TAPHONOMY AT KALKBANK: A LATE PLEISTOCENE SITE IN THE LIMPOPO PROVINCE, SOUTH AFRICA

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A research report submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg, in partial fulfillment of the requirements for the degree of Master of Science.

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DECLARATION

I declare that this thesis is my own, unaided work. It is being submitted for the degree of Master of Science in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

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ABSTRACT

Drawing on the large body of taphonomic, ethnoarchaeological, and general zooarchaeological literature currently available, the main goal of this research report is to provide the first comprehensive taphonomic account of the fauna at Kalkbank in order to establish whether humans, carnivores, or other natural processes were the major accumulators of the assemblage.

Through examination of species presence and abundance, patterns of bone breakage, various surface modifications to the bones, several aspects of skeletal part representation, and mortality profiles, it has been proven that carnivores were the main agent of accumulation. Furthermore, it has been determined that the site accumulated sometime during the late Pleistocene, but closely resembles several open-air sites dated from the Acheulean.

ACKNOWLEDGEMENTS

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CHAPTER 1: INTRODUCTION

The reanalysis and reinterpretation of archaeological sites is fundamental to the study of archaeology as a whole. Sites such as Olduvai Gorge and Klasies River Mouth have been analyzed numerous times by numerous researchers, leading to revised interpretations of the sites, as well as new research methods for conducting thorough zooarchaeological and taphonomic investigations (see Klein 1999 and references within for an overview of the Olduvai Gorge and Klasies River Mouth sites). Reanalysis is also crucial to sites excavated prior to the onset of large-scale taphonomic studies which began in the 1960s, 70s, and 80s. Taphonomic studies attempt to understand what happens to an organism after its death until its discovery. The recognition of these processes provides insight into the life history of the once living organism, and when interpreted properly, leads to a clearer understanding of the significance of a faunal assemblage. Kalkbank is one of these sites that warrant reanalysis and reinterpretation.

Previous Research

The Kalkbank site is located on the farm De Loskop, 64 kilometres northwest of Polokwane (formerly Pietersburg) in the Limpopo Province, South Africa (Mason *et al*. 1958). A map depicting the location of Kalkbank in relation to other major South African cities can be seen in Figures 1.1 and 1.2. At Kalkbank, Revil Mason first excavated a 5 x 8 metre area of the site in 1954, uncovering 3 619 faunal remains and 88 stone artifacts. All bones and artifacts were contained within a 20 centimetre thick horizon overlain by two to three hardpan calcrete layers up to 1,2 metres in thickness (Mason *et al*. 1958; Mason 1962; Netterberg 1974). A second excavation undertaken in 1966, also by Revil

Mason, revealed a further 2 775 faunal remains and 42 stone artifacts (Brown 1988). In total, an area of 190 m^2 was excavated, revealing 6 394 faunal remains and 130 stone tools at Kalkbank (Brown 1988; Mason 1988a). Plan and section views of both excavations can be seen in Figures 1.3 – 1.6. Over the years numerous faunal analysts studied the Kalkbank material, leading to various interpretations of the principal bone accumulator. What follows is a brief overview of the work of previous analysts and their interpretations of the site.

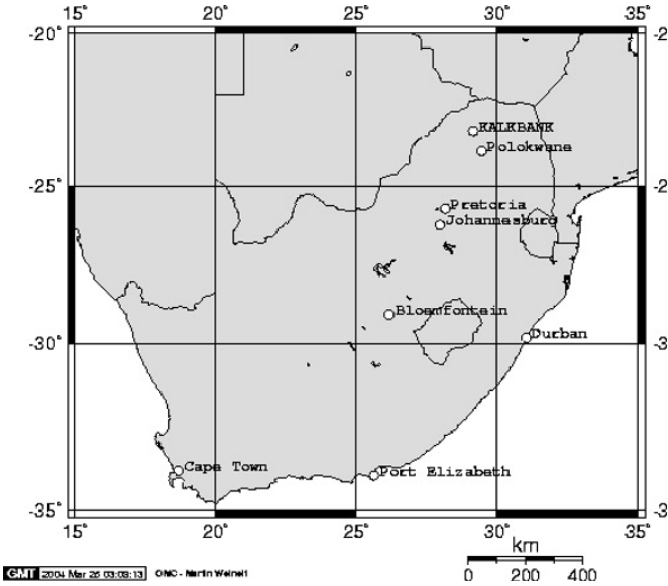


Figure 1.1. Map of Kalkbank's location near Polokwane in relation to major South African cities.

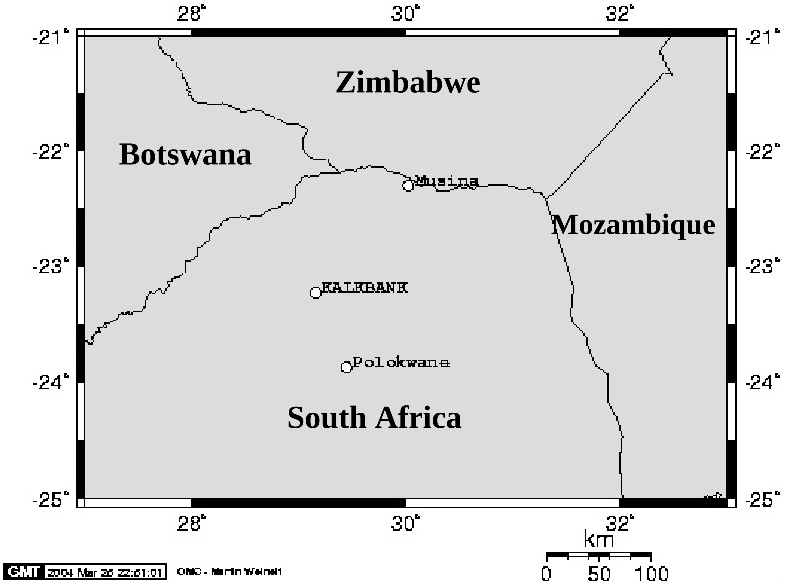


Figure 1.2. Close-up map of Kalkbank's location in the Limpopo Province, South Africa.

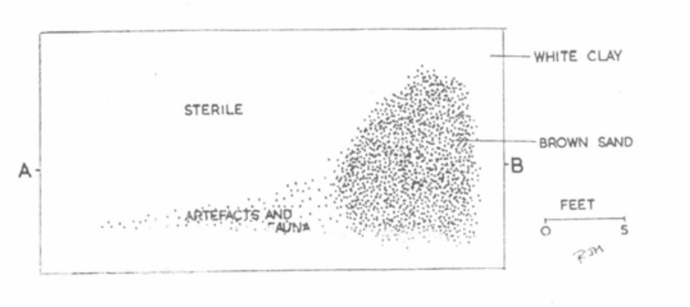


Figure 1.3. Plan view of the 1954 excavation. From Mason *et al*. (1958: Figure 3). North arrow not provided.

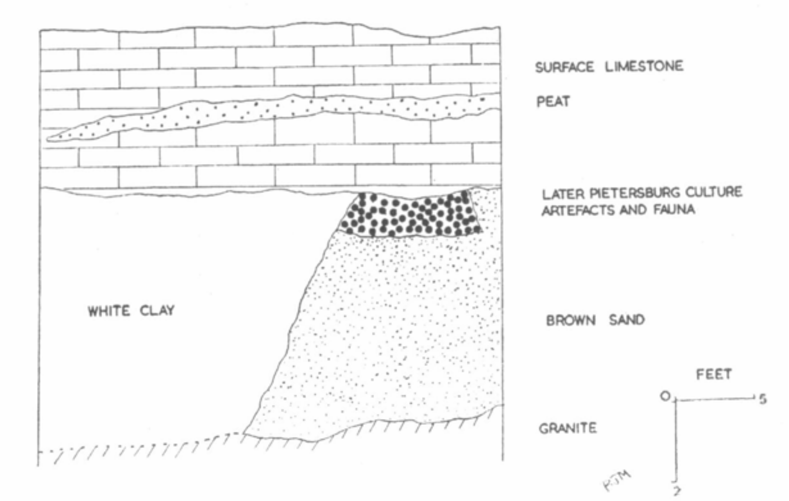


Figure 1.4. Section view (A-B in Figure 1.3) of the 1954 excavation. From Mason *et al*. (1958: Figure 4).

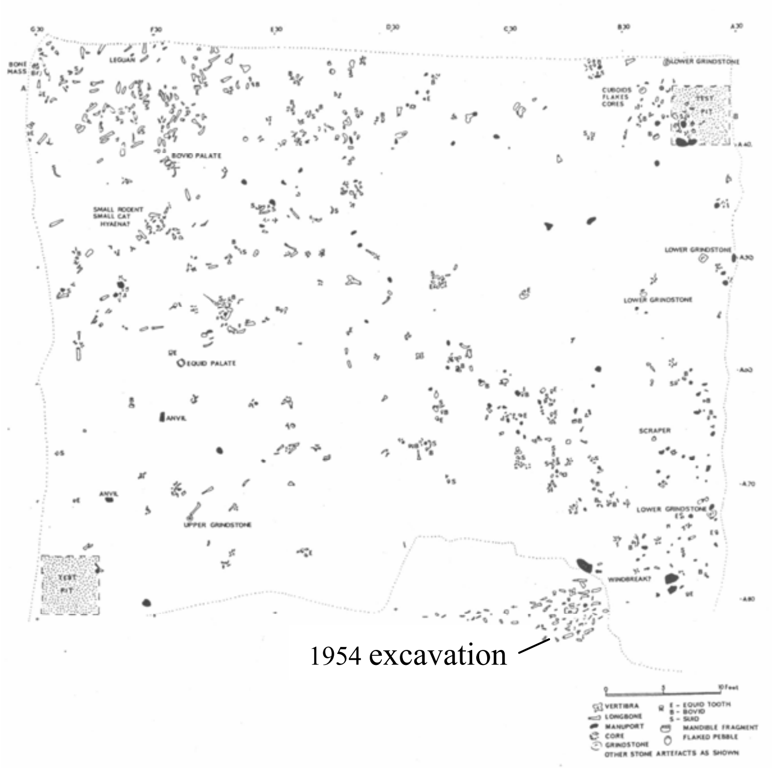


Figure 1.5. Plan of the 1966 excavation, including the 1954 excavation. From Mason (1988b: Figure 150). North arrow not provided.

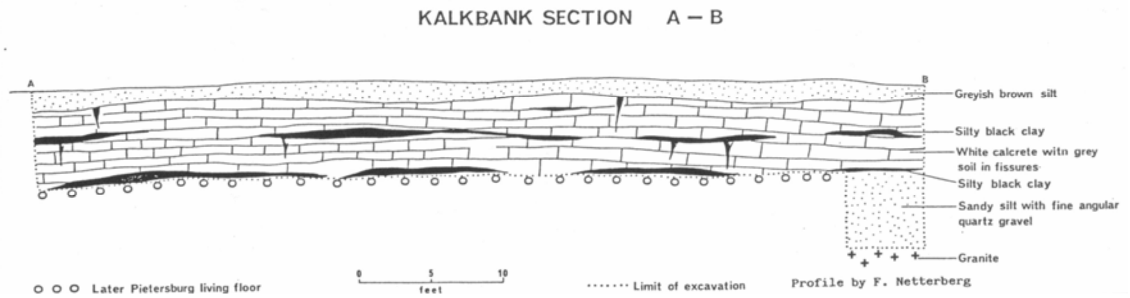


Figure 1.6. Section of the 1966 excavation. From Mason (1988b: Figure 151).

H. B. S. Cooke (1962) studied much of the faunal material from the 1954 excavation, along with R.F. Ewer (1958, 1962), who studied only the Suids. Together, they identified 38 mammalian individuals represented by 15 species on the basis of 1 040 cranial and 847 post-cranial remains (see Table 1.1). They noted the presence of three extinct species: the Giant Cape zebra (*Equus* *capensis*), giant hartebeest (*Megalotragus priscus*), and giant longhorn buffalo (*Homoioceras sp*.), which typify Late Pleistocene faunal assemblages usually associated with Middle Stone Age archaeological sites in the area (Cooke 1962). Of the 3 619 faunal remains, 24,5% (903) were deemed to have been gnawed by porcupines (Mason *et al*. 1958:97).

Table 1.1. Species lists obtained by previous analysts. Numbers represent MNI, (?) denotes uncertainty regarding presence or absence, (-) denotes absence.

Species	Cooke (1962)	Welbourne (1971)	Brown (1988)
Homoioceras sp., Giant longhorn buffalo	1	-	-
Alcelaphus buselaphus, Red hartebeest	3	2	4
Connochaetes taurinus, Blue wildebeest	5	5	6
Aepyceros melampus, Impala	1	1	2
Kobus ellipsiprymnus, Waterbuck	2	-	-
Antidorcas marsupialis, Springbok	1	4	3
Antidorcas bondi, Bond's springbok	-	3	3
Damaliscus pygargas, Blesbok	1	3	6
Taurotragus oryx, Eland	-	-	1
Redunca fulvorfula, Mountain reedbuck	-	1	1
Megalotragus priscus, Giant hartebeest	-	4	4
Giraffa camelopardalis, Giraffe	1	-	-
Equus capensis, Giant Cape zebra	4	3	3
Equus burchelli, Burchell's zebra	6	4	9
Phacochoerus aethiopicus, Warthog	8	11	21
Diceros bicornis, Black Rhinoceros	2	1	1
Hippopotamus amphibius, Hippopotamus	-	1	1
Loxodonta africana, Elephant	-	-	1
Panthera leo, Lion	1	-	-
Panthera pardus, Leopard	2	-	-
Crocuta crocuta, Spotted hyaena	?	1	1
Ichneumia albicauda, White-tailed mongoose	-	1	1
Hystrix africaeaustralis, Porcupine	-	-	1
cf. *Georychus capensis yatesi,* Mole	-	1	-
Struthio camelus, Ostrich	-	-	1
Tortoise sp.	-	-	1
Mollusk sp.	-	2	-
Crab sp.	1	-	-

Early interpretations, based on evidence from the 1954 excavation, focused on linking a number of “bone tools” identified at Kalkbank and the "osteodontokeratic assemblage" described by Dart (1957) at Makapansgat, just 80 kilometres to the southeast. According to Mason *et al*. (1958), both sites display comparable treatment of mammalian long bones as bone tools and weapons. For example, humeri provided clubs and "pounders", metapodials produced stabbing and digging tools, and tibiae provided for use as clubs or "perforant tools" (Mason *et al*. 1958). These similarities led Mason to conclude:

> The Kalkbank evidence shows that stone age people could depend almost entirely on bone tools at some sites, and moreover, that a skilled stone tool-maker of the *Homo sapiens* grade could make bone tools little different than those associated with the australopithecines, perhaps half a million years older (1962:101).

Although the authors presented convincing evidence for similarities between the two assemblages (see Mason *et al*. 1958: Figures 1-11), it has been proven that implements argued to represent an osteodontokeratic culture result from the natural properties of bone fracture (Myers *et al*. 1980; Shipman 1981; Haynes 1983; 1991).

R.G. Welbourne (1971) later studied 268 cranial specimens from the 1966 excavation (see Table 1.1). The major contribution of this analysis was the inclusion of Bond's springbok (*Antidorcas bondi*) to the species list. Little else came of his analysis as Kalkbank was not the focus of the study, and humans were still thought to have accumulated the entire faunal assemblage.

Brown (1988) identified 20 species and 71 individual animals from 1 527 skeletal parts (see Table 1.1). However, she was not given the entire assemblage for study (Brown, personal communication). A small-scale taphonomic description of the assemblage was also undertaken at this time. Butchering damage was found on 4 specimens, 4 specimens were burnt, and 3,6 % of the assemblage was gnawed. Of the gnawed bones, 198 specimens were modified by porcupines, 24 by small rodents, and 11 by carnivores. Concerning skeletal part frequencies, Brown (1988) attributed the lack of phalanges to the "schlepp effect", in which the phalanges may have been attached to animal skins used to transport meaty limb portions back to a campsite (see Perkins and Daley 1978). From the small number of stone tools and few butchery marks, Brown (1988:209) determined Kalkbank to be a kill or butchery site. However, Mason (1988a:201) did not rule out hunting by carnivores and animals dying in the vicinity of a water supply as factors in accumulation.

Research Goals

Drawing on the large body of taphonomic, ethnoarchaeological, and general zooarchaeological literature currently available, the main research goal of this study is to provide the first comprehensive taphonomic account of the fauna at Kalkbank in order to establish the agent or agents of accumulation. More specifically, by examining the entire faunal collection with modern taphonomic methods, the aim of this study is to demonstrate whether humans, carnivores, or other natural processes were the major accumulators of the Kalkbank faunal assemblage.

Methods to be included in this comprehensive taphonomic analysis concern bone breakage patterns, various surface modifications to bones, several aspects of skeletal part representation, and mortality profiles. Patterns of bone breakage, revealed through the analysis of a “Completeness Index” and long bone breakage, are employed to determine if natural processes, physical and chemical, have altered the makeup of the assemblage in any way. Surface modifications, namely porcupine gnawing, carnivore damage, human butchery damage, and burning offer tangible evidence for a particular agent of accumulation, especially when an overwhelming proportion of one type of damage is present. Although root etching and insect damage do not aid in the determination of the agent of accumulation, they do offer relevant taphonomic data about the site. Skeletal part representation in terms of presence, absence, and abundance, used in conjunction with long bone completeness and cranial-postcranial ratio, is used determine patterns in the assemblage indicative of a specific accumulating agent. Likewise, mortality profiles often show a distinction between carnivore, human, and natural accumulations. Also included in this study is a brief review of previous research dealing with the Kalkbank site, and issues such as reconstructing the palaeoenvironment, dating, and comparisons to other archaeological and palaeontological sites within southern Africa.

CHAPTER 2: KALKBANK—GEOLOGICAL SETTING AND PALAEOENVIRONMENTAL RECONSTRUCTION

The Kalkbank site lies at 1 100 metres above sea level in a region of grass and bush-covered granite and gneiss Archaean Complex plains. A single prominent granite ridge, called Kameelkop (Ziervogelkop), rises 300 metres above the level of the Kalkbank flats a few kilometers north of the site. The dominant geological feature at Kalkbank is a thick bed of surface calcrete, known to cover several acres, probably indicating the site of an ancient pan (Mason *et al.* 1958). Pan sediments, especially calcrete, are useful in the reconstruction of vegetation and palaeoclimate during and immediately after deposition of an assemblage. Unfortunately, the Kalkbank calcretes were found to be devoid of the pollens (Mason 1967) upon which many researchers base palaeoenvironmental reconstructions when dealing with calcrete. However, in the absence of palynological evidence, a general understanding of pan and calcrete formation can be used in conjunction with stratigraphic and faunal evidence for a site-specific palaeoenvironmental reconstruction of Kalkbank at the time of accumulation.

Pan Formation

Pans are impermanent or seasonal lakes, occurring in many arid and semi-arid regions of low relief with less than 500mm of precipitation per year or 1000mm of free surface evaporation (Goudie and Thomas 1985). The formation of pans is largely governed by the interaction of several factors: a suitable substrate of easily weathered rock (Marshall and Harmse 1992; De Briuyn 1971); drainage disruption due to tectonic uplift or climate change (Marshall and Harmse 1992; Marshall 1988; Shaw 1988; Cooke and Verstapen 1984); deflation of sediments through wind erosion (Verhagen 1991; Lancaster 1978; Le Roux 1978; Boocock and van Straten 1962); and animal activity (Verhagen 1991; Le Roux 1978). Of concern here is climate change, namely the transition to a drier climate, which led to the formation of several layers of calcrete at the site.

Netterberg (1969b) indicates that former pan surfaces are often associated with hardpan calcretes, similar to the ones found at Kalkbank. Numerous other South African archaeological and palaeontological sites bear remnants of calcrete formations and relic water accumulations, such as, Doornlaagte (Mason 1966; Butzer 1974), Elandsfontein (Butzer 1973), and Swartklip (Hendey 1969; Klein 1975). However, no such accumulations have been found in a similar setting as Kalkbank in the Limpopo Province.

Calcrete Formation

Calcrete is known to form in several ways, all of which are poorly understood. But, it is known that calcrete generally results from the cementation and replacement of calcium carbonate into soil profiles in areas where groundwater becomes saturated with calcium carbonate (Watts 1980). Initially, calcium carbonate, originating from groundwater, rainwater, dust, terrestrial gastropods, vegetation litter, and rock, among other sources (Goudie 1973, 1983; Machette 1985), gets deposited on the ground surface and then dissolved by rainwater. The carbonate is then filtered down into the soil profile, and upon evaporation, the carbonate eventually solidifies into nodular calcrete and ultimately develops into thick hardpan calcretes (Netterberg 1980). Other forms of calcrete vary in hardness and structure from the very loose calcareous soils, calcified soils and powder calcretes, to the more consolidated nodular and honeycomb calcretes. Some researchers (Goudie 1983; Netterberg 1969a, 1969b) have suggested that these forms follow an evolutionary continuum, from the least consolidated calcareous soils to the hardpan. However, calcrete often goes through a cycle of degradation and regeneration due to dissolution from rainwater, groundwater, or humic acid from plants, so that many calcretes are composed of several generations of accumulations, which become reincorporated into previous generations (Goudie 1989).

Stratigraphy

A general profile of the Kalkbank calcrete, fossil horizon, and underlying sediments are shown in Figure 2.1. The dominant stratigraphic features at Kalkbank are several thick layers of hardpan calcrete, with layers of silty sand or sandy clay interspersed between them. Netterberg (1974) notes that two to three hardpan calcretes directly overly the 0,3m thick fossil horizon. In some places, the lower hardpan is absent and replaced by white, sandy clay with 5mm nodules and 120mm thick patches of powder calcrete.

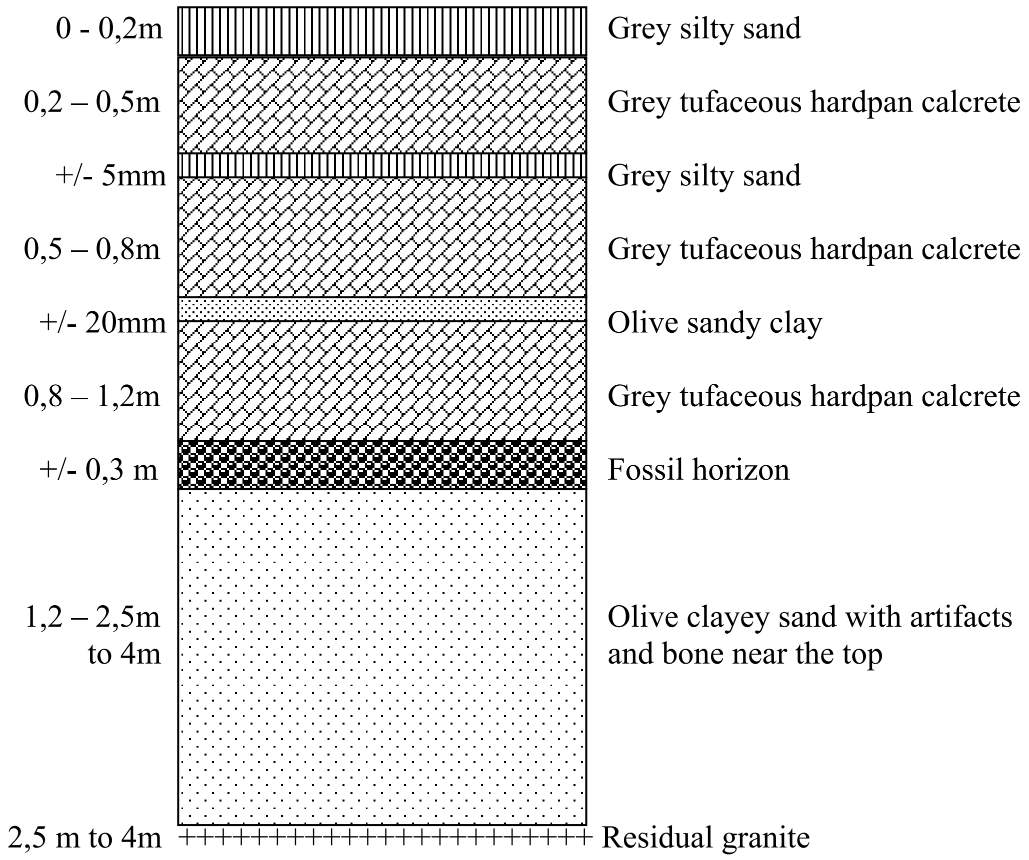


Figure 2.1. Kalkbank stratigraphy based on Netterberg (1974) and Mason (1988b).

