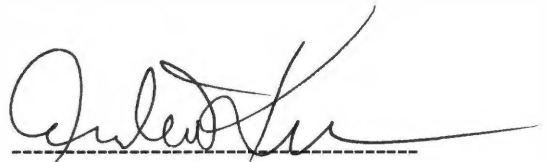


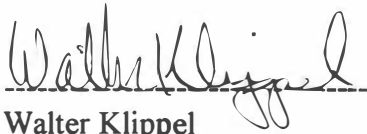
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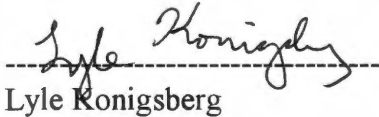


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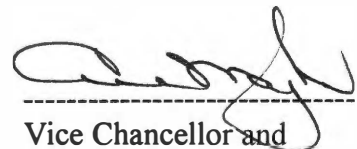


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Vice Chancellor and
Dean of Graduate Studies

Thesis
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**PRELIMINARY REPORT ON THE FAUNAL REMAINS AND TAPHONOMIC
ANALYSIS OF PLOVER'S LAKE CAVE, CRADLE OF HUMANKIND,
SOUTH AFRICA**

**A Thesis
Submitted for the
Master of Arts Degree,
The University of Tennessee, Knoxville**

**Juliet K Brophy
December 2004**

Dedication

This thesis is dedicated to my best friends, my family: James M Brophy III, Shirley Brophy, Anne Brophy, James Brophy IV, Shannon Brophy, Karin Lenhart, Phil Lenhart, Susan Brophy and Ibrahim Sendijarivic. Thank you for always being the wind beneath my wings.

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Abstract

This study examines a sample faunal assemblage from Plover's Lake Cave, South Africa, and uses the faunal identification and taphonomic indicators to determine the bone accumulating agents and make inferences about their behavior and environment. Fossil assemblages can be dramatically affected by ancient bone collectors as evident by their taphonomic signatures. The taphonomic overprint given to a site is typically due to episodic factors and the paleoenvironmental reconstructions that are based upon these assemblages must take into account any biases the accumulating agents may impart. After performing several analyses involving bone modification and taxonomic abundance, I suggest three accumulators were active at Plover's Lake Cave: carnivores, hominids and rodents. While the investigations illustrate an assemblage heavily manipulated by carnivores, several factors including skeletal part representations, certain breakage patterns and hammerstone percussion marks suggest a significant amount of hominid involvement. Additionally, commingled, agent-induced indicators hold behavioral implications for seasonal involvement between the carnivores and hominids. This research augments current knowledge about the behavior of ancient bone collectors, specifically carnivores and hominids, and their affects on southern African, Pleistocene cave site assemblages.

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1. Introduction

Previous studies of South African cave sites extracted information from their archaeological assemblages such as faunal identification and taphonomic indicators in order to reconstruct the environment and behavior of ancient bone collectors (Binford, 1981; Brain, 1981; Cruz-Urbe, 1991; Marean, 1998; Pickering, 2004a). The studies describing these taphonomic indicators and their effects on assemblages is prolific (Blumenshine and Selvaggio, 1988; Brain, 1981; Bunn, 1989; de Ruiter and Berger, 2000; Kuhn, 2001; Lam, 1992) and utilized as comparative models for this study.

Plover's Lake Cave is located in the Cradle of Humankind, Gauteng Province, South Africa, within 15 km of Sterkfontein and Swartkrans as shown in Figure 1. The external and internal deposits of this dolomitic cave were mined for lime in the 1930s and preliminary investigation/excavation of the cave was initiated by the Transvaal Museum in 1989 (Thackeray and Watson, 1994). The Duke Paleoanthropology Field School began excavating the internal deposits of Plover's Lake in 2001 and has continued working at the site through 2004. Due to the fact that the site's excavations are still in their infancy, many of the subsequent research explorations are still in progress.

However, due to an abundance of Middle Stone Age tools within the deposit as well as the lithostratigraphy, the site is able to be dated to approximately 250,000 years B.P.

Collectively, these excavations have produced approximately 50,000 specimens of faunal and archaeological material.

