 1997)). PM were found on upper limb elements only, while CM were found throughout the skeleton, although with a focus on the axial elements. MG-A1 demonstrated the greatest number of CM and human-affected marks within the entire assemblage. The relative abundance of well-preserved bone and the large sample size must both be considered as factors for this outcome.

As mentioned above, the faunal assemblage from both sites is highly fragmented with over 60% being less than 25mm in length (see Table 6.11). This large degree of heavy fragmentation is a trend exhibited throughout each analytical unit. Within MG-A1, the largest length category is 21-25mm, indicating that the assemblage has been subjected to heavy fragmentation processes. These may be both diagenetic and human-influenced, as a large number of specimens also present evidence of being burnt. The abundance of small fragments within the assemblage can be used to argue against processes of post-depositional attrition that would selectively cause their removal (such as hydraulic effects) (Dominguez-Rodrigo, n.d.). Post-depositional attrition that can lead to an increase in small size specimens (such as sediment compaction) must, however, be considered (Lyman, 1994).

Breakage was identified in 97.3% of the long bone specimens within the MG-A1 assemblage (see Table 6.12). The majority identified were green breakages, with few instances of diagenetic breakage. Approximately 20% of the assemblage consisted of both green and diagenetic breaks, with the majority of breakage being identified in indeterminate limb shaft fragments. The large amount of green breakage indicates the active role of biotic agents in the assemblage's accumulation.

Limb shaft circumferences were measured for MG-A1 and in keeping with the literature; the majority of the specimens are represented by less than half the shaft circumference (Class 1, 84%, see Table 6.13). The ratio of Class 1 to Classes 2 and 3 was calculated at 0.19, which is towards the lower end of Bunn's (1982) reported range of 0.44-0.10. Following Dominguez-Rodrigo and colleagues (2007:25) this may be interpreted as comprising a more significant human, as opposed to carnivore, impact on this aspect of assemblage formation.

Humans generally cause higher ratios of Class 1 to Classes 2, because of the dynamic loading used to crack the shaft and expose the marrow, as well as their generally greater attention paid to marrow acquisition. Carnivores use static loading to open limb shafts and generally do not process the shafts to the same degree as humans, leading to a higher ratio (Bunn, 1982; Dominguez-Rodrigo, *et al.*, 2007).

MG-A1 appears to have been accumulated largely as a result of human-effected behaviours, with the presence of carnivore ravaging being negligible. Other post-depositional factors also appear to have been influential in the assemblage's formation, with substantial amounts of fragmentation being identified.

6.3 - *Results for MG-A2*

MG-A2 represents the LSA levels from TP2 and is comprised of 124 specimens, from which an NISP of 46 was determined (see Table 6.1). While it has been discussed above, this is an extremely small sample size and NISP count, which makes any inferences and measures used on this data necessarily broad and conservative in order to maintain accuracy in the analysis. Of the 46 identified specimens, 46% (21/46) of the elements were identified to indeterminate limb shaft only, with rib shafts proving to be the next most ubiquitous element consisting of 24% (11/46) of the assemblage (see Table 6.2).

Small size animals consist of 38/46 (83%) of the NISP, with large size animals consisting of 5/46 (11%), and the remainder being comprised of size-indeterminate specimens. This level then represents a heavy bias in small, as opposed to large sized animals.

MNE counts show that the tibia and humerus are both the most equally abundant elements, having an MNE of 3, followed by the metacarpals (see Table 6.3 and Figure 6.5). What is of interest is the large number of elements that are not represented, which may be related to the small sample size. %MNE also elicits humeri and tibia as the proportionally most represented elements, followed by the metacarpals (see Table 6.4). Again, such an abundance of high-survival elements may have taphonomic relevance, discussed further below. No MNE estimates were calculated for large size animals in MG-A2 due to the lack of diagnostic specimens.

MNI estimates for MG-A2 yield a count of three small size animals and no large size animals. Despite there being the presence of large size animal bone, these specimens consist of limb shaft fragments and rib shaft fragments only and are therefore not applicable to MNI estimates. No taxa were able to be identified for MG-A2 (see Tables 6.5 and 6.6).

MG-A2 displays an evenness index for small animals only, consequent of the lack of large animal remains (see above). The index for small animals is 0.65, which represents an uneven skeletal element abundance, focused on high-survival elements (see Table 6.7). There are several possible explanations for this result, with bias in the small sample size (NISP of 46) presenting the most persuasive argument (following Faith and Gordon (2007)). A significant taphonomic influence, as well as a gourmet procurement strategy, indicative of long distance transport, must also be considered as possibilities, as must some combination of the above.

MG-A2 small size animals yielded a Spearman's rho of 0.19 (p=0.55) for the relationship between %MAU and SFUI, indicative of a non-significant, positive relationship (see Figure 6.6). An r^2-value of 0.004 for the covariance, argues strongly against any linear relationship between the two variables. These results can be interpreted as demonstrating the lack of relationship between the variance of the two variables.

As there were no large sized animal data to analyse, no test for the relationships between %MAU and SFUI and %MAU and VD could be conducted.

The results of the test for a relationship between %MAU and VD for small size animals produced a Spearman's rho of 0.08 (p=0.84), again indicative of no significant relationship (see Figure 6.7). This conclusion is supported by an r^2-value of 0.11 and suggests that density-mediated attrition was not a significant factor in this assemblage.

MG-A2 displayed the highest amount of well-preserved bone, with 65.2% of the specimens being within this category (see Table 6.9). It should be noted, however, that MG-A2 also has an NISP of only 46, so this may be an effect of the small sample size.

Some diagenetic factors were at play within the MG-A2 assemblage, with the presence of biochemical marks being identified on approximately 2% of the specimens (see Table 6.9). No trampling marks were identified however. Of the poorly preserved bone, a significant amount was carbonate-affected (28% of the entire assemblage), inhibiting element and bone surface modification identifications.

Unfortunately, despite the high number of well-preserved specimens, no human or carnivore bone surface modifications were identified (see Table 6.10). Again, this may be the result of the small sample size.

MG-A2 is also a very highly fragmented assemblage, with approximately 43.5% of the specimens being less than 20mm in length and no specimens over 50mm being recovered (see Table 6.11). The presence of substantial fragmentation within this assemblage must also be considered as a factor in the dearth of identified human and carnivore-effected bone surface modifications. The abundance of small specimens does argue against agents of post-depositional attrition that affect their removal, but not attrition that would facilitate fragmentation.

Breakage was identified in 41.4% of the sample, with diagenetic breakage occurring approximately twice as frequently as green breakage (see Table 6.12). The majority of breaks were identified in indeterminate limb shaft fragments.

Limb shaft circumference measurements yielded a ratio of approximately 0.17 (see Table 6.13). When considered within the context of Bunn's (1982) data, this value can be used to infer a greater human, rather than carnivore, component in this aspect of assemblage formation.

When taken together, the results of the taphonomic analysis for MG-A2 can be used to infer a predominant role for human action in the assemblage's formation. The lack of evidence for carnivore activity and attritional post-depositional processes support this inference, although the paucity of specimens restricts the scope of any interpretation.

6.4 – *Results for MG-A3*

MG-A3 represents the MSA levels from Magubike and proved to be the largest analytical unit within the faunal assemblage, consisting of 2041 total specimens. From this unit an NISP of 616 was determined (see Tables 6.1 and 6.2). Of the total NISP, small size animals account for 496 specimens (81%), with large size animals accounting for 107 specimens (17%). Again limb shaft fragments and rib fragments dominate the NISP counts, but within MG-A3 the next most frequent element is teeth.

MNE estimates for small size animals are dominated by ribs (MNE=20) and followed by tibia (MNE=15) and vertebrae (MNE=12) (see Table 6.3 and Figure 6.8). When %MNE is calculated tibia appear to be overrepresented (125%), indicating that there are some discrepancies in the identification and quantification procedures. Tibia are followed by femurs and metatarsals, indicating a strong hind-limb component, as well as strong representation of high-survival elements.

MNE estimates for large size animals display a fairly even spread amongst the elements, with vertebrae being the most represented with an MNE estimate of three. %MNE again shows a fairly even occurrence of skeletal elements, although with a slightly greater focus on high-survival elements (skull and long bones) (see Table 6.4 and Figure 6.9).

The MNI estimate for MG-A3 small size animals is 6 individuals, with large size animals having an MNI estimate of 1. Therefore the total MNI for this analytical unit is 7 (see Table 6.5). The identified taxa represent an interesting mix, with one African buffalo, one equid and one goat all being present (see Table 6.6). The presence of an undomesticated bovid and a domesticated caprid exhibits that there are some issues regarding the boundaries between the cultural phases and that taphonomic factors appear to be present. One reptile vertebra was also found in this unit and may be linked to the reptile in MG-A1, as it is morphologically very similar and exhibits a similar state of preservation, with both lacking significant carbonate-coating.

The evenness index values for MG-A3 are 0.83 for small size animals and 0.89 for large size animals (see Table 6.7). Both values attest to slightly uneven skeletal abundances apparent in this analytical unit, with the higher value for large size animals being indicative of greater element evenness. When considered together, these values are indicative of a relatively unbiased procurement strategy, in tandem with minimal taphonomic interference.

The relationship between %MAU and SFUI for small size animals was analysed using Spearman's rho and yielded a value of -0.02 (p=0.948) (see Figure 6.10). This value is indicative of no relationship occurring between the two variables. To further examine the lack of relationship, the linear covariance was calculated and found to be r^2=0.02. Both these results demonstrate the strongly independent nature of the two variables.

The large size animal relationship between %MAU and SFUI gave a Spearman's rho of 0.43 (p=0.16), which is indicative of a marginally insignificant, positive relationship between the two variables. Linear covariance was established as r^2=0.28, also indicating a marginal relationship between %MAU and SFUI. This relationship is somewhat indicative of a positive utility curve and in conjunction with the evenness index, may indicate an unbiased procurement strategy.

The relationship between %MAU and VD for small size animals using Spearman's rho is 0.45 (p=0.22), indicating an insignificant relationship between the two variables (see Figure 6.11). This interpretation is supported by an r^2-value of 0.14.

For large size animals, Spearman's rho for the relationship between %MAU and VD is 0.08 (p=0.84), indicating no relationship between the two variables. This conclusion is supported by an r^2-value of 0.01. The lack of any relationship can be used to infer that density-mediated attrition was not a significant taphonomic factor for this part of the assemblage.

Bone preservation in MG-A3 is comparatively poor with regard to the other analytical units. MG-A3 displays the second lowest percentage of well-preserved bone, with only 8.8% of the specimens falling within this category (see Table 6.11). Due to the large sample size, however, 54 specimens were considered well-preserved, ranking the unit third in this category.

The dearth of both trampling and biochemical marks identified within the assemblage argue against these two diagenetic factors having a significant impact in the assemblage's formation (see Table 6.9). Carbonate-effects, however, were a significant post-depositional agent, being identified in 89.5% of the specimens. The large amount of carbonate present accounts for the paucity of well-preserved specimens and may be related to both the physical and temporal depth of this unit.

Human and carnivore bone surface modifications were scarcely identified within this unit, with only one PM and one CM being found (see Table 6.10). The paucity of TM, CM and PM is likely resultant of the poor preservational character of the assemblage. Unfortunately, the lack of these diagnostic criteria impinges on any taphonomic insight into the nature of the assemblage's formation.

MG-A3 is again an extremely fragmented assemblage, with over 60% of the specimens being less than 25mm in length (see Table 6.11). This constitutes a large proportion of extremely small specimens and when considered with the poor preservational nature of the assemblage, may in part provide an explanation for the scarcity of bone surface modifications. As with the other assemblages, the abundance of small specimens attests to absence of post-depositional processes that affect their removal. However, post-depositional processes that increase fragmentation must be considered.

MG-A3 exhibits identified breakage in 26.3% of the assemblage (see Table 6.12). Green breakage accounts for 52.8%, with the remainder being diagenetic. The majority of the breaks were identified in indeterminate limb shaft fragments. Roughly even numbers of green and diagenetic breaks suggest that both biotic and post-depositional processes (such as sediment compaction) had roles in the formation of this assemblage.

MG-A3 exhibited the lowest proportion of Class 1 limb shafts (78%) in comparison with all of the units studied (see Table 6.13). In turn, the lower frequency of Class 1 limb shafts resulted in a higher ratio of Class 1 to Classes 2 and 3 (0.27). This value is in the middle of the ranges found by Bunn (1982) and warrants caution in attributing the breakage to either human or carnivore behaviour specifically.

The poor preservational character of MG-A3 limits the scope of the taphonomic information available for this study. What can be discerned is the largely in situ nature of the assemblage's formation and the lack of evidence against a significant human behavioural component. The latter is based on the presence of few taphonomic agents within the assemblage.

6.5 – *Results for MB-A1*

MB-A1 represents the Iron Age levels from Mlambalasi. This unit consists of 698 total specimens, of which an NISP of 304 was generated. MB-A1 is the largest analytical unit from Mlambalasi. As seen with the Magubike assemblage, small size taxa dominate this assemblage, representing 236/304 specimens (78%). Large size specimens consist of 60/304 specimens (20%) with the rest of the NISP being size indeterminate specimens (see Table 6.14). Limb shaft fragments again constitute the bulk of the assemblage, comprising 173/304 specimens (57%), with tooth and rib fragments being the next most frequent elements with 29/304 (10%) and 26/304 (9%) specimens respectively.

MNE estimates for small size animals display an abundance of humeri (MNE=11), followed by tibia, ribs and vertebra; all with MNE estimates of six (see Table 6.15 and Figure 6.12). The %MNE estimates again show a predominance of humeri, followed by other high-survival elements (skull and long bones) (see Table 6.16). The large numbers of high-survival elements may be indicative of either transport or taphonomic effects, discussed below.

Large size animals are represented by fairly few elements, with ribs being the most abundant and having an MNE estimate of three (see Table 6.15 and Figure 6.13). When converted to %MNE, high-survival elements tend to dominate; however, the scapula is well represented. This may be in part due to the denser part of the scapula being retained within the assemblage and proving identifiable.

MB-A1 has the greatest MNI estimate for all analytical units within the Magubike and Mlambalasi assemblages, with a total MNI estimate of nine (see Table 6.5). Small size animals have an MNI estimate of six and large size animals have an estimate of three.

Despite the relatively large number of tooth fragment specimens (NISP of 29) and the large MNI estimates, no taxa could be identified to species. However, one equid and one caprid are represented within the unit (see Table 6.6). Microfauna consisted of two birds and one rodent.

MB-A1 exhibits an evenness index for small size mammals of 0.82, indicative of a somewhat uneven representation of high and low-survival elements (see Table 6.7). The large animal evenness index is 0.67, representing an uneven element abundance, with bias towards high-survival elements. These data may be taken to indicate differential transportation patterns for small and large size animals, with smaller animals being transported more completely to the site. Taphonomic bias may account in part for some of the difference; however, the differential effect on large and small size animals provokes consideration. A further possibility for the disparity between the two evenness indices may lie in differential sample size and its associated bias (Faith and Gordon, 2007). MB-A1 displays twice as many small size individuals (MNI=6) as opposed to large size individuals (MNI=3) and both substantially greater NISP and MNE counts.

Spearman's rho for the correlation between %MAU and SFUI for small size animals in MB-A1 is -0.34 (p=.28), indicating the possibility of a slightly negative relationship between the two variables (Figure 6.14). This is not supported by the linear covariance, with an r^2-value of 0.04. These results cannot be taken to infer a relationship between the two variables.

For large size animals, Spearman's rho is 0.11 (p=0.73), strongly indicating the absence of a relationship between the two variables. This conclusion is strongly supported by an r^2-value of 0.00, again indicative of the lack of any relationship between the variation exhibited by the two variables.

When the relationship between %MAU and VD is considered for small size animals, Spearman's rho is -0.16 (p=0.68), again indicating the absence of a relationship (see Figure 6.15). This conclusion is supported by an r^2-value of 0.00. The lack of any relationship between %MAU and SFUI, and %MAU and VD makes interpretation difficult.

For large size animals, Spearman's rho for %MAU and VD is 0 (p=1), indicating that the two variables are completely independent of one another. A covariance value of $r^2=0.02$, supports this conclusion. The lack of any relationship suggests that density-mediated effects were not an issue within this assemblage.

MB-A1 exhibits bone preservation data that are similar to MG-A1, with 27.6% of the sample being classed as well-preserved (see Table 6.9). The similarities between the comparatively high proportions of well-preserved specimens in MB-A1 and MG-A1 may reflect the relatively short burial times, as both analytical units comprise Iron Age only deposits and thus reflect the past 3,000 years only. MB-A1 is also the largest analytical unit from Mlambalasi and in possessing such a relatively large number of well-preserved specimens proffers a good opportunity for the observation of bone surface modifications.

Diagenetic factors are not as significant within MB-A1 in comparison to the other analytical units. Biochemical marks are absent from this assemblage and trampling marks are found on only 2.3% of the sample (see Table 6.9). Carbonate-affected specimens comprise only 54.3% of the sample, making MB-A1 the second least carbonate-affected analytical unit. The small impact of these diagenetic factors can be considered to help facilitate the relatively large proportion of well-preserved specimens.

MB-A1 yields the second highest count of combined TM, PM and CM, with 14 in total (see Table 6.17). Of these, the majority are TM (6) and CM (7), both of which are focused on long bone elements. It should be noted that the majority of both TM and CM, as well as the only PM were identified on undetermined limb shafts, illustrating their analytical importance and arguing for methodologies that press for their retention within the analytical sample (Marean, *et al.*, 2004; Dominguez-Rodrigo, *et al*, 2007; Dominguez-Rodrigo, n.d.).