Palaeoenvironment

Since no pollen was found in any of the calcrete hardpans, only the calcrete morphology, the presence of a pan, and the recovered fauna can be used to reconstruct the palaeoenvironment at Kalkbank. Even with this evidence, little more than the immediate environment around the Kalkbank pan can be determined. But, overall, the palaeoenvironment at the time of accumulation does not seem much different to the environment of the present day.

Due to the presence of calcrete at Kalkbank instead of silcrete or dolocrete, particularly arid or saline conditions are not indicated (Netterberg 1974). As mentioned previously, most modern pans are distributed throughout areas with less than 500mm of rainfall per year or 1000mm of free surface evaporation (Goudie and Thomas 1985). The average yearly rainfall of Polokwane, 64 km to the south-east of Kalkbank, from the years 1961-1990 is just 478mm, and the average daily high temperature recorded is 25°C (South African Weather Service, 2003), offering high enough average temperatures for considerable free surface evaporation and pan formation. All of the hardpans contain fossil gastropod shells that are typical of the porous diatomaceous hardpans associated with present day pans in the Kalahari. As the calcrete does not suggest extremely arid conditions, it seems likely that the local climate during deposition was similar to that of the present day.

The previously identified faunal remains also indicate a climate similar to the present. The list of identified species in Table 1.1 includes typical grass and open woodland animals, most of the large ungulate species being grazers, while a few are both browsers and grazers. Only the black rhinoceros is strictly a browser, thus the immediate environment likely consisted predominantly of grassland with some open woodland nearby. There may also have been grasses, reeds, or sedges in and around the pan, as many of the bones exhibit prefossilisation root etching, a topic that will be dealt with in a later section.

According to Mason (1988a), the lower part of the profile, the olive, clayey sand seen in Figure 2.1, was deposited by combined colluvial and alluvial action related to pan formation, prior to site formation, followed by the deposition and calcification of the overlying calcrete. Although the climate at the time of deposition seems to be much the same as it is today, the climate sometime in the intervening millennia was probably drier during the formation of the calcretes. Netterberg (1974) believes that the hardpans indicate an aggrading soil profile associated with deflation, and therefore a more arid climate after the bones and stone artifacts were deposited. Stable isotope measurements on the upper hardpan indicate considerable evaporation during calcrete formation (Netterberg 1974), thus a drier climate. So, evidence from the pan itself and the calcrete hardpans suggests that the pan formed in a climate similar to that of today, followed by the formation of calcrete due to a drier climate with more evaporation than rainfall soon after the Kalkbank site was deposited.

CHAPTER 3: DATING KALKBANK

Attempts to date Kalkbank have provided some insight into the time frame from which the site accumulated. However, published data on the age of Kalkbank can be argued. Previous dates for the site relied solely on relative dating techniques and C^{14} samples taken from the calcrete. The use of stone tools and fauna in dating are generally reliable, on the other hand, there are many inaccuracies associated with the use of C^{14} to date calcrete. Here, the calcrete is only used as an indicator of palaeoclimate related to its formation.

Stone Tools

The small stone tool assemblage led to early published dates of the Kalkbank site. A list of the stone tool types found at Kalkbank is shown in Table 3.1. The majority of the recognizable tool types are grindstones or heavy "pounding" artefacts (Mason 1988a:202). According to Mason (1962, 1988a), the flakes and cores, mostly made from quartz, quartzite, and diabase, are not diagnostic of any period, but similar grindstones found at Cave of Hearths MSA unit 6-15 link Kalkbank to the Later Pietersburg, dated to between 30 000 and 15 000 BP. Historically, the term Pietersburg was used to refer to the developed phases of the Middle Stone Age (Mason 1962). Although no longer a favored term among southern African archaeologists, it can still be taken to mean of MSA origin. However, grindstones appear throughout the Middle Stone Age and into the Later Stone Age in southern Africa (McBrearty and Brooks 2000). Unfortunately, the dates of 30 000 to 15 000 BP were determined at a time when C^{14} dating was rather unreliable, so these dates are probably a little too young. A more recent examination of the Kalkbank stone tool assemblage has confirmed its lack of diagnostic stone tools (K. Kuman, personal communication), and it remains impossible to attribute a more specific date to the site using only the stone tool assemblage.

Table 3.1. List of the Kalkbank stone tool assemblage from both excavations according to type. Data from Mason (1988b:Table 1).

1954	1966
3 stone flakes	17 stone flakes
8 cores	5 cores
19 slabs with utilized edges	8 slabs with utilized edges
2 spheroids	1 large polished stone slab
2 upper grindstones	6 lower grindstones
38 waste fragments	12 flat anvils
	1 chopper
	8 flaked pebbles
Total=130	

Fauna

The Kalkbank faunal assemblage is typical of the Florisian Land Mammal Age (Hendy 1974), which could indicate a time period between the Pleistocence/Holocene boundary and as far back as 500 000 years BP (Brink 1987, 1988; Grün *et al*. 1996; Lacruz *et al*. 2002). The only species listed in Table 1.1 that offer any further information on age are four extinct species—*Antidorcas bondi*, *Megalotragus priscus*, *Homoioceras sp*., and *Equus capensis*. All four species were formerly thought to have gone extinct at the end of the Pleistocene, their disappearance coinciding with the initiation of somewhat moister conditions and the replacement of an open grassland fauna by one dominated by browsers (Klein 1984). However, new information shows that several of these species have been found in deposits well within the Holocene. *Antidorcas bondi,* or Bond's springbok, known for its extremely hypsodont molars, has been recorded as recently as 7 570 ± 100 BP at Kruger Cave near Rustenburg in the North-West Province (Brown and Verhagen 1985). *Megalotragus priscus*, or the giant hartebeest, the last surviving species of an ancient lineage of large alcelaphines (Gentry 1978), became extinct in the early Holocene (Plug and Engela 1992). Similarly, *Homoioceras*, the giant longhorn buffalo, persisted in southern Africa until sometime between 8 000 and 6 000 BP (Thackeray 1983). *Equus capensis*, referred to as the Giant Cape zebra, also went extinct during the early Holocene, sometime between 10 000 and 8 000 BP (Plug and Badenhorst 2001). With the present knowledge concerning the last appearance of these species and similar Middle Stone Age sites, it can most accurately be said that the fauna represents an accumulation nearer to Pleistocene/Holocene boundary.

Calcrete and Palaeoclimate

Netterberg (1974) has attained C^{14} dates for the calcrete hardpans at Kalkbank. The lower hardpan was dated to 16 700 years BP while the upper hardpan yielded an age of A. D. 150. Thus, a minimum age of 17 000 years BP for the accumulation of bones and artifacts is indicated since the site accumulated prior to the formation of the lower hardpan (Netterberg 1974). While this date mirrors that of Mason's (1962) estimate of between 30 000 and 15 000 BP based on the stone tools, dating calcrete can be quite problematic. The main problem lies in the actual formation of the calcrete itself. Calcrete undergoes continuous dissolution and recalcification, and, in such an open system, it becomes increasingly difficult to date during later stages of development. The Kalkbank calcrete appears to be in a late stage of development, but may also incorporate earlier stages, thus making it difficult to reliably date the site from the age of the calcrete.

Looking at palaeoclimatic data, one hypothesis would be to put the accumulation of the Kalkbank site near the end of Oxygen isotope stage 3. Evidence from the Tswaing Crater (formerly the Pretoria Saltpan) north of Pretoria indicates that during Oxygen isotope Stage 3, at around 30 000 years ago, the climate over much of southern Africa was much wetter than the present (Partridge *et al*. 1997; Partridge *et al*. 1993), and just prior to the Last Glacial Maximum, the beginning of Oxygen Isotope stage 2, conditions were very similar to that of the present day. Subsequent to the Last Glacial Maximum, annual rainfall appears to have been much lower over the entire sub-continent (Partridge 1997), with some areas receiving only up to 40% of the present annual rainfall. Analyses of the Uitenhage aquifer (Heaton *et al*. 1986) and speleothems from Cango Cave (Talma and Vogel 1992) show that temperatures were suppressed about 5 degrees Celsius during this time, about 20 000 years ago. This time frame, between 30 000 and 20 000 years ago, fits with evidence from the Kalkbank pan and associated calcrete. However, without a specialized analysis of the Kalkbank calcrete to provide a substantial connection with these climate changes, these dates remain purely speculative.

Discussion

Mason's placement of the site within the Middle Stone Age may be correct, but the nature of the stone tools does not provide enough evidence to date the site with any confidence. The earliest occurrence of Middle Stone Age artefacts in the interior of southern Africa is at Florisbad, at about 280 ka. (Kuman *et al*. 1999), but Kalkbank does not appear to be that old according to the fauna. The transition from the Middle Stone Age to the Later Stone Age may have taken place as late as 20 000 years ago (Wadley 1997, 1993) or as early as 40 000 years ago (Mitchell 2002; Miller *et al*. 1993). The fauna points to accumulation of the site nearer to this Middle/Later Stone Age transition. Additionally, the calcrete and palaeoclimatic data could also lend support to a late Pleistocene age.

CHAPTER 4: FAUNAL IDENTIFICATION

The combined comparative collections from the Bernard Price Institute for Palaeontological Research and the School of Geography, Archaeology and Environmental Studies at the University of the Witwatersrand were used in faunal identification, as was the collection at the Transvaal Museum in Pretoria. Each specimen was individually analyzed and recorded by part, portion, segment, and side following Gifford and Crader (1977). All effort was made at identification to the species level, but most postcranials only allowed for identification down to more general taxa (i.e. Bovid, Suid, Equid, Felid, etc.). As many bovid postcranial elements were difficult to identify to species, Bovids were separated into general size classes according to Brain (1974). Bovid size class 2 (23-84kg) includes, impala, springbok, Bond's springbok, and mountain reedbuck. Bovid size class 3 (84-296kg) includes hartebeest, wildebeest, and blesbok/tsessebe. Bovid size class 4 (296-400kg) includes the giant hartebeest and eland. The giant buffalo is often placed in Bovid size class 5 (>900kg) (Klein 1976), but here it was included into the indeterminate large mammal category.

Species Abundance

Methods of quantifying species abundance include, but are not limited to, number of identifiable specimens (NISP), minimum number of individuals (MNI), and minimum number of elements (MNE)/minimum animal units (MAU) (Binford 1978, 1981, 1984; Grayson 1984; Klein and Cruz-Uribe 1984). For this analysis, both NISP and MNI were used to calculate species abundance (Klein and Cruz-Uribe 1984). MNI was the major unit of analysis, while NISP was provided mainly as an indicator of the number of identified specimens used to achieve MNI per skeletal element and taxon.

The reason for using MNI for quantification was twofold. First, the most recent comprehensive analysis by Brown (1988) employed MNI when calculating species abundance. This current analysis, in part, aims to build on her prior work, making MNI a favorable unit for analysis. Also, data obtained from the Kalkbank faunal assemblage using MNI was readily comparable to other archaeological and experimental assemblages selected for comparison to Kalkbank. Secondly, according to Binford (1978, 1981, 1984), using MNI assumes complete animal carcasses were once present at any given site. For archaeological sites, he advocates the use of MNE/MAU because this method of quantification takes into account the transportation of complete animal carcasses or skeletal elements to a site. However, Mason (1988a) and Brown (1988) do not consider Kalkbank to be a living site, but rather a butchery site, carnivore kill site, a natural death accumulation, or a combination of the three. Any one of these processes would produce complete carcasses once present at the site. Thus, using MNI for calculating species abundance was not affected by the introduction of skeletal parts suggested by Binford.

MNI was calculated following Klein and Cruz-Uribe (1984), with only minor modifications. In most instances, teeth were the only elements that could be assigned to species. But, in some cases, appendicular elements could be identified as such and were used to calculate MNI. In these cases, MNI was calculated by separating the skeletal element into rights and lefts, and the higher of the two values represented MNI for that species. For unpaired elements, the total number observed was divided by the number of times that element is represented in a complete skeleton (*cf*. MAU; Binford 1978, 1981, 1984). Using epiphyseal fusion and certain anatomical landmarks, a procedure advocated by Bunn and Kroll (1988), matching was employed when ever possible.

A new species list is represented in Table 4.1 based on the abovementioned guidelines. As compared to the previously determined species lists in Table 1.1, there are few changes to the new list. Identified were 112 individuals from 26 species. The wild dog is the only new inclusion to the species list, but other identifications or exclusions clear up some of the discrepancies between previous lists, as each prior researcher did not analyze the entire assemblage.

Table 4.1. Current species list based on MNI/NISP.

Species	**MNI/NISP**
Homoioceras sp., Giant longhorn buffalo	1/3
Alcelaphus buselaphus, Red hartebeest	4/11
Connochaetes taurinus, Blue wildebeest	10/78
Aepyceros melampus, Impala	4/15
Antidorcas marsupialis, Springbok	5/25
Antidorcas bondi, Bond's springbok	6/13
Damaliscus sp., Blesbok/Tsessebe	9/36
Taurotragus oryx, Eland	2/2
Redunca fulvorufula, Mountain reedbuck	1/1
Megalotragus priscus, Giant hartebeest	6/35
Equus capensis, Giant Cape zebra	5/98
Equus burchellii, Burchell's zebra	12/283
Phacochoerus aethiopicus, Warthog	30/652
Diceros bicornis, Black rhinoceros	1/8
Hippopotamus amphibius, Hippopotamus	1/1
Loxodonta africana, Elephant	1/2
Panthera leo, Lion	1/2
Panthera pardus, Leopard	1/2
Crocuta crocuta, Spotted hyaena	4/10
Lycaon pictus, Wild dog	1/2
Ichneumia albicauda, White-tailed mongoose	1/1
Hystrix africaeaustralis, Porcupine	1/1
Struthio camelus, Ostrich	1/1
Tortoise sp.	1/-
Mollusk sp.	1/2
Crab sp.	1/2

Skeletal Part Identification

The analysis of skeletal parts was based on minimum number of elements (MNE), largely following Binford (1978, 1981, 1984). MNE for each element represents the sum of both left and right sides based on the most common portion of that particular element. The most common portions were identified using distinct anatomical landmarks (Bunn and Kroll 1988), such as foramina and muscle attachments. For example, one distal left humerus and one distal right humerus, both from a size class III Bovid, would result in an MNE value of two for Bovid size class III humerus. As with species abundance matching was employed when ever applicable.

Table 4.2 includes all skeletal parts identified to ungulate species or larger taxonomic group based on MNE. All other species are represented in Table 4.3. As none of the bovid postcranial elements was identified to species, Table 4.2 represents all bovid skeletal elements including elements of the crania by bovid size classes following Brain (1974). As with the bovid postcranial elements, carnivore postcranial elements were not identified to species, but, instead, they were identified to small, medium, and large carnivore categories.

Table 4.2. Ungulate skeletal parts by MNE/NISP.

	Bovid 2	*Bovid 3*	*Bovid 4*	*Zebra*	*Giant Cape zebra*	*Warthog*	*Black rhinoceros*	*Hippopotamus*	*Elephant*	*Indet. Large Mamma*
Skull:teeth	9/24	18/60	7/30	12/182	5/38	22/148	1/3	-	1/1	-
Horn core	2/2	23/36	2/3	-	-	-	-	-	-	-
Hemi-mandible:teeth	17/27	27/46	4/7	12/43	3/11	44/86	-	-	-	1/4
Atlas	4/4	18/35	3/4	2/2	-	-	-	-	-	1/2
Axis	1/1	7/9	1/1	-	-	-	-	-	-	-
Cervical vertebrae 3-7	1/1	13/22	9/10	1/2	-	-	-	-	-	-
Thoracic vertebrae	3/3	-	1/1	-	-	-	-	-	-	-
Lumbar vertebrae	2/5	1/1	2/3	-	-	-	1/1	-	-	-
Sacrum	0/0	-	-	-	-	-	-	-	-	-
Caudal vertebrae	0/0	-	9/10	-	-	-	-	-	-	-
Ribs	6/6	8/8	2/2	-	-	-	-	-	-	-
Pelvis:half	6/13	6/21	7/13	5/7	-	-	-	-	-	1/2
Humerus	17/27	34/115	15/36	7/10	6/6	6/9	-	1/1	-	1/2
Radius	11/23	32/88	12/27	2/6	1/1	5/5	-	-	-	-
Ulna	-	9/20	3/4	1/1	-	4/5	-	-	-	-
Scapula	6/11	8/16	5/7	-	1/1	2/2				
Metacarpal	5/12	27/54	6/10	7/9	5/5	7/13	1/1	-	-	-
Indet. metapodial	2/3	4/28	2/20	1/4	-	-	-	-	-	-
Carpals	-	11/11	3/3	1/1	1/1	1/1	-	-	-	-
Femur	4/8	9/22	2/4	-	1/1	1/1	-	-	-	-
Tibia	7/13	17/55	14/23	11/25	6/10	3/5	1/1	-	-	-
Metatarsal	9/16	28/67	11/24	7/9	3/3	1/1	-	-	-	-
Acc. metapodials	-	-	-	1/1	1/1	-	-	-	-	-
Patella	1/1	1/1	-	1/1	-	1/1	-	-	-	-
Astragalus	1/1	16/16	2/2	12/12	8/8	3/3	1/1	-	-	-
Calcaneum	3/3	17/22	8/9	3/3	2/2	-	-	-	-	-
Other tarsals	-	1/1	1/1	2/2	2/3	-	-	-	-	-
Phalanges	5/6	9/11	5/5	4/6	3/6	4/7	-	-	-	-
Lateral maleolus	-	3/3	1/1	-	-	-	-	-	-	-
Sesamoids	-	1/1	-	-	-	-	-	-	-	-

Table 4.3. All non-ungulate mammalian skeletal parts by MNE/NISP

	Porcupine	Spotted Hyaena	Leopard	Lion	Wild dog	Mongoose	Small Carnivore	Medium Carnivore	Large Carnivore
Cranium:teeth, skull, mandible	1/1	4/10	1/2	2/5	1/2	1/1	-	-	-
Atlas	-	-	-	-	-	-	-	-	-
Axis	-	-	-	-	-	-	1/1	-	-
Cervical vertebrae 3-7	-	-	-	-	-	-	-	-	-
Thoracic vertebrae	-	-	-	-	-	-	-	-	-
Lumbar vertebrae	-	-	-	-	-	-	1/1	-	-
Sacrum	-	-	-	-	-	-	-	-	-
Caudal vertebrae	-	-	-	-	-	-	-	-	-
Ribs	-	-	-	-	-	-	-	-	-
Pelvis:half	-	-	-	-	-	-	-	-	-
Humerus	-	-	-	-	-	-	1/1	-	-
Radius	-	-	-	-	-	-	1/1	-	-
Ulna	-	-	-	-	-	-	-	1/1	-
Scapula	-	-	-	-	-	-	1/1	-	1/2
Metacarpal	-	-	-	-	-	-	-	-	-
Indet. metapodial	-	-	-	-	-	-	-	-	-
Carpals	-	-	-	-	-	-	-	-	1/1
Femur	-	-	-	-	-	-	-	-	1/1
Tibia	-	-	-	-	-	-	-	-	-
Metatarsal	-	-	-	-	-	-	-	-	-
Patella	-	-	-	-	-	-	-	-	-
Astragalus	-	-	-	-	-	-	-	-	-
Calcaneum	-	-	-	-	-	-	-	-	-
Other tarsals	-	-	-	-	-	-	-	-	-
Phalanges	-	-	-	-	-	-	-	-	-
Sesamoids	-	-	-	-	-	-	-	-	

CHAPTER 5: PATTERNS OF BONE BREAKAGE

Post-depositional destruction refers to the processes that fragment and delete bones from an assemblage (Klein & Cruz-Uribe 1984). These processes, both mechanical and chemical, can render many bones unidentifiable or destroy them completely, confounding interpretations as to the principal accumulator. Before proceeding with a discussion of surface modification, skeletal part representation, and mortality profiles it must be determined if patterns of bone breakage, more specifically post-depositional destruction, has biased the faunal assemblage in any way. With nearly 1,2 meters of calcrete overlying the Kalkbank assemblage, both chemical and mechanical processes may have affected the site. At Kalkbank, 51% of the bone assemblage consists of unidentifiable bone flakes (Brown 1988), possibly a result of post-depositional destruction, rather than human or carnivore action.

In the past, post-depositional destruction was measured using NISP/MNI ratios (Klein & Cruz-Uribe 1984). Assemblages with high NISP counts and low MNI counts were thought to have suffered from high post-depositional destruction. Klein and Cruz-Uribe (1984) also suggest comparing the NISP of compact bones (i.e. carpals and tarsals) in relation to long bones and axial elements. However, these approaches are subject to influence by bone collector behavior and do not necessarily reflect post-depositional destruction (Marean 1991).

More recently, methods independent of skeletal part abundance (NISP, MNI) have been used to circumvent interpretive problems associated with bone collector behavior. Marean (1991) proposes the use of a "Completeness Index", using ungulate compact bones as a measure of post-depositional destruction. Alternatively, Villa and Mahieu (1991) have used long bone breakage patterns to suggest whether bones in an assemblage were broken in a fresh or dry state. These two procedures will be used to identify the level of post-depositional destruction in the Kalkbank faunal assemblage in order to determine if skeletal part frequencies have been biased in any way.

Completeness Index

Marean (1991:680) has proposed three requirements for an accurate measure of post-depositional destruction. Any methodology must be 1) inclusive of only those bones that are rarely fragmented by people or animals for food; 2) independent of the bone transport of bone collectors; and 3) independent of measures of skeletal element abundance. For this study, only carpals, tarsals, and fibulae are used. Because these bones contain relatively little nutritional value, humans and carnivores rarely or never fragment them. However, humans are known to damage some compact bones (Binford 1978), especially calcanei (Marean 1991), and some carnivores, namely hyaenas, even swallow and subsequently regurgitate them (Sutcliffe 1970; Bearder 1977). Therefore, no calcanei or bones displaying any human or carnivore-induced alterations have been included in the Completeness Index. Those bones exhibiting root etching are included, as root action is part of the post-depositional system and indiscriminately attacks all bones in an assemblage, regardless of density.