In this study, I identify and examine the faunal assemblage from the internal deposits of Plover's Lake Cave in order to determine the accumulator(s) at the site. This analysis concentrates on the taphonomic history of the mammals found at the site in an effort to better understand the role of hominids and carnivores at a Middle Stone Age, Pleistocene cave. Bone accumulating agents can have a significant effect on faunal assemblages and impact them with very distinct signatures such as tooth marks, cut marks or percussion marks. Based on these impacts and the numerous studies describing them, a definitive taphonomic overprint is often given to a site. However, the impacts made by the accumulating agent are often the result of idiosyncratic or episodic factors (Lam, 1992; de Ruiter and Berger, 2000) despite the fact that they have such a dramatic influence on the final composition of the resulting fossil assemblage. Paleoenvironmental and paleoecological reconstructions are based upon these fossil assemblages and must, therefore, consider the biasing which may occur from interpreting the faunal assemblage and not accounting for the impact of the accumulating agents. Therefore, the identification of these collecting agents is imperative to an assemblage analysis. Plover's Lake Cave provides a medium to examine the impact of the ancient bone collectors involved in the accumulation of a Pleistocene cave.

Another reason why this research is important involves the taphonomic history of the bones. Carnivores and hominids exploit bones with the intention of procuring nutrition. Non-nutritive processes, coined by Marean *et al.* (2000), include an agent/process affecting the bone without the goal of obtaining nutrition such as animal trampling, root etching and sediment compaction. These factors can sometimes manipulate the bones in

a manner analogous to accumulators and the effects of the collecting agents are sometimes mistaken for non-nutritive factors. With the determination of the behavior and impact of bone collectors, researchers can identify fragments manipulated by an agent seeking nutrition.

The faunal identification offers the researcher a sample of what organisms existed in or around the cave at a certain time. The analysis can list the animals the accumulator(s) preferred but does not necessarily provide an accurate image of all of the animals that existed in and around the cave in the same time frame. The taphonomic analysis, an examination of all aspects of the bone fragment, suggests how the organism's remains got into the cave. Consequently, anthropologists can make inferences about the behavior of the bone collecting agent(s) based on what animal, provided by the faunal identification, and what signatures, provided by the taphonomic analyses, are found within the accumulation.

This study is modeled after similar paleoenvironmental and paleoecological research that has been performed in South Africa and throughout the world. However, this geologically recent site offers a unique and diverse faunal assemblage with its own variety of taphonomic indicators as well as behavioral implications for accumulating agents. The site coupled with the research design provides a valuable opportunity to augment current knowledge about collecting agents and their affects on Pleistocene cave site assemblages.

2. History of Interpretation

The study of fossil assemblages in order to reconstruct and interpret the behavior of ancient bone collectors is a burgeoning field which was ignited by the research efforts of Raymond Dart (1949a, 1949b, 1955, 1957). Dart's examination of South African assemblages led him to suggest that due to artificial fracturing and disproportionate preservation of the animal remains, these fossil assemblages were produced by hominids. His suggestion involved australopithecines as predatory and cannibalistic using animal limb bones and jaws as tools (Dart, 1957). While these proposals have been discounted by subsequent research, the theory created a niche for further research inquiries on bone accumulating agents. The proposition of bone accumulations stemming from carnivore and/or rodent involvement led to the need for further confirmation of exactly what agents were influencing cave assemblages.

Numerous studies have subsequently taken place determining bone accumulating agents and examining taphonomic indicators including cut marks, carnivore tooth marks, percussion marks and fragmentation patterns as inflicted by carnivores and hominids. These studies employ fossil assemblages, extant accumulations and actualistic studies to decipher the accumulating agent.

Hominid Manipulation

After Dart, C.K. Brain (1981) pioneered the field of African cave taphonomy with *The Hunters or the Hunted? An Introduction to African Cave Taphnomy*. In this book, he addresses every important aspect required for determining bone accumulating agents such

as: skeletal part representation, food remains in caves from modern tribes (an analogy for what was likely occurring in the past), remnants of carnivores in caves, the influence of porcupines, involvement of owls and bone preservation (Brain, 1981). Brain examined several accumulations at sites produced by modern hunters and gatherers in order to reveal patterning in fossil assemblages. In an effort to ease discussion of the bovid remains, Brain (1981) divided the bovids up into four size categories based on modern bovid live weight: Class I <23 kg., Class II 23-84 kg., Class III 84-296 and Class IV <296. The modern human produced assemblages were all extremely fragmented thus making the butchery practice identification impossible. He concludes that an assemblage with a high degree of fragmentation indicates an intensely occupied cave site. He discusses several additional factors which can be identified as being potential indicators of hominid accumulated assemblages: artifacts associated with skeletal remains, the existence of hominid teeth marks on bones, evidence of percussion marks or cut marks, stratigraphic layers of ash and bones found with charring.