MB-A1 follows the general trend in fragmentation patterning illustrated in the preceding analytical units. Over 40% of the specimens are less than 20mm in length, with over 60% being 25mm or less (see Table 6.11). MB-A1 does contain the highest number of specimens greater than 60mm (7), again indicating the relatively well-preserved nature of the assemblage. The high frequency of small specimens is indicative of in situ site formation, with the absence of post-depositional factors that would facilitate their removal. Post-depositional factors that increase fragmentation (such as sediment compaction) cannot be excluded.

Bone breakage was identified in approximately 54% of the MB-A1 assemblage (see Table 6.12). Of the specimens were breakage was identified, the majority (almost 75%) were diagenetic, with the remainder consisting of both green only and green and diagenetic breakage. The amount of breakage is considerably less than that exhibited by MG-A1 and the proportions of green and diagenetic breakage are reversed, emphasising the role of different taphonomic agents in assemblage formation between these two culturally equivalent units from different sites. The amount of diagenetic breakage is suggestive of a diminished role for biotic agents and strengthens the hypothesis that sediment compaction made have played a significant role in the assemblage's formation.

Limb shaft circumference data fall within the range of values indicated by Bunn (1982), with the majority being Class 1 (approximately 86%) (see Table 6.13). These data yielded a ratio of approximately 0.17 and following Dominguez-Rodrigo and colleagues (2007), are indicative of a generally greater human behavioural component, as opposed to a carnivore one.

The comparatively well-preserved nature of MB-A1 allows for greater taphonomic insight than possible in other assemblages. The presence of both TM and human-affected marks indicates that both carnivores and humans played a role in the assemblage's formation. The large amount of fragmentation and the limb circumference data may cautiously be used to infer that the human-behavioural component was somewhat greater. However the strong possibility of significant post-depositional attrition, leading to increased fragmentation is suggested by the ubiquity of diagenetic breaks and must also be taken into consideration.

6.6 – *Results for MB-A2*

Analytical unit MB-A2 consists of the LSA only and mixed LSA-Iron Age levels from Mlambalasi. The total number of specimens in this unit is 504, with an identifiable component constituting an NISP of 165 (see Table 6.14). Again, small size animals dominate the assemblage comprising 131/165 (79%) of the NISP, with large size animals being represented by only 32/165 (19%) of the identified specimens. The remaining NISP are accounted for by animals of indeterminate size. Limb shafts again represent the majority of elements identified, comprising 85/165 (52%) specimens, distantly followed by rib shaft fragments at 25/165 specimens (15%).

MNE estimates for small size animals show a predominance of tibia, femurs, ribs and vertebra, all having MNE estimates of six (see Table 6.15 and Figure 6.16). When %MNE is calculated, long bones appear to be evenly represented, except for tibia and femurs, which have higher estimates (see Table 6.16). With the exception of the skull, these elements constitute the high-survival set and may be indicative of taphonomic interference.

The large size animal MNE estimates are comparatively small when considered with the small size animal MNE estimates. Ribs and vertebra are both the most frequent elements, with MNE estimates of two (see Figure 6.17). An examination of %MNE reveals that the long bone elements present in the assemblage have a proportionally higher value, but only consist of an MNE of one. The small nature of this sample reduces its interpretative potential.

The MNI estimates for small size animals in this unit is five, which represents the second highest MNI estimate for small sized individuals in all of the analytical units, behind only MB-A1 with an estimate of six (see Table 6.5). In contrast the MNI estimate for large size animals is two. The identified taxa in MB-A2 consist of one domesticated cow and an African Buffalo (see Table 6.6). Such a mix of domesticated and undomesticated bovids may be indicative of different cultural groups (both hunter-gatherers and foragers) using the same site. One bird specimen was also found and may be related to the birds in MB-A1, based on morphological similarities and the absence of carbonate-coating.

Analytical unit MB-A2 demonstrates an evenness index of 0.77 for small size animals and 0.70 for large size animals (see Table 6.7). Both of these values are indicative of uneven skeletal element abundances, with an abundance of high-survival elements. Taphonomic factors, differential transportation or some combination of the previous may account for these index values. The predominance of high-survival elements could be indicative of taphonomic bias, as well as a more selective procurement strategy associated with greater transportation distances.

The correlation between %MAU and SFUI for small size animals in MB-A2 yielded a Spearman's rho value of 0.2 (p=0.53), indicating an insignificant positive relationship (see Figure 6.18). The covariance value, however, is r^2=0.4 and indicates that there is a very weak linear relationship between the two variables. Together this information can be used to cautiously infer that there is a slight positive relationship between %MAU and SFUI, which can be related to the strong presence of high-utility elements within this assemblage.

The large size animal data provided a Spearman's rho of 0.23 (p=0.47), also indicating an insignificant positive relationship. This relationship is much weaker than that evinced for the small size animals, illustrated by the r^2-value of 0.01.

When the relationship between %MAU and VD is assessed for small size animal data, Spearman's rho is 0 (p=1), indicating that there is no relationship between the variance of the two variables (see Figure 6.19). This result is supported by an r^2-value of 0.02, indicating that density-effected processes do not seem to play a role within this assemblage.

For large size animals the relationship between %MAU and VD gave a Spearman's rho of 0 (p=1) as well. The r^2-value for this assemblage is 0.02, the same as for the small size animal assemblage. These results indicate that density-mediated processes cannot be considered to play a large role in the formation of this analytical unit.

MB-A2 is a culturally complicated unit, containing the presence of materials from both the Iron Age and LSA. The assemblage is poorly preserved, with well-preserved specimens amounting to only 10.9% of the total sample (see Table 6.9). This figure is somewhat surprising given the fairly well preserved nature of MB-A1 directly above it. When a sample exhibits such poor preservation, the difficulty in identifying bone surface modifications is greatly increased and the chances of their discovery reduced.

Trampling marks were identified on only one specimen within the entire sample and biochemical marks were also scarce, exhibited on only 2.4% of the assemblage (see Table 6.9). Carbonate-affected specimens were much more ubiquitous, however, comprising 80% of the sample. Despite the small influence of trampling and biochemical marks, the diagenetic effects of carbonate coating has resulted in a substantial impact on the assemblage, evinced in the paucity of well-preserved specimens.

TM, PM and CM are all present within the assemblage, but in very small numbers (see Table 6.17). All of the marks are to be found on long limb elements or indeterminate limb shafts, again justifying the retention of the latter. While there are few marks within the assemblage, the presence of both human and carnivore-affected marks indicates that both agents played a role in the assemblage's formation.

The amount of fragmentation in MB-A2 is quite high, with greater than 60% of the specimens being 25mm or less in length (see Table 6.11). From a qualitative perspective, MB-A2 does appear to demonstrate a more bell-shaped distribution of specimen sizes than other analytical units. The retention of a large amount of small size specimens argues for both in situ site formation and the possible presence of post-attritional fragmentation effects.

Bone breakage data for MB-A2 are quite similar to MB-A1, with breakage being identified in 58.6% of the specimens (see Table 6.12). Diagenetic breakage outnumbers green-only and mixed diagenetic and green breakage by approximately three to one and is indicative of post-depositional attrition. The large amount of diagenetic breakage may also be interpreted as indicative of a reduced role for biotic agents in the bone breaking process.

Limb shaft circumference data are slightly different from MB-A1, with the proportion of Class 1 fragments being slightly less at 82.5% (see Table 6.13). The ratio of Class 1 to Class 2 and 3 shaft specimens is therefore somewhat higher at 0.21. This value is towards the middle of Bunn's (1982) range and may be indicative of both human and carnivore action.

The ubiquity of poorly preserved specimens hampered the effort to identify particular taphonomic agents for MB-A2. What could be discerned was that there were both carnivore and human behavioural components involved in the assemblage's formation. The strong presence of post-depositional and diagenetic attrition, illustrated by carbonate-coating and possible sediment compaction, are also indicated.

6.7 – *Results for MB-A3*

Analytical unit MB-A3 describes the MSA only and mixed MSA-LSA levels from Mlambalasi. The total number of specimens from this unit is 244 from which an NISP of 105 was generated (see Table 6.14). Following the trend for the rest of the units, small size animals dominate the assemblage, consisting of 79/105 specimens (75%) in comparison with large size animals, represented by an NISP of 23/105 (22%). The remainder of the NISP are constituted by animals of indeterminate size. In following with the other units, limb shafts comprise the majority of the elements represented, 63/105 specimens (60%), and are distantly followed by ribs and tooth fragments.

MNE estimates for the small size animal portion of this unit are fairly uneven, with ribs and vertebra being represented by four elements each and the remainder of the elements present consisting of estimates of one only (see Table 6.15 and Figure 6.20). The remaining elements are all high-survival elements and become predominant with the conversion to %MNE (see Table 6.16).

Large size animals display a small MNE estimate, with few elements being represented. Vertebrae have the highest MNE estimate with two, while the only other elements are again indicated by estimates of one (see Figure 6.21). As with the small size animal MNE estimates, conversion to %MNE indicates a predominance of high-survival elements. However, MNE estimates for both small and large size animals are very small and again this limits the interpretive potential.

MNI estimates for MB-A3 display a total MNI estimate of five individuals, which is the lowest estimate for all analytical units, except MG-A2 (total MNI of three) (see Table 6.5). The MNI estimate for small size individuals is three and for large size individuals, two. Unfortunately, no taxa could be identified within this analytical unit (see Table 6.6).

MB-A3 displays an evenness index of 0.69 for small size animals and 0.54 for large size animals (see Table 6.7). These index values are the lowest encountered for the Mlambalasi assemblage and with the exception of the small animal index for MG-A2, for all analytical units considered. The reasons for such low values most likely have roots in both the small sample sizes for both the small and large size animals, as well as the presence of taphonomic factors.

Large size animal high survival elements consist of an NISP of nine only and an MNE of 5, while small size animals display an NISP for high-survival elements of 30 and an MNE of 13. Small sample sizes are convincingly argued by Faith and Gordon (2007) to have an effect on the evenness index. Taphonomic bias is also most likely a factor, as this unit proved to be heavily carbonated and therefore reduced the sensitivity of identification and quantification.

MB-A3 small size animals provided a Spearman’s rho of -0.44 (p=0.16) for the relationship between %MAU and SFUI (see Figure 6.22). This is indicative of a marginally insignificant negative relationship between the variation in the two variables. Such an inference is supported by an r^2-value of 0.31, and together this data can be used to broadly infer the possibility of a selective transport strategy.

Large size animals provide a Spearman's rho of 0.16 (p=0.63) for the relationship between %MAU and SFUI. This result suggests that there is a lack of relationship between the two variables and this inference is supported by an r^2-value of 0.12. There thus appears to be a disparity between the large animal and small animal assemblages within MB-A3 in regard to their %MAU-SFUI relationship. As mentioned above, this could be resultant of different approaches taken towards the different size groups, taphonomic bias, preservational bias, analyst bias or some combination of the preceding.

The relationship between %MAU and VD for small size animals yields a Spearman's rho of 0.07 (p=0.86), indicative of the lack of a relationship between the two variables (see Figure 6.23). This conclusion is supported by an r^2-value of 0.01 and can be used to support the hypothesis of a differential transportation strategy.

For large size animals, Spearman's rho is 0.46 (p=0.23), indicating a slightly significant positive relationship between %MAU and VD. Again, this provides an interesting contrast with the small size animal assemblage. The r^2-value is 0.17 and suggests that there is small covariance between the two variables.

The results for MB-A3 are quite interesting, as they consistently seem to exhibit contrasting interpretations for the small and large size animal components of the assemblage. As mentioned above, this may be the result of several factors, and it should be noted that MB-A3 comprises a complex cultural assemblage containing both levels with mixed MSA and LSA artefacts, as well as MSA only levels. This gives contextual support to the presence of taphonomic bias.

MB-A3, like MB-A2 represents a complicated analytical unit, as it contains a mixture of MSA and LSA artefacts, suggestive of a complex taphonomic history. This analytical unit is the most poorly preserved amongst all of the units studied, with well-preserved specimens comprising less than 5% of the sample, which itself is quite small (NISP of only 105) (see Table 6.9). The dearth of well-preserved specimens facilitates against a comprehensive study of bone surface modifications and attests to the presence of biostratinomic and diagenetic attritional factors.

Biochemical and trampling marks are each represented in only one specimen, possibly due to the poor preservational character of the assemblage (see Table 6.9). Their presence, however, is indicative of diagenetic attritional factors. Carbonate-coating is present in over 92% of the sample, the highest percentage exhibited in all of the analytical units. The significantly large number of carbonate-affected specimens can be inferred as one of the main causes of poor assemblage preservation, as the carbonate coating hides the bone's surface and therefore both the presence of bone surface modifications and landmark features, important for element identification.

Despite the low count of well-preserved specimens, one CM was identified (see Table 6.17). This CM was identified on an indeterminate limb shaft fragment and further emphasises the importance of retaining limb shaft fragments for analytical purposes. No PM or TM were identified; however, the small number of well-preserved specimens should be taken into consideration as a biasing factor against their potential discovery.

Following the fragmentation pattern illustrated in the preceding analytical units, MB-A3 is also a highly fragmented assemblage, with over 55% of the specimens being 25mm or less in length (see Table 6.11). Interestingly though, almost 3% of the assemblage was greater than 60mm in length, which is proportionally the highest value for all units studied. The large number of small fragments attests to in situ assemblage formation and the possibility of post-depositional processes that increase fragmentation.

The MB-A3 assemblage exhibited breakage in 55.7% of the specimens studied (see Table 6.12). Of this, the significant majority were determined to be diagenetic (79.5%), with only 2.6% being identified as green breakage and the rest a combination of the two. MB-A3 exhibits both the highest percentage of diagenetic breakage and the lowest percentage of green breakage seen in all of the analytical units. This is indicative of bone breakage occurring after the bone has dried out and argues against a significant role for biotic agents in the bone breaking process. These data instead support agents of diagenetic attrition as having greater influence in this aspect of assemblage formation.

The limb shaft circumference data for MB-A3 follows the trends seen in the other analytical units and with Bunn's (1982) experimental study. The percentage of Class1 fragments is the highest found in all of the analytical units (87%) and leads to the lowest ratio of Class 1 to Class 2 and 3 circumferences seen within the analytical units studied (0.15) (see Table 6.13). This value is very much at the lower end of Bunn's (1982) range and is suggestive against carnivores and for humans as the agents of shaft breakage. Unfortunately, there is no discussion in Bunn (1982) or of which the author is currently aware that examines the effects of post-depositional attrition on limb shaft circumference ratios. This would be a fruitful avenue of study, as it would help to resolve the contrasting information displayed in this assemblage when breakage patterns and shaft circumferences are jointly considered.

The results of the taphonomic analysis for MB-A3 are indicative of a severely altered unit that has been subjected to significant diagenetic and post-depositional attrition. No carnivore presence was detected; however, the assemblage is so poorly preserved that the signal may have been obfuscated. A small human behavioural presence was detected, but again the poor preservational character of the assemblage obscures any significant insight.

6.8 – *Summary*

This chapter discussed the results of the analyses used in the study of the faunal assemblages from Magubike and Mlambalasi. In general, both sites exhibited significant amounts of diagenetic attrition and taphonomic bias, limiting the signal of the human behavioural component. Skeletal element abundances provided a general idea of the role and type of human activity that could be conservatively inferred. The effects of density-mediated attrition and the interpretation of human procurement strategies were demonstrated in some units with the use of Shannon’s evenness index following Faith and Gordon (2007), and comparisons of %MAU and VD.

A comprehensive taphonomic analysis for each unit was able to discern the relative presence and absence of carnivore and human-affected behaviours, as well as the presence of biostratinomic and diagenetic factors that affected assemblage formation and preservation. The assemblages studied are overall poorly preserved, with the frequency of well-preserved specimens decreasing with increased physical and temporal depth. Mlambalasi appeared to undergo greater attrition than Magubike, especially with regard to the incidence of carbonate-coating.

It can be broadly stated that the skeletal element abundance analysis and the taphonomic analysis were successful, in that they were both able to determine the interpretive potential for each unit; and identify confounding factors that affect human behavioural inferences. Further discussion of the results within their interpretive context will be the focus of the following chapter.

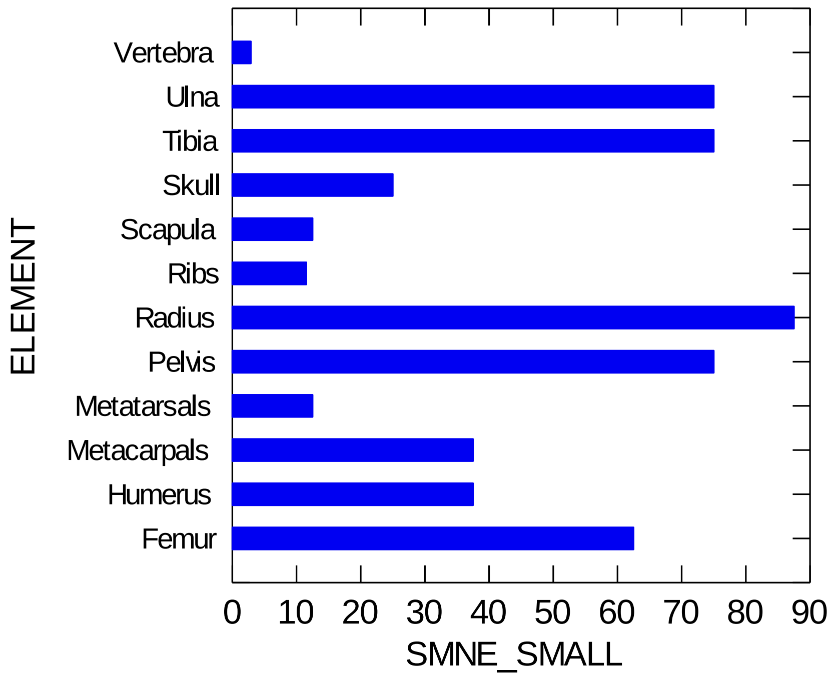


Figure 6.1 Standardised MNE (SMNE) for selected elements of small size animals for MG-A1. SMNE is calculated by dividing the MNE for an element in the assemblage by the total expected MNEs based on the MNI for the assemblage and multiplying by 100.