The Completeness Index is calculated by estimating the fraction of all ungulate compact bones present. In order to standardize estimates, complete compact bones for various size groups of ungulates were drawn on a 2mm grid, and squares were counted within the preserved section of each Kalkbank specimen. Summing the values, dividing by the total number of specimens attributed to that bone, and multiplying by 100 results in percentage values (Marean 1991:685). These percentages were then compared to two late Pleistocene sites in Kenya used by Marean (1991) whose Completeness Indexes are known.

Results

Figure 5.1 depicts the Completeness Index achieved for the compact bones of all ungulates at Kalkbank. A majority of the bones exhibits completeness in excess of 80%, although the sample size is low for many bones. Of importance are the astragalus and navicular-cuboid (including naviculo-cuboid of Bovids and navicular of Equids), for which the sample sizes are sufficient (32 astragali and 19 navicular-cuboid). In figure 5.2, the astragalus and navicular-cuboid specimens from Kalkbank are compared with those from GvJm22 and GvJm46 used by Marean (1991:687). The Completeness Index for astragali and navicular-cuboid at Kalkbank are 78% and 55%, respectively. At site GvJm22 the completeness index for astragali is 87% and 58% for navicular-cuboid. In contrast, the Completeness Index for astragali and navicular-cuboid at GvJm46 are 19% and 18%, respectively. These data show that Kalkbank is very similar to GvJm22 in completeness of compact bones.

Marean (1991) suggests that site GvJm46 has undergone considerably more post-depositional destruction than at GvJm22, supported by the scarcity of less dense axial elements at GvJm46. There is also a relative scarcity of these less dense axial elements and ribs at Kalkbank. As there seems to be little post-depositional destruction at Kalkbank, the absence of these elements is likely due to the action of humans or carnivores, a possibility discussed in later chapters.

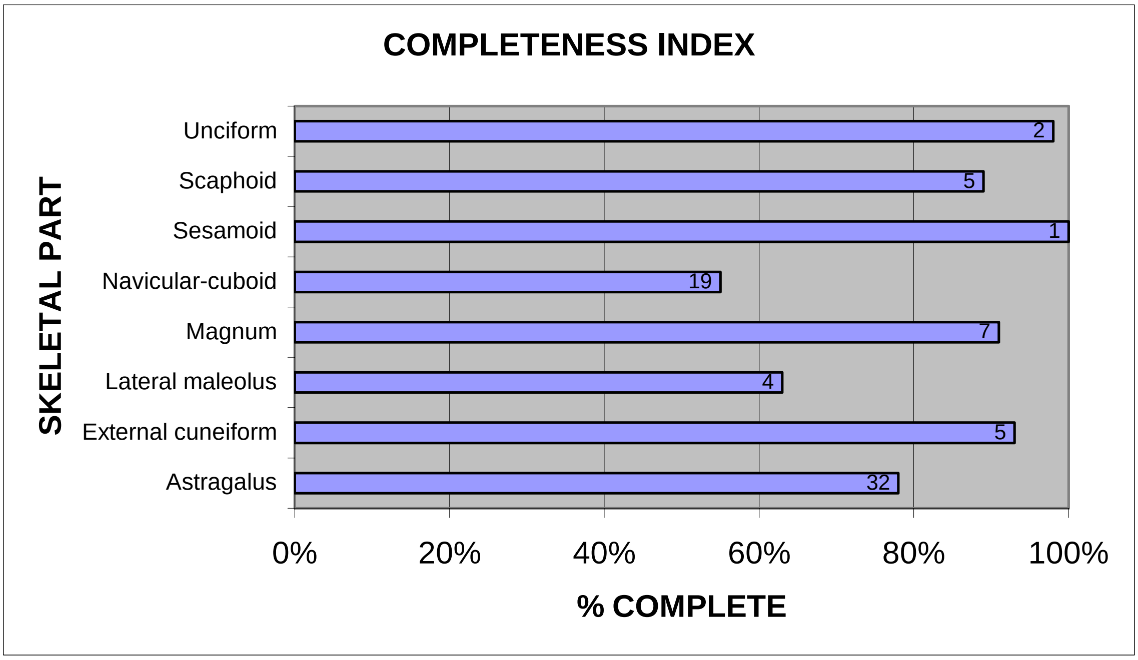


Figure 5.1. Completeness Index for all ungulate compact bones. Navicular-cuboid category includes all Bovid naviculo-cuboids and Equid navicular.

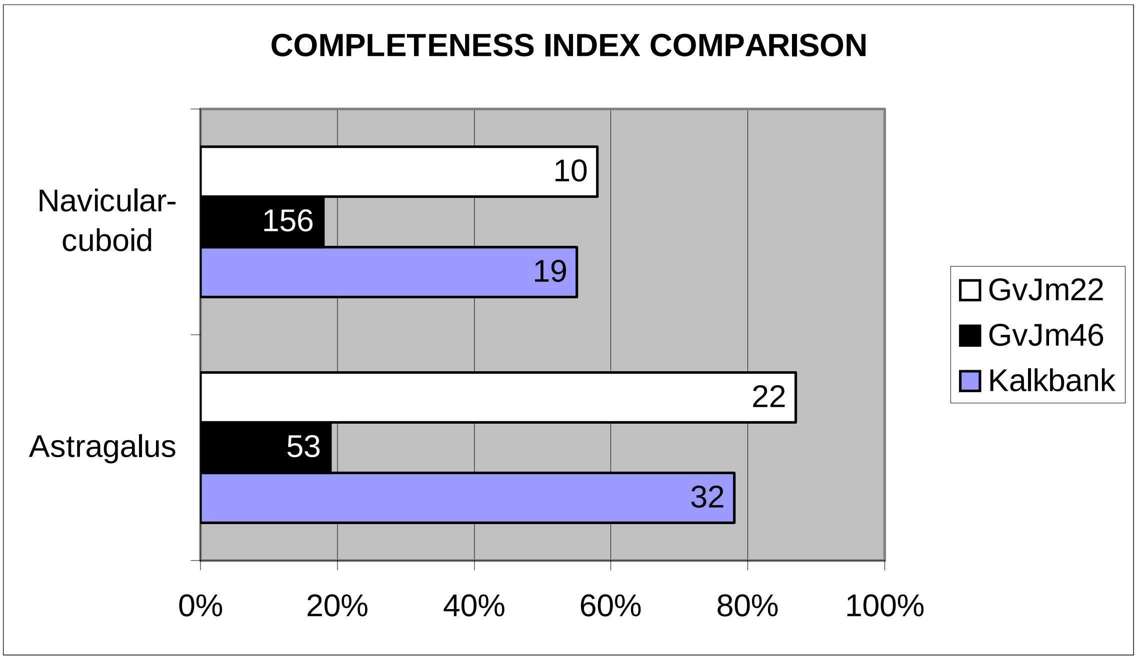


Figure 5.2. Completeness Index comparison between Kalkbank and two sites in Kenya (Marean 1991). Kalkbank Navicular-cuboid category includes Bovid naviculo-cuboid and Equid navicular.

Long Bone Breakage Patterns

To confirm the data from the Completeness Index, long bone breakage patterns were also studied. Villa and Mahieu (1991) have outlined several procedures to infer whether bones in an assemblage were broken in a fresh or dry state. For this analysis, fracture angle, fracture outline, and fracture edge will be used, and the results from Kalkbank will be compared with those from Fontbrégoua, Sarrians, and Bezouce, three sites in southern France of known origin and modifying agent analyzed by Villa and Mahieu (1991). As analysis of this type is subjective in nature, the proscribed methods set out by Villa and Mahieu (1991) are employed, with as few alterations as possible.

Long bone shaft fragments exhibiting at least 3/4 of their original circumference were used in analysis, due to the fact that long bone shafts may show varied types of breakage patterns across their circumference. Only epiphysis-plus-shaft fragments were included into the study if the shaft portion extends a sufficient distance away from the epiphysis, as not to be affected by the differential natures in the fracture patterns between shafts and epiphyses. Epiphysis only fragments, partial epiphyses, juvenile specimens, and modern breaks will also be excluded. And lastly, specimens displaying fracture locations on both proximal and distal ends are "averaged" to reflect the overall breakage pattern for that particular specimen. "Averaging” reflects the true nature of the breaks more accurately than counting breaks separately. This was not problematic as most specimens with two breakage surfaces displayed similar breakage patterns at both the proximal and distal ends of the bone.

Fracture angle

Villa and Mahieu (1991) define this attribute as the angle formed by the fracture surface and the cortical bone surface. Obtuse angles are indicative of green bone breaks, and right angles with dry bone breaks (Johnson 1985; Morlan 1984). Figure 5.3 shows that 70% of the bones sampled at Kalkbank display obtuse angles, while only 1% display right angle breaks. Also, 29% are intermediate between the two. This pattern shows that a majority of the bones at Kalkbank were broken in a green state, prior to deposition. A similar pattern is seen at Fontbrégoua, a cave site in southern France with an assemblage of cannibalized long bones broken for marrow extraction (Villa & Mahieu 1991).

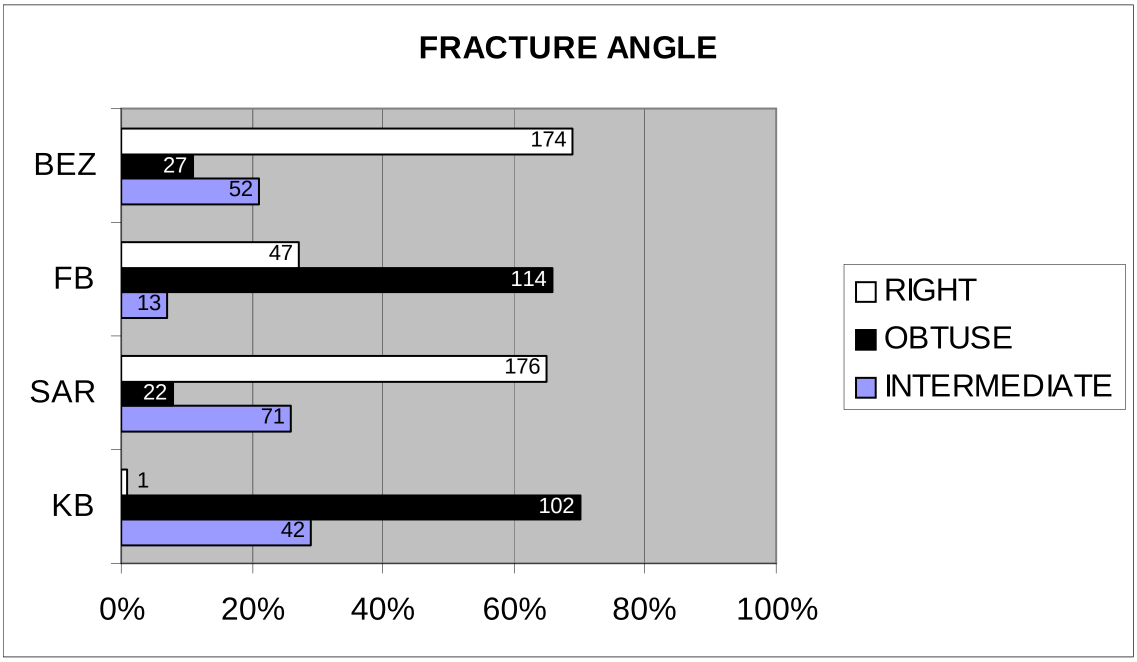


Figure 5.3. Fracture angle of the Kalkbank long bones as compared to the three assemblages studied by Villa and Mahieu (1991).

Fracture outline

Fracture outlines were separated into three categories: 1) transverse, fractures straight or transverse to the bone's long axis; 2) curved, spiral or v-shaped; and 3) intermediate, including straight, diagonal or stepped outlines. Studies by Villa and Mahieu (1991), Figure 5.4, shows that specimens from Fontbrégoua display a majority of curved outlines, while the sites of Sarrians and Bezouce, both known to have been heavily affected by post-depositional destruction, display mostly transverse outlines. Thus, curved outlines suggest green bone breakage, and transverse outlines are found on dry bone. Figure 5.4 also shows 77% of the Kalkbank specimens have curved outlines, while transverse and intermediate outlines only represent 9% and 14% of the sample, respectively. Again, a pattern of green bone breakage is evident.

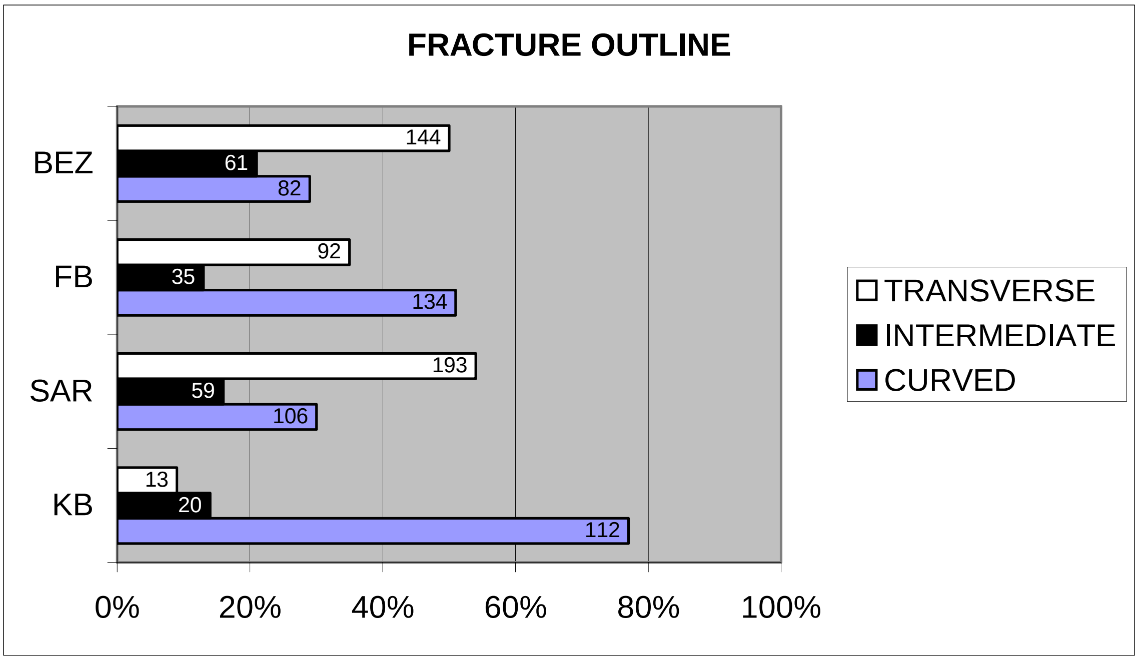


Figure 5.4. Fracture outline of the Kalkbank limb bones as compared to the three assemblages studied by Villa and Mahieu (1991).

Fracture edge

Fracture edge is simply the texture of the fracture surface. Bone specimens are easily separated into two categories: smooth or jagged. Smooth fracture edges indicate green bone breakage, while jagged edges represent dry bone breaks (Johnson 1985; Morlan 1984). Expected patterns would be for Sarrians and Bezouce to display a majority of jagged edges (dry breaks), and Fontbrégoua and Kalkbank to show smooth edge breaks (fresh breaks). However, Figure 5.5 shows that fracture edge does conform to this pattern.

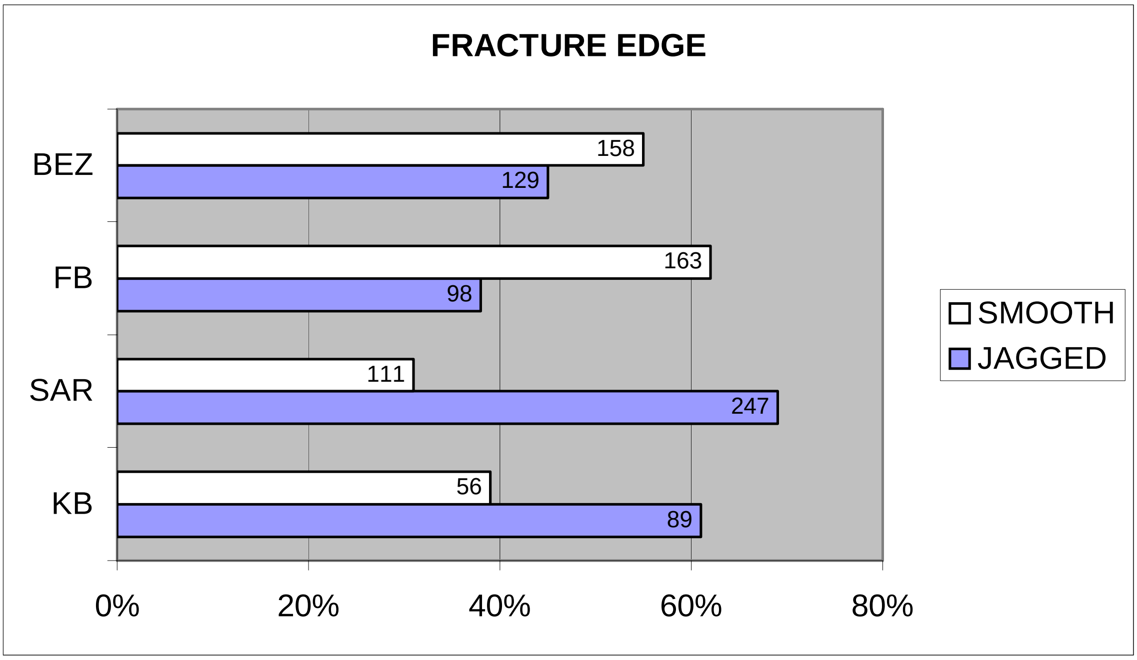


Figure 5.5. Fracture edge of the Kalkbank long bones as compared to the three assemblages studied by Villa and Mahieu (1991).

Alternatively, fracture edge may be a factor in determining the type of force (static or dynamic) used to break the bones (Villa & Mahieu 1991). This makes sense as the Fontbrégoua and Bezouce assemblages are quite similar as opposed to Sarrians. Hammerstone percussion marks are present on 20% of the

Fontbrégoua assemblage, and many of the Bezouce specimens were known to have been broken by a pick-axe during excavation. Dynamic forces affected both of these assemblages, and both display a higher frequency of smooth fracture edges (62% at Fontbrégoua and 55% at Bezouce). Sarrians, on the other hand, was affected by sediment pressure, a static force, and displays a majority (69%) of jagged edges. As depicted in Figure 5.5, Kalkbank shows a pattern similar to Sarrians, both suggesting a static force causing bone breakage. Sediment pressure can be excluded as the force used to break the bones at Kalkbank as the Completeness Index, fracture angle, and fracture outline suggest little post-depositional destruction. Carnivore jaws also create a static force, and could account for the majority of jagged fracture edges on the long bones at Kalkbank.

Discussion

The data presented suggests little post-depositional destruction and a majority of fresh breaks. However, some post-depositional destruction takes place at most sites. The dry bone breaks that are present can be safely attributed to post-depositional destruction.

At Kalkbank post depositional destruction is a factor, but not on a scale that compromises skeletal element proportions. Using bone surface modifications, skeletal element proportions, and mortality profiles, it will be discussed in later sections whether humans or carnivores are to account for the majority of bone breakage.

CHAPTER 6: SURFACE MODIFICATION

Humans, carnivores, porcupines, and other biostratinomic factors leave certain marks on bones attributable to that agent only (see Binford 1981; Brain 1981). Although these marks may resemble one another morphologically, they can be differentiated, and are clues to the agent of accumulation. In this analysis, root etching, insect damage, porcupine gnawing, carnivore damage, butchery damage, and burning were recorded. The criteria to identify each type of modification are discussed below.

When the Kalkbank material was excavated, the bones were in a damp and friable condition, becoming dry and brittle upon exposure to the air (Mason *et al.* 1958). Glyptal originally applied to consolidate the bone surfaces had to be reapplied by Brown (1988), which has led to variable surface preservation. With this in mind, all identifiable and unidentifiable specimens with adequate surface preservation were analyzed for modifications. A 10x hand lens was used to magnify any indistinct or ambiguous marks.

The main surface modification totals are shown in Table 6.1. It should be noted that these numbers are very conservative. Only those clearly definitive marks have been included in the sample. Caution was especially taken with marks thought to be carnivore or human butchery marks. Strict criteria were outlined to differentiate between the two, and any ambiguous marks not definitively identified as either carnivore or human induced were excluded.

Table 6.1. Surface modification on all post-cranial elements. (*) includes 46 mandibular fragments.

	NISP	Porcupine gnawed	Carnivore gnawed	Root etched	Butchery marks
Identifiable	1184*	169	207	792	3
		14,3%	17,5%	66,9%	0,3%
Unidentifiable	1478	93	74	797	0
		6,3%	5,0%	53,9%	0,0%
Total	**2662***	**262**	**281**	**1589**	**3**
		9,8%	**10,6%**	**59,7%**	**0,1%**

Root Etching

The acids and fungi associated with plant roots in contact with bone surfaces produce root etching in many environments (Behrensmeyer 1978; Binford 1981; Grayson 1988). These markings have been described as dendritic patterns of shallow grooving (Behrensmeyer 1978); distinctive, broad, sinuous, smooth-bottomed, u-shaped grooves (Andrews & Cook 1985); spaghetti-like (Hesse & Wapnish 1985); and linear-to-wavy depressions (Grayson 1988). Kalkbank was certainly one of these environments, as a total of 59,7% of the Kalkbank postcranial and mandibular specimens have been root etched (see Table 6.1). Most specimens display very shallow, discontinuous depressions, while others show rather deep pitting (see Figure 6.1-6.3).

Extensive root etching at Kalkbank, as well as other sites, has the capacity to destroy carnivore and human induced markings on bone surfaces (Binford 1981). In several cases, carnivore tooth marks directly underlay very shallow root marks. There is no doubt that some of the more deeply penetrating root marks could have completely obliterated any other marks previously left by humans and carnivores.

According to White (1992), root marks on fracture surfaces of limb bone shafts may provide clues to the timing of bone fracture. At Mancos 5MTUMR-2346, White found many root markings that crossed fracture surfaces and occurring on external and internal bone surfaces in equal numbers. Root marks on the fracture surfaces and in the marrow cavity suggest that the bones were broken prior to burial. At Kalkbank, of the 563 identifiable limb shaft, and proximal- and distal-plus-limb fragments with surface preserved, 26% (148) show root etching

Figure 6.1. Top. Heavy root etching on an *E. burchelli* tibia.
Figure 6.2. Right. Shallow root etching on an *E. burchelli* metacarpal.
Figure 6.3. Bottom. Close up of metacarpal section near arrow in Figure 6.2.

on either their fracture surface or within the marrow cavity. Just over 50% (289) are root etched on their outer surfaces, only, and 22% (126) with none at all. Also, 29% (355) of the unidentifiable specimens are root etched on the outer surface, while 27% (334) show root etching on their fracture surface, marrow cavity, or both. With such high percentages of bones that display root etching on the inner cavity, it seems likely that the majority of the bones was broken prior to deposition.

Behrensmeyer (1978) has written that roots may also cause splitting and fragmentation of buried bones. This does not seem to be the case with the Kalkbank assemblage, as much of the root etching is superficial, and does not appear to penetrate through the bone into the marrow cavity. Moreover, fracture patterns indicate that most specimens were broken in a fresh state. It may be possible for roots to grow very quickly in order to split or fragment fresh bones, but it is more probable that the bones were already broken when exposed to root action around the Kalkbank pan prior to or shortly after burial.