In a later work, Brain (1989) specifically examined Dart's research results and addressed each part using more modern techniques and recent information to outline some of Dart's misconceptions and assumptions. He begins by discussing Dart's suggestion that the depressed fractures on the vaults of the baboon and australopithecine skulls could only result from deliberate blows to these areas. Brain (1989) explains that while this theory is plausible, the lack of distinction between an antemortem fracture and a compressional one creates a dubious situation. In fact, localized damage from hard objects in the matrix in the vicinity of the fossil specimen has been shown to produce fractures analogous to

the ones caused by antemortem injuries. The depositional environment for these specimens is unknown; therefore, the contextual effects cannot be accounted for. With the loss of provenience, the cause of these fractures cannot be confirmed either way. Next, Dart (1956, 1957) opposed the idea of hyenas as bone collectors in caves while it is now widely cited and known that hyenas are major contributors to bone assemblages in caves (Brain, 1989). Brain (1989) then addresses Dart's (1953) theory that the evolution of ape-men to humanity involved the ape-men becoming hunters and no longer scavengers. While most studies do not dispute the involvement of meat in the australopithecine's diet, more recent bone modification studies suggest that these hominids were mainly scavengers (Shipman, 1983). When Dart (1957) looked at the preliminary faunal and skeletal results from Makapansgat from which he made several suggestions such as the role of australopithecines as professional decapitators and headhunters as well as using the tails of animals as flags and whips. Dart did not take into account the survival and disappearance of skeletal parts from the effects of carnivore activity, research that had not yet been published (Brain, 1989). Dart (1964) also held ideas about hominids alone making a "crack and twist" type spiral fracture by smashing a bone on the shaft and then twisting the ends apart while Brain (1989) highlights these results can also be mimicked by hyenas. He discusses how the structure of the bone seems to have a significant effect on what type of fracture occurs (Brain, 1989). Dart's research while no longer substantiated catalyzed the field of zooarchaeology and the implications of these assemblages on the behavior of the accumulator. Brain (1989) simply utilized the subsequent information available to address the shortcomings of his predecessor's research.

Bunn (1989) concentrates on the complexity of site formation processes and specifically focuses on diagnosing hominid activity through hammerstone fracturing. In this article, he states that an assemblage with a high degree of limb shaft fragmentation coupled with impact notches on the limb shafts results from the influence of a hominid demonstrating a hammer and anvil technique. Additional evidence of hammerstone breakage includes bone flakes with a platform of cortical bone, bulb of percussion and a piece of the cortical bone extending into the marrow cavity. Hammerstone fractures, however, can sometimes be mimicked by hyenas and even trampling. As Brain (1989) also emphasized, the structure of the bone affects the way a limb breaks regardless of the manipulator. However, extensive research differentiating between cut marks and percussion marks including the size of the notches as well as the piece itself exists making this overlap insignificant. In an effort to aid in the identification of bone collecting agents at a cave site, Bunn performs several actualistic studies to identify patterns of limb fragmentation resulting from hammerstone breakage. While he recommends his results as just preliminary suggestions, he states that certain characteristics of hominid modified assemblages can be used to confidently distinguish carnivore assemblages. These differentiations include: extensive shaft fragmentation, hammerstone impact notches, numerous bone flakes and patterned consistency of limb fragmentation as opposed to carnivore assemblages which would exhibit an increased amount of less extensive fragmentation, more complete limb bones, tooth pressure notches, and less common, overall smaller bone flakes (Bunn, 1989). These conclusions are directly applicable to studies determining the bone collectors of a cave.

Marean and Kim (1998) offer another important aspect to deciphering the existence of hominid behavior within an assemblage. These authors address the issue of Neanderthal and/or early modern humans as scavengers. The overwhelming quantitative existence of skeletal parts of little nutritional quality including head-dominated or head and foot dominated assemblages led Marean and Kim (1998) to suggest that these hominids were practiced scavengers. Their paper suggests that the abundance of head and foot elements results from analysts disregarding species-unidentifiable shaft fragments. To support this approach, they examined the assemblage from Kobeh Cave in Iran. This Mousterian site yielded a limb bone dominated assemblage, skeletal elements of the highest flesh and marrow yields as well as a paucity of head and lower foot bones. These limb bones do not coincide with what one would expect to find amongst a scavenger assemblage. These results were possible due to the incorporation of the mid-shaft fragments of long bones typically considered unidentifiable. These fragments were refitted, identified and then were able to be included in the skeletal element representation calculations. The skeletal part abundance methodology combined with a taphonomic analysis of indicators such as tooth marks, cut marks and percussion marks on the bones further validates these results that the hominids at Kobeh Cave consistently obtained the highest quality limb bones from regularly hunted kills. Additionally, this site's lack of compact bones and phalanges correlates with carnivore scavenging of discarded bone. This article highlights the importance of including as much of the fossil evidence as possible and further examining the shaft fragments in order to include them in the results. Marean and Kim

also warn researchers not to automatically assume that the hominids were scavengers based on small, preliminary faunal representations.