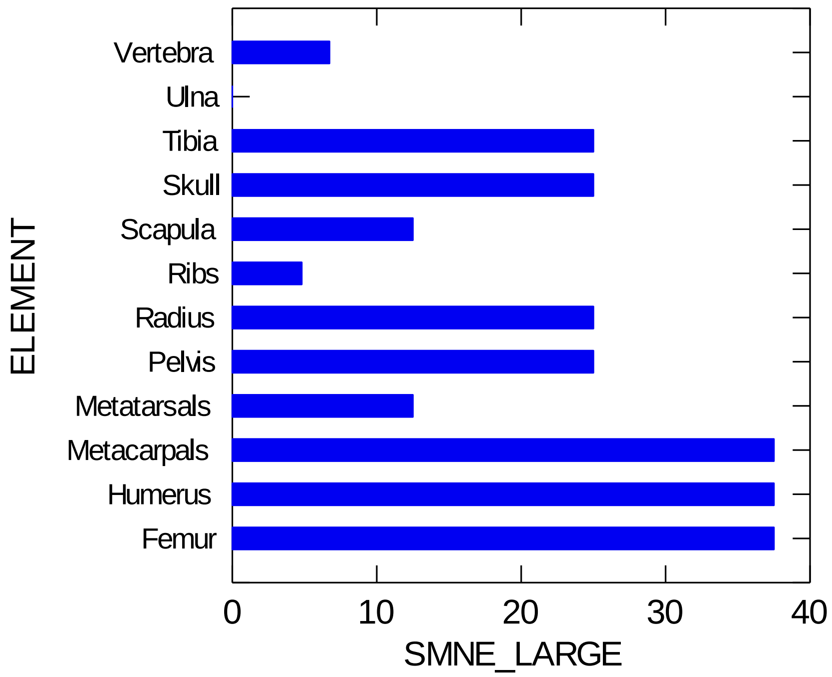


Figure 6.2 Standardised SMNE for selected elements of large size animals from MG-A1.

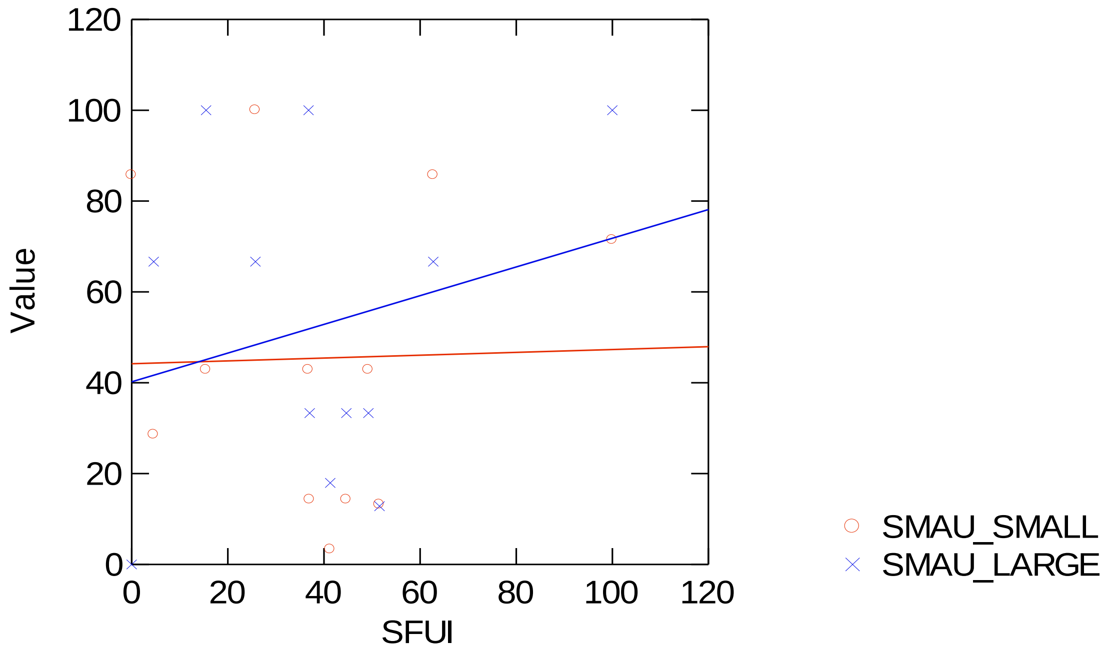


Figure 6.3 Plot of %MAU (referred to as SMAU) against SFUI for the small and large animals in MG-A1.

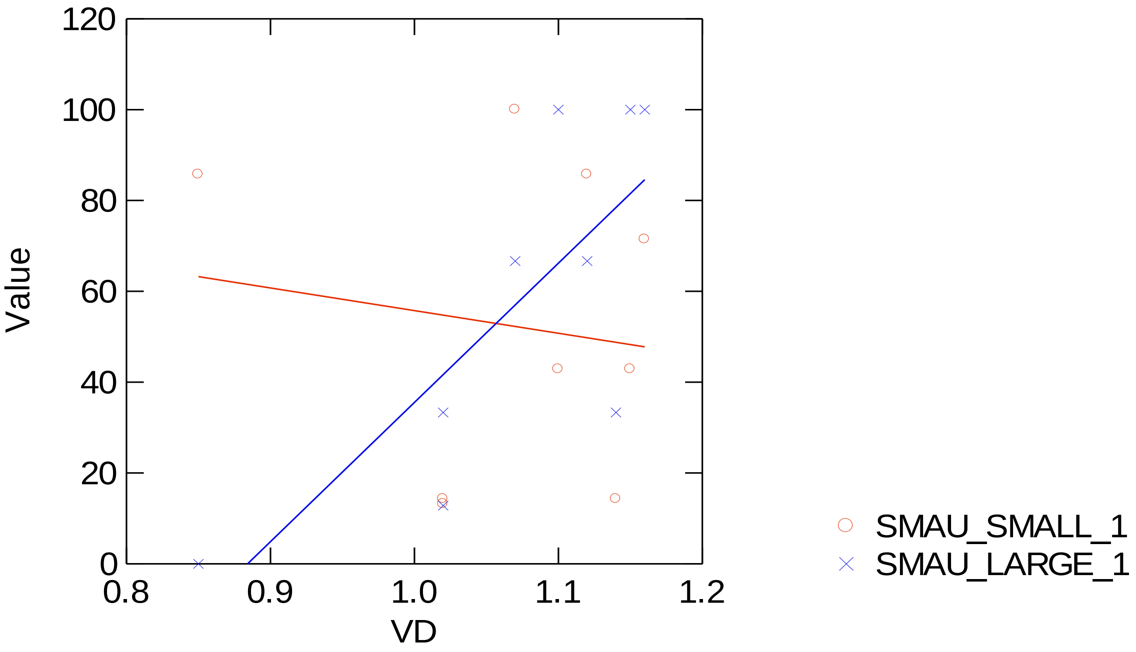


Figure 6.4 Plot of %MAU (referred to as SMAU) against Volume Density (VD) for the small and large animals in MG-A1.

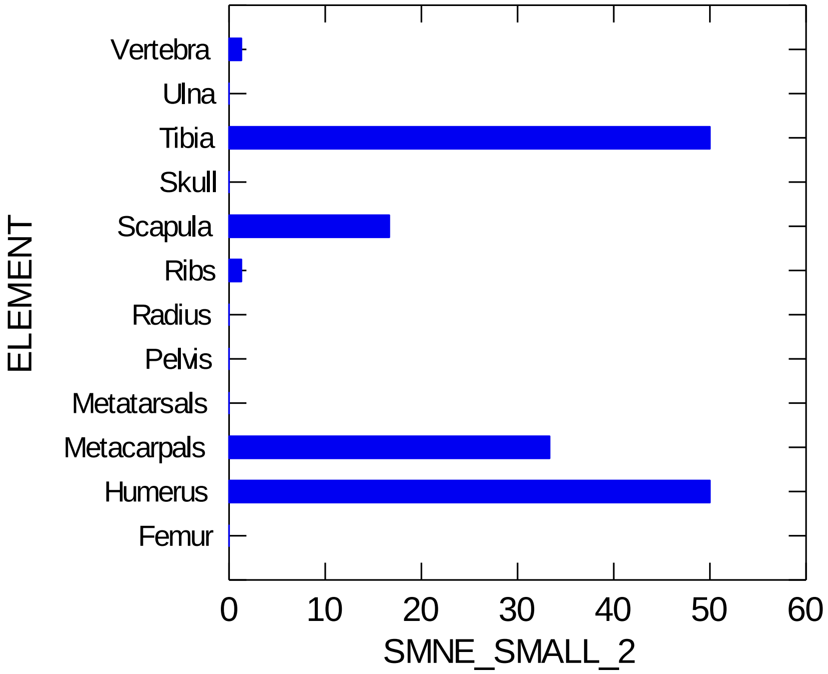


Figure 6.5 Standardised SMNE for selected elements of small size animals from MG-A2.

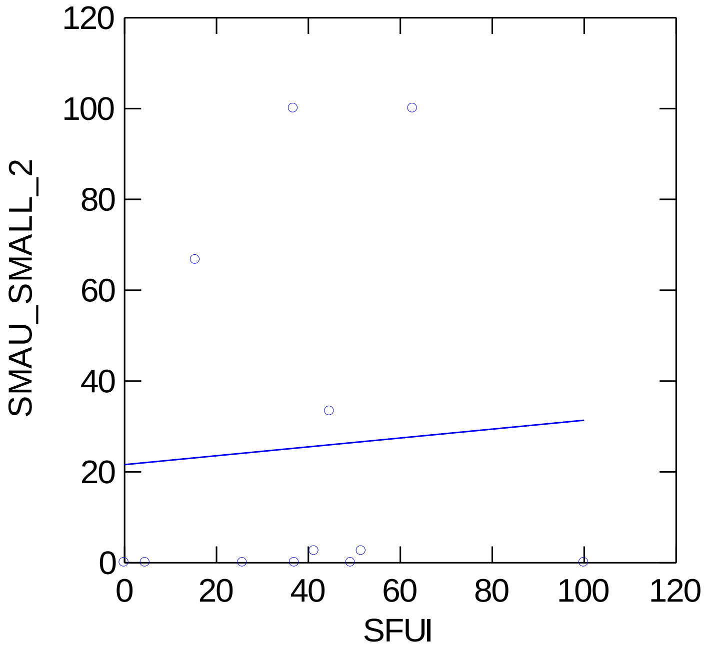


Figure 6.6 Plot of %MAU (referred to as SMAU) against SFUI for the small animals in MG-A2.

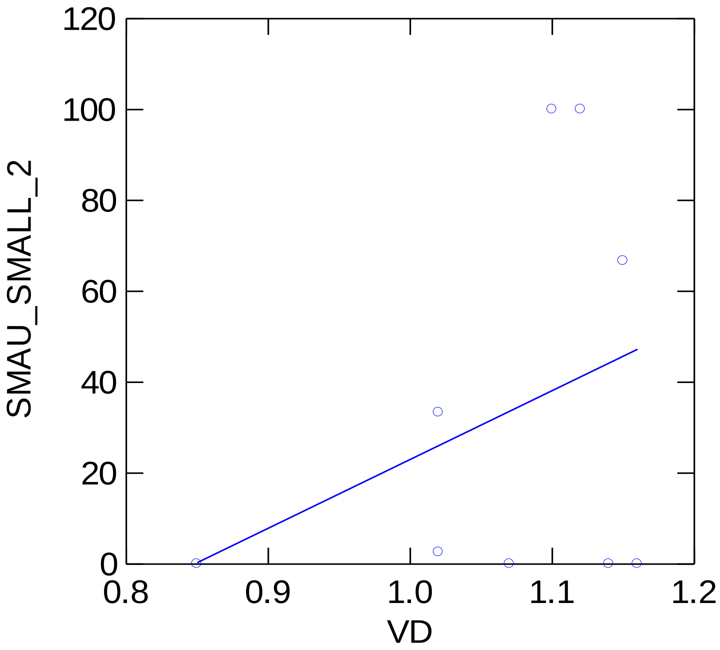


Figure 6.7 Plot of %MAU (referred to as SMAU) against VD for the small animals in MG-A2.

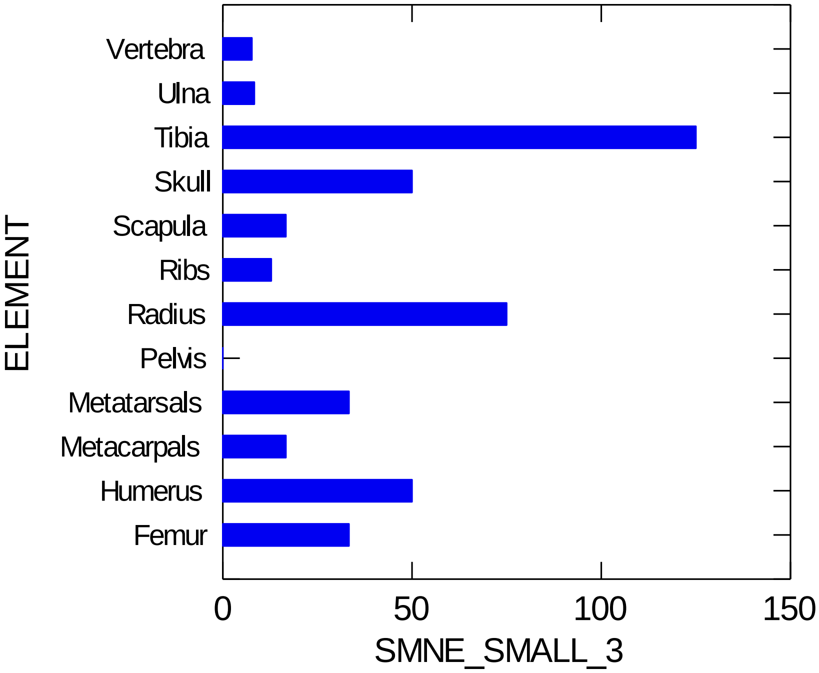


Figure 6.8 Standardised SMNE for selected elements of small size animals from MG-A3.

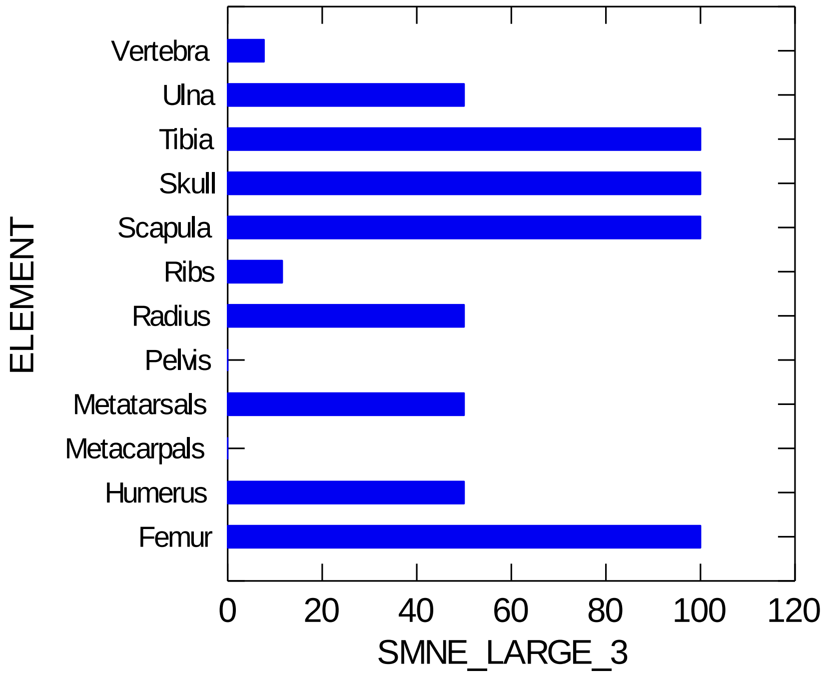


Figure 6.9 Standardised SMNE for selected elements of large size animals from MG-A3.