Insect Damage

Several specimens in the assemblage, all bovid carpals or tarsals, exhibit markings that are likely insect damage. In total, 8 specimens have this “bored into” and “hollowed out” damage. A few examples are shown in Figures 6.4-6.7. Hesse & Wapnish (1985) distinguish insect damage from carnivore tooth punctures in that the former are larger in size and lack crushed bone in the bottom of the mark. The damage on these specimens was easily differentiated from carnivore damage, as they seem to have been bored into and "eaten" from the inside. No carnivore damage has been found on any of these specimens. Another possible explanation for this damage may be that these bones were punctured or broken in such a way as to expose the softer, less-dense cancellous bone within and then eroded away. Whatever agent is to account for this damage, it preferred very compact carpals and tarsals, as comparable damage does not appear on any other specimens in the assemblage—insects seem to be a likely agent.

Figure 6.4. Left. Anterior view of insect damage to a Bovid size 3 astragalus.
Figure 6.5. Right. Posterior view of insect damage to astragalus in Figure 6.4.

Figure 6.6. Left. Dorsal view of insect damage to a Bovid size 3 naviculo-cuboid.
Figure 6.7. Right. Ventral view of insect damage to naviculo-cuboid in Figure 6.6.

Porcupine Gnawing

Porcupine (*Hystrix africaeaustralis*) incisors continuously grow throughout their life, and they gnaw on hard objects to keep them at an appropriate length (Brain 1980, 1981). Bones are commonly used, and numerous porcupine dens and their associated faunal assemblages have been discovered in southern Africa (see Hendy and Singer 1965; Maguire 1976; Maguire *et al*. 1980; Brain 1980, 1981). Porcupine gnawing takes the form of "broad, continuous, shallow scrape marks on bone" (Maguire *et al*. 1980:93). Also, cancellous bone is often scooped out of the ends of long bones, creating tubular shafts, which may mimic carnivore damage. However, distinctive gnaw marks are "invariably present" (Maguire *et al*. 1980). Although other rodents gnaw bones for the same reason, porcupines will be the focus of this analysis, since very little small rodent damage was observed on the Kalkbank assemblage.

Cooke (1962), in his analysis of the 1954 Kalkbank faunal material, identified nearly 25% (903 of 3 619) of the assemblage as porcupine gnawed. On the other hand, Brown (1988) only identified 3% (the sample size used is unclear, but 193 bore porcupine marks), when provided with a portion of both the 1954 and 1966 faunal material. This is a considerable drop considering Brown analyzed nearly twice as many specimens. In this current analysis, 14,3% (169 of 1184) of the identifiable postcrania were gnawed. A further 6,3% (93 of 1478) of the unidentifiable specimens were also modified by porcupines, bringing the total to 9,8% (262 of 2662) (see Table 6.1). A few examples are depicted in Figures 6.8-6.10.

The percentage of porcupine gnawed bones at Kalkbank is relatively high for an open-air site, but relatively low for a porcupine lair. As Kalkbank shows a relatively high proportion of gnawed bones, the possibility of a porcupine accumulation deserves mention. Of the known porcupine lair accumulations in southern Africa, most range from 60% to 100% of the specimens gnawed (see Brain 1981:117). However, only 22% of the bones at Winkelhoek lair in northern KwaZulu Natal were gnawed (Maguire 1976). Porcupines usually bring bones from the surrounding landscape to a den. The open-air setting of Kalkbank near an ancient pan does not seem a likely place for a porcupine accumulation. However, the Nossob porcupine lair was located in a solution cavity in the calcrete on the bank of the Nossob River in Botswana (notes by A Hughes in Brain 1980:109, 1981:112), a similar setting to Kalkbank. Although it is not known if solution cavities within the calcrete existed at any point at Kalkbank allowing for a porcupine lair, there are several reasons why the assemblage does not fit the pattern of a porcupine accumulation despite the high incidence of porcupine gnawing.

Maguire *et al.* (1980) point out that porcupines are incapable of splitting or cracking limb shafts of large ungulates, and bone flakes are rare in porcupine accumulations. Of the total identifiable and unidentifiable postcranial specimens at Kalkbank, 47.3% (1237 of 2616) consist of unidentifiable limb shaft fragments. Also, porcupines tend to prefer bleached, defatted bones (Brain 1980, 1981). It has been shown that there seems to be little post-depositional breakage and most bones were broken in a fresh state, making the assemblage an unlikely porcupine accumulation. It is thus more likely that the bones at Kalkbank were already broken prior to the arrival of porcupines, which intermittently visited the site to gnaw on bones, and possibly remove some dry bones to gnaw elsewhere.

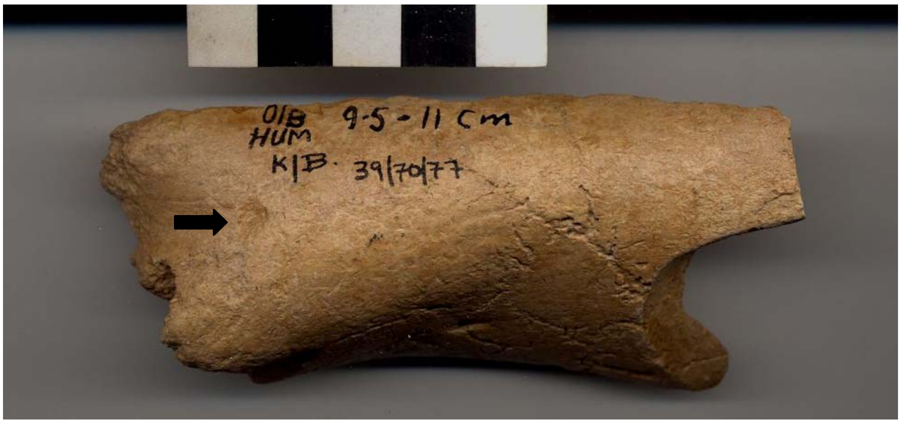
Figure 6.8. Left. Full view of porcupine gnawing on an *E. burchelli* radius.
Figure 6.9. Top right. Close up view of *E. burchelli* radius in Figure 6.4.
Figure 6.10. Bottom right. Porcupine gnawing on a Bovid size 3 pelvis fragment.

Carnivore Damage

Many large African carnivores, especially the spotted hyaena, are extremely efficient at gnawing and crushing bone (Sutcliffe 1970). All large carnivores leave an array of marks on bone that can be distinguished from those made by other agents. Tooth pits and punctures, crenulated edges, scoring, and "scooping out" damage are considered here. Hyaenid species also have the capacity to swallow and digest bone, leaving many bones acid etched after passing through their digestive system. However, no acid etching has been recorded in the Kalkbank assemblage, nor were any hyaena coprolites recovered.

Tooth pits leave small, oval depressions, occurring when bone is sufficiently strong or dense to resist collapsing (Brain 1981; Maguire *et al.* 1980). Similarly, tooth punctures, caused by the collapse of a bone under pressure from a single tooth cusp or canine, also leave a small circular or oval depression, often with flakes of bone pressed into the puncture (Binford 1981; Maguire et al. 1980; Blumenschine & Selvaggio 1988, 1991; Potts & Shipman 1981). In many instances, another tooth pit or damage appears on the reverse side of the bone made by a corresponding tooth. Crenulated edges, typically found toward the ends of limb bone shafts and very thin bones (e.g., scapulae), form when a tooth penetrates through the bone and the edge of the bone is broken away (Binford 1981; Maguire *et al.* 1980). When a carnivore drags one of its teeth across the surface of a bone, short, linear, U-shaped marks appear. These marks are referred to as scoring (Binford 1981; Potts & Shipman 1981; Shipman & Rose 1983a). And lastly, "scooping out" damage occurs when cancellous bone is removed from the epiphyses of long bones, at times producing large holes or furrows on or near the epiphyseal ends of long bone shafts (Binford 1981; Haynes 1980, Haynes 1983, Maguire *et al*. 1980).

In the Kalkbank assemblage, all of these marks are well represented. A few examples are depicted in Figures 6.11-6.22. Carnivore damage has been recorded on 17,5% (207 of 1184) of the identifiable postcranial elements (including 46 mandibular fragments and 5,0% (74 of 1478) of the unidentifiable postcranial elements, bringing the total to 10,6% (281 of 2662) (see Table 6.1). In modern hyaena collections, upwards of 80 % of the bones show carnivore damage (see Bearder 1977; Maguire *et al*. 1980; Bunn 1983; Skinner *et al*. 1986; Horwitz & Smith 1988). In contrast, as low as 0,4% and 1,2% of the specimens at Swartklip (Klein 1975) and Equus Cave (Klein *et al*. 1991), two known carnivore accumulations, possibly hyaena, in South Africa, show carnivore damage, respectively.



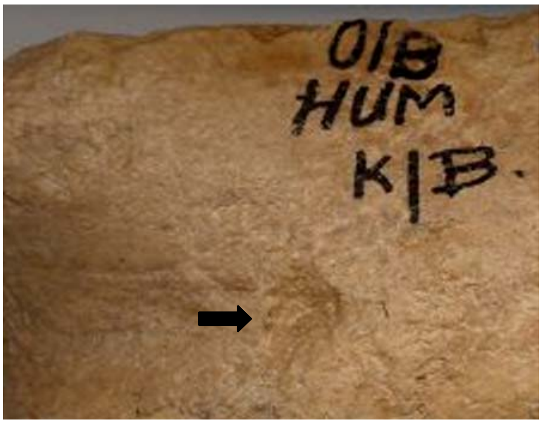


Figure 6.11. Top. Tooth pit damage on a Bovid size 3 humerus fragment.

Figure 6.12. Bottom. Close up view of tooth pit in Figure 6.11.

Figure 6.13. Top. Tooth puncture damage on a Bovid size 3 metacarpal.
Figure 6.14. Middle left. Close up of tooth puncture in Figure 6.13.
Figure 6.15. Middle right. Close up of posterior view of metacarpal in Figure 6.13 with corresponding tooth pit.
Figure 6.16. Bottom. Posterior view of metacarpal in Figure 6.13 with corresponding tooth pit.

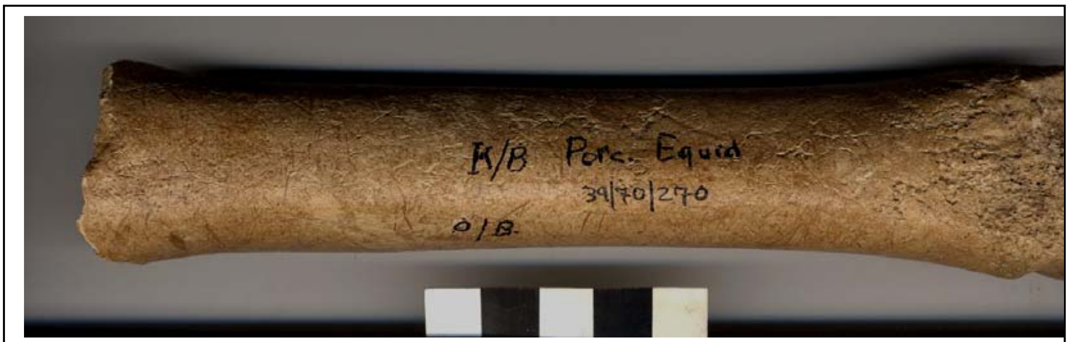


Figure 6.17. Top. Crenulated edge damage on an *E. burchelli* metacarpal.
Figure 6.18. Bottom left. Close up proximal anterior view.
Figure 6.19. Bottom right. Close up proximal posterior view.

Figure 6.20. Scoring damage on a Bovid size 3 humerus fragment.

Figure 6.21. Top. Scooping out damage on an *E. burchelli* metacarpal. Same specimen as in Figures 6.17-6.19.

Figure 6.22. Left. Close up view of distal metacarpal.

Of the identifiable remains, 172 Bovid bones (17 size 2, 109 size 3, 46 size 4) show carnivore damage, as do 32 Equid bones, 2 Suid bones, and 1 rhinoceros third metacarpal. The distribution of carnivore marks from all bovid skeletal parts is shown in Figure 6.23. Table 6.2 shows the same distribution across bovid long bones. The highest concentrations of marks occur on limb bones, especially humeri. Furthermore, long bone shafts exhibit the most damage, while epiphysis+shaft specimens also display considerable damage, as opposed to epiphysis-only specimens, which show the least. This fits the pattern described by several researchers (Sutcliffe 1970; Horwitz & Smith 1988; Potts et al. 1988;

Cruz-Uribe 1991), in which hyaenas tend to attack limb bone ends, leaving the shafts intact. That is to say, the shafts bearing carnivore damage survived more often than epiphyses that were often completely gnawed away.

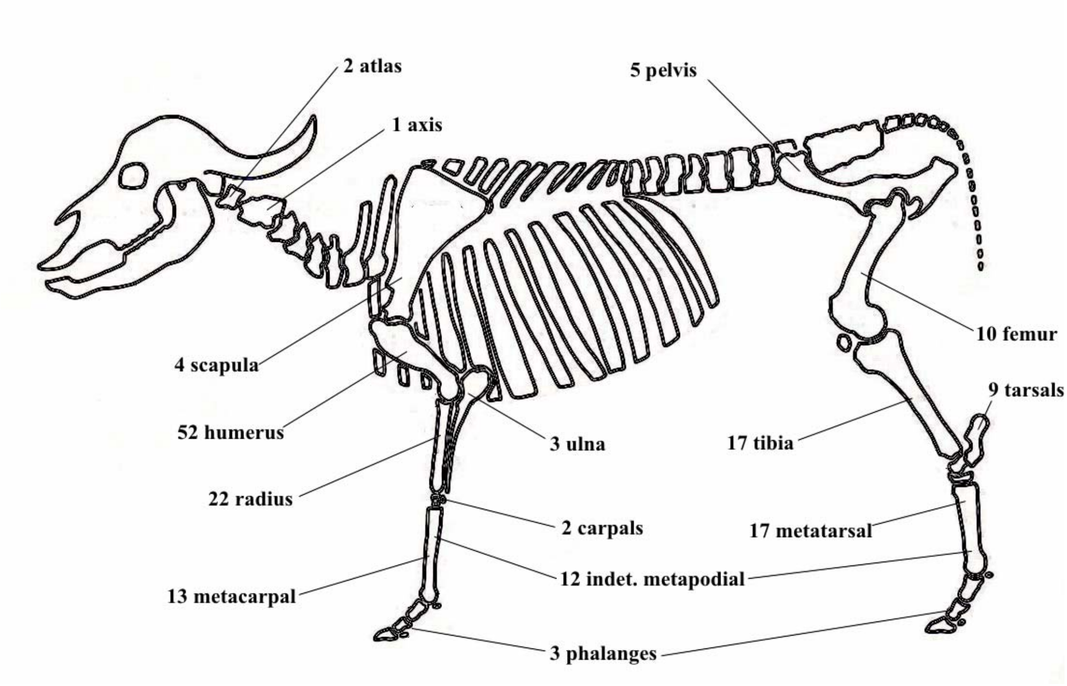


Figure 6.23. Carnivore damage to all Bovid skeletal parts.

Table 6.2. Carnivore damage to all bovid limb bones.

	NISP	Complete	Proximal	Proximal+shaft	Shaft	Distal+shaft	Distal
Humerus	52	1	0	0	33	12	6
Radius	22	0	0	6	10	5	1
Metacarpal	13	1	0	9	2	1	0
Tibia	17	0	0	0	15	2	0
Femur	10	0	0	0	8	0	2
Metatarsal	17	3	0	10	3	1	0
Indet. metapodial	12	0	0	0	2	2	8
Total	**143**	**5**	**0**	**25**	**73**	**23**	**17**

Butchery Damage

Researchers recognize human induced damage to bones as cut marks or hammerstone percussion marks when dealing with Stone Age sites. The presence of these marks is direct evidence of human involvement, in some capacity, to a particular bone or set of bones. Cut marks tend to be elongate and V-shaped in cross-section. Also, small striations on the inner walls of the cut mark and possibly parallel to the main cut mark on the bone surface are invariable present under magnification (Potts & Shipman 1981; Shipman 1981a, 1981b, 1983; Shipman & Rose 1983a, 1983b, 1984). Hammerstone percussion marks are more difficult to identify confidently, as they can closely mimic carnivore tooth pits. But, the two can usually be differentiated under low magnification. Percussion marks exhibit quite dense microstriations in and around the mark, as opposed to tooth pits, which rarely include a few less dense striations (Potts & Shipman 1981; Blumenschine & Selvaggio 1988, 1991). Hammerstone percussion marks are also characterized by micro-flakes of bone still clinging to the mark, while tooth marks are rather more like depressions, with the crushed section of bone relatively intact at the bottom of the mark (Potts & Shipman 1981). These criteria were adhered to in the strictest sense when analyzing the Kalkbank faunal material.

Brown (1988) identified four specimens with butchery damage: a Bovid size 3 distal tibia with chopping damage, an *Equus* cf. *burchelli* distal tibia with numerous cut marks, a Bovid size 4 proximal radius with parallel cut marks, and a Bovid size 3 proximal radius which has two parallel groove or batter marks on the shaft. Upon further review, all of the markings appear much different in color and texture than the surrounding bone surface and are undoubtedly fresh marks, either caused during excavation, preparation, or analysis.

In this analysis, only three specimens exhibiting possible butchery damage have been identified. All are possible hammerstone percussion marks on metapodials (see Figures 6.24-6.29), presumably to access the marrow within. One occurs on a Bovid size 3 proximal metatarsal, one on a Bovid size 4 proximal metacarpal, and the other on an indeterminate Bovid size 3 distal metapodial. These specimens provide examples of modifications that most closely resemble hammerstone percussion marks; however, it is difficult to suggest significant human involvement in the Kalkbank faunal material with only three possible butchery marks and relatively few undiagnostic stone tools (Mason 1988). Potential for human involvement exists, but very little.

Figure 6.24. Top. Possible hammerstone percussion mark on a bovid size 3 metatarsal.

Figure 6.25. Left. Close up view of possible percussion mark in Figure 6.24.

Figure 6.26. Top. Possible hammerstone percussion mark on a bovid size 3 metacarpal fragment.

Figure 6.27. Left. Close-up of possible percussion mark in Figure 6.26.

Figure 6.28. Left. Possible hammerstone percussion mark on an indeterminate bovid size 3 metapodial.

Figure 6.29. Right. Close up of possible percussion mark in Figure 6.28.

Burning

Brown (1988) reported four burned bones in her analysis of the Kalkbank faunal material. However, none was recorded in the available documentation, and subsequently, none has been identified in the current analysis. The possibility exists that previously identified specimens were stained by manganese as suggested by Brain & Sillen (1988) for the Swartkrans material. A probable cause is moisture in the vicinity of the bone at some time in the ancient past. If burning was present, it cannot be determined if the cause was anthropogenic or natural.

Summary

Bone surface modifications provide overwhelming evidence to suggest that carnivores were responsible for accumulation of the faunal remains at Kalkbank. A relatively high percentage (10,6%) of the postcranial and mandibular elements show carnivore damage. Furthermore, the locations of these marks are consistent with carnivore feeding. Porcupine damage is also common, but it is not frequent enough to indicate a porcupine accumulation. Possible human butchery marks appear very infrequently, and based on surface modification alone, the Kalkbank assemblage does not fit with a human accumulation. This data, with results from subsequent chapters on skeletal element proportions and mortality profiles, verifies that carnivores were the major accumulators of bone at Kalkbank.

CHAPTER 7: SKELETAL PART REPRESENTATION

Skeletal part representation can provide significant information on the taphonomic history of faunal assemblages. Rarely does skeletal element representation at archaeological and palaeontological sites reflect actual anatomical proportions. This could be due to: selective transport of parts to or from the site before burial; selective or differential destruction of some parts before burial; selective or differential destruction after burial; and excavation or investigator bias against some parts (Klein and Cruz-Uribe 1991). All four of these hypotheses for accumulation of the Kalkbank fauna deserve comment and will be discusses below.

Regarding selective or differential destruction after burial, it has been previously determined that post-depositional destruction at Kalkbank is low enough as not to compromise skeletal element proportions. However, the effects of post-depositional destruction are not negligible and may play a minor role in the final proportions.

Excavation bias must always be addressed when dealing with faunal assemblages. Often, small unidentifiable bones are discarded. According to Mason *et al*. (1958:100), fortunately, all of the bones from the 1954 excavation were kept. The same is likely true for the 1966 excavation, so there was no initial excavation bias against any skeletal parts at Kalkbank. But, Welbourne (1971) believes there to be an unknown amount of material which remains to be exposed. If there exists a larger accumulation of bones awaiting excavation, the skeletal element proportions presented here would undoubtedly change, but to what extent cannot be known. Nevertheless, the available sample likely represents an accurate representation of original on-site skeletal element proportions.

With post-depositional destruction and excavation or investigator bias accounted for, the probable explanations for the skeletal element proportions at Kalkbank appear to result from pre-burial conditions. The site was not a place to which bones were transported, therefore selective or differential pre-depositional destruction and transport of bones from the site to another location are the only explanations for the observed skeletal element proportions. Based on other taphonomic data, humans and other non-human carnivores represent the only likely accumulators, while natural death is also possible.

Skeletal part representation can be represented in numerous ways. Three aspects of skeletal part representation are discussed here. First, basic skeletal element proportions, calculated as % survivorship, compare skeletal elements within and across different taxa. Second, completeness of long bones measures the abundance of bone breakage prior to burial. And lastly, cranial/post-cranial ratio compares MNI tabulated using both cranial and post-cranial elements. All three of these aspects of skeletal element proportions differ in respect to human and non-human carnivore accumulations. The functions of each of these methods are discussed below.

Percent Survivorship

Basic skeletal element proportions can be calculated in two ways: %survivorship (Brain 1969, 1976) and %MAU (Binford 1978, 1981, 1984). These two methods differ only in terminology and measure the same values

(Lyman 1996). %survivorship will be used, as it entails the use of MNI previously determined for species abundance. Values were calculated following Brain (1969, 1976), using the equation:

$$\frac{(MNE_{i})\ 100}{MNI\ (\text{number of times }_{i}\text{ occurs in one skeleton})}$$

where MNE_i was calculated following Binford (1978, 1981, 1984) and MNI were calculated following the methods put forth earlier to achieve species abundance strictly by skeletal part. MNE_i is used in this equation to refer to Minimum Number of Elements in terms of %survivorship and differentiate between strict MNE calculations used elsewhere.

Figures 7.1-7.7 depict % survivorship for all Bovids, Equids, and Suids. Not surprisingly, teeth display high survivorship throughout. Therefore, skulls, represented by maxillary teeth, occupy the highest survivorship spot for nearly all taxa. Only humerus of Bovid size 4 ranks higher than maxillary teeth in that taxon. Furthermore, hemi-mandibles, represented by mandibular teeth, are also very numerous. This pattern is to be expected, as teeth are much more likely than bone to survive the many taphonomic process associated with extended periods of burial, as well as potential taphonomic agents discussed in Chapter 6.

Teeth aside, there are a few points of interest regarding % survivorship. In Brown's (1988) analysis, she reported there to be a discrepancy between front and hind limb bones. Most notable, there were 145 humerus and 106 radii fragments, but only 26 and 84 femur and tibia fragments, respectively. These numbers are merely NISP counts, but remain prevalent with new survivorship percentages based on MNE. As shown in Figures 7.1-7.7, humerus and radius, for the most part, survived more often than tibia and femur. With regard to total Bovid survivorship (Figure 7.4), MNE values of 66 humerus and 55 radius far outnumber the MNE values of 38 and 15 for tibia and femur, respectively.