Valensi and Psathi (2004) examined faunal assemblages from six Middle Paleolithic sites in France and Italy spanning the Oxygen Isotopic Stages 6 to 3. Their taphonomic analysis reveals some carnivore indicators on the assemblage as well as an increased number of carnivores in terms of number of identified specimens. However, due to a prevalence of cut marks and cone fractures on the large mammal remains the accumulations are mainly produced by hominids. Their data also illustrate an irregular pattern of ungulate age distribution implying a lack of relationship between seasonal site occupation and the hunting of a particular species. Thus, the abundance of red deer in the assemblage is thought to be indicative of their high frequencies in nature as well as their high returns in terms of food and skins. These relatively uniform assemblages across France and Italy from Oxygen Isotope Stages 6 to 3 lead Valensi and Psathi (2004) to suggest a lack of any behavioral evolution in Neanderthal subsistence strategies in the aforementioned area.

Capaldo and Blumenschine (1994) propose that zooarchaeologists can confidently decipher hominid from carnivore accumulated assemblages simply by quantifying tooth and percussion notches. In their study, they quantitatively outline the differences between the notches produced by hominids and those by carnivores. The article explains the differences between the notch morphologies as well as the varying frequencies of notched fragments and how each actor's loading affects the bone differently. Carnivores

crush open a bone by imposing tooth pressure until the bone breaks, loading known as static. Hominids, on the other hand, utilize dynamic loading when smashing the bone with a hammer and anvil. Furthermore, Capaldo and Blumenschine (1994) discuss how salient notches can be in an assemblage since they are more resistant than surface marks when exposed to environmental factors such as weathering, corrosion and abrasion. This durability is especially informative at a site with poor preservation. The authors' ability to decipher the actor producing the notches suggests that these features hold the possibility of enhancing the list of bone modification criteria as well as the possibility of identifying a hominid influence at a site without other indicators.

Determining a primary accumulator is problematic when indicators of both hominid and carnivore activity occur on the same archaeological bone assemblage. Therefore, Blumenschine (1988) formulated an actualistic study of simulations in order to assess the timing of hominid and carnivore influence on bone assemblages. These experiments illustrate that carnivores do not avoid bones already obtained and consumed by hominids. These assemblages hold particular characteristics such as a limited number of hammerstone produced epiphyseal fragments, a fragment preferred by carnivores when consuming whole bones, and an average of tooth marked long bones of ~15%. In contrast, bones first obtained and consumed by spotted hyenas had an average incidence of tooth marked long bones of ~82%. Different frequencies are also apparent with the incidences of features of hammerstone breakage while not as dramatic as the tooth marks. Blumenschine (1988) thus concludes that the simple presence of carnivore tooth marks at a site does not translate to a lack of hominid influence on the assemblage and that relative

frequencies of tooth marked bones hold the potential for identifying the timing of bone modifiers.

Carnivore Assemblages

Horwitz and Smith (1988) examine the effects of striped hyena activity on human skeletal remains found in two dens in Israel. This paper begins by reminding the reader that all three species of hyena carry food back to their dens to consume or to feed their young. Therefore, depending on the geographic area of a site, either one or all three hyena species may have accumulated at least some of the remains found in a fossil assemblage. These authors examined human remains scavenged from a nearby cemetery and accumulated in two striped hyena dens. Their research concludes that puncture marks, deep holes usually accompanied by crushed bone at the periphery, are uncommon when dealing with hyena accumulations even when the bones have undergone severe damage. This study suggests the diagnostic pattern of skull and mandible damage such as completely missing facial bones, chewing on the lateral margins of the orbit, destruction of the ramus and mandibular condyles are better indicators of hyena activity than are puncture marks. Finally, they conclude that these characteristic patterns of remains in addition to jagged edges on bone fragments allow for a confident identification of hyena manipulation at a site.

Cruz-Urbe (1991) also performed research on distinguishing hyena influences on a site from hominid bone accumulations. She explored the assemblages from two caves, Equus Cave and Swartklip in South Africa. While negligible evidence of hominid, owl,

porcupine or small carnivore activity exists in these caves, strong circumstantial evidence suggests the assemblages were accumulated by hyenas. When examining an assemblage, certain features can signal that an assemblage is a result of hyena activity: high number of carnivore remains within the assemblage, existence of hyena indicative surface damage, record of relatively complete shafts lacking epiphyses, decreasing correlation between the cranial – postcranial ratio as ungulate size decreases, scarcity of hard compact bones and attritional age profiles (Cruz-Uribe, 1991). The presence of coprolites and absence of artifacts also strongly suggests a hyena accumulation. Deelpan, Elandsfontein, Sea Harvest, Hoedijies Punt, Yserfontein similarly exhibited these defining characteristics of a hyena accumulation (Cruz-Uribe, 1991).