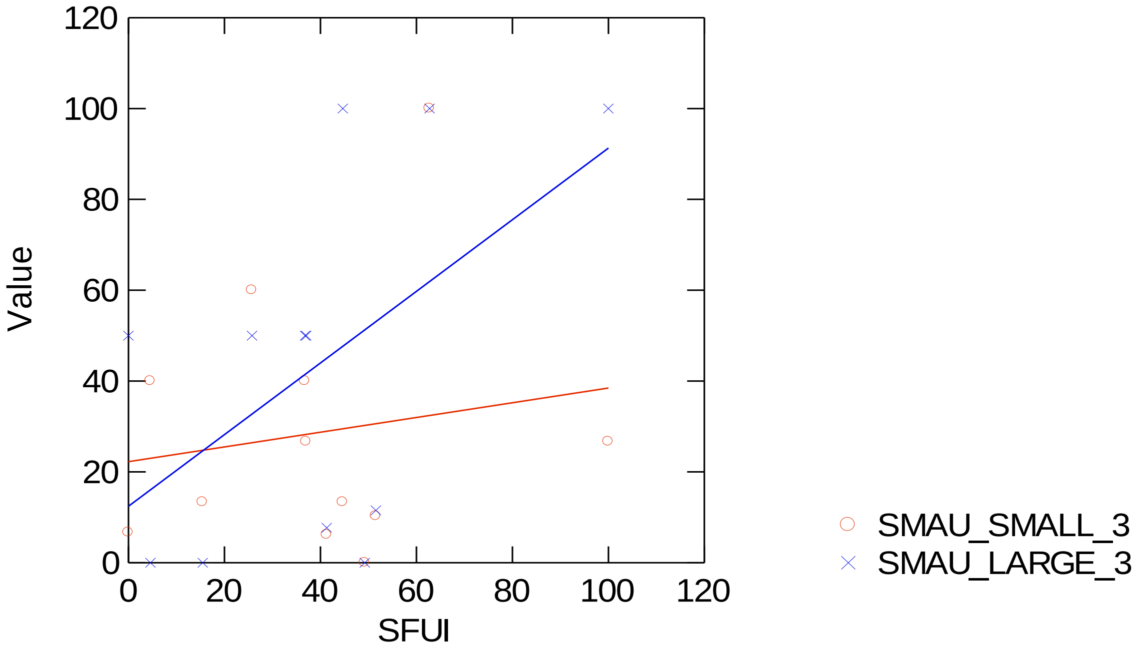


Figure 6.10 Plot of %MAU (referred to as SMAU) against SFUI for the small and large animals in MG-A3.

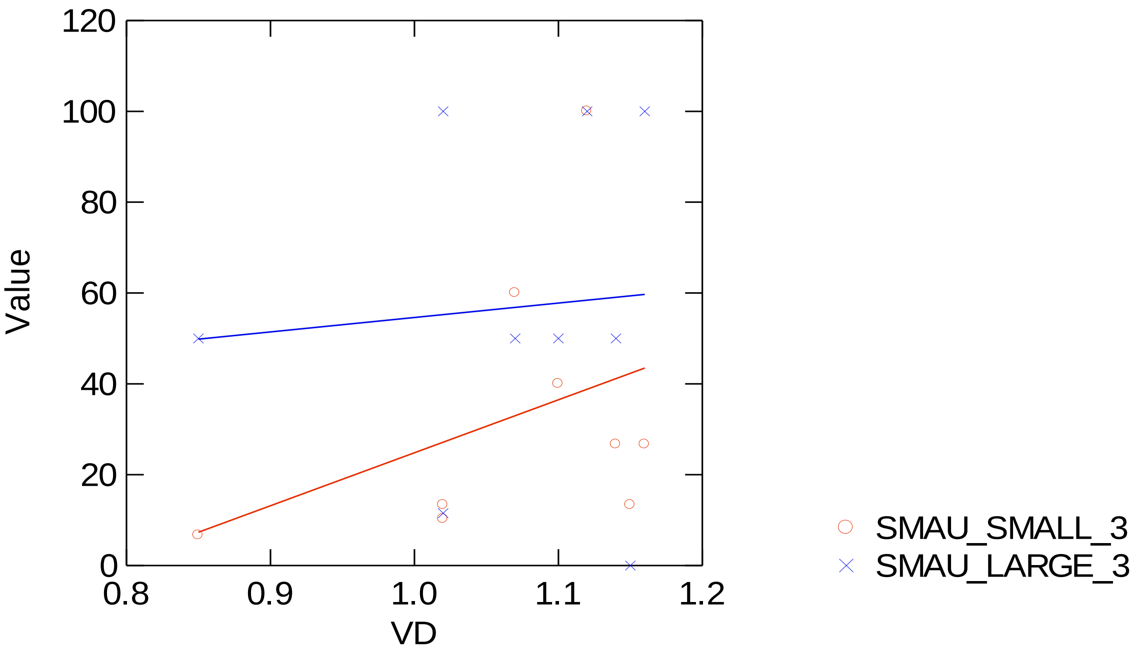


Figure 6.11 Plot of %MAU (referred to as SMAU) against VD for the small and large animals in MG-A3.

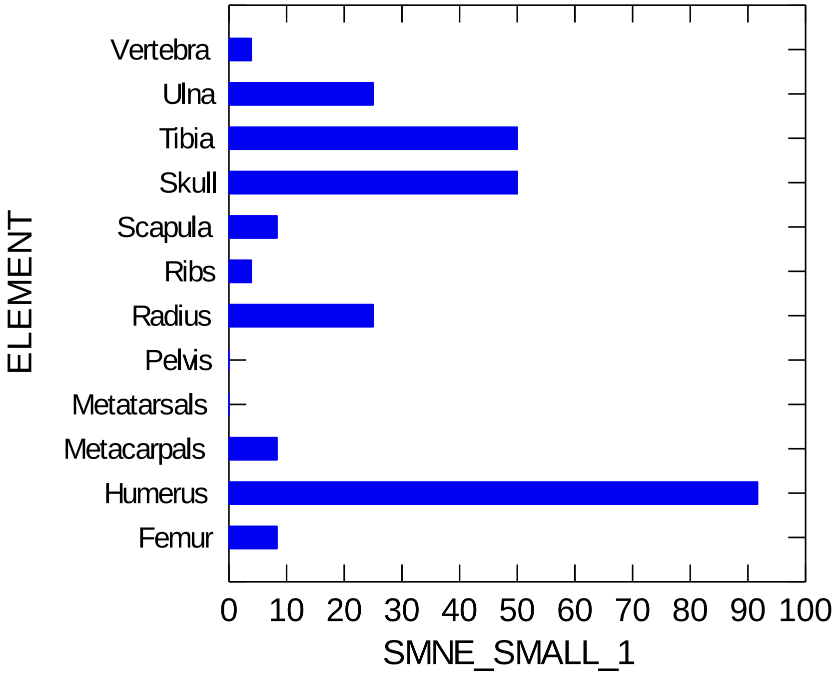


Figure 6.12 Standardised SMNE for selected elements of small size animals from MB-A1.

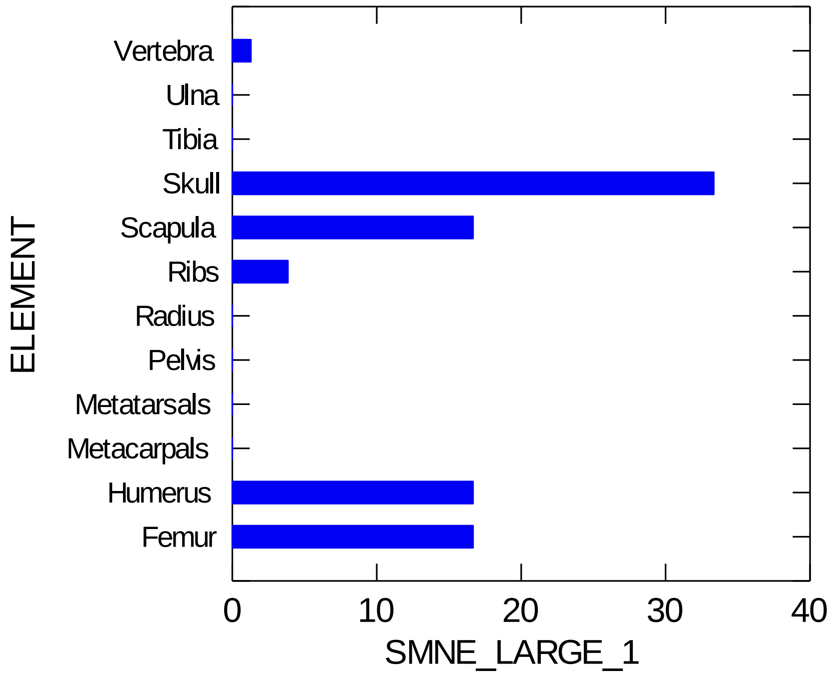


Figure 6.13 Standardised SMNE for selected elements of large size animals from MB-A1.

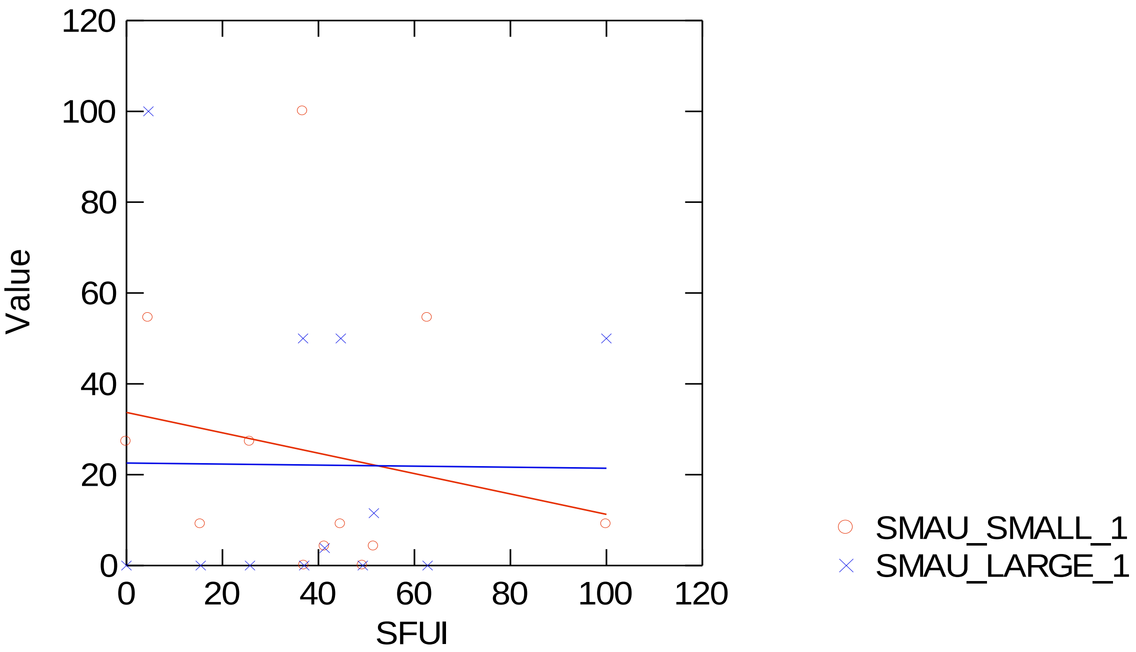


Figure 6.14 Plot of %MAU (referred to as SMAU) against SFUI for the small and large animals in MB-A1.

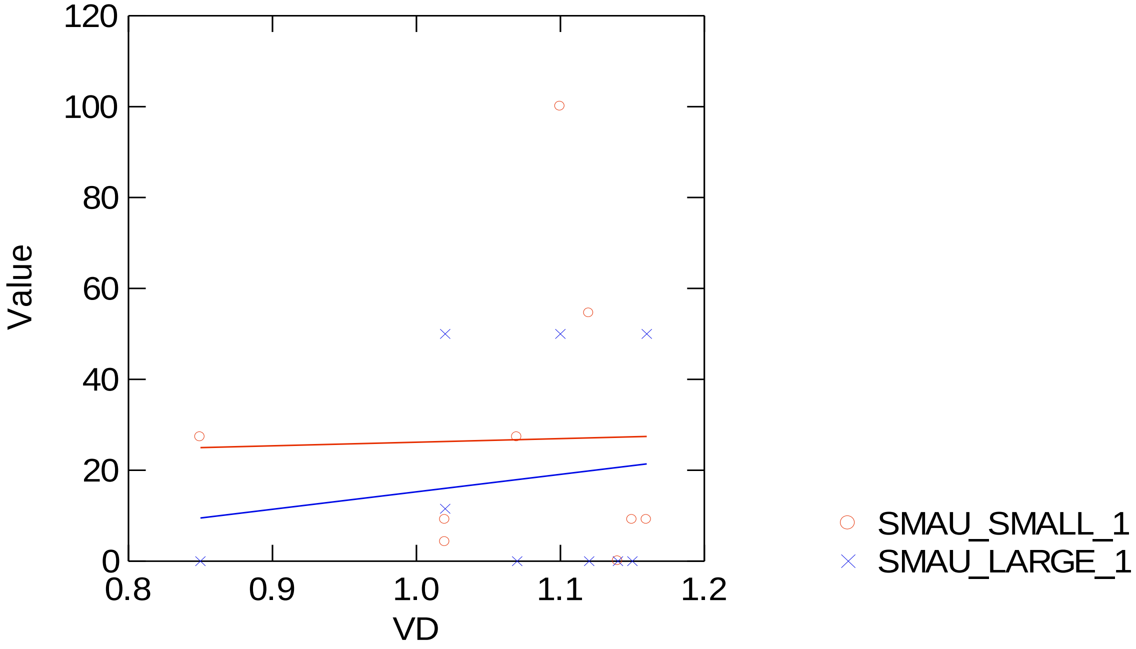


Figure 6.15 Plot of %MAU (referred to as SMAU) against VD for the small and large animals in MB-A1.

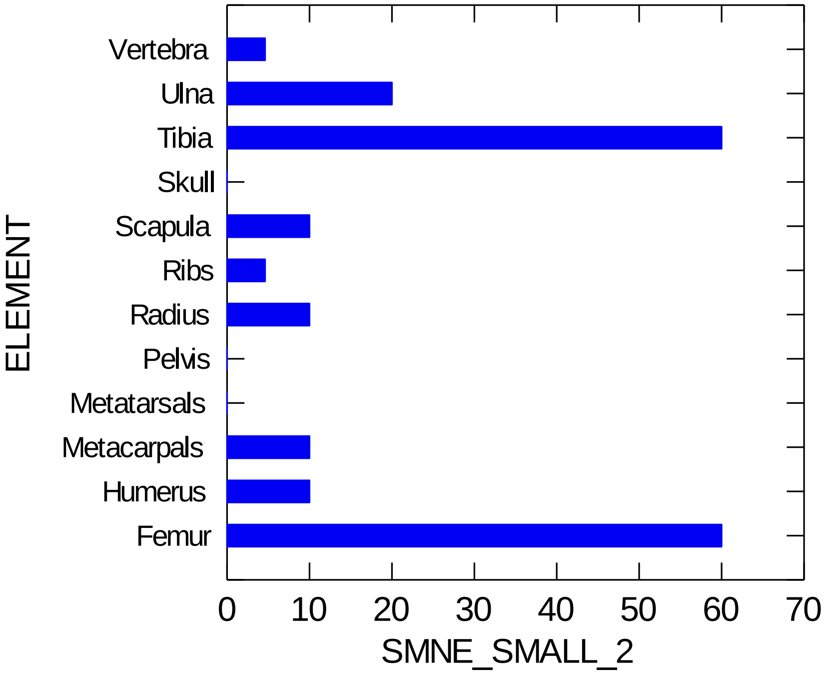


Figure 6.16 Standardised SMNE for selected elements of small size animals from MB-A2.

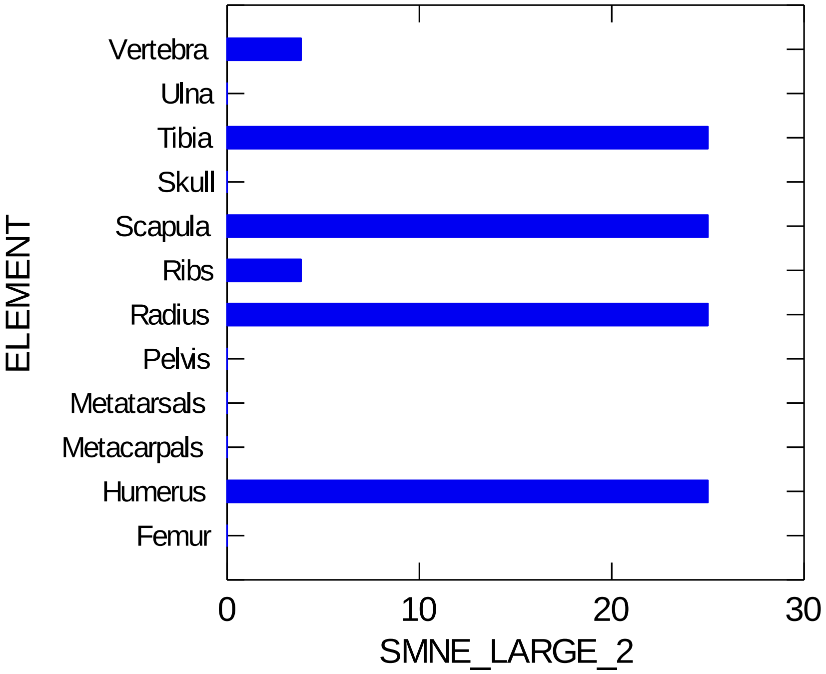


Figure 6.17 Standardised SMNE for selected elements of large size animals from MB-A2.