Brown (1988) also notes the low numbers of phalanges. She counted 40 NISP, while this current analysis only records 41 NISP with an MNE of 30. Phalanges should be well represented, as there are up to 24 per individual in the case of bovids, but there are very few phalanges at Kalkbank. Brown (1988) attributes this pattern to the "schlepp effect," popularized by Perkins and Daly (1968).

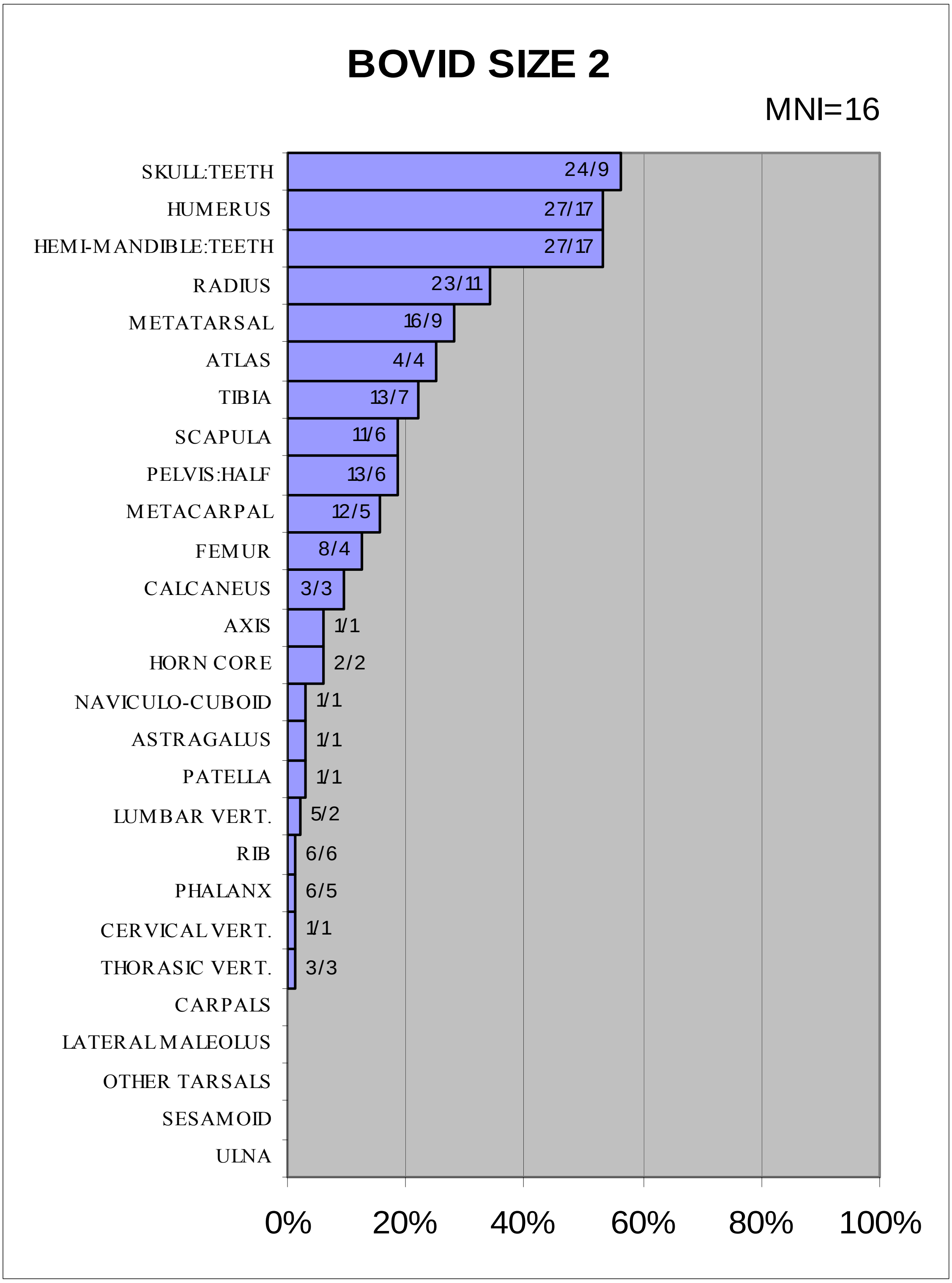


Figure 7.1. Bovid size 2 skeletal part representation based on %survivorship. Numbers within the graph represent NISP/MNE values.

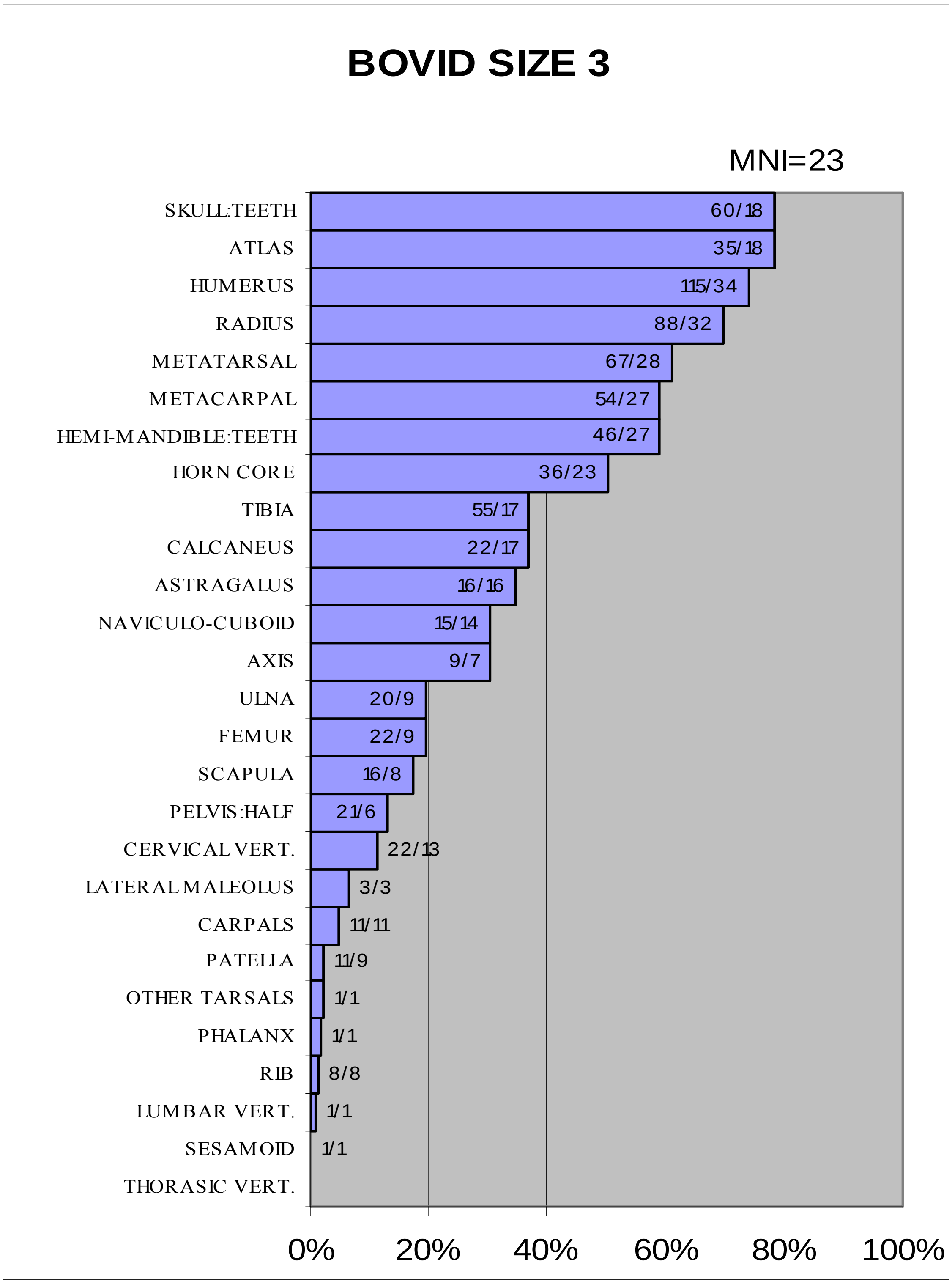


Figure 7.2. Bovid size 3 skeletal part representation based on % survivorship. Numbers within the graph represent NISP/MNE values.

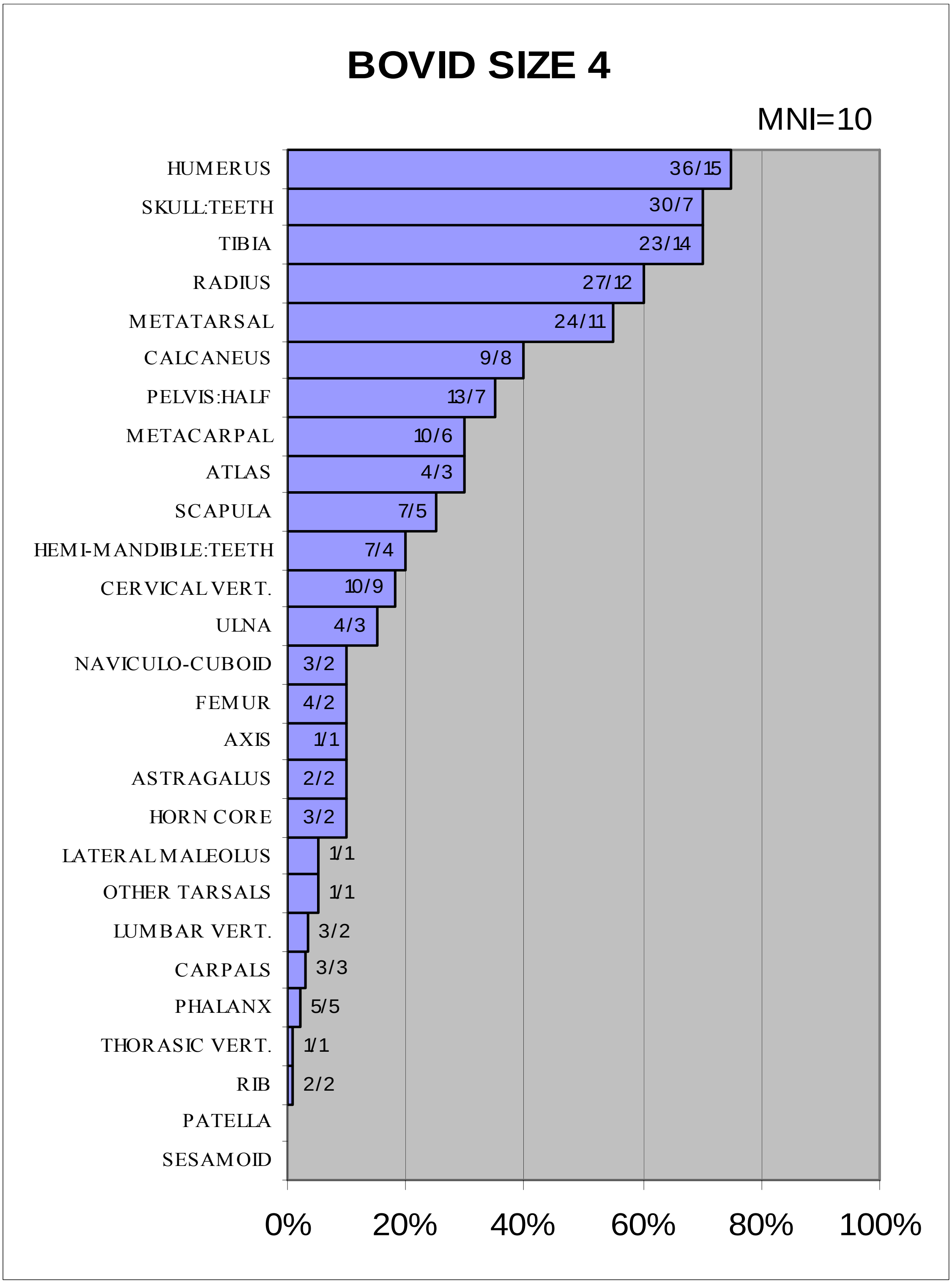


Figure 7.3. Bovid size 4 skeletal part representation based on % survivorship. Numbers within the graph represent NISP/MNE values.

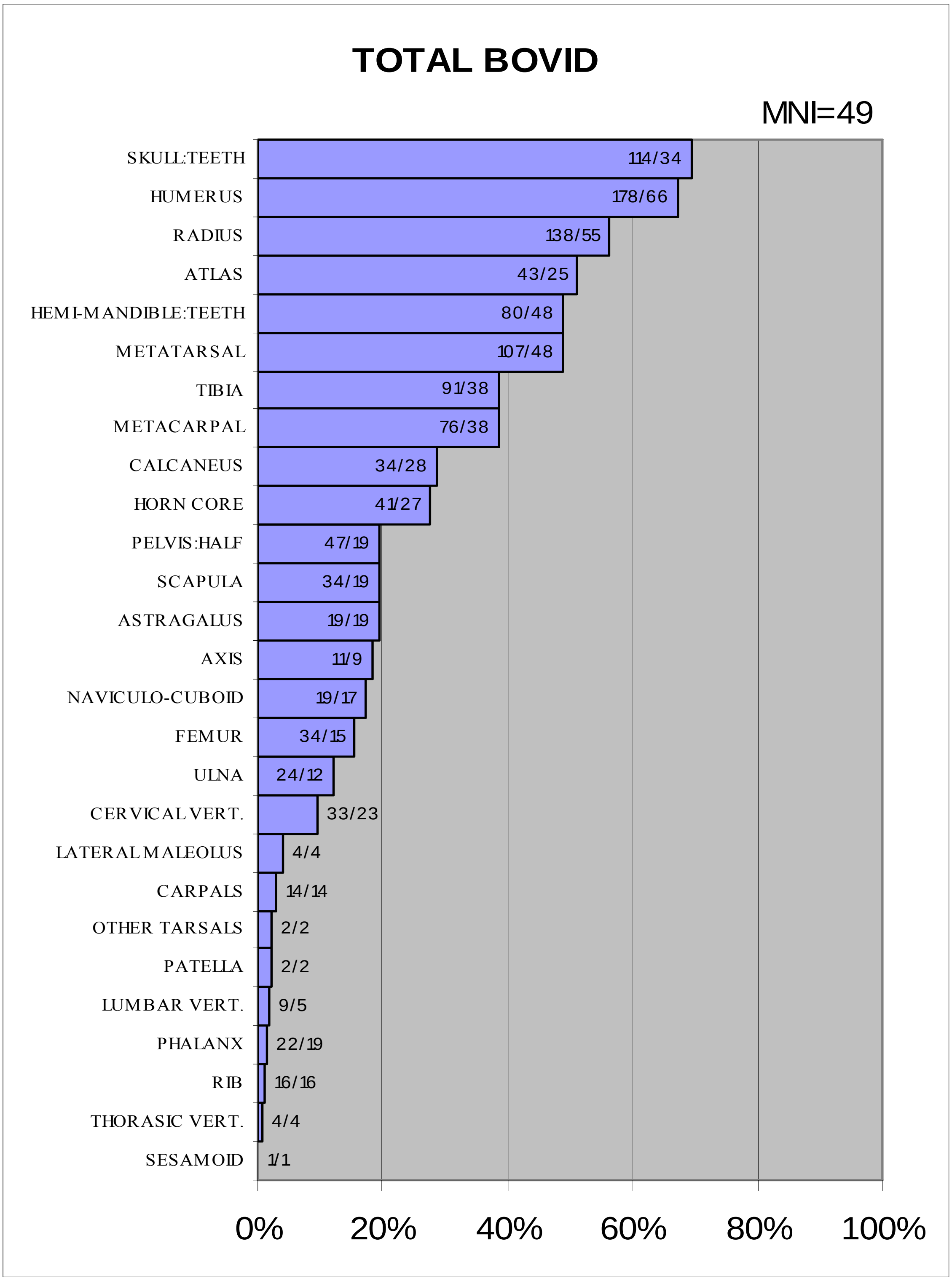


Figure 7.4. Total Bovid skeletal part representation based on % survivorship. Numbers within the graph represent NISP/MNE values.

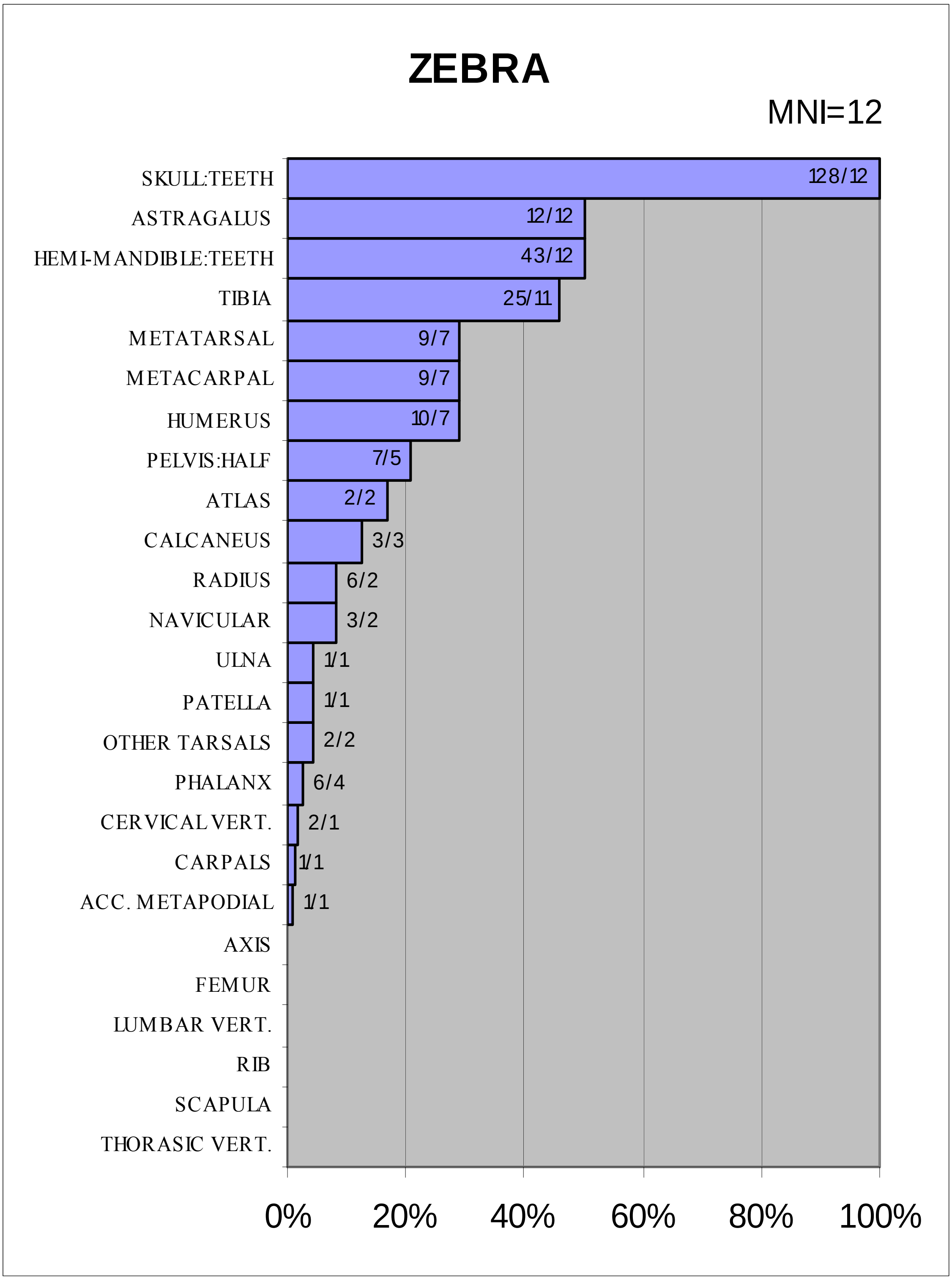


Figure 7.5. Zebra skeletal part representation based on % survivorship. Numbers within the graph represent NISP/MNE values.

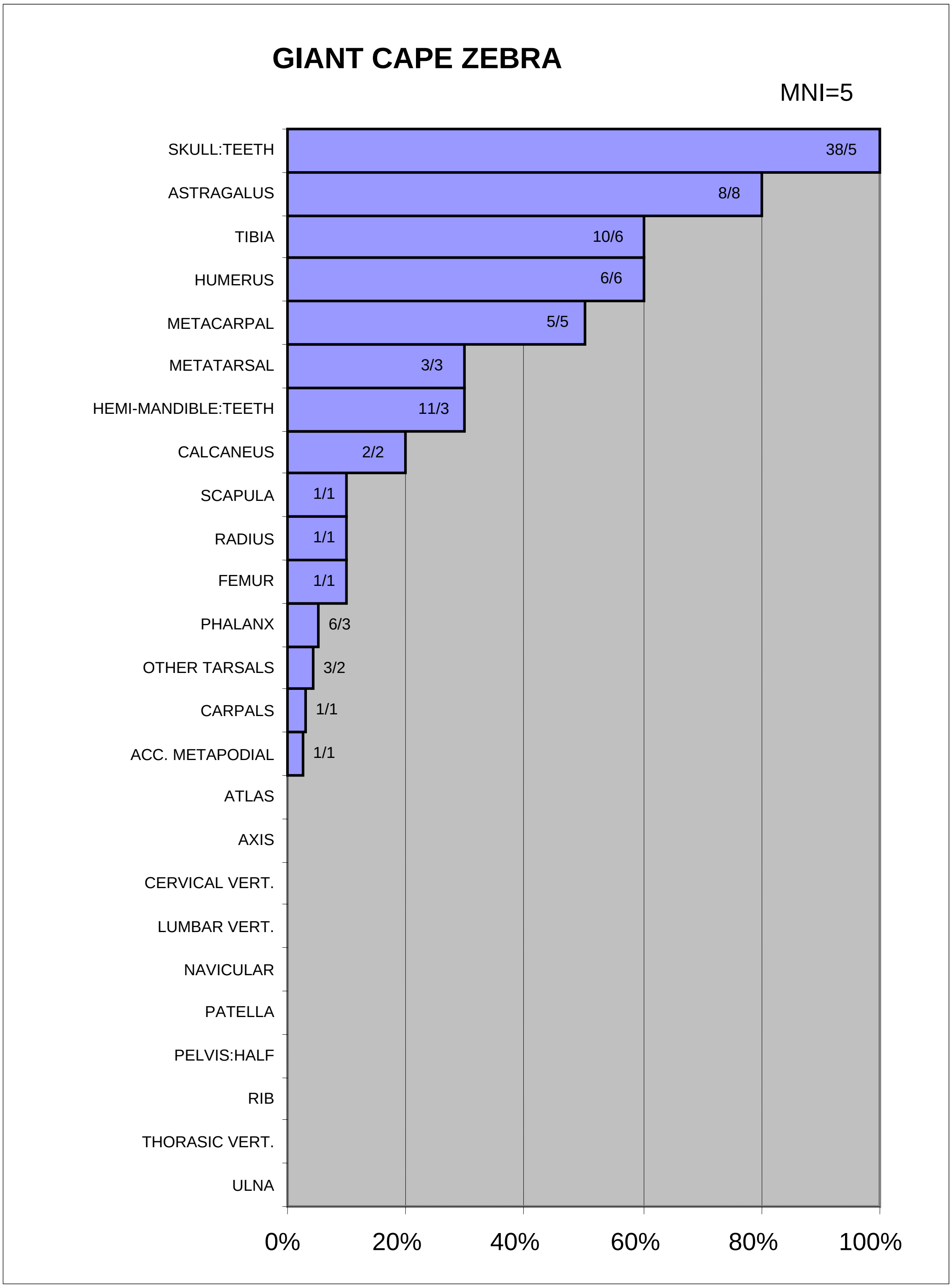


Figure 7.6. Giant Cape zebra skeletal element representation based on % survivorship. Numbers within the graph represent NISP/MNE values.