Pickering (2002) suggests that only three of the criteria proposed by Cruz-Uribe (1991) are diagnostic for identifying if hyenas were a primary accumulator at a site. He cautions that a definitive geomorphological context is also necessary to utilize these three criteria confidently. According to Pickering (2002), the first of the Cruz-Uribe (1991) conditions to be retained is if the relative abundance of carnivores is greater than or equal to 20 percent of the total number of individuals based on their MNI's. He supports this standard due to the fact that it holds true for modern brown hyena dens. As Brain (1981) suggested, Pickering (2002) concurs that small carnivores were frequently obtained to provision their young hyena cubs due to the carnivore bodies being easier to consume for the cubs. Due to this provisioning, the author also states that the existence of juvenile hyena remains in the cave is probably the most indicative of a hyena assemblage. Secondly, the abundance of relatively complete limb bones with no epiphyses can be

characteristic of a hyena accumulated assemblage (Cruz-Uribe, 1991). This component also relies on actualistic studies for its relevance illustrating that hyenas typically start gnawing on a bone at the epiphyses. Logically, human generated assemblages would retain the epiphyses due to their lack of nutritional value. Hominids would break open the bones for their marrow content leaving bone fragments with epiphyses and a lack of complete shaft circumference. Thirdly and most obviously, Pickering (2002) endorses Cruz-Uribe's (1991) idea that when hyena inflicted bone damage is evident on an assemblage, it is likely produced by a hyena. The paper champions the use of diagnostic bone surface modifications as taphonomic indicators of the accumulator. With bone preservation sometimes being poor, the existence of bones with chewing damage, a common feature for hyenas, can be essential for accumulator determination. Pickering (2002) suggests that these criteria are sufficient enough to decipher the bone accumulator without skeletal part ratios of bovids or mortality profiles.

Pickering *et al.* (2004a) presented new taphonomic data on Sterkfontein Member 4 that demonstrated carnivore accumulations of hominids. The hominid sample from Member 4 consists primarily of gnathic remains and a limited amount of post crania. While this sample restricts the analysis, the carnivore tooth marks on some of the fossil specimens coupled with a pattern of skeletal part representation analogous to extant carnivore assemblages suggest that carnivores composed this assemblage. While this might seem contradictory to his conclusions from 2002 that skeletal part representation can be ignored, the paucity of postcrania and existence of carnivore tooth marks allows the

authors to determine that this is a carnivore assemblage. The skeletal part representation merely bolsters the conclusions determined from the primacy of the tooth marks.

Marean *et al.* (2000) present in depth zooarchaeological and taphonomic data of two layers, 10 and 11, of Die Kelders Cave 1, a supplement to Marean (1998) which preliminarily discussed the taphonomy of the site. Between the two papers, they determine hominids to be the primary accumulators with carnivores and raptors having secondary influence. Class I mammals Brain (1981) were largely accumulated in Layer 10 by owls and other large raptors. This conclusion is due to the increased frequency of gastric etching only found in this layer. Hyenas are known (Brain, 1981) to gastrically etch bone and dramatic discrepancies exist between this layer and others. Additionally, when the authors observed gastric etching from captive hyenas, the etching differed from what they found in Layer 10. These authors concur with previous studies that the most confident way to determine an accumulator stems from the actual marks made on the bones. Based on this reasoning, Marean *et al.* (2000) determine that mammals in body weight classes II-IV mammals, based on Brain (1981), from Layers 10 and 11 were primarily accumulated by hominids. The bones of these sizes in these layers exhibit high percentages of percussion marks and a low frequency of carnivore tooth marks. With the low percentage of carnivore tooth marks, however, the authors conclude that at least part of this assemblage was likely accumulated by carnivores though they were not the primary accumulators. The paper also suggests that since a paucity of less dense, spongy greasy bone portions recovered from the cave exists, carnivores were scavenging these discarded bones from the hominids. Furthermore, body weight class sizes III-IV bovids

dominate Layer 10 and shaft portions from these large individuals, primarily eland, exhibit the highest frequencies of cut marks. This result further supports a hominid accumulated site. The paper also discusses non-nutritive breakage within a sample, processes not related to feeding such as animal trampling, rodent gnawing, root etching, sub-aerial weathering and sediment compaction. Marean *et al.* (2000) caution researchers to account for non-nutritive breakages, i.e. dry bone breakages and their affect on the frequency of modification of an assemblage. To resolve this, this paper restricts its analysis to the surface modification on bones with dry bone breaks.