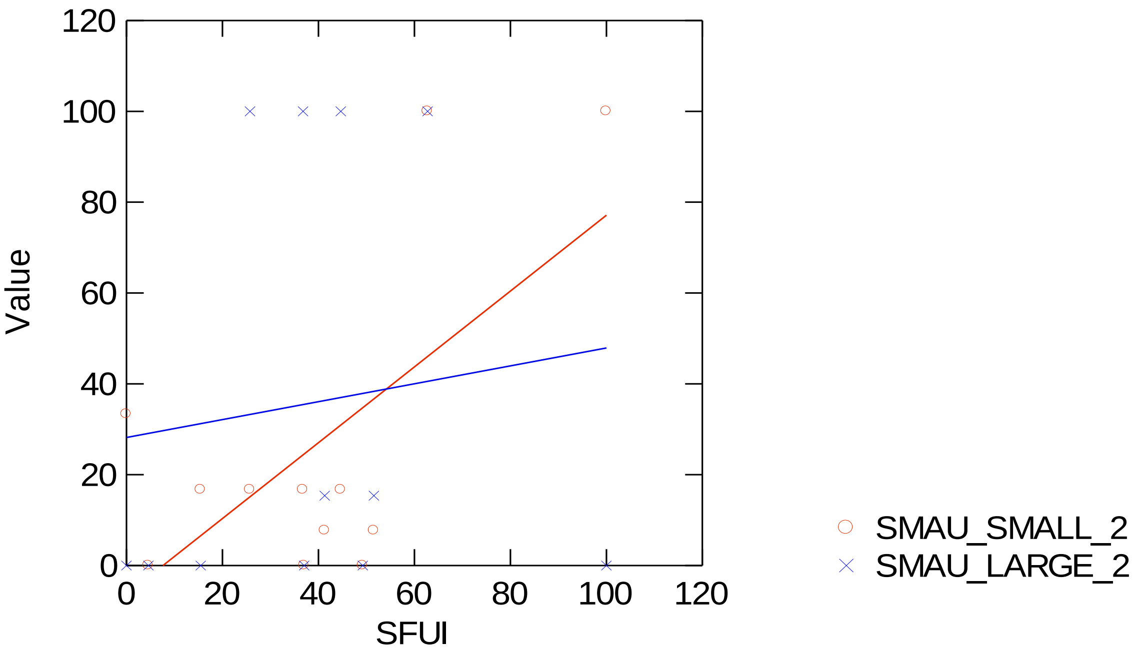


Figure 6.18 Plot of %MAU (referred to as SMAU) against SFUI for the small and large animals in MB-A2.

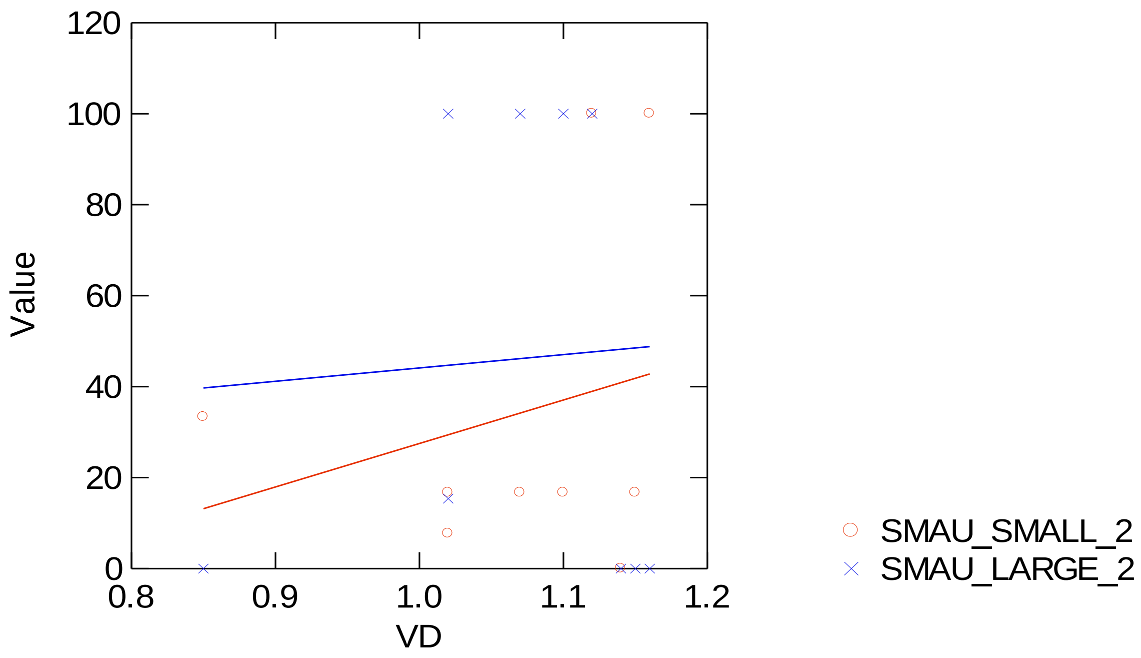


Figure 6.19 Plot of %MAU (referred to as SMAU) against VD for the small and large animals in MB-A2.

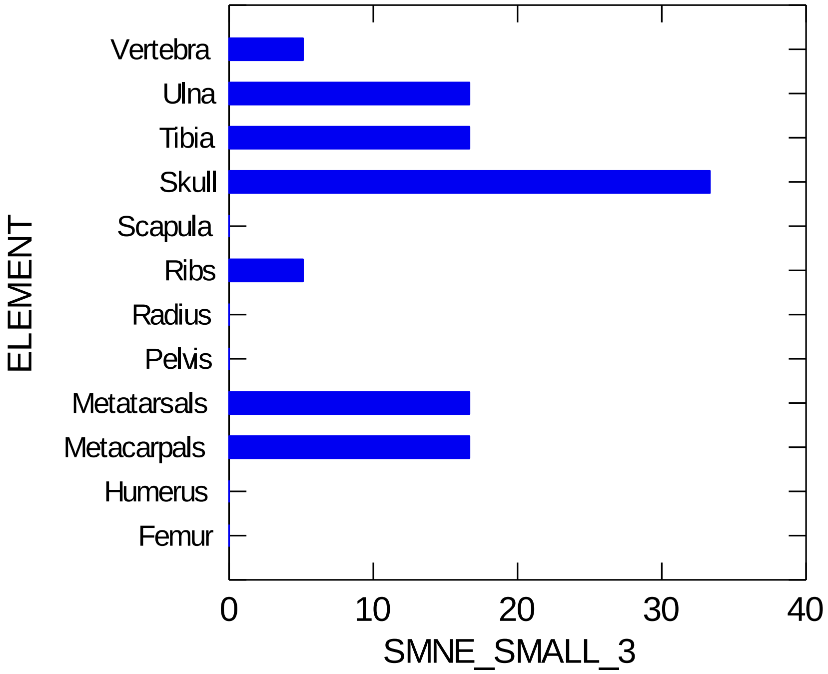


Figure 6.20 Standardised SMNE for selected elements of small size animals from MB-A3.

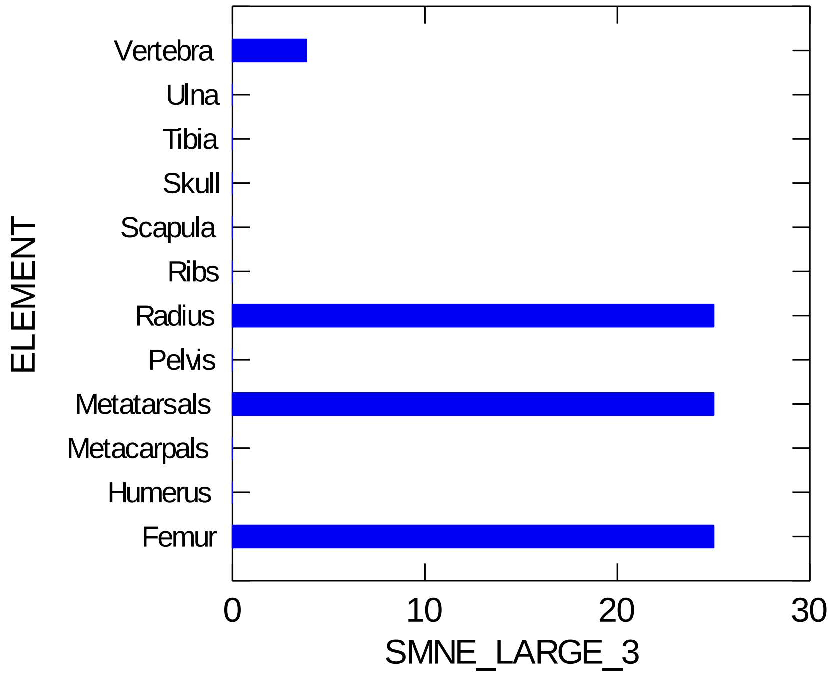


Figure 6.21 Standardised SMNE for selected elements of large size animals from MB-A3.

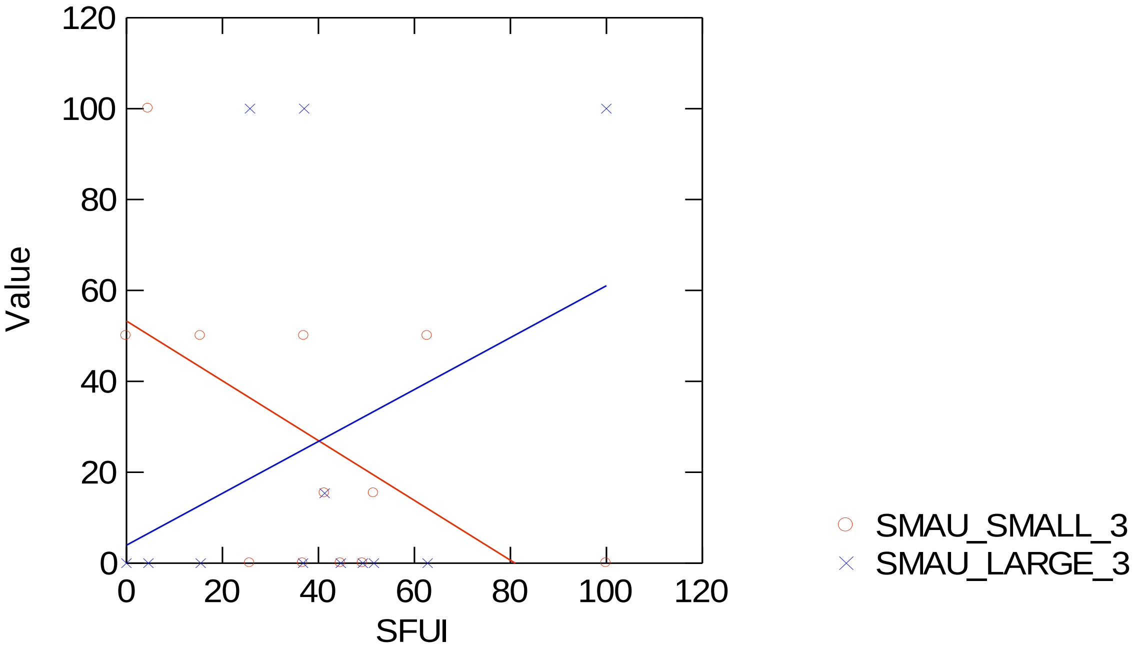


Figure 6.22 Plot of %MAU (referred to as SMAU) against SFUI for the small and large animals in MB-A3.

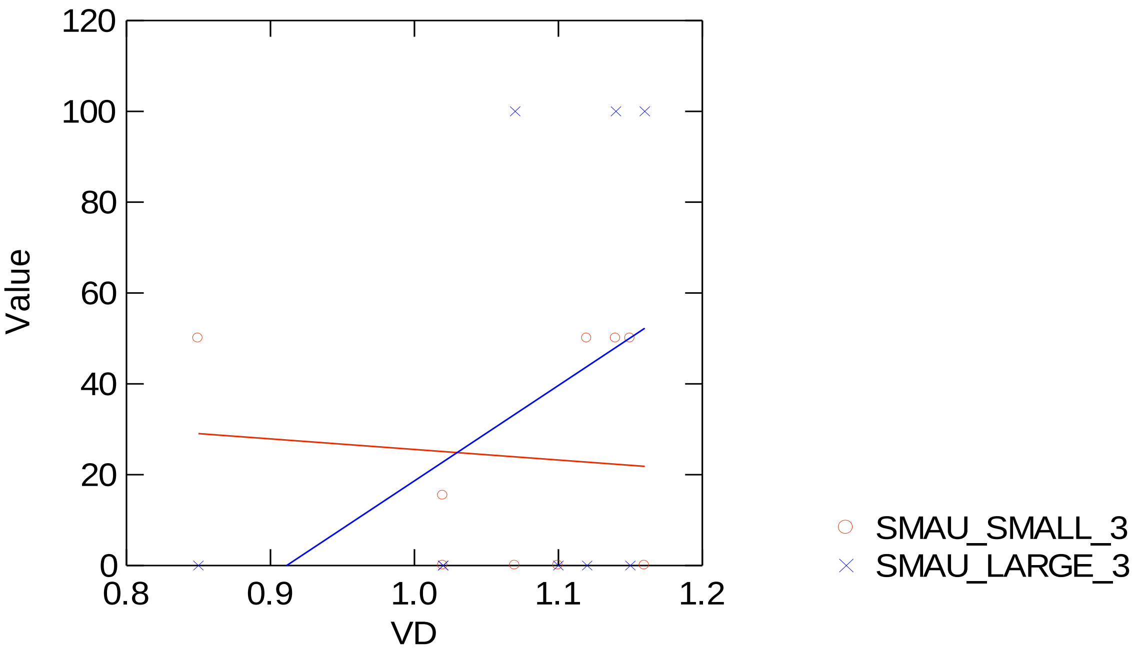


Figure 6.23 Plot of %MAU (referred to as SMAU) against VD for the small and large animals in MB-A3.

Table 6.1 Summary of identification and quantification results for each analytical unit.

Unit	**NSP**	**NISP**	**MNE**	**MNI**
MG-A1	1212	502	80	8
MG-A2	78	46	12	3
MG-A3	1425	616	94	7
MB-A1	698	304	49	9
MB-A2	504	165	38	7
MB-A3	244	105	18	5
Total	4161	1738	291	39

Table 6.2 Number of identifiable specimens (NISP) by element for small, large and indeterminate (indet) carcasses for Magubike

		Magubike											
		MG-A1				**MG-A2**				**MG-A3**			
Element		small (size 1-2)	large (size 3-4)	indet (size 2-3)	Indet	small (size 1-2)	large (size 3-4)	indet (size 2-3)	indet	small (size 1-2)	large (size 3-4)	indet (size 2-3)	Indet
Horn													
Cranium		11	2	4	10			1	1		1		2
Mandible		7	1							2			
Teeth		13		1						26	5	1	
Vertebrae	**Indet**	32	9	4	3	1				16	12		1
	Cervical	3	1										
	Thoracic		1										
	Lumbar	2	4										
	Caudal	1											1
Ribs		74	3	2	9	8	2		1	90	13	2	
Scapulae		6	1							4			
Innominates		9			1					2			
Humerus		12	6			3				23			
Radius		7	2	1						14	1	1	
Ulna		9								3	2		
Metacarpal		11	3			2				1			
Carpals										1			
Femur		8	3							8	4		
Tibia		20	1			3				23	2		
Metatarsal		5	1							9	1		
Phalanges		15	3	2		2				22	3		
Limb Shafts		95	42	12	22	18	3			245	59	2	

Tarsals	**Astragalus**	1								1			
	Calcaneum	1								4			
	Scaphoid	1											
	Naviculo-Cuboid												
	Lunar												
	Other					1							
Others	**Patella**	1	1										
	Coracoid	1											
Shell	**Turtle**	2								3			
	Snail												
Reptile										1			
Total		347	84	26	45	38	5	1	2	498	103	6	4

Table 6.3 Minimum number of elements (MNE) for small and large carcasses according to analytical unit for Magubike (HxJf-1)

		MG-A1											
		Size 1			**Size 2**			**Size 3**			**Size 4**		
Element		Shafts	Epiphyses	Other	Shafts	Epiphyses	Other	Shafts	Epiphyses	Other	Shafts	Epiphyses	Other
Humerus		2	0					1	1		1	0	
Radius		3	3		1	0					1	1	
Ulna		3	3										
Metacarpals		2	1		1	0		1	0		2	0	
Femur		3	1		1	0		2	0		1	0	
Tibia		4	1		1	0		1	1				
Metatarsals		1	0					0	1				
Scapula				1						1			
Ribs		10	2					3	2				
Pelvis				3						1			
Skull				1						1			
Vertebra	**Cervical**			2						1			
	Thoracic									1			
	Lumbar			1						2			
	Caudal												
	Miscellaneous									3			

		MG-A2											
		Size 1			**Size 2**			**Size 3**			**Size 4**		
Element		Shafts	Epiphyses	Other	Shafts	Epiphyses	Other	Shafts	Epiphyses	Other	Shafts	Epiphyses	Other
Humerus		2	0		1	0							
Radius													
Ulna													
Metacarpals		1	1										
Femur													
Tibia		2	1										
Metatarsals													
Scapula													
Ribs		1						1					
Pelvis													
Skull													
Vertebra	**Cervical**												
	Thoracic												
	Lumbar												
	Caudal												
	Miscellaneous			1									