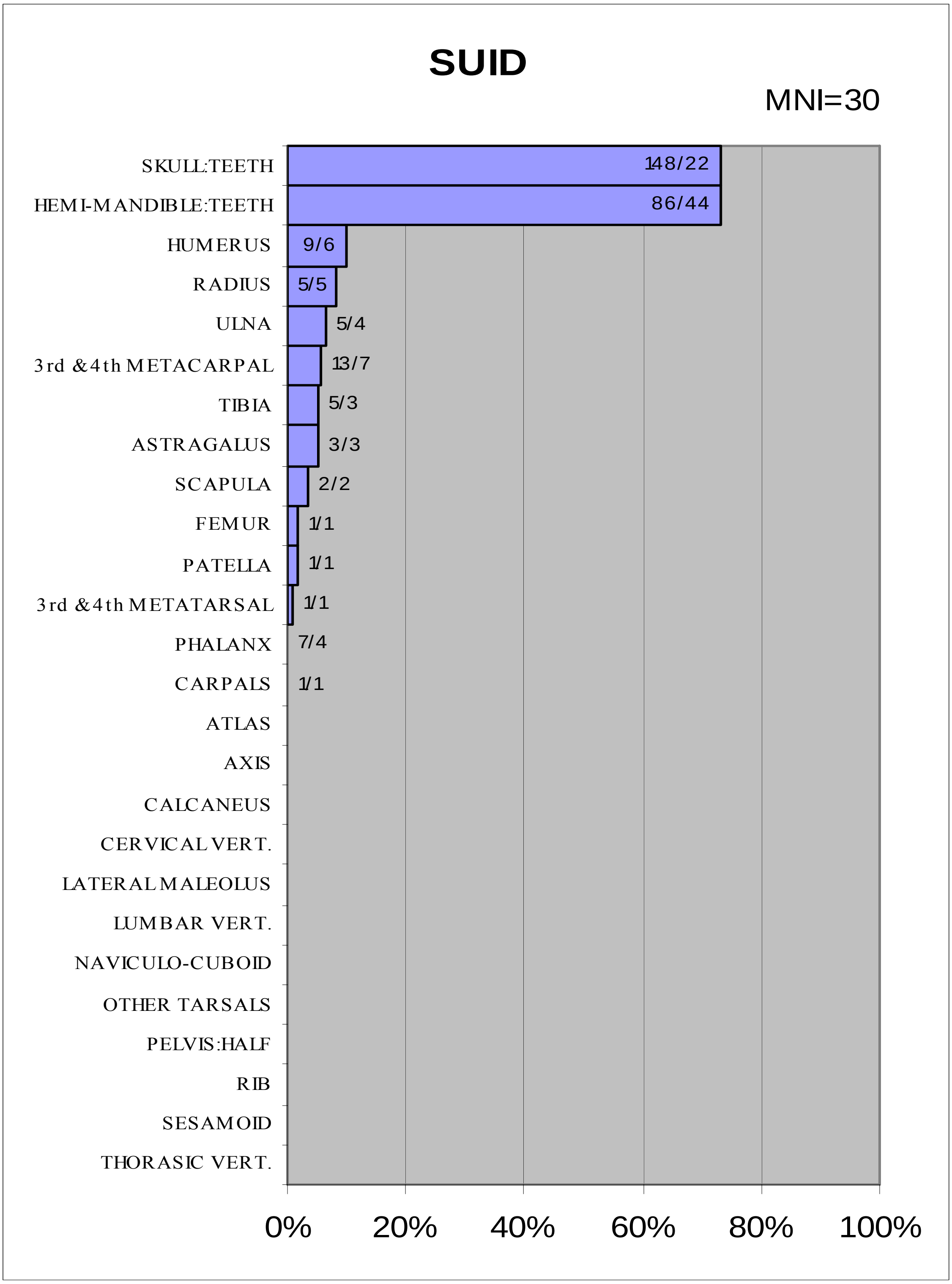


Figure 7.7. Suid skeletal element representation based on % survivorship. Numbers within the graph represent NISP/MNE values.

While the “schlepp effect” pattern is possible, the cause may not be exclusively the result of human activity. Many carnivore accumulated sites exhibit low numbers of phalanges and other small bones, such as, carpals, tarsals, and sesamoids. Both Equus Cave (Klein 1991) and Swartklip (Klein 1975), two known carnivore accumulations, show very low numbers of these bones. Phalanges are also nearly absent at modern hyaena dens. Bearder (1977) collected only 9 out of a 409 total bones at a spotted hyaena den in the Timbavati, and Skinner *et al*. (1980) only record 7 from a total of 267 bones from a striped hyaena den in Israel.

As discussed previously, Marean (1991) has shown that carpals and tarsals accurately measure post-depositional destruction. In addition to the relative absence of carpals and tarsals in hyaena accumulations, further studies by Marean *et al*. (1992:119) show that, “the result of hyaena ravaging is to mimic the schlepp effect.” Their experimental data show that when hyaenas scavenged from a simulated hominid site, consisting of defleshed hind-limb bones broken with hammerstones and several sections of vertebrae and ribs, all portions of the vertebrae and ribs were destroyed nearly 100% of the time, all portions of pelves and compact bones (tarsals) were destroyed between 50 and 75% of the time, and the limb bone epiphyses were destroyed frequently, but the middle shaft fragments were virtually never destroyed. The same pattern was also seen when the limb bones were left unbroken and then ravaged by hyaenas. Based on %survivorship of the Kalkbank assemblage shown in Figures 7.1-7.7, ribs, vertebrae (excluding the atlas and axis), pelves and compact bones show very low survivorship—never more than 40%, and rarely over 20%.

Although the experiments performed by Marean *et al*. (1992) focused on skeletal element survival subsequent to simulated hominid activity and is not directly relevant to assemblages exclusively ravaged by hyaenas, they also determined that hyaenas actively destroy bone elements with the lowest densities following Lyman (1984). In addition, experimental data provided by Richardson (1980) shows that when hyaenas feed on whole carcasses, they do destroy the elements with the lowest densities. Richardson's (1980) study records very low survival rates for ribs, vertebrae, pelves, and small compact bones—the same pattern seen at Kalkbank.

Completeness

Numerous researchers have noticed that hyaenas tend to attack long bones from the epiphyses and gnaw down the shaft, consuming the epiphyses, but leaving the shaft fragments unconsumed (Cruz-Uribe 1991; Marean and Spencer 1991; Capaldo 1990; Binford *et* al. 1988; Blumenschine 1988; Horwitz and Smith 1988; Potts *et al*. 1988; Hill 1983; Skinner *et* al. 1980; Sutcliffe 1970). Alternatively, humans break long bones at the mid-shafts when using hammerstones to extract marrow, resulting in faunal assemblages more fragmented than those of hyaenas (Brain 1981; Payne 1983; Bunn 1983; Richardson 1980). Assemblages with greater proportions of intact limb shafts than epiphyses can represent hyaena accumulations, but the opposite is not always true. Human accumulations are not always characterized by high fragmentation due to other factors, such as weathering, leaching, trampling, and profile compaction (Potts 1988; Cruz-Uribe 1991). At Kalkbank, there are few specimens beyond Behrensmeyer's (1978) weathering stage 1, and little profile compaction. Although the effects of leaching and trampling have not been assessed, the breakage is likely due to either carnivores or humans on fresh bone.

Figures 7.8-7.13 represent the completeness of all bovid limb bones by portion. All limb bones were identified as proximal, proximal + shaft, shaft, distal + shaft, distal, or complete. The proximal and distal portions are defined as “epiphysis only” specimens with no shaft included, while proximal + shaft and distal + shaft portions do include some length of shaft. Shaft portions are portions of the mid-shaft with no epiphysis. All values are based on MNE and record each specimen only once.

Humerus

The humerus is the most abundant limb bone in the Kalkbank assemblage. As shown in Figure 7.8, the humerus is most well represented in the majority of bovid size classes by shaft portions, followed by distal + shaft portions, and then the distal epiphysis. The Bovid 4 sample however, contains more distal + shaft portions, probably because of the extreme density of the distal portion. It is not surprising that there are very few proximal epiphysis or proximal + shaft epiphysis portions, as these portions have a very low density. The low density proximal humerus is easily consumed by carnivores.

Radius

Radius completeness (Figure 7.9) follows roughly the same pattern as humerus completeness, except that the proximal + shaft portions outnumber shaft portions. The pattern holds true for Bovid 3 and 4, as well as total bovid, but not for Bovid 2. This may be due to the inability of the epiphyses of smaller bones to withstand any number of destructive forces, most notably feeding by carnivores. There is also a reduced number of distal and distal + shaft portions due to their lower densities.

Metacarpal

Bone density studies by Lyman (1984) reveal that the density of proximal metapodials is only slightly higher than that of distal metapodials. Therefore, the abundance of proximal + shaft portions of the metacarpal, especially in Bovid 3 (Figure 7.10), does not fit the pattern of survival based on density. The cause of this discrepency may be based on identifiability rather than bone density. Proximal metacarpals are easily distinguished from proximal metatarsals, but many distal portions and shaft portions can only be identified as metapodials. Portions identified as metapodials were not included in skeletal element proportions or limb bone completeness tallies. As proximal portions are more identifiable, more are included in MNE counts.

Femur

Since very few femur specimens survived, little can be said about completeness for this limb bone (Figure 7.11). But, it does show the necessity of including shaft portions in MNE counts of limb bones as shaft portions are the most abundant for all bovid size classes.

Tibia

The tibia is also an example of the necessity of including shaft portions in MNE counts. The Kalkbank tibae further represent a classic case of survival based on density. The much denser distal + shaft and distal portions of the tibia greatly outnumber the much less dense proximal + shaft and proximal portions (Figure 7.12). In fact, the more dense distal portions survived 8 times more often than the proximal portions.

Metatarsal

The metatarsal counts suffer the same identifiability concerns as those for metacarpals. The proximal metatarsal portions are more identifiable than the distal and shaft portions, thus resulting in inflated numbers for the proximal portions. However, the proximal metatarsal is slightly denser than the distal metatarsal (Lyman 1984), so higher survival of proximal portions is expected, but not nearly to the degree shown in Figure 7.13.

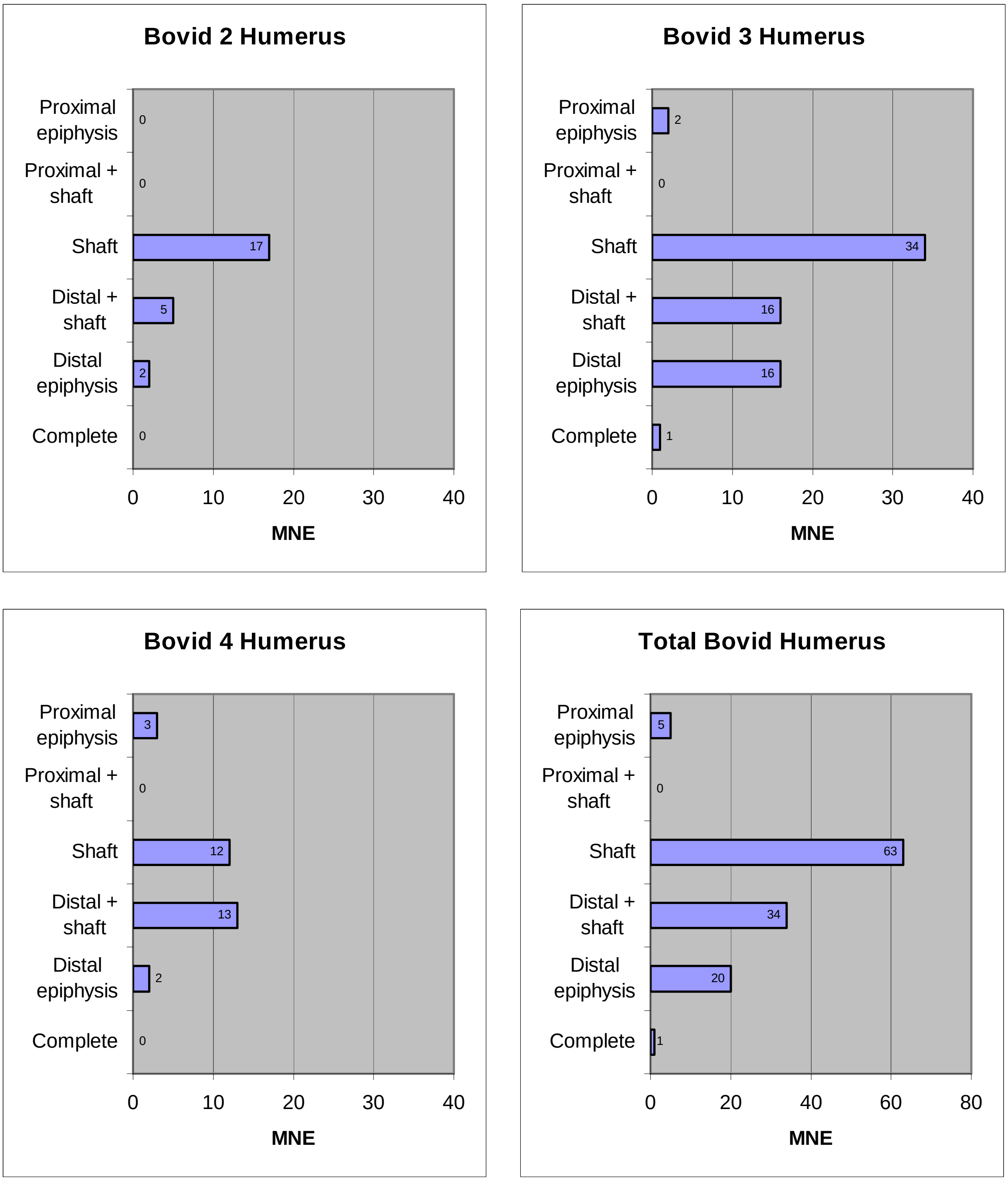


Figure 7.8. Bovid humerus completeness.

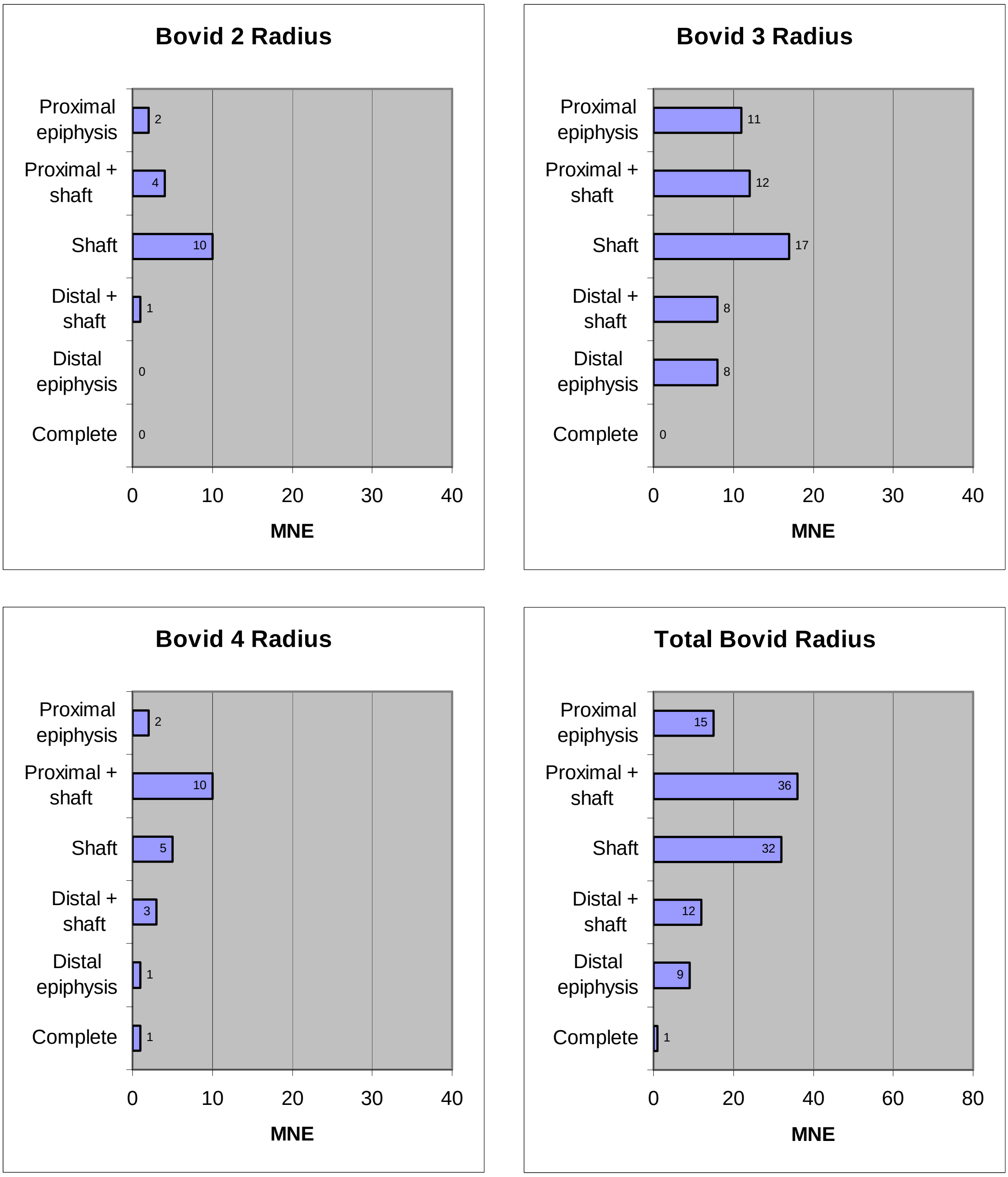


Figure 7.9. Bovid radius completeness.

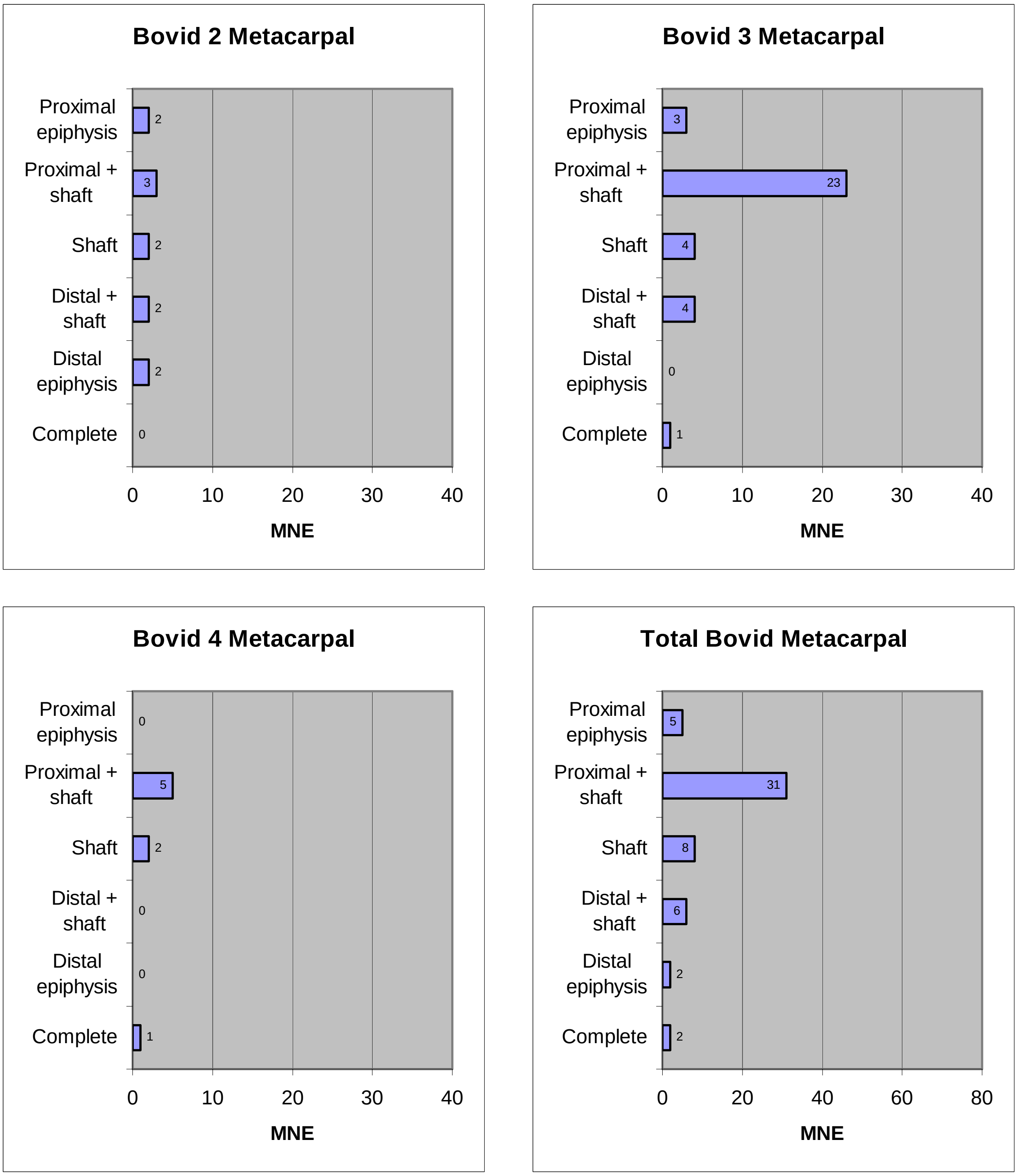


Figure 7.10. Bovid metacarpal completeness.