Lam (1992) suggests that some of the specific criteria proposed to be indicators of hyena influence such as the frequency of tooth marked specimens, degree of bone fragmentation and spatial distribution of faunal remains are too confining. Additionally, more variability in the behavior of hyenas needs to be recognized. The author came to these conclusions by studying the faunal assemblage from a spotted hyena den near Koobi Fora. The first peculiarity includes the unexpectedly high number of small bovid remains contradictory to documented spotted hyena dens consisting of large bovid remains. Also, the fact that the small bovid bones were recovered at all is significant since hyenas are known to crush and consume all but the small, compact bones. Lam (1992) suggests that this abundance stems from the disproportionate high number of small bovids in the park where the den is located. Additionally, the unusual existence of the small bovid remains stems from the idea that during a drought hyenas do not consume carcasses as completely as they usually do. Lam (1992) determined that this environmental stress was occurring at the time of the accumulation. The next extraordinary feature involves the high

frequency of crocodile and fish at the site. While these specimens have been found at hyena sites before, they were not in such large quantities. Also an unusually low number of tooth marks were present on the assemblage, particularly on the crocodile and fish remains. Finally, a preponderance of cranial elements was found inside of the den including specimens with no significant damage. Typically small, damaged amounts of cranial elements are recovered from hyena dens. The paper also cites other interesting foraging and social behaviors of spotted hyenas including behavior which fluctuates with the environmental conditions, feeding on fruit and the killing and abandoning of large numbers of prey. While this behavior is not consistent, it warns researchers that depending on simple criteria for determining a bone accumulating agent can limit the results of an analysis. A pattern of bone modification, a common goal of paleoanthropologists, must account for variation and unconventional behavior when examining a potential hyena accumulation.

Another article that assesses a faunal assemblage and proposes a hyena accumulation was written by Enloe *et al.* (2000). The assemblage he examined comes from Prolom II Cave, Crimea, Ukraine. These authors found a high percentage of carnivores, mainly foxes and hyenas, in the faunal remains which, as stated previously, is typically indicative of a carnivore agent. Additionally, most of the herbivore skeletal element specimens recovered exhibit morphological characteristics typical for carnivore assemblages such as gouged, gnawed and punctured metapodials, depressed fractures on a humerus, frequent tooth punctures on a variety of bones with paired punctures identified on a calcaneus. These authors also recognized other commonplace carnivore traits including the

channeling of diaphyses, crenellated edges, chewing damage on both herbivore and carnivore fragments and, most commonly, gastric etching. Carnivore behavior was also evident from the bone fragmentation patterns which are comparable with modern studies of carnivores. Finally, hominid induced marks, particularly stone tool cut marks, were found on only six specimens out of 1300 but are consistent with disarticulation cut marks, i.e. multiple horizontal cut mark striations adjacent to the articular surface. Ironically, Prolom II did yield dense, high frequency layers of stone tools, particularly in the same levels of the highest frequencies of hyena remains. The fact that hominids were not likely hunting hyenas suggests that the tool makers probably only occupied Prolom II occasionally. These results remind the reader that the mere existence of stone tools at a site does not necessarily translate to a hominid caused faunal assemblage.

Skinner *et al.* (1998) examined the rate of accumulation of two brown hyena maternity dens in the Namib Desert and collected the remaining bones starting in 1982 and ending in 1996. A comparison of the accumulations over the years showed that the total number of individuals recognized in 1982 was greater than the ones from 1990 despite the fact that the number of bones collected in 1990 was greater. Skinner *et al.* (1998) suggest that this find indicates how the diagnostic bones typically used to identify the fauna frequently survive to the fossil record. Interestingly, porcupines were present in the area around the dens for a short while despite the fact that no evidence of porcupine gnawing was recognized on the assemblages. Overall, the bone assemblage accurately represents the area's vertebrate fauna, leading Skinner *et al.* (1998) to conclude that fossil hyena dens can be valuable in reconstructing regional paleoecology.

de Ruiter and Berger (2000) examined the effects leopards have on fossil assemblages. To date, most of the evidence for leopard activity is based upon reports of leopard behavior in parts of Africa lacking caves (Brain, 1981). These authors examined the bone accumulation of a modern leopard lair in a dolomitic cave in South Africa. This site provides an appropriate representation of felid derived assemblages in the Plio-Pleistocene fossil caves of South Africa. From their observations, de Ruiter and Berger (2000) conclude that when a dolomitic cave is accessible, leopards prefer the deep recesses of caves over the limbs of trees. These results contradict the early suggestions previously made by Brain (1981) that leopards feed and store food in trees overhanging cave entrances. Thus, the evidence for leopard accumulation in the cave would stem from the debris having fallen into the cave (Brain, 1981). The spatial distribution of leopard manipulated bones in caves does not reflect the randomness of falling debris from a tree but rather the feeding behavior of the leopards themselves. Leopards dragging prey into their lairs often dragged the new kills over the older ones displacing the bones creating a unique spatial distribution. Also, previous studies hold sabre-tooth cats responsible for the accumulation of large prey (Brain, 1981). Based on the aforementioned leopard lair, these prey sizes, once considered too large for leopards to capture and drag into a cave, fall into the range of animals that are found at the lair. The abilities of leopards were severely underestimated by previous studies and their involvement should be taken into account. The assemblage found at the leopard lair held a paucity of remains with chewing marks. Therefore, the authors suggest that in lieu of other taphonomic indicators at a site, a leopard indicator might include the presence of