		MG-A3											
		Size 1			**Size 2**			**Size 3**			**Size 4**		
Element		Shafts	Epiphyses	Other	Shafts	Epiphyses	Other	Shafts	Epiphyses	Other	Shafts	Epiphyses	Other
Humerus		4	0		2	0		1	0				
Radius		4	3		2	0		1	0				
Ulna		1	0		0	0		1	0				
Metacarpals		0	1		0	1							
Femur		1	2		0	1		1	1				
Tibia		5	5		2	3		1	0				
Metatarsals		3	1					2	0				
Scapula				2			1						
Ribs		9	2		7	2		2	0		1	0	
Pelvis													
Skull				3			2			1			
Vertebra	**Cervical**												
	Thoracic												
	Lumbar												
	Caudal						1						
	Miscellaneous			4			2			2			

Table 6.4 %MNE for Magubike (Calculated with Shafts and Epiphyses and Based on MNI)

	MG-A1					
	Size 1 and Size 2			**Size 3 and Size 4**		
Element	**MNE**	**$\mathbf{MNE_{max}}$**	**%MNE**	**MNE**	**$\mathbf{MNE_{max}}$**	**%MNE**
Humerus	3	8	37.5	3	8	37.5
Radius	7	8	87.5	2	8	25
Ulna	6	8	75	0	8	0
Metacarpals	3	8	37.5	3	8	37.5
Femur	5	8	62.5	3	8	37.5
Tibia	6	8	75	2	8	25
Metatarsals	1	8	12.5	1	8	12.5
Scapula	1	8	12.5	1	8	12.5
Ribs	12	104	11.54	5	104	4.81
Pelvis	3	4	75	1	4	25
Skull	1	4	25	1	4	25
Vertebra	3	104	2.88	7	104	6.73

	MG-A2					
	Size 1 and Size 2			**Size 3 and Size 4**		
Element	**MNE**	**MNE$_{max}$**	**%MNE**	**MNE**	**MNE$_{max}$**	**%MNE**
Humerus	3	6	50		0	
Radius		6	0		0	
Ulna		6	0		0	
Metacarpals	2	6	33.33		0	
Femur		6	0		0	
Tibia	3	6	50		0	
Metatarsals		6	0		0	
Scapula	1	6	16.67		0	
Ribs	1	78	1.28	1	0	
Pelvis		3	0		0	
Skull		3	0		0	
Vertebra	1	78	1.28		0	

	MG-A3					
	Size 1 and Size 2			Size 3 and Size 4		
Element	**MNE**	**MNE$_{max}$**	**%MNE**	**MNE**	**MNE$_{max}$**	**%MNE**
Humerus	6	12	50	1	2	50
Radius	9	12	75	1	2	50
Ulna	1	12	8.33	1	2	50
Metacarpals	2	12	16.67		2	0
Femur	4	12	33.33	2	2	100
Tibia	15	12	125	2	2	100
Metatarsals	4	12	33.33	1	2	50
Scapula	2	12	16.67	2	2	100
Ribs	20	156	12.82	3	26	11.54
Pelvis		6	0		1	0
Skull	3	6	50	1	1	100
Vertebra	12	156	7.69	2	26	7.69

Table 6.5 MNI Totals (based on MNE) for small and large carcasses

Size Class	**Mlambalasi**			**Magubike**			**Total**
	MB-A1	**MB-A2**	**MB-A3**	**MG-A1**	**MG-A2**	**MG-A3**	
Size 1 and Size 2	6	5	3	4	3	6	27
Size 3 and Size 4	3	2	2	4	0	1	12
Total	9	7	5	8	3	7	39

Table 6.6 Minimum number of individuals (MNI) discovered in each analytical unit. (Macrofauna – based on teeth only)

		Mlambalasi			**Magubike**		
		MB-A1	**MB-A2**	**MB-A3**	**MG-A1**	**MG-A2**	**MG-A3**
Macrofauna							
Equus sp.		1					1
Bovini (*Bos taurus*)			1		1		
Bovini (*Syncerus caffer*)			1				1
Caprini (goat, *Capra hircus*)					3		1
Caprini (indet.)		1			1		
Microfauna							
Bird		2	1		2		
Rodent		1					
Reptile					1		1
Turtle					1		
Small Carnivore					1		

Table 6.7 Shannon's evenness indices calculated for small and large animals in each analytical unit, following Faith and Gordon (2007)

Unit	**Evenness Value**
MG-A1 - small	0.88
MG-A1 - large	0.83
MG-A2 - small	0.65
MG-A2 - large	No data
MG-A3 - small	0.83
MG-A3 - large	0.89
MB-A1 - small	0.82
MB-A1 - large	0.67
MB-A2 - small	0.77
MB-A2 - large	0.7
MB-A3 - small	0.69
MB-A3 - large	0.54

Table 6.8 Quantitative Skeletal Abundance Data for Magubike and Mlambalasi

				MG-A1		**MG-A2**		**MG-A3**	
Element	**FUI**	**SFUI**	**VD**	**Small**	**Large**	**Small**	**Large**	**Small**	**Large**
				%MAU	**%MAU**	**%MAU**	**%MAU**	**%MAU**	**%MAU**
Humerus	1891	36.80	1.1	42.86	100	100		40	50
Radius	1323	25.74	1.07	100	66.67	0		60	50
Ulna		0	0.85	85.71	0	0		6.67	50
Metacarpals	795	15.47	1.15	42.86	100	66.67		13.33	0
Femur	5139	100	1.16	71.43	100	0		26.67	100
Tibia	3225	62.76	1.12	85.71	66.67	100		100	100
Metatarsals	1903	37.03	1.14	14.29	33.33	0		26.67	50
Scapula	2295	44.66	1.02	14.29	33.33	33.33		13.33	100
Ribs	2650	51.57	1.02	13.19	12.82	2.56		10.25	11.54
Pelvis	2531	49.25		42.86	33.33	0		0	0
Skull	235	4.57		28.57	66.67	0		40	0
Vertebra	2123	41.31		3.30	17.95	2.56		6.15	7.69

				MB-A1		**MB-A2**		**MB-A3**	
Element	**FUI**	**SFUI**	**VD**	**Small**	**Large**	**Small**	**Large**	**Small**	**Large**
				%MAU	**%MAU**	**%MAU**	**%MAU**	**%MAU**	**%MAU**
Humerus	1891	36.80	1.1	100	50	16.67	100	0	0
Radius	1323	25.74	1.07	27.27	0	16.67	100	0	100
Ulna		0	0.85	27.27	0	33.33	0	50	0
Metacarpals	795	15.47	1.15	9.09	0	16.67	0	50	0
Femur	5139	100	1.16	9.09	50	100	0	0	100
Tibia	3225	62.76	1.12	54.55	0	100	100	50	0
Metatarsals	1903	37.03	1.14	0	0	0	0	50	100
Scapula	2295	44.66	1.02	9.09	50	16.67	100	0	0
Ribs	2650	51.57	1.02	4.20	11.54	7.69	15.38	15.38	0
Pelvis	2531	49.25		0	0	0	0	0	0
Skull	235	4.57		54.55	100	0	0	100	0
Vertebra	2123	41.31		4.20	3.85	7.69	15.38	15.38	15.38

Table 6.9 Preservation and agents affecting the bone assemblages in each analytical unit.

	Good Preservation (%)	Good to Moderate Preservation (%)	Poor Preservation (%)	Biochemical Marks (%)	Water/Carbonate Affected (%)	Trampling (%)
MG-A1	86/502 (17.1)	74/502 (14.7)	342/502 (68.2)	36/502 (7.2)	0/502 (0)	11/502 (2.2)
MG-A2	7/46 (15.2)	23/46 (50)	16/46 (34.8)	1/46 (2.2)	13/46 (28.2)	0/46 (0)
MG-A3	3/612 (0.5)	51/612 (8.3)	558/612 (91.2)	16/612 (2.6)	548/612 (89.5)	1/612 (0.2)
MB-A1	21/304 (6.9)	63/304 (20.7)	220/304 (72.4)	0/304 (0)	165/304 (54.3)	7/304 (2.3)
MB-A2	5/165 (3)	13/165 (7.9)	147/165 (89.1)	4/165 (2.4)	132/165 (80)	1/165 (0.6)
MB-A3	1/105 (0.9)	4/105 (3.8)	100/105 (95.3)	1/105 (0.9)	97/105 (92.3)	1/105 (0.9)

Table 6.10 Percentage of bone surface modification (tooth marks, TM, percussion marks, PM, and cut marks, CM) on the combined specimens for Magubike with good and moderate preservation (considered well preserved) shown for element.
*non-identifiable to skeletal element
** combined good and good to moderate preservation

	MG-A1				**MG-A2**				**MG-A3**			
Element	**NISP (well preserved) ** **	**TM**	**PM**	**CM**	**NISP (well preserved) ** **	**TM**	**PM**	**CM**	**NISP (well preserved) ** **	**TM**	**PM**	**CM**
Skull	9	0	0	2	1	0	0	0	1	1	0	0
Mandible	3	0	0	1								
Vertebrae	19	0	0	2	1	0	0	0				
Ribs	32	0	0	2	8	0	0	0	12	0	0	0
Scapula	4	0	0	0								
Innominate	5	0	0	0								
Humerus	7	0	1	0	3	0	0	0				
Radius-ulna	5	0	0	2					2	0	0	0
Metacarpal	4	0	1	0	2	0	0	0				
Femur	5	0	0	2					0			
Tibia	4	0	0	1	3	0	0	0	2	0	0	0
Metatarsal	2	0	0	0					1	0	0	0
Phalanges	8	0	0	1	2	0	0	0	5	0	0	0
Shafts*	33	0	0	0	10	0	0	0	24	0	1	0
TOTAL	140	0	2	13	30	0	0	0	47	1	1	0
Frequency (%)		0	1.43	9.30		0	0	0		2.13	2.13	0

Table 6.11 Amount of Total Sample Fragmentation for each analytical unit

				Mlambalasi					
	Total			**MB-A1**		**MB-A2**		**MB-A3**	
Specimen Size	**Count**	**Percent**	**Cumulative Percent**	**Count**	**%**	**Count**	**%**	**Count**	**%**
0-10mm	27	1.56	1.56	6	0.02	3	0.02	2	0.02
11-15mm	210	12.10	13.65	53	0.17	19	0.11	8	0.08
16-20mm	404	23.27	36.92	72	0.24	42	0.25	26	0.25
21-25mm	422	24.31	61.23	72	0.24	46	0.28	23	0.22
26-30mm	254	14.63	75.86	40	0.13	19	0.11	16	0.15
31-35mm	162	9.33	85.20	21	0.07	16	0.10	13	0.12
36-40mm	95	5.47	90.67	14	0.05	8	0.05	6	0.06
41-50mm	97	5.59	96.26	15	0.05	10	0.06	4	0.04
51-60mm	38	2.19	98.44	5	0.02	3	0.02	4	0.04
>60mm	20	1.15	99.60	7	0.02	0	0	3	0.03
no measurement	7	0.40	100				0		0
Total	1736	100		305		166		105	

				Magubike					
	Total			**MG-A1**		**MG-A2**		**MG-A3**	
Specimen Size	**Count**	**Percent**	**Cumulative Percent**	**Count**	**%**	**Count**	**%**	**Count**	**%**
0-10mm	27	1.56	1.56	8	0.02	0	0	8	0.01
11-15mm	210	12.10	13.65	50	0.10	9	0.20	71	0.12
16-20mm	404	23.27	36.92	98	0.19	11	0.24	155	0.25
21-25mm	422	24.31	61.23	109	0.21	8	0.17	164	0.27
26-30mm	254	14.63	75.86	93	0.19	9	0.20	77	0.13
31-35mm	162	9.33	85.20	50	0.10	5	0.11	57	0.09
36-40mm	95	5.47	90.67	34	0.07	2	0.043	31	0.05
41-50mm	97	5.59	96.26	34	0.07	2	0.043	32	0.05
51-60mm	38	2.19	98.44	15	0.03		0	11	0.02
>60mm	20	1.15	99.60	6	0.01		0	4	0.01
no measurement	7	0.40	100	5	0.01		0	2	0.00
Total	1736	100		502		46		612	

Table 6.12 Percent green and diagenetic breakage at each of the analytical units, based on shaft specimens.

	% Green Only	% Green and Diagenetic	% Diagenetic Only	% of Assemblage with breakage
MG-A1	64	19.8	16.2	97.3
MG-A2	33.3	0	66.6	41.4
MG-A3	52.8	0	46.2	26.3
MB-A1	10.5	14.9	74.6	54.3
MB-A2	15.4	12.3	72.3	58.6
MB-A3	2.6	17.9	79.5	55.7

Table 6.13 Distribution of Limb Shaft Circumferences for each analytical unit

Analytical Unit	Class 1	Class 2	Class 3	Total	% Class 1	% Class 2	% Class 3	Ratio of Type 1 to Types 2 and 3
MG-A1	273	23	29	325	84	7.08	8.92	0.19
MG-A2	36	4	2	42	85.71	9.52	4.76	0.17
MG-A3	398	53	54	505	78.81	10.50	10.69	0.27
MB-A1	185	20	11	216	85.64	9.26	5.09	0.17
MB-A2	99	14	7	120	82.5	11.67	5.83	0.21
MB-A3	67	5	5	77	87.01	6.49	6.49	0.15
Total	1058	119	108	1285	82.33	9.26	8.40	0.21

Table 6.14 Number of identifiable specimens (NISP) for small, large and indeterminate (indet) carcasses for Mlambalasi.

		MB-A1			
Element		small (size 1-2)	large (size 3-4)	indet size 2-3	indet
Horn					
Cranium		1			
Mandible					
Teeth		25	3		1
Vertebrae	**Indet**	16	2		2
	Cervical	1			
	Thoracic				
	Lumbar				
	Caudal	1			
	Reptile				
Ribs		19	4	1	2
Scapulae		1	2		
Innominates		6			
Humerus		14	4		
Radius		3	1		
Ulna		3			
Metacarpal		1			
Carpals		2			
Femur		1	1		
Tibia		6	3		
Metatarsal					
Phalanges		3			
Limb Shafts		132	38	1	2
Tarsals	**Astragalus**		1		
	Calcaneum		1		

	Scaphoid				
	Naviculo-Cuboid	1			
	Lunar				
	Other				
Others	**Patella**				
	Coracoid				
Shell	**Turtle**				
	Snail				
Total		236	60	2	7

		MB-A2			
Element		small (size 1-2)	large (size 3-4)	indet size 2-3	indet
Horn					
Cranium					
Mandible					
Teeth		5		1	
Vertebrae	**Indet**	2			
	Cervical				
	Thoracic				
	Lumbar				
	Caudal				
	Reptile				
Ribs		6			
Scapulae		1			
Innominates					
Humerus		1			
Radius		1			
Ulna					
Metacarpal					
Carpals					
Femur				1	
Tibia		1			
Metatarsal					
Phalanges		1			
Limb Shafts		13			
Tarsals	**Astragalus**				
	Calcaneum				
	Scaphoid				
	Naviculo-Cuboid				

	Lunar	1			
	Other				
Others	**Patella**				
	Coracoid				
Shell	**Turtle**				
	Snail				
Total		32	0	2	0

		MB-A3			
Element		small (size 1-2)	large (size 3-4)	indet size 2-3	indet
Horn					
Cranium					
Mandible					
Teeth		7	1		1
Vertebrae	**Indet**	3	3		
	Cervical				
	Thoracic				
	Lumbar				
	Caudal	1			
	Reptile				
Ribs		12	1		1
Scapulae					
Innominates					
Humerus					
Radius			1		
Ulna		1			
Metacarpal		1			
Carpals			1		
Femur			1		
Tibia		1			
Metatarsal		1	1		
Phalanges		2			
Limb Shafts		49	13	1	
Tarsals	**Astragalus**	1	1		
	Calcaneum				
	Scaphoid				
	Naviculo-Cuboid				

	Lunar				
	Other				
Others	**Patella**				
	Coracoid				
Shell	**Turtle**				
	Snail				
Total		79	23	1	2

Table 6.15 Minimum number of elements (MNE) for small and large carcasses according to analytical unit for Mlambalasi (HwJf-2)

		MB-A1											
		Size 1			Size 2			Size 3			Size 4		
Element		Shafts	Epiphyses	Other	Shafts	Epiphyses	Other	Shafts	Epiphyses	Other	Shafts	Epiphyses	Other
Humerus		5	3		2	1		1	0				
Radius		2	0		1	0							
Ulna		1	2										
Metacarpals		0	1										
Femur		0	1					1	0				
Tibia		3	1		2	0							
Metatarsals													
Scapula				1									1
Ribs		3	1		2	0		2	0				1
Pelvis													
Skull				2			1			1			
Vertebra	**Cervical**												
	Thoracic												
	Lumbar						1						
	Caudal			2			3			1			
	Miscellaneous												

		MB-A2											
		Size 1			Size 2			Size 3			Size 4		
Element		Shafts	Epiphyses	Other	Shafts	Epiphyses	Other	Shafts	Epiphyses	Other	Shafts	Epiphyses	Other
Humerus		2	0					1	0				
Radius		0	1					0	1				
Ulna		0	1		0	1							
Metacarpals		0	1										
Femur		2	2		0	2							
Tibia		3	3					1	0				
Metatarsals													
Scapula							1			1			
Ribs		4	2		1	0		2	0				
Pelvis													
Skull				1			1						1
Vertebra	**Cervical**												
	Thoracic												
	Lumbar												
	Caudal			2									
	Miscellaneous			2			2			2			