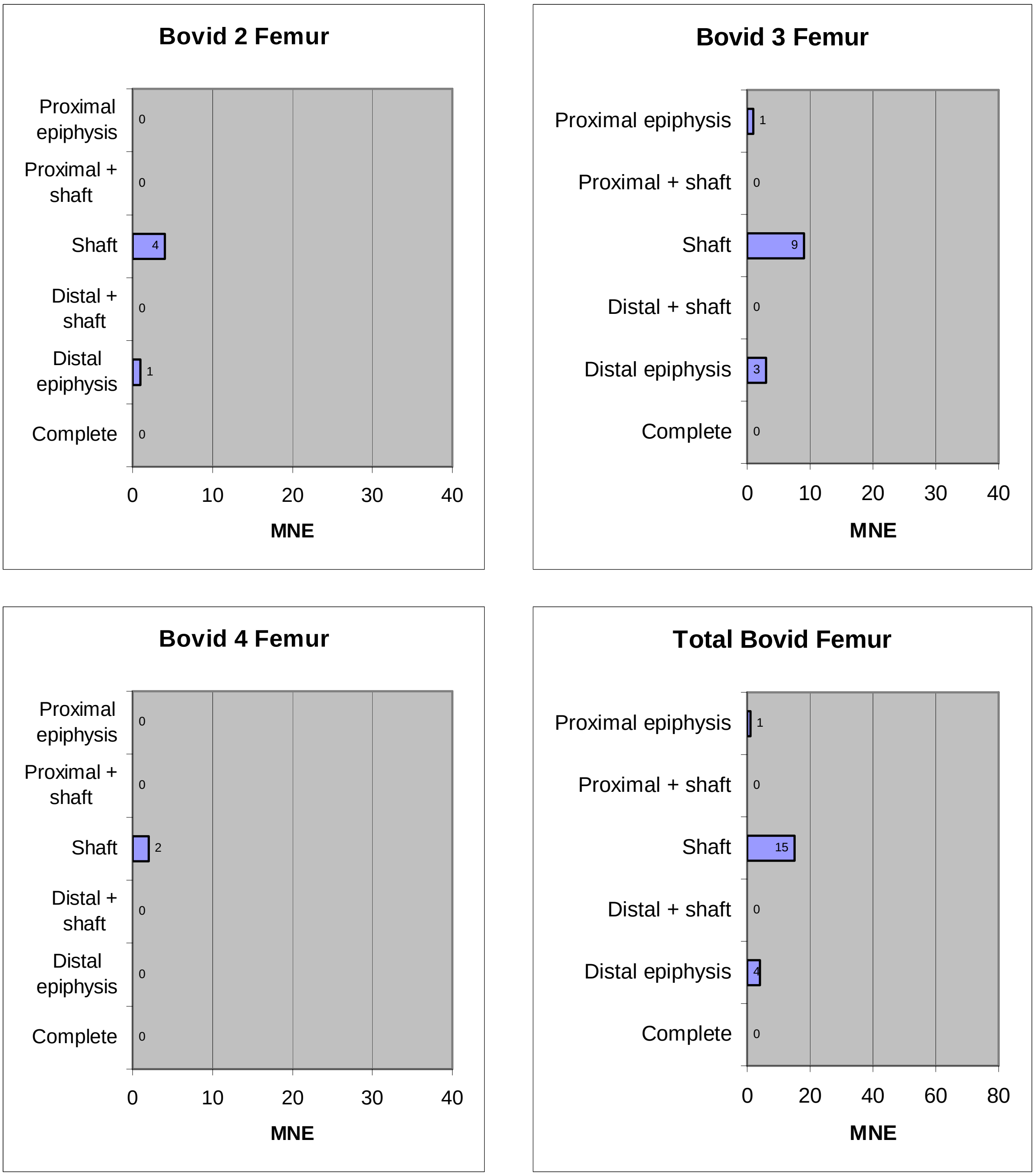


Figure 7.11. Bovid femur completeness.

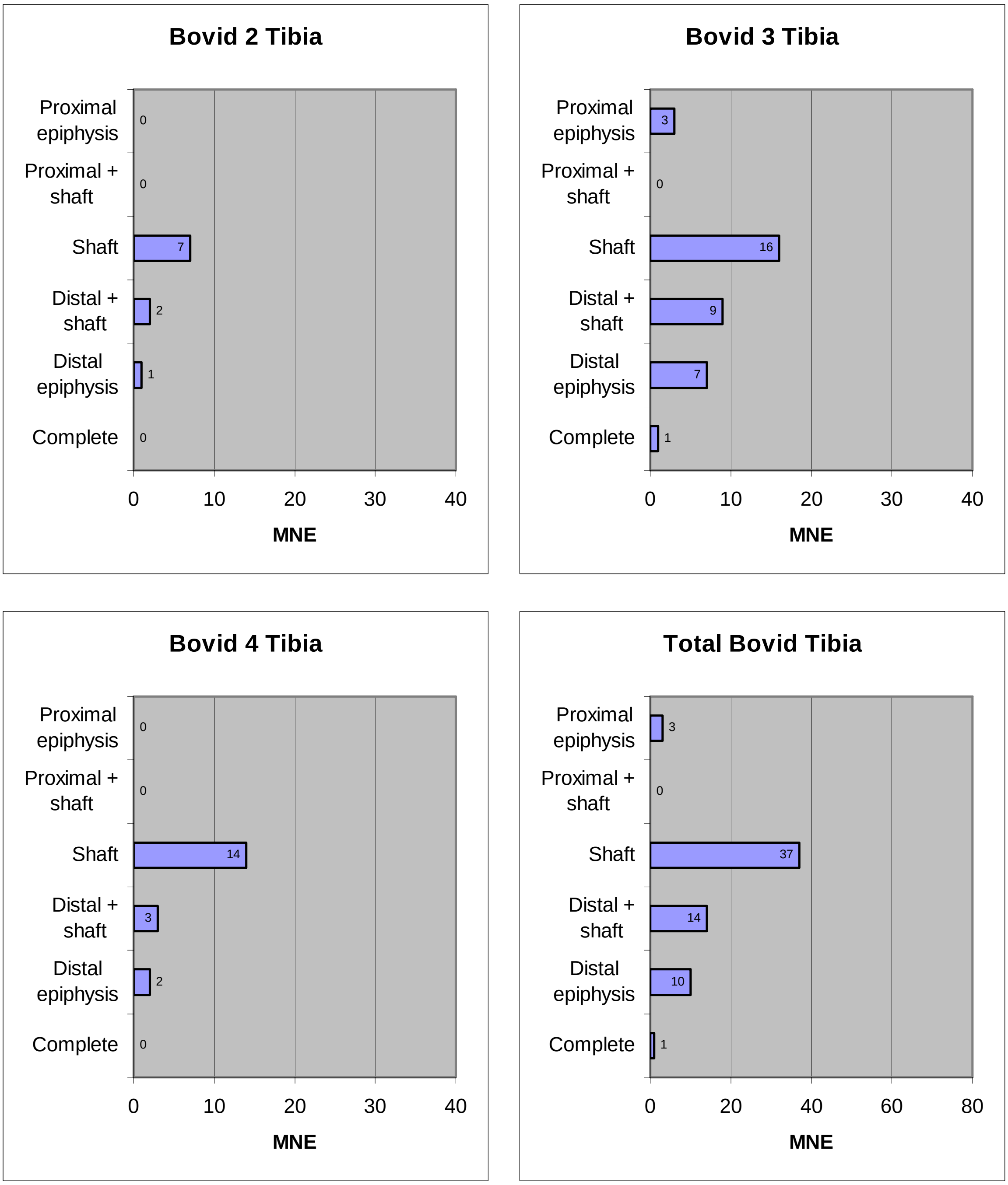


Figure 7.12. Bovid tibia completeness.

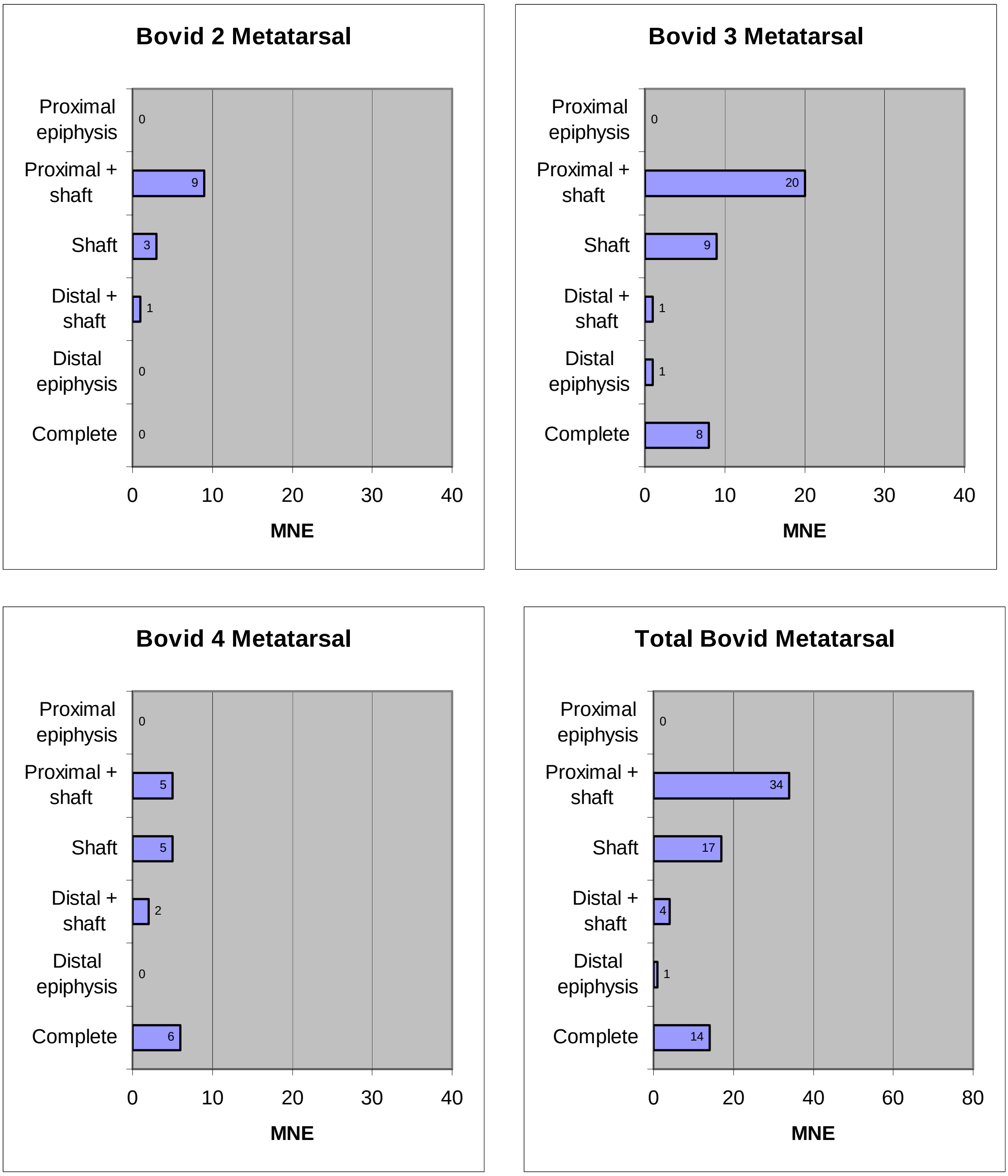


Figure 7.13. Bovid metatarsal completeness.

Summary

The analysis of limb bone completeness reveals two impotant points. First, the importance of limb bone shaft fragments in MNE counts. Klein (1975) first made zooarchaeologists aware of this through analysis of a hyaena accumulation at Swartklip. Bunn and Kroll (1986; also see Bunn 1986, 1988) later reiterated the importance of limb shafts when analyzing the assemblage from FLK *Zinjanthropus*. The Kalkbank evidence shows that limb shaft fragements are often the most abundant portion of limb bones that survives, and therefore the most accurate estimate of MNE.

Limb shaft fragments can also provide additional evidence about the accumulator. It has been noted that humans tend to leave assemblages that are more highly fragmented than those left by hyaenas (Cruz-Uribe 1991). However, a highly fragmented assemblage is not necessarily indicative of human activity. What is indicative of human activity is a highly fragmented assemblage in which the limb bone shaft fragments bear features of hammerstone breakage. At Kalkbank, only 3 specimens show evidence of hammerstone breakage. Alternatively, 143 bovid limb bone specimens show evidence of carnivore gnawing. The occurrence of tooth-marked bone in archaeological sites does not disqualify humans as primary accumulators of a site. According to Blumenschine (1988), such an overlap is even expected. It is the low number of cut marks and hammerstone percussion marks in relation to carnivore marks that eliminates humans as primary accumulators at Kalkbank.

The second important observation about limb bone completeness at Kalkbank is that the survival of nearly every bone portoin is governed by its density. Post-depositional destruction appears to be a minor aspect of bone breakage; therfore much of the damage was likely done by carnivores, possibly hyaenas. Hyaenas often choose for consumption the bones and bone portions that are least dense. The least dense bones tend to have greater amounts of cancellous bone and bone grerase (Binford 1978; Lyman 1985), which makes them more attractive to hyaenas as food.

Cranial/Postcranial Ratio

In hyaena accumulations, smaller ungulates are better represented by cranial elements (namely teeth) and larger ungulates by postcranial bones, thus, the cranial/postcranial ratio decreases with ungulate size based on MNI (Klein 1975; Cruz-Uribe 1991). This pattern is especially seen in a number of fossil hyaena den accumulations (see Cruz-Uribe 1991:Figure 6) to which hyaenas could not transport the skulls of large ungulates. The same pattern is evident at Kalkbank when compared to the cranial/postcranial ratios of Equus Cave and Swartklip, two known carnivore accumulations (see Table 7.1).

Table 7.1. Cranial/postcranial ratios of the Kalkbank Bovids and Equids compared to Equus Cave and Swartklip Data on Equus Cave and Swartklip from Cruz-Uribe (1991).

TAXA	EQUUS CAVE	SWARTKLIP	KALKBANK
Bovid 1	5,8	1,9	N/A
Bovid 2	5,6	1,2	1,6
Bovid 3	2,3	1,1	1
Bovid 4	0,8	0,5	0,8
Burchell's zebra	1,6	N/A	1,7
Giant Cape horse	0,5	N/A	0,6

However, Kalkbank is in an open-air setting, and not likely to be a hyaena den. If transport was the sole factor, the opposite pattern would be probable at Kalkbank, where hyaenas transported the skulls of smaller ungulates away from the site, leaving the larger ungulate skulls behind. Thus, the cause for this pattern must result from a factor other than carnivore transport.

Consumption, rather than transport seems a feasible alternative. The postcranial elements of smaller ungulates are less likely to survive hyaena feeding in comparison to the more robust postcranial elements of larger ungulates. The simplest argument for consumption can be seen in the NISP values for bovid postcranial elements, seen in Table 7.2.

Table 7.2. Cranial/postcranial ratios for Kalkbank Bovids, Equids, and Suids based on MNI and NISP.

TAXA	CRANAIL MNI	POST-CRANAIL MNI	MNI RATIO	NISP RATIO
Bovid 2	16(53)	10(155)	1,6	0,34
Bovid 3	23(142)	23(614)	1	0,23
Bovid 4	8(40)	10(193)	0,8	0,21
Zebra	12(171)	7(100)	1,7	1,71
Giant Cape horse	3(49)	5(48)	0,6	1,02
Suid	30(234)	4(53)	7,5	4,4

The NISP ratios for all bovid size classes are extremely low, decreasing with bovid size. Since hyaenas possess the capacity to completely destroy the postcranial elements of ungulates, especially smaller ungulates, cranial/post cranial ratios based on NISP may be a better method of quantification when dealing with open-air accumulations, such as Kalkbank. Furthermore, the % survivorship of Bovid size 2 postcranial elements is much lower than the same values for bovid sizes 3 and 4 (see Figures 7.1-7.3). The same is also true for Burchell's zebra and Giant Cape zebra, but to a lesser extent, whereas Suids represent the most extreme example of this pattern (see Figures 7.5-7.7). With these ratios and %survivorship taken into account, the complete destruction and/or consumption of ungulate limb bones can account for the cranial/postcranial ratios in relation to ungulate size.

Summary

There are several important points regarding skeletal element proportions at Kalkbank, all of which can be determined to result from carnivore consumption of lower density bones. In terms of % survivorship, experimental data provided by Marean *et al*. (1992) and Richardson (1980) show that hyaenas tend to completely destroy skeletal parts with low densities, namely the ribs, vertebrae and pelves. Kalkbank also shows very low numbers of the same low density skeletal elements. When looking at long bone completeness, many of the long bones consist of shaft fragments only, a common occurrence in both human and carnivore accumulations. But, the presence of 143 carnivore gnawed Bovid long bones, as opposed to only 3 human induced hammerstone percussion marks, points towards carnivores as the principal accumulators. And lastly, the cranial-postcranial ratio decreases with ungulate size in the Kalkbank faunal assemblage, a pattern seen in several other hyaena accumulations. The complete destruction or consumption of the smaller Bovid post-cranial elements by carnivores is the most likely explanation for this pattern.

CHAPTER 8: MORTALITY PROFILES

Age frequency data for deceased animals, or mortality profiles, have been used by many researchers as evidence for past human foraging habits, land use, and evolutionary changes in hominid sociality (Stiner 1990; see also Klein and Cruz-Uribe 1984). Mortality patterns have also been used in palaeontology to interpret the agents of accumulation in the absence of humans (Kurtén 1953; Van Valen 1964; Voorhies 1969). Although mortality patterns alone cannot exclusively diagnose the cause of accumulation, they can be an effective tool when used in conjunction with other taphonomic data.

In most archaeological and palaeontological cases, mortality patterns usually fall into one of two categories—catastrophic or attritional. A catastrophic profile refers to an assemblage that parallels the actual or theoretical age structure of a living population of animals in which successively older age classes consist of progressively fewer individuals. A catastrophic profile may result from such natural causes as epidemic diseases, floods, or volcanic eruptions and will affect all age classes equally. In an archaeological context, catastrophic profiles may imply communal game drives, the use of nets, or some other cooperative hunting technique (Klein and Cruz-Uribe 1984).

Attritional age profiles are quite different, in that reproductively active, prime-aged adults are underrepresented in relation to their actual live abundance. On the other hand, very young and very old individuals are overwhelmingly abundant. Causes for this pattern can also be explained either in terms of natural processes or predation. Starvation, disease and other natural mortality circumstances affect very young and very old individuals disproportionately, leading to attritional mortality. In terms of predation, attritional profiles may represent the relative ease of killing the weaker, young and old individuals.

A third mortality pattern, the prime dominated profile, is seen less often in archaeological and palaeontological assemblages (Stiner 1990). This pattern is similar to the attritional profile, but rather than a very old and very young dominated assemblage, prime-aged adults dominate. Prime-dominated profiles contrast with patterns normally associated with most mammalian carnivores, but they can especially be seen in assemblages associated with ambush hunting (Frison 1984; Todd and Hofman 1987). Selection of prime-age adults with the aid of long-range weapons by humans or cooperative hunting strategies could undoubtedly produce this type of mortality profile (Stiner 1990). This pattern would involve considerable selection not particularly seen in non-human predators, but it may be most common in instances where large groups of animals congregate during feeding or around water holes.

Methods of Age Determination

The first step is to identify the age at time of death for each individual in the assemblage. Numerous researchers have put forth methodologies to determine the age at which an animal died. The most reliable methods concern epiphyseal fusion, counting of cementum annuli in teeth, and examination of dental eruption and wear. The latter is the most used by researchers dealing with archaeological and palaeontological assemblages and will be used here.

Stages of dental eruption and wear can be determined in two ways. One method uses crown height measurements to assess the age of animals with high crowned teeth. Traditionally, the relationship between unworn crown height, the age of tooth eruption or shedding, and potential ecological longevity is used to determine age using crown heights (Spinage 1971, 1973, 1976; Klein and Cruz-Uribe 1983, 1984). The crown height is the minimum distance between the occlusal surface of the tooth and the line separating the enamel from the dentine of the roots. This method is ideal because crown heights in ungulates vary strongly with age due to wear. Moreover, single teeth can be aged using this method. The only drawback is that the whole tooth or nearly the whole tooth must be present to assess crown height. As many of the teeth in the Kalkbank assemblage are fragmentary and do not include both enamel and roots, this method was deemed unsuitable for assessment of age at time of death and calculating mortality profiles.

As an alternative, visual assessment of dental wear was used in this analysis. This method requires only the simple inspection of occlusal wear on the Kalkbank specimens as compared to known-age individuals of the same or very closely related species. While less accurate than crown-height measurement, the examination of occlusal wear represents the only method capable of including all teeth in the assemblage representing a single individual.

Whereas mortality profiles are often constructed using actual numerical ages of individuals, this analysis utilized three age divisions following Stiner (1990), with the intent of avoiding many of the complexities involved with smaller sample sizes. The three age divisions used are juvenile, adult, and old adult. Individuals in the juvenile age division possess deciduous teeth or emerging, but unworn, teeth. The juvenile individuals are easily differentiated from those individuals of the adult age division, which have a full set of permanent teeth. The separation between adult and the old adult age division, however, is less clear. Here, the old age adult division begins at roughly 60-70% of an individual's maximum potential lifespan (see Stiner 1990:311-312 and references cited within), the age at which productivity and reproduction sharply decline. All age divisions were further separated into tooth wear stages or percentage of maximum lifespan, explained below, according to species or higher taxonomic group.

It should be noted that only mortality profiles for Bovid size 2, Bovid size 3, and Suids were calculated. Bovid size 4 included too few individuals and the available data on Equid tooth wear proved unreliable, resulting in their exclusion from the calculation of mortality profiles. Nonetheless, Bovid size 2, Bovid size 3, and Suids constitute the bulk of the large mammals present at Kalkbank and provide adequate data for the construction of mortality profiles.

Bovid size 2

The mortality profile for Bovid size 2, which includes impala (*Aepyceros melampus*), springbok (*Antidorcas marsupialis*) , and Bond's springbok (*Antidorcas bondi*), can be seen in Figure 8.1. In total, 16 specimens were included. The one specimen from a mountain reedbuck was excluded due to a lack of data available on tooth wear for that species. Table 8.1 shows the specimens and the corresponding wear stages used in the construction of the mortality profile. The wear stages in regards to Bovid size 2 all follow that of Rautenbach (1971) for springbok. Although the teeth of Bond's springbok were unusually hyper-hypsodont, according to Klein and Cruz-Uribe (1984:50, Table 4.2) they shared a similar life history (i.e. dental shedding/eruption ages and maximum lifespan) with the extant springbok, and therefore all wear stages for Bond's springbok follow those outlined for the extant springbok. In regards to impala, the wear stages of Spinage (1971) were adapted to fit the scheme outlined by Rautenbach (1971), discussed below.

Rautenbach (1971) identifies eight wear stage classes, designated I, II, III, IV, V-light wear, V-moderate wear, V-heavy wear, and VI. In this analysis wear stage classes I through IV were grouped together under juveniles based on the eruption of the third molar at stage IV. The differentiation between juvenile and adult is drawn between wear stages IV and V. There are three levels of wear in class V, light, moderate, and heavy, similar to Simpson (1966). Finally, wear stage class VI represents very old individuals with extra-heavy wear on their teeth, where the lowest occlusal surface is at the gum line. Spinage (1971) employs ten wear stage classes (I, II, III, A, B, C, D, E, F, and G) for impala, but many of them overlap with those outlined by Rautenbach (1971). The corresponding wear stages are as follows: stages I through IV following Rautenbach (1971) and I through III following Spinage (1971); V-light wear and A through B; V-moderate wear and C through E; V-heavy wear and F; and VI and G.

The pattern seen in Figure 8.1 usually indicates a stable living population, where the frequencies of individuals decrease with age. However, the sample in this case comes from three distinct species, so little can be said of the population structure at the time of accumulation. But, taken as a whole, the mortality profile seems to indicate that very young and young adult individuals of Bovid size 2 died at a disproportionately high rate compared to older individuals. The resultant pattern mirrors that of a catastrophic mortality pattern, except for the complete absence of very old individuals.