relatively complete or articulated skeletons. Additionally, one might look for chewing damage possibly on bones with low structural density, the existence of most skeletal elements, low fracture damage to the skeleton and the lack of further carnivore damage as possible indicators of leopard as agents. The authors warn that the assemblages from one leopard to another might be distinct and variable. de Ruiter and Berger propose leopards as opportunistic hunters and that their assemblages could, therefore, be used as paleoenvironmental and paleoecological indicators.

Other Methods of Accumulation

Pickering *et al.* (2004b) examined the mammalian faunal assemblage associated with Stw 573, a Pliocene hominid from Member 2 of Sterkfontein Cave. The associated faunal assemblage was largely made up of cercopithecoids and felids based on a number of identified specimens, minimum number of elements and minimum number of individuals. The recovered assemblage included a large number of partial skeletons and articulating bones as depicted mostly by the primates and antimeric sets of bones mainly from the felids but also among some bovids. Typically, assemblages with a high number of primates and felids have been cited as being carnivore accumulated. However, the amount of carnivore damage to the bones is limited including some carnivore tooth marks but no tooth notches or chipped back edges. Only two specimens exhibited signs of carnivore chewing damage with a mere five others as potentially displaying chewing damage. These results coupled with good preservation of the site caused the authors to conclude that the animals were not dragged into the cave by an accumulator. Rather they accidentally fell into the cave through openings in the cave ceiling or they entered of their

own volition and were unable to escape. Thus, the faunal remains are skewed towards animals with climbing abilities. Therefore, the paleoenvironment reconstruction attempted in this study offers biased results. Despite the discrepancy, they interpret the assemblage to suggest an environment of prolific rock clutter with brush and scrub covered hills and possibly standing water at the bottom of the valley perhaps supporting tree cover, though further research is required for a more accurate picture. Finally, the paper cautions that a mere faunal identification of primates and carnivores may not represent a complex accumulation process (Pickering *et al.*, 2004b).

These articles illustrate how the importance of understanding the impact of bone accumulating agents on different sites has been recognized and explored. This background review provides a general overview of what other research approaches have been performed in order to determine the behaviors of ancient bone accumulators. Each article offers a new outlook on examining bone characteristics and the subsequent criteria to look for when performing ones own assemblage analysis. These articles set the stage for the research performed on Plover's Lake. They provide standards and criteria for myriad accumulator indicators as well as comparative models with which to refer.

3. Materials and Methods

Plover's Lake Cave is located within 15 km of Swartkrans and Sterkfontein in the Cradle of Humankind, Gauteng Province, South Africa and positioned on a game reserve just 65 miles northwest of Johannesburg. The Duke Field School excavated this Middle Stone Age site for four field seasons from May to August in the years 2001-2004. The materials used for this study were extracted during this time frame from the internal deposit of the cave, an area approximately 4 x 6 x 4 meters all located within the specific coordinates indicated by a theodolite: E: 760.3290- 776.7270, N: -598.5686 - -540.4850; H: 1428.5676 - 1432.9419. During excavation, any artifact found larger than 3 cm was point provenienced meaning it received its own set of coordinates and then was individually bagged. The sediment and <3 cm material from the student's 25 x 25 x 5 cm. pit was bucketed and sieved for archaeological and faunal remains using double screens sized 1 cm. on top and 1/2 cm. underneath. The bag of remains was then sent to the lab. In this next step, the materials from the screens were divided and bagged individually according to seven specific categories: identifiable material (a fragment that exhibits some diagnostic mark on it making it identifiable to a researcher), unidentifiable material, lithics, microfauna, coprolites, taphonomy and teeth fragments.

The four field seasons excavating the internal deposits produced ~23,000 specimens. Of this assemblage, the author personally organized and sorted ~12,000. Unfortunately, due to inexperienced sorters, a large number of specimens were considered identifiable when actually they were unidentifiable. This error as well as the subtraction of non-mammal material decreased the sample assemblage to 8,086. The pieces confirmed as identifiable

were continually sorted into different categories such as their respective orders or families, cranio-dental and postcranial, cranial and dental, etc. until they were reduced into small, specialized categories that necessitated the use of a comparative collection to positively identify. Due to the critical factor of time, a total of 2,107 were able to be identified and examined in great detail.