		MB-A3											
		Size 1			Size 2			Size 3			Size 4		
Element		Shafts	Epiphyses	Other	Shafts	Epiphyses	Other	Shafts	Epiphyses	Other	Shafts	Epiphyses	Other
Humerus													
Radius								0	1				
Ulna		0	1										
Metacarpals		0	1										
Femur											0	1	
Tibia		0	1										
Metatarsals		1	0								0	1	
Scapula													
Ribs		4	0										
Pelvis													
Skull							1						
Vertebra	**Cervical**												
	Thoracic												
	Lumbar												
	Caudal			1									
	Miscellaneous			3						2			

Table 6.15 %MNE for Mlambalasi (Calculated with Shafts and Epiphyses and Based on MNI)

	MB-A1					
	Size 1 and Size 2			**Size 3 and Size 4**		
Element	**MNE**	**MNE$_{max}$**	**%MNE**	**MNE**	**MNE$_{max}$**	**%MNE**
Humerus	11	12	91.67	1	6	16.67
Radius	3	12	25		6	0
Ulna	3	12	25		6	0
Metacarpals	1	12	8.33		6	0
Femur	1	12	8.33	1	6	16.67
Tibia	6	12	50		6	0
Metatarsals		12	0		6	0
Scapula	1	12	8.33	1	6	16.67
Ribs	6	156	3.85	3	78	3.85
Pelvis		6	0		3	0
Skull	3	6	50	1	3	33.33
Vertebra	6	156	3.85	1	78	1.28

	MB-A2					
	Size 1 and Size 2			Size 3 and Size 4		
Element	**MNE**	**MNE$_{max}$**	**%MNE**	**MNE**	**MNE$_{max}$**	**%MNE**
Humerus	1	10	10	1	4	25
Radius	1	10	10	1	4	25
Ulna	2	10	20		4	0
Metacarpals	1	10	10		4	0
Femur	6	10	60		4	0
Tibia	6	10	60	1	4	25
Metatarsals		10	0		4	0
Scapula	1	10	10	1	4	25
Ribs	6	130	4.62	2	52	3.85
Pelvis		5	0		2	0
Skull		5	0		2	0
Vertebra	6	130	4.62	2	52	3.85

	MB-A3					
	Size 1 and Size 2			Size 3 and Size 4		
Element	**MNE**	**MNE$_{max}$**	**%MNE**	**MNE**	**MNE$_{max}$**	**%MNE**
Humerus		6	0		4	0
Radius		6	0	1	4	25
Ulna	1	6	16.67		4	0
Metacarpals	1	6	16.67		4	0
Femur		6	0	1	4	25
Tibia	1	6	16.67		4	0
Metatarsals	1	6	16.67	1	4	25
Scapula		6	0		4	0
Ribs	4	78	5.13		52	0
Pelvis		3	0		2	0
Skull	1	3	33.33		2	0
Vertebra	4	78	5.13	2	52	3.85

Table 6.17 Percentage of bone surface modification (tooth marks, TM, percussion marks, PM, and cut marks, CM) on the combined specimens for Mlambalasi with good and moderate preservation (considered well preserved) shown for element.
*non-identifiable to skeletal element
** combined good and good to moderate preservation

	MB-A1			
Element	**NISP (well preserved) ****	**TM**	**PM**	**CM**
Skull	1	0	0	0
Mandible				
Vertebrae	6	0	0	0
Ribs	10	1	0	1
Scapula				
Innominate	2	0	0	0
Humerus	5	1	0	0
radius-ulna	1	0	0	0
Metacarpal				
Femur	1	1	0	0
Tibia	2	1	0	1
Metatarsal				
Phalanges	1	0	0	0
shafts*	34	2	1	5
TOTAL	63	6	1	7
Frequency (%)		9.52	1.59	11.11

	MB-A2			
Element	**NISP (well preserved) ****	**TM**	**PM**	**CM**
Skull				
Mandible				
Vertebrae	2	0	0	0
Ribs	3	0	0	0
Scapula				
Innominate				
Humerus				
radius-ulna				
Metacarpal				
Femur	1	0	0	0
Tibia	2	1	0	1
Metatarsal				
Phalanges				
shafts*	5	0	1	1
TOTAL	13	1	1	2
Frequency (%)		7.69	7.69	15.38

	MB-A3			
Element	**NISP (well preserved) ****	**TM**	**PM**	**CM**
Skull				
Mandible				
Vertebrae				
Ribs				
Scapula				
Innominate				
Humerus				
radius-ulna				
Metacarpal				
Femur				
Tibia				
Metatarsal				
Phalanges	1	0	0	0
shafts*	3	0	0	1
TOTAL	4	0	0	1
Frequency (%)		0	0	25

Chapter 7 – Discussion and Interpretation

7.1 – *Introduction*

In order to best to examine the results that have been generated in this study, each analytical unit will be first considered by itself; followed by a discussion of the general trends exhibited within each site, with special regard to the behavioural modernity debate. Subsequently a necessarily qualitative comparison of the two sites will be undertaken. The Iringa sites will then be compared to other Tanzanian sites with faunal remains in an effort to understand how they fit within the greater East African archaeological framework. Lastly, there will be a brief discussion of the role of limb shafts in this study, as they represent a point of some contention within current zooarchaeological methodologies.

7.2 – *Interpretation of MG-A1*

The combined analyses of MG-A1 are indicative of a significant human-behavioural component, as evinced by the relatively high number of cut marks and the absence of evidence for significant taphonomic bias in the small animal sample. No TM were identified, indicating that carnivore-ravaging did not play a significant role in the assemblage's formation, despite the presence of a small carnivore in the assemblage. The absence of carbonate-coated specimens and the large amount of green fractures is indicative of minor post-depositional attrition and a relatively well-preserved assemblage. These factors, when considered together, offer the possibility of insight into the human behavioural component.

The evenness indices for MG-A1 are indicative of an even-representation of elements, which is reflected in the comparisons of %MAU and SFUI. Interestingly, there is a strong relationship between %MAU and VD for large size animals, which may be resultant of density-mediated processes. Whether this is an artefact of sample bias, the result of human behaviour or a taphonomic effect cannot be determined. The absence of significant relationships between %MAU and SFUI, and %MAU and VD, coupled with the evenness indices for small size animals, may be interpreted as representing an unbiased procurement strategy in which these carcasses were transported largely whole to the site. A large presence of goats within the assemblage adds contextual depth to this hypothesis, as they are typically transported as a complete unit (Robertshaw, 1990).

The large size animal sample from this unit is more difficult to interpret, as there is a significant correlation between %MAU and VD, yet no correlation between %MAU and SFUI. When considered together, these data are indicative of a density-mediated taphonomic factor, such as possible carnivore ravaging. However, the lack of TM within the assemblage and the absence of density-mediated effects on the small size animal sample both argue against a carnivore presence. Therefore there are unidentified taphonomic factors involved that will require future consideration.

The presence of solely domesticated species within this assemblage is indicative of the temporal period to which the assemblage is ascribed (Iron Age), as domesticated fauna are only present in the Iringa region with the onset of the Iron Age (Robertshaw, 1990; Kingdon, 1989). Cut marks, heavy fragmentation and large amounts of burnt and calcined bone may be taken together to hypothesise that this unit represents a possible campsite that was repeatedly used over time. The contextual location of the site (within a rockshelter), is also suggestive of this hypothesis.

7.3 – *Interpretation of MG-A2*

The small sample size of MG-A2 precludes a thorough understanding and interpretation of the assemblage's formational history; however, some broad inferences may be made. Carnivore-ravaging was absent in this assemblage and other taphonomic and post-depositional factors appear to play a small role in the assemblage's formation. This is particularly evinced by the comparatively small amount of carbonate-affected bone and the absence of any relationship between %MAU and VD. If the assemblage were of a larger size, its well-preserved nature might offer insight into the human behavioural component.

The evenness index is suggestive of a biased procurement strategy for small size animals; however, this is most likely the result of the small sample size and not an artefact of human behaviour. Another likely artefact of the small sample size is the complete absence of large size animals, unique for MG-A2 in comparison with the other analytical units. It is unfortunate that the small nature of this assemblage necessitates such a conservative approach towards its interpretation, but until the sample is increased, there is no foundation for any further conclusions.

7.4 – *Interpretation of MG-A3*

MG-A3 is the largest analytical unit of those studied, however it is quite poorly preserved, with almost 90% of the sample being carbonate-affected, thus limiting the scope of the taphonomic analysis. The results of the taphonomic analysis are useful for determining that the assemblage formed in situ and was largely unaffected by carnivores and other non-human taphonomic agents. This indicates that humans played a significant role in the assemblage's formation, proffering the possibility of insight into MSA subsistence behaviour.

Post-depositional mixing processes must be considered though, as a goat tooth was identified in the assemblage and its presence (albeit in the upper levels of the assemblage) should be taken to indicate that this unit is somewhat mixed with the above layer in its uppermost parts. The presence of a reptile vertebra also supports post-depositional mixing, especially as it largely lacked carbonate-coating and is very similar in size and morphology to the reptile vertebra found in MG-A1.

Unfortunately the paucity of CM and PM limits the scope of information that can be directly discerned about the human behavioural component, but skeletal element abundance data is of some relevance. The evenness indices for both small and large animals support the hypothesis of minimal taphonomic interference and suggest an unbiased procurement strategy. While there is no relationship between SFUI and %MAU for small animals, there is a weak relationship between %MAU and VD, indicating some form of density-mediated activity.

The opposite is true of large size animals, with a weak relationship between SFUI and %MAU being found and no relationship between %MAU and VD. This contrastive information may be taken to imply that small and large animals were being treated differently, but it should be acknowledged that the small size animals' MNI estimate outnumbers the large size animals' estimate by six to one. Therefore the nature of the sample has most likely instigated some bias in these results and merits caution for accepting a differential transport hypothesis.

The absence of secure provenance and small estimate of large size animals renders a necessarily conservative approach to the interpretation of MG-A3. There is definitely a human-behavioural component present in this unit, but it cannot be clearly or confidently interpreted at this time. The possibility of differing approaches to small and large size animal carcasses is tantalising, but should be properly vetted through further excavation and study of this unit, and only considered when the unit's formational history is better understood.

7.5 – *Interpretation of MB-A1*

MB-A1 represents the Iron Age levels from Mlambalasi and is the only unit at Mlambalasi that is culturally homogeneous and it features the largest faunal assemblage. The taphonomic analysis indicated that the assemblage was comparatively well-preserved, displaying a reduced incidence of carbonate-coating. This most likely resulted in identification of numerous TM and CM. The presence of an almost equal number of TM and CM indicates that both carnivores and humans had active roles in the assemblage's formation. Limb shaft circumference data and fragmentation data may be taken to indicate that human behaviour was more significant in the assemblage's initial formation, with carnivores impacting the assemblage at a later time. This is in contextual agreement with the unit's ascribed Iron Age date.

Skeletal element abundance data reflected by the evenness indices are indicative of differential procurement strategies for small and large size animals. The unevenness indicated for large size animals is more suggestive of a gourmet procurement strategy, which following Central-Place Foraging models, is associated with greater transportation distances. However, there was no relationship detected for small and large size animals in the other quantitative skeletal element abundance analyses and this negates such a straight-forward interpretation. The absence of density-mediated effects does attest to the well-preserved nature of the assemblage and a relatively minor carnivore-ravaging effect.

Human behaviour can be confidently attributed to playing a significant role in MB-A1's formation, with carnivores playing a smaller, secondary role and post-depositional attrition also being a minor factor. The results of the combined analyses proffer the possibility for differential treatment of small and large size animals. This hypothesis is still preliminary in nature and will require further archaeological excavations and an increased sample size in order to be fully tested. The generally well-preserved nature of MB-A1 lends this hypothesis some initial support; however, carnivores have been identified as a taphonomic factor. Based on the current data, the carnivore effect is thought to be relatively small, but further study is required in order to verify this hypothesis and only then can sound inferences of the human behavioural component be drawn.

7.6 – *Interpretation of MB-A2*

The interpretation of MB-A2 must be necessarily more conservative from the outset, as this unit represents a mix of cultural periods (the Iron Age and the LSA). This mixing is indicative of the absence of secure context for the recovered archaeological materials, including the zooarchaeological assemblage.

The taphonomic analysis attests to the poor-preservation of the MB-A2 fauna, with carbonate-coating having a significant effect. Few bone surface modifications were identified, but TM, PM and CM were all present, indicating both carnivore and human roles in the assemblage's formation. The results of the limb shaft circumference analysis are inconclusive with regard to the relative impacts of carnivores and humans. Unfortunately the poor-preservation of this assemblage impairs the interpretative potential for human behaviour.

Evenness indices for both small and large animals suggest an uneven element representation, and the quantitative tests both indicated no relationship between %MAU and SFUI; and %MAU and VD, for small and large size mammals. Due to the small sample size, poor preservation and inability to account for the role of different agents of accumulation, no hypothesis can be confidently put forth to interpret these data. If human behaviour could be confidently attributed as being significant to assemblage formation, then a differential procurement strategy might be inferred. However, as discussed above, this inference lacks a solid taphonomic and contextual foundation.

7.7 – *Interpretation of MB-A3*

MB-A3, as with MB-A2 represents a mix of cultural periods (the LSA and MSA). This again necessitates a necessarily conservative interpretation from the outset, as the context and provenance are not secure. MB-A3 is also the most poorly-preserved unit, having the highest incidence of carbonate-affected specimens within all of the units studied. Such poor preservation also limits the possible interpretive potential.

The results of the taphonomic analysis indicate the absence or minimal presence of carnivore behaviour in the assemblage's formation, as no TM were identified and the limb shaft circumference ratio was at the extreme lower end of the range. Human behaviour can be attributed to the assemblage, as one CM was confidently identified. Post-depositional attrition also played a large role in the assemblage's formation, as evinced by the high percentage of diagenetic breaks. The small presence of human traces identified within the assemblage, coupled with the poor preservational quality and large amount of post-depositional attrition handicapped any inferences that could be made about the human behavioural component.

The quantitative analyses indicated an uneven elemental representation for both small and large animals. Unevenness is reflected in a weakly significant relationship between SFUI and %MAU for small size animals, and coupled with the absence of a relationship between %MAU and VD, may be interpreted as resultant of human behaviour. If this relationship could be founded on more secure taphonomic footing, the presence of a gourmet procurement strategy, associated with greater transport distances might be cautiously hypothesised. However, this inference is not supported by the conservative approach used in this study.

While the large size animals display a similar evenness value as the small size animals, they exhibit contrastive results with regard to the other quantitative analyses. No relationship was found between %MAU and SFUI, but a very weak relationship was potentially identified for %MAU and VD. This may indicate some density-mediated bias within the assemblage, but the absence of a similar result for the small size animals detracts from this interpretation.

The absence of secure cultural contexts, poor assemblage preservation and a clouded taphonomic history all mitigate against any insight into the human behavioural component within this assemblage.

7.8 – *Discussion and Interpretation of Magubike*

Magubike is comprised of three analytical units, each representing a particular cultural period. The somewhat secure boundaries between the three units allows for some general comments to be made about the site’s formational history and trends observed in the human behavioural component. Again there is a requirement for a cautious approach, as MG-A3 does contain a domesticated goat tooth, indicative of post-depositional mixing and MG-A2 is an extremely small unit.

From a preservational-taphonomic perspective, Magubike generally appears to be in a better condition than Mlambalasi, especially within the upper two units. MG-A1 offers broad insight into Iron Age subsistence practices and has been cautiously hypothesised to be a campsite, where small size animals were brought whole to be consumed. Unfortunately, the human behavioural component from the remaining two units was not as clearly understood, due to the small sample size of MG-A2 and the poor-preservational character of MG-A3.

What can be discussed is the increase in carbonate-affected specimens associated with the increase in temporal and physical depth. The bedrock is predominantly granitic and the area is not karstic, therefore the carbonate-coating may be indicative of past fluvial activity and a somewhat different environment. A study focusing upon the diagenetic and post-depositional attritional processes would shed light on this issue and help to further clarify the site's formational history and taphonomic framework.

Also important in creating the taphonomic framework is the general absence of carnivore-ravaging at this site, with only one TM being found and this in MG-A3. The lack of a significant carnivore presence in all units bodes well for future studies, as this can be used to infer that human behaviour played a large part in the assemblage's formation. With further excavations, more insight into the particular aspects of human subsistence behaviour across the three cultural periods should be achievable.

The current study has been framed to some extent by the behavioural modernity debate. It was discussed at the outset that one of the goals of this research was to try and compare subsistence strategies from the different cultural phases and determine whether these are representative of qualitative differences in behavioural capacity. Unfortunately, with the lack of insight into the human behavioural components from MG-A2 and MG-A3, this has proved an unsuccessful venture for Magubike.

7.9 – *Discussion and Interpretation of Mlambalasi*

Mlambalasi is difficult to interpret, as the analytical units, apart from MB-A1, represent combined cultural periods. General interpretations regarding the site’s formation can still be made, as they are not as reliant upon a discrete cultural framework. Unfortunately interpretations regarding the human behavioural component prove much more complicated.

Mlambalasi can be said to exhibit much poorer preservation than Magubike, with a greater percentage of carbonate-effected bone. The presence of carbonate-effected specimens increases with physical and temporal depth and, as with Magubike, appears to indicate the presence of increased past fluvial activity. This inference can be supported by the granitic nature of the bedrock and absence of karst. Therefore, while Magubike and Mlambalasi have broadly similar environmental contexts, each site’s microenvironment is distinct. A study comparing the two microenvironments, through an examination of microfauna and geomorphology might be quite enlightening. Microfauna within this context are considered to be small organisms, such as snails, rodents, snakes and insects, which are used to indicate microenvironmental conditions (Reitz and Wing, 1999).