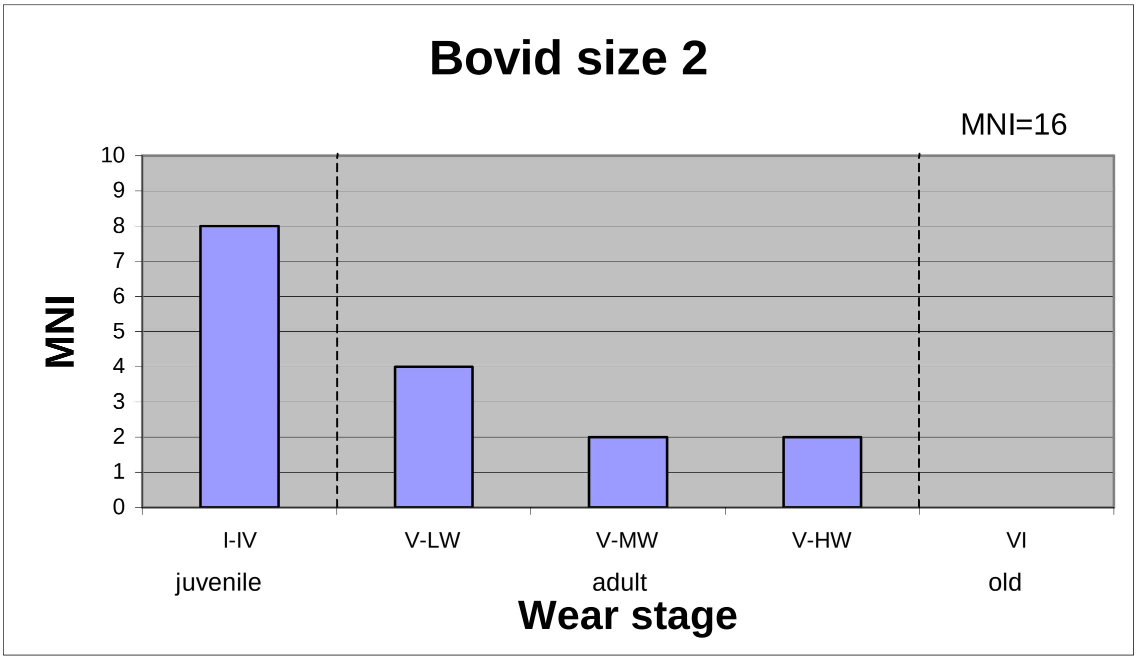


Figure 8.1. Mortality profile for Bovid size 2. Wear stages from Rautenbach (1971).

Table 8.1. Bovid size 2 mortality profile data. Wear stage class data from Rautenbach (1971).

Species	MNI	Catalog #	Part	Wear stage
Antidorcas marsupialis	5	11/67/702	lower L M3	V-HW
Springbok		11/67/703	lower L M3	V-LW
		11/67/705	lower L M3	IV
		K/B 923	lower L M3	IV
		11/67/710	upper R dP4	II
Antidorcas bondi	6	11/67/648	lower R M2	V-LW
Bond's springbok		11/67/649	lower R M2	V-MW
		11/67/650	lower R M2	III
		11/67/651	lower R M2	V-LW
		11/67/773	lower R M2	II
		11/67/654	lower L dP4	I
Aepyceros melampus	5	11/67/724	upper R M1	V-MW
Impala		K/B 735	upper R M1	II
		K/B 863	upper R M2	V-HW
		K/B 754	upper L M2	V-LW
		K/B 760	upper L M3	III

Bovid size 3

Figure 8.2. depicts the mortality profile for bovid size 3, including: blue wildebeest (*Connochaetes taurinus*), red hartebeest (*Alcelaphus buselaphus*), and blesbok/tsessebe (*Damaliscus sp.*). Table 8.2 displays the background data for constructing the profile. All of these species share similar dental shedding/eruption ages and potential maximum lifespan (Klein and Cruz-Uribe 1984:50, Table 4.2); therefore the teeth of those species were all aged following Attwell (1980) for the blue wildebeest (*Connochaetes taurinus*). An MNI of 23 was used when constructing the mortality profile for Bovid size 3. Atwell (1980) separated wear stages into yearly increments (i.e. 3 - <4, 4 - <5, 5 - <6, etc.) up to 21 years of age, the determined maximum longevity. This facilitated easy separation of the mortality profile of Bovid size 3 into 10% increments of an estimated 20-year lifespan. Juveniles constitute only the first 10%, or two years, of the lifespan based on the minimum ages at which the milk teeth are shed and the permanent molars erupt, determined to occur between 18 and 32 months of age (Atwell 1980:123, Table 1). Adult individuals account for the lifespan ranging from >10% to <70%. The latter boundary was chosen because significant wear does not appear on the molars until approximately 14 years of age, or 70% of the lifespan. All individuals past 70% of the maximum lifespan were designated old individuals.

The mortality profile of Bovid size 3 (Figure 8.2) differs greatly from that of the smaller bovid size 2 profile. Undoubtedly prime age adults constitute the bulk of individuals represented in the Bovid size 3 profile. Of the 23 MNI, 87% are adults, 13% are juveniles, and none were determined to be old individuals.

Stiner (1990) refers to this as a prime-dominated mortality pattern. No cases outside of those associated with selective ambush hunting by humans have been described. At Kalkbank the prime-dominated pattern for Bovid size 3 is identifiable, yet evidence for human involvement is poor.

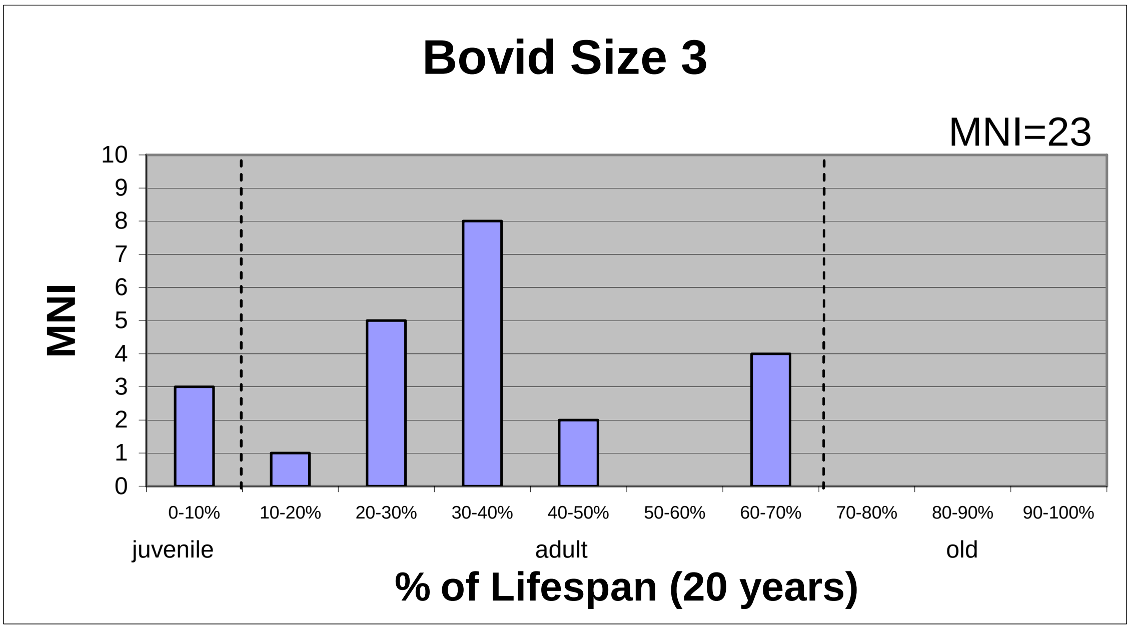


Figure 8.2. Mortality profile for Bovid size 3. Wear stages and corresponding % of lifespan data from Attwell (1980).

Table 8.2. Bovid size 3 mortality profile data. Wear stages and corresponding % of lifespan data from Attwell (1980).

Species	MNI	Catalog #	Part	Age	% of lifespan
Connochaetes taurinus	10	11/67/735	upper R M2	5-6	20-30%
Blue wildebeest		11/67/736	upper R M2	4-5	20-30%
		11/67/737	upper R M2	6-7	30-40%
		11/67/738	upper R M2	9-10	40-50%
		11/67/739	upper R M2	5-6	20-30%
		K/B 734	upper R M2	4-5	20-30%
		K/B 739	upper R M2	6-7	30-40%
		K/B 745	upper R M2	12-13	60-70%
		K/B 748	upper R M2	12-13	60-70%
		11/67/747	upper L dP4	JUV	0-10%
Alcelaphus buselaphus	4	11/67/722	upper R M1	7-8	30-40%
Red hartebeest		11/67/723	upper R M1	5-6	20-30%
		11/67/721	upper L M1	7-8	30-40%
		K/B 872	upper R M3	3-4	10-20%
Damaliscus sp.	9	11/67/657	lower R M2	6-7	30-40%
Blesbok/Tsessebe		11/67/658	lower R M2	8-9	40-50%
		11/67/659	lower R M2	7-8	30-40%
		11/67/661	lower R M2	7-8	30-40%
		11/67/662	lower R M2	12-13	60-70%
		K/B 858	lower R M2	12-13	60-70%
		K/B 879	lower R M2	6-7	30-40%
		11/67/667	lower R dP4	JUV	0-10%
		11/67/668	lower R dP3	JUV	0-10%

Suid

Suid mortality is depicted in Figure 8.3, and Table 8.3 shows the background data. A total of 30 individuals is represented in the profile, all representing the extant Warthog, *Phacochoerus aethiopicus*. Shaw (1940) describes the wear patterns for what was termed the extant *P. africanus*, but here *P. africanus* and *P. aethiopicus* refer to the same species. Wear stages for the lower third molar, following Shaw (1940), are lettered from A to I. Both A and B represent the unerupted molars of juvenile individuals. Wear stages C marks the separation between juvenile and adult based on the almost complete eruption of the third molar by stage C. Separation of the adult and old adult takes place between wear stages F and G, the time when Shaw (1940) notes a number of important characteristics related to heavy tooth wear. The mortality profile for Suids (Figure 8.3.) looks quite similar to that of the Bovid size 3—dominated by prime-adult individuals. Over 75% (23 of 30) of the individuals come from the prime-adult category, with only 16% (5 of 30) and 7% (2 of 30) coming from the juvenile and old adult categories, respectively. This pattern undoubtedly represents a prime dominated mortality profile described by Stiner (1990) and also seen with the Bovid size 3 from Kalkbank (Figure 8.1).

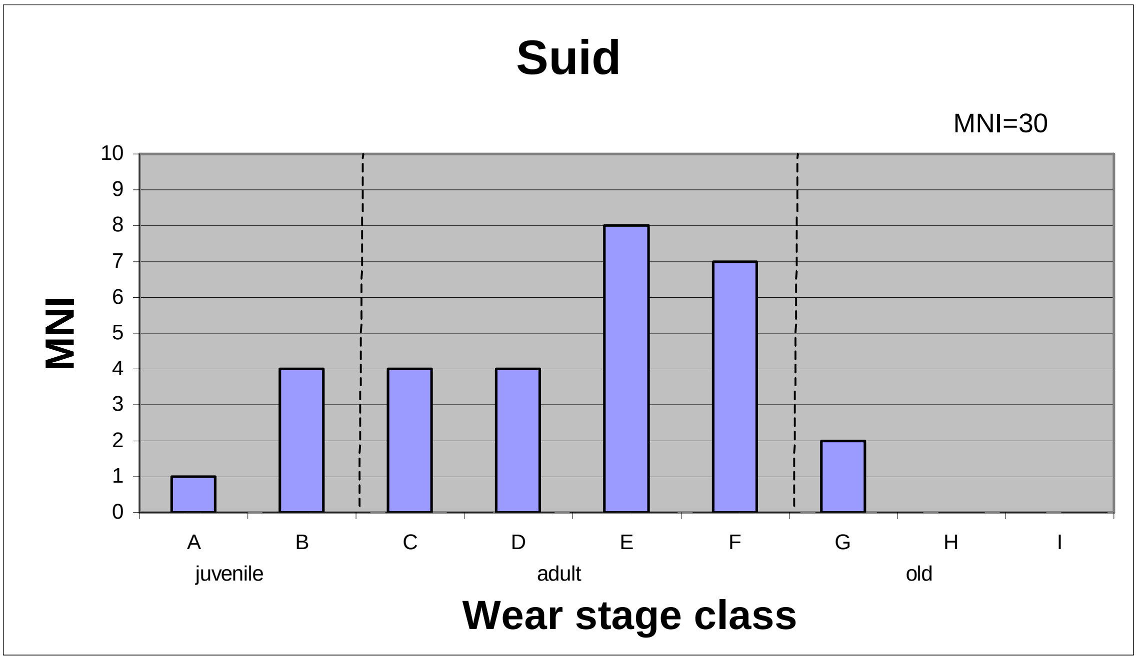


Figure 8.3. Suid mortality profile. Wear stage classes from Shaw (1940).

Table 8.3. Suid mortality profile data. Wear stage classes from Shaw (1940).

Species	MNI	Catalog #	Part	Wear stage
Phacochoerus aethiopicus	30	11/67/458	lower L M3	F
Warthog		11/67/459	lower L M3	E
		11/67/462	lower L M3	C
		11/67/463	lower L M3	B
		11/67/464	lower L M3	F
		11/67/465	lower L M3	D
		11/67/475	lower L M3	E
		11/67/476	lower L M3	D
		11/67/481	lower L M3	C
		11/67/497	lower L M3	E
		11/67/505	lower L M4	B
		K/B 3	lower L M3	C
		K/B 6	lower L M3	F
		K/B 21	lower L M3	B
		K/B 40	lower L M3	F
		K/B 53	lower L M3	E
		K/B 55	lower L M3	D
		K/B 64	lower L M3	B
		K/B 67	lower L M3	G
		K/B 72	lower L M3	F
		K/B 78	lower L M3	C
		K/B 87	lower L M3	D
		K/B 92	lower L M3	E
		K/B 101	lower L M3	E
		K/B 102	lower L M3	F
		K/B 104	lower L M3	E
		K/B 105	lower L M3	F
		K/B 125	lower L M3	E
		11/67/451	lower L M3	G
		11/67/472	lower L dP4	A

Summary

The environmental and geological context of the bones at Kalkbank coupled with mortality profile data rule out the possibility of a catastrophic event as the agent of accumulation. Attritional mortality is suggested for Bovid size 2, while prime-dominated mortality is suggested for Bovid size 3 and Suid. Attritional mortality profiles are often seen with carnivore hunting and especially hyaena accumulations (Cruz-Uribe 1991), but prime-dominated mortality profiles have generally been associated with humans aided by the use of long-range weapons and cooperative hunting strategies. Routine selection of prime-age adults implies considerable foresight, typically not seen in non-human predators. If humans were to account for the prime-dominated assemblage at Kalkbank, some form of routine butchery would also be expected.

Ambush hunting by carnivores may be a possible explanation for the Bovid size 3 and Suid mortality pattern. Haynes (1988) observed just this at Ngamo Pan in the Hwange National Park, Zimbabwe. The more than 70 individuals recovered from the pan were probable victims of lion or hyaena predation, which was often witnessed at the pan. Moreover, the counted skeletons only account for a small portion of the complete bone deposit buried there. No figures on age of the individuals recovered were given, but this example clearly illustrates the capability of large non-human predators to accumulate large numbers of bones near pans.

Other factors, however, may be involved in producing the prime-dominated patterns seen here. Of concern is the complete lack of old adult individuals for all taxa. Klein (1982) notes the rise in mortality among the oldest age group is often undetectable. In this case, a lack of detailed data on the ageing criteria for many ungulates may be part of the problem. The absence of very old individuals in the mortality profile may be due to a number of factors. Firstly, data for very old individuals is inadequate. Ageing criteria for old individuals are not detailed because of debates on the potential maximum lifespan and corresponding wear patterns (see Spinage 1971:213-214). Therefore, much of the data on potential maximum lifespan are calculated rather than observed. The calculated ages render it difficult to assess those ages to a wear stage. And secondly, a very old tooth from within the assemblage may act as a sort of internal constant from which to gauge the reliability of assigning teeth into relatively older wear stage classes. No teeth from Bovid size 2 in the Kalkbank assemblage qualify to act as an internal constant, ultimately producing no individuals from the very old wear stage classes.

The possibility exists that the complete lack of old individuals resulted in the prime-dominated profile. The reasons for this may be similar to those described above for Bovid size 2. Additionally, Attwell (1980) notes that with dentitions over 14 years of age, the reliability of age determination drops sharply. However, there are only four individuals past 50% of their potential lifespan. These four could arguably be included in the old age class, but prime adult individuals would still dominate and the overall shape of the mortality pattern would remain the same.

All in all, it seems that further information on the mortality of the Kalkbank individuals is required in order to reliably interpret the mortality patterns.

CHAPTER 9: DISCUSSION AND CONCLUSION

The stone tools and fauna uncovered at Kalkbank point toward accumulation of the site during the latter part of the Middle Stone Age. The pan sediments indicate a climate similar to that of today, possibly wetter at the time of accumulation, and a much drier climate subsequent to deposition. The site likely dates to the later Middle Stone Age after 30 000 years ago, when the local climate became drier and cooler, leading to the formation of several layers of calcrete caused by evaporation of the ancient pan. The immediate environment around the Kalkbank pan, as indicated by the fauna, was predominantly grassland with patches of open woodland nearby, similar to the local environment today.

At sites such as Kalkbank, only three agents are generally thought to be able to accumulate such large amounts of fauna: carnivores, humans, and porcupines. A relatively low percentage of bones were gnawed by porcupines, therefore the site was not a porcupine accumulation. Instead, porcupines likely gnawed on the dry bones of animals previously killed by carnivores or humans. At the same time insects and roots were acting to leave their marks on the large accumulation of dried, broken bones.

The number of carnivore gnaw marks, especially on limb shaft fragments, greatly outnumber the marks created by humans, leading to the hypothesis that carnivores were the major accumulators of the Kalkbank faunal assemblage. The absence of ribs and vertebrae, the least dense parts of the skeleton, also suggests a large-scale involvement on the part of carnivores. Whether this involvement was through active hunting or scavenging of natural deaths is difficult to determine. Mortality profiles calculated for Bovid size 3 and Suids indicate that a majority of these animals were prime-aged adults, the least likely candidates for natural death. It is easy to imagine that carnivores actively hunted these animals near the Kalkbank pan where large concentrations of animals would gather during periods of water shortage.

Sites with a similar pattern to Kalkbank are not uncommon in southern Africa. Few are contemporaneous with Kalkbank, but several can be dated to Acheulean times. In the southern African Acheulean, Cave of Hearths, Olieboompoort, Wonderwerk, and Montagu account for the only hominid cave occupations. All other sites are open-air sites, generally occurring around streams, lakes, springs, and pans (Deacon 1975; Klein 2000, 1988, 1977) –very similar to the environment around the Kalkbank pan. At these sites, the presence of stone tools indicates some level of hominid involvement with the faunal assemblages, but evidence of carnivore activity is more significant. Two sites in near-primary context that demonstrate this pattern are Duinefontein 2 and Elandsfontein "Cutting 10". There are other sites such as Namib IV (Shackley 1980, 1982) and Kathu Pan (Beaumont *et al*. 1984; Klein 1988) in southern Africa, Olorgessaile (Leakey 1952; Isaac 1968,1977; Shipman *et* al. 1981; Potts 1989; Potts *et al*. 1999;) in Kenya, and Torralba (Freeman 1975, 1994; Howell and Freeman 1983; Shipman and Rose 1983; Binford 1987; Klein 1987), Aridos (Villa 1990), Bilzingsleben (Schwarcz *et al*. 1988; Mania 1995) and Schöningen (Dennell 1997; Thieme 1997) in Europe that display a pattern similar to that at Kalkbank. Only Duinefontein and Elandsfontein "Cutting 10" are discussed here, as they are closest, geographically, and offer more relevant comparison to Kalkbank.

Duinefontein 2 is located 35 kilometres north of Cape Town on the Atlantic coast of South Africa. Of importance at this site is Horizon 2, where numerous bones and artifacts accumulated during a period of time when dune formation ceased and the sea level was relatively high, sometime between 400 000 and 200 000 years ago (Klein *et al*. 1999). Large ungulate remains in Horizon 2 consist of both browsers and grazers, suggesting a grass and bush mosaic or savanna woodland environment. Hippopotamus, reedbuck, and toad remains show that standing water must have been near by (Klein 1976; Klein *et al*. 1999). Many axial elements of large bovids found in near anatomical position have led Klein *et al*. (1999) to conclude that the site experienced little fluvial transport or post-depositional disturbance.

A few carnivore coprolites were found, but too few for the site to be considered a carnivore denning area (Klein 1976). The presence of carnivores is also shown by marks left on 33% of the Bovid bones (Klein *et al*. 1999:173, Table 2). In contrast, only 1% of the Bovid bones show any evidence of human-produced tool marks (Klein *et al*. 1999:173, Table 2). The assemblage, with its articulated axial elements, is consistent with a gradual accumulation of carcasses partially disarticulated during carnivore feeding according to Klein *et al*. (1999) and Cruz-Uribe *et al*. (2003).

Elandsfontein "Cutting 10", located 100 kilometers northwest of Cape Town, is also in near-primary context. Cutting 10 displays no geomorphic evidence for deflation of the sediments, and no wind or sand abrasion occurs on the bones (Klein 1978). Also, none of the bones show any degree of rolling, which might suggest fluvial transport. The environmental conditions at Cutting

10 appear much wetter than the present day. The presence of hippopotamus in the faunal assemblage suggests that water was near the site. Taxonomically, the faunal assemblage is of Mid-Pleistocene age, consisting of elephant (*Loxodonta atlantica*), equid, hartebeest, and wildebeest, among others. Singer and Wymer (1968) characterized the artifacts, including 47 handaxes and 3 cleavers, as Late Acheulean. A date of 400,000-200,000 is probable when considering both the fauna and stone artifacts (Klein 1978).

Klein (1978), following Isaac (1971), states that the bone-to-stone artifact ratio suggests Cutting 10 exhibits qualities of a kill/butchery site. But, there is no evidence of cut marked bones to suggest a human presence large enough for the site to be considered a kill site. Like Duinefontein 2, "the extent to which hominids are responsible for the presence of the bones is hard to establish" (Klein 1976: 17). According to Klein (1988), an Acheulean living site or base camp is the only occurrence that can be excluded. Rather, Cutting 10 could represent carnivore kills, natural deaths, or hominid scavenging.

The similarities between these sites and Kalkbank offer insight into the subsistence and land use patterns of hominids during the southern African Acheulean and Middle Stone Age. It is generally believed that Acheulean hominids preferred living close to standing water, while MSA sites are more common in caves (Thackeray 1992; Wadley 1993). It is also generally held that MSA humans were much more adept at hunting than their Acheulean counterparts (Klein 2000). Sites such as Klasies River Mouth (see Klein 1999 and references within) offer solid evidence for active hunting during the MSA at a cave setting. It would be expected that MSA open-air sites would show a closer resemblance to

MSA cave sites. At ≠Gi, an MSA site dated to 77 000 BP, evidence for the hunting of some dangerous species like zebra, warthog, and *Homoioceras*, is present (Brooks *et. al.* 1980; Helgren and Brooks 1983; Brooks and Yellen 1987). However, most MSA open-air sites, including Kalkbank, do not show a large scale human involvement and more closely mirror Acheulean open-air sites. It is certainly possible that MSA and Acheulean people exploited these sites in a similar fashion—only marginally scavenging carcasses from sites close to standing water. It is equally possible that sites with similar formation processes suffer from similar site formation biases. With that said, sweeping statements about how Acheulean and Middle Stone Age people used open-air sites cannot be made. What can be said is that the Kalkbank site resembles many of the Acheulean open-air sites, and was likely exploited in a similar fashion.

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