Tooth marks are also much more frequent, especially in MB-A1, indicating a greater carnivore presence in the site's formational history. This may be an example of the differing microenvironmental contexts exhibited by the two sites, or a result of sample bias, as the poor preservational nature of both assemblages limited the scope for bone surface modification identifications.

A human behavioural component could be identified in all units. However, only MB-A1 offered insight into possible subsistence practices, with the possibility of the differential treatment of small and large size animals. This interpretation is still quite exploratory, however, with exact nature and extent of the carnivore presence needing to be determined.

The lack of insight for MB-A2 and MB-A3 hampered an attempt to observe and compare subsistence practices from across the temporal depth represented at the site. Even if the human behavioural component offered further interpretative potential, the mixed cultural phases in MB-A2 and MB-A3 would prohibit a specific comparison between the Iron Age, LSA and MSA subsistence practices. Unfortunately, Mlambalasi does not currently provide any insight into the behavioural modernity debate.

7.10 – *Comparison of Magubike and Mlambalasi*

One of the goals of this study was to attempt to conduct a comparison between the subsistence strategies identified at Magubike and Mlambalasi. This comparison sought to evaluate any differences between and within the respective cultural periods in order to both provide insight into the behavioural modernity debate and to examine the range of subsistence behaviours employed by past people in comparatively similar environments.

A comprehensive comparison could not be conducted during this study for two principle reasons, the first being the lack of insight into the human behavioural components from MG-A2, MG-A3, MB-A2 and MB-A3; and secondly because of the culturally mixed levels from MB-A2 and MB-A3. The Iron Age units from Magubike and Mlambalasi can be subjected to a conservative, qualitative comparison, as they both contain information regarding the human behavioural components and exhibit comparatively well-preserved assemblages, situated in a broadly understood taphonomic framework.

The cautious interpretation of MG-A1 is that of a campsite to which small animals were largely brought whole and consumed. MB-A1 offers the potential for the same kind of site, as small size animals appear to have been brought mostly whole to the site. Both units offer the potential for the differential treatment of small and large size animals, but the large size animal sample at MG-A1 may be affected by a currently unknown taphonomic factor while MB-A1 demonstrates a significant carnivore presence that must be taken into account. At the present time, an interpretation of why small and large size animals display such differences, either through human behaviour, taphonomic agents, or both, cannot be made.

7.11 – *Comparison between the Iringa Sites and other Tanzanian Sites*

A broad comparison can also be made between Magubike and Mlambalasi and other Tanzanian sites containing faunal remains. These sites, specifically Mumba-Höhle, Nasera and Lake Eyasi, are found in the Eyasi Basin of Northern Tanzania, as previously mentioned in Chapter 4. The faunal records of the Eyasi Basin sites are similar to those in Iringa in that both assemblages are significantly carbonate-affected, which makes identification and quantification difficult. Unfortunately, the Iringa sites' MSA faunal assemblages appear to have been more effected by carbonate-coating, inhibiting any substantial comparison with those from the Eyasi Basin (Dominugez-Rodrigo, pers. comm., September, 2008). What can be noted is that the MSA assemblages from both parts of Tanzania demonstrate a large bovid component, as well as the presence of equids. The Eyasi material also contains some extinct species, while none were identified from Magubike and Mlambalasi (Mehlman, 1989; Mabulla, 2007).

LSA faunal assemblages from the Eyasi Basin, dating from approximately 45kya to 5kya, demonstrate a greater diversity in fauna, with fish and birds being comparatively well represented (Mabulla, 2007; 1996; Mehlamn, 1989). An absence of fish in the Iringa faunal assemblages is to be expected, as there are no substantial water sources nearby, in contrast to the Eyasi Basin sites, which are located near Lake Eyasi. Some bird remains were identified at Magubike and

Mlambalasi, but they are extremely rare and predominantly found in the Iron Age levels. The Eyasi Basin sites also contain floral remains (predominantly baobab), indicative of plant-gathering foraging behaviours, while no floral remains have yet been recovered from Magubike or Mlambalasi (Mabulla, 2007).

Both the Eyasi Basin and the Iringa LSA assemblages display evidence of burning and fragmentation, possibly indicative of human food preparation techniques. Other similarities between the Eyasi Basin and Iringa sites include the repeated use of rockshelters and the strong possibility of exchange networks, indicated by the presence of non-local lithic materials (Mabulla, 2007; 1996; Mehlman, 1989; Biittner, *et al.*, 2006).

The Iron Age assemblages of the two regions are difficult to compare, as their late Holocene cultural histories are quite distinct. The Iringa region witnessed the arrival of Bantu-speaking peoples approximately 3kya, sparking the onset of the Iron Age in this part of Tanzania. In contrast, the Eyasi Basin saw an influx of pastoralists from further north around 5kya, resulting in a Pastoral Neolithic period associated with the introduction of ceramics and domesticates (Marshall and Hildebrand, 2002). Subsequently, around 1,800 years ago, there is evidence in the Eyasi Basin for the production of metals and possible plant domestication, indicating the onset of the Iron Age (Mabulla, 2007; Marshall and Hilderbrand, 2002). The faunal assemblages from both regions at this time consist of the first appearance of domesticates, as well as the continued presence of wild species. The Eyasi Basin assemblages again demonstrate a greater range of faunal diversity, with an increase in fish, birds, reptiles and suids (Mabulla, 2007; Mehlamn, 1989). This contrasts with the Iringa assemblages, which demonstrate a narrow taxonomic diversity, dominated by caprids and bovids.

Both the Eyasi Basin sites and Magubike and Mlambalasi demonstrate broad similarities in their faunal assemblages, especially with regard to the high frequencies of carbonate-affected specimens. The Eyasi Basin sites, however, demonstrate greater taxonomic diversity, which may be resultant of the differing local environments, the size and preservation of the respective assemblages and the ability of the researcher to identify to taxonomically distinctive levels. Future excavations and the further recovery of faunal materials from the Iringa region should facilitate more sensitive comparisons.

7.12 – *The Role of Limb Shaft Fragments*

Chapters 4 and 5 have extensively discussed the contentious nature of incorporating limb shaft fragments into the analytical sample. On the well-demonstrated strength of the "Shaft Critique" espoused most comprehensively by Marean and colleagues (2004), this study included limb shaft fragments within the analytical sample.

It has been noted above that by including limb shaft fragments from the outset, the analyst may be able to increase MNE estimates by following the rubric outlined in Barba and Dominguez-Rodrigo (2005). The current study greatly benefited from the, albeit more time-consuming, effort made to identify shaft fragments. Without the inclusion of shaft fragments, estimates of all identifiable long bone elements would be significantly less, subsequently affecting MNE and

MNI estimates, as well as the qualitative analyses that were conducted. Decreased estimates would have further limited the analytical power of the qualitative analyses and necessitated an even less specific interpretation of the human and taphonomic components.

In order to demonstrate the importance of retaining limb shaft fragments within the analytical sample, one need only look at the NISP counts for each analytical unit (see Tables 6.2 and 6.14). These data demonstrate that for each unit, the overwhelming majority of specimens identified are limb shaft fragments and without including them in the sample, NISP estimates for each unit would be significantly less.

While it can be correctly argued that limb shaft fragments identified as indeterminate have no value for MNE and MNI estimates, this does not mean that they lack analytical and interpretive value. The majority of the taphonomic analyses conducted relied heavily upon limb shaft fragments as a source of information. In particular, the majority of bone surface modifications were found on limb shaft fragments (this includes trampling marks, biochemical marks, TM, CM and PM), which is in keeping with the published literature on the topic (Marean and Frey, 1997; Marean and Spencer, 1991; Marean, 1998; Marean and Kim, 1998; Marean, *et al.*, 2004; Dominguez-Rodrigo, *et al.*, 2007; Dominguez-Rodrigo, 1997; Bunn, 1982; Bunn and Kroll, 1986). Without the inclusion of limb shaft fragments, the taphonomic analysis would have been considerably vaguer, decreasing the acuity of the results and interpretations that this study has put forth in favour of those that are necessarily broader and more conservative.

Other taphonomic analyses, such as the identification and interpretation of fragmentation and fracture patterns, and the limb shaft circumference ratios would again be largely biased without the inclusion of limb shaft fragments. Through discarding limb shaft fragments at the outset (as advocated by some, see Klein and Cruz-Uribe (1984)), one dismisses a large proportion of the assemblage that has a significant analytical effect. The data and resulting interpretations of the analyses mentioned above would be significantly different were limb shaft fragments to be excluded, leading to specious conclusions regarding the relative roles of human and taphonomic agents (Marean, *et al.*, 2004).

7.13 – *Summary*

This chapter has attempted to interpret the results of the analyses with regard to specific questions that were posed at the outset of this study. Taphonomic interpretations proved to be the richest source of information, generating insight into each analytical unit's formational history. These units were compared and contrasted to generate conservative taphonomic frameworks for both Magubike and Mlambalasi; however future research in this area is required and should be strongly contemplated during the next phase of excavation.

Human subsistence behaviour was only able to be cautiously identified in the Iron Age units from Magubike and Mlambalasi (MG-A1 and MB-A1). The poor preservational nature and small sample sizes variously apparent in the remaining units precluded any interpretation of human subsistence behaviour being ascertained. Both MG-A1 and MB-A1 appear to demonstrate unbiased procurement strategies for small size animals and both units are cautiously considered to represent campsites where carcass processing and consumption took place. MG-A1 and MB-A1 may both possess an indication of differential procurement strategies for small and large size animals, but this will need to be further clarified with continued research.

Unfortunately, the absence in interpretive scope for human behaviour from the LSA and MSA units precluded the utility of the current study with regard to the behavioural modernity debate. A broad comparison with other Tanzanian sites from the Eyasi Basin was accomplished and demonstrated both similarities in the preservational nature of the faunal remains and differences regarding the diversity of fauna present. The Magubike and Mlambalasi LSA and Iron Age assemblages displayed less faunal diversity than those from the Eyasi Basin, which is likely the result of both different environmental contexts; and the difficulty encountered in identifying particular taxa at the Iringa sites.

Limb shaft fragments were found to be crucial to the analytical power of this study. Without their inclusion, this study would have lacked the interpretive ability it currently has and would have yielded less insight into the taphonomic and human behavioural components of both sites’ formational histories.

Chapter 8 – Conclusions

8.1 – *Introduction*

The results of this study have been discussed and interpreted within current taphonomic and zooarchaeological methodological frameworks. This study has been able to illuminate a portion of the formational histories for both Magubike and Mlambalasi and provide insight into possible human subsistence strategies present in the Iron Age levels at both sites. In concluding this study there are two areas that will be given some consideration: problems and issues that have affected this study, with reference to improvements that can be made in subsequent analyses; and future directions and research questions that have arisen.

8.2 – *Problems and Issues*

There are three problems, or issues, which impeded the insightfulness of the current study: poor sample preservation, small and culturally heterogeneous samples, and analyst experience. Despite being the first recovered faunal remains from the LSA and MSA in the Iringa region, the overall poor preservational nature of the faunal assemblage mitigated against a more comprehensive identification of the sample. Better preserved specimens would have proved easier to identify to both element and taxon, as key landmarks would have been more apparent and frequent. Often, especially with heavily fragmented assemblages, small morphological landmarks indicative of a particular element or taxon provide one of the only means of identifying the specimen (Barba and Dominguez-Rodrigo, 2005; Reitz and Wing, 1999). With the ubiquity of carbonate-coated specimens, it may prove to be of some use for future studies to establish a method of acid washing that proves to be both time-effective and productive in increasing the number of well-preserved specimens.

Small sample sizes provided another barrier to greater interpretive insight. This is one issue that can be easily remedied, however. The exploratory nature of this study, being based on several test pits only, precluded the generation of a large sample at the outset, with poor preservation further reducing the sample's size. With subsequent excavations, it is hoped that more faunal remains will be recovered and thus larger assemblages generated. Bigger samples would greatly help the quantitative aspects of the study, allowing for more powerful statistical results and the possibility of applying other statistical analyses that require larger samples. Increasing and strengthening the quantitative portion of the analysis would provide further insight into both the human and taphonomic components of the assemblage's formation.

Maintaining secure provenance and context are critical for conducting comparative studies. Units with heterogeneous cultural representation cannot be compared with other units in order to assess trends, similarities and differences in human behaviours and taphonomic processes. Careful excavation and the incorporation of both geomorphological and micromorphological perspectives, are required to identify the agents and post-depositional processes that are generating these effects. Once these processes can be identified and the cultural periods can be disentangled from one another, comparisons between subsistence behaviours exhibited in the MSA, LSA and Iron Age can be made and inferences with regard to the behavioural modernity debate drawn.

It was hoped that the conservative approach adopted by the analyst precluded errors and misidentifications from playing a significant part in the current study. In following such an approach and despite access to the excellent reference collection at the Harvard University's Museum of Comparative Zoology, taxa were extremely conservatively identified. This was undertaken due to the close morphological similarities exhibited amongst African ungulates and the author's relative novitiate in this area. With further training and experience, the author intends to provide a more detailed future analysis of both the macro- and microfauna, generating further insight into the assemblages' formational histories.

Incorporating a specialist in African microfauna into the research design would also be of great use, as the microfaunal component of the zooarchaeological assemblage has not yet been addressed. Microfauna, such as snails, insects and small mammals, are important indicators of paleoenvironmental conditions and the presence of bioturbation agents (Lyman, 1994; Reitz and Wing, 1999). A comprehensive faunal analysis comprising both the macro- and microfaunal elements would generate significant insight into the formational history of both sites.

8.3 – *Future Research*

It is hoped that further, more comprehensive excavations will be undertaken at both Magubike and Mlambalasi, as both sites provide rich sources for insight into the development of modern human behaviour. Future excavations will hopefully encompass a more holistic approach, incorporating a variety of specialists from amongst the archaeological sub-disciplines. Paramount amongst them should be a geoarchaeologist who specialises in geomorphology and micromorphology, as the results of this study indicate that there are complex post-depositional processes at work, particularly evinced by the lack of secure provenance in the lower two units from Mlambalasi (MB-A2 and MB-A3). It would also prove extremely insightful to be able to ascertain what is causing the high incidences of carbonate coating on the archaeological materials.

Future research should focus on strengthening the taphonomic framework initially constructed in this study, as only by securely identifying and acknowledging the taphonomic factors present within an assemblage's formational history can productive inferences be drawn regarding the human behavioural component. The current study, being of an exploratory nature, has laid the broad groundwork for a taphonomic framework, but it needs to be further bolstered with future excavations and research.

Unfortunately, the results generated by the current research proved to be largely unsuccessful in identifying human subsistence behaviours from Magubike and Mlambalasi. It is hoped that with future excavations and larger samples, more insight can be obtained. As mentioned above, the two sites offer a unique opportunity to explore the behavioural modernity question from a zooarchaeological perspective, as they contain the first recovered faunal materials from the LSA and MSA in the Iringa region. Further research should also maintain a focus on this question and compare the subsistence behaviours present in the MSA to those from the LSA.

Another interesting topic would be examining the change in subsistence patterns from the LSA to the Iron Age, as the Iron Age is associated with the arrival of first domesticates. How domesticates impacted the zooarchaeological record and when they arrived in the region are both pertinent research questions. This area of research may also prove to be the most fruitful, as it encompasses the better preserved part of the faunal assemblage.

Regarding the Iron Age assemblages, future research should focus on the possible differential treatment of small and large size animals at MG-A1 and MB-A1. If the differential representation of small and large size animals is accurate, then hopefully insight into whether this faunal pattern is reflective of particular subsistence behaviours, or if it is resultant of different taphonomic agents, can be achieved.

Geoarchaeological and microfaunal research into the microenvironments of both sites would also be productive. The taphonomic analysis indicated that different taphonomic and post-depositional agents may play significantly different roles at each site, with both carbonate-coating and carnivore-ravaging proving to be more ubiquitous at Mlambalasi. A comparison of the two sites' microenvironments would also help to establish a more comprehensive paleoenvironmental context for any subsequent research that would compare and study the subsistence patterns from both sites.

8.4 – *Final Remarks*

The study of the faunal remains recovered from the test excavations at Magubike and Mlambalasi has been largely successful in generating an initial taphonomic framework. A transparent, thorough methodology incorporating rigorous zooarchaeological and taphonomic methodologies, in tandem with a conservative approach, was successfully used in analysing the faunal assemblage.

Unfortunately, human subsistence behaviours proved difficult to discern from the current data. It is hoped that future excavations, expanding the current faunal assemblage, will facilitate a more comprehensive analysis of the formational histories of Magubike and Mlambalasi, including their human behavioural components and taphonomic histories.

The current study has been of a necessarily exploratory nature and while not being able to address all of the questions initially (and somewhat ambitiously) posed, was productive in generating as much insight and information possible from the data available. As with any research, mistakes are to be learned from and experience is never easily attained. That being said, this research project was intended, in part, to be a learning experience and the author has learnt a great deal and is a better zooarchaeologist for it. Despite still being at a relatively early stage in his zooarchaeological career, the author, through incorporating a conservative approach, feels that he has been able to provide a sound foundation upon which future zooarchaeological and taphonomic analyses can be conducted.

Both Magubike and Mlambalasi deserve the best, not only because of their unique and important archaeological records, producing the first LSA and MSA faunal assemblages in the Iringa region, but also because of the complexity inherent in understanding these records. The complicated preservational nature of Magubike and Mlambalasi require experience, patience and skill, and it is hoped that both the current study has done them justice; and that future studies will be able to rise to the challenge.

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