The actual faunal analysis initiated with the author identifying each of the remains to the lowest, confident taxon by comparing the specimen to individuals of known identification. An extensive and comparative, extinct and extant faunal collection housed in the Paleoanthropology Unit for Research and Exploration at the University of Witwatersrand, Bernard Price Institute of Paleontology was utilized to aid in the identification of these remains. Each specimen was then entered into Microsoft Access based on an assigned accession number and classified based on its theodolite coordinates, taxonomic identification, body weight class, element, side, age, upper/lower where appropriate and degree of completeness. The bones assigned to the family Bovidae were further grouped into the four size categories described previously, as defined by Brain (1974, 1981).

During this procedure, the identification of what, if any, taphonomic processes had affected the bone were identified. This analysis included the identification of taphonomic indicators such as cut marks, carnivore tooth marks, percussion marks and gnawing. The ability to recognize these different taphonomic patterns stems from studying the research of previous authors (Behrensmeyer, 1978; Blumenschine and Selvaggio, 1988;

Blumenschine *et al.*, 1996; Brain, 1981, 1989; Bunn, 1989; de Ruiter, 2004; Horwitz and Smith, 1988; Klein and Cruz-Urbe, 1984; Shipman, 1989; White, 1992). Additionally, characteristics of each bovid long bone, in particular, were examined including fracture angle, fracture outline, shaft circumference and degree of shaft fragment completeness. The analytical procedure utilized for the breakage patterns was suggested by Villa and Mahieu (1991). Based on their research, the angle exhibited by the fracture surface and the bone cortical surface is considered the fracture angle. These fractures fall into one of three descriptive categories: oblique, right and intermediate and are used when examining proximal and distal shaft fractures (Villa and Mahieu, 1991). Adapted illustrations of right fractures and oblique fracture angles are exhibited in Figure 12 and Figure 13, respectively (Villa and Mahieu, 1991). Their exact category for intermediate fracture angles is oblique and right for “fractures that have variable angles” (Villa and Mahieu, 1991:34). The fracture outline involves the shape of the broken bone and also includes three separate categories: transverse, curved and intermediate. Transverse breakages are perpendicular to the shaft of the bone while curved breakages refer to spiral fracture results. Adapted images of curved fracture outlines can be seen in Figure 14 and transverse fracture outlines in Figure 15. The intermediate category includes the specimens that express a “straight morphology but are diagonal” as well as those that exhibit a stepped outline (Villa and Mahieu, 1991:36). The authors define this option as a category for the outlines which cannot neatly be described as either transverse or curved. The shaft circumference asks how complete the bone circumference is ($\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ or 1) at any point along that bone fragment. The degree of shaft completeness refers to the how much of the entire bone remains. Villa and Mahieu (1991) ignore fractures on or

near epiphyses due to their unique and varied breakage patterns; therefore, this study also ignores such fractures.

The fracture pattern of each bone was also assessed as outlined by White (1992). The author opted for these choices due to their convenience and proficiency of describing proximal and distal limb shaft fractures. These options include: stepped or columnar, saw-toothed, V-shaped, flaking, irregular perpendicular, smooth perpendicular, spiral, longitudinal and indeterminate.

Additionally, proficiency with the gross identification of bone fragmenting factors was necessary to accurately identify the type of taphonomic indicator. This author's previous research involving signature fractures resulting from hammerstone percussion allowed for more confident identifications of bone breakage patterns with this manipulation.

A weathering factor was also included in the analysis and upon the occurrence of this component, a five-point scale of degree of weathering was utilized following Behrensmeyer (1978). Finally, the type of surface damage to the bone was identified. The options for damage were suggested by Lyman (1994) and White (1992) and included: chattering, crenulated edges, cut marks, hammerstone percussion, cortical peeling, punctuate depressions, rodent gnawing, root etching, scooping or hallowing, spalling, splintering, step fractures, gastric etching, tooth notches, tooth pitting, tooth scoring, eroded, chewing, crushing, melted, carnivore damage, cracked, pathology,

flattened, rotted, boring, worn tip, burnt, porcupine gnawing, termite damage and trowel damage.

This faunal examination and taphonomic analysis not only provides an extensive list of the fauna extracted from Plover's Lake but also aids in the identification of the accumulator by illustrating what marks are found on the bones, determining how they got there and by whom.

After the taphonomic analysis was completed, further research was undertaken regarding the quantification of the taxonomic abundance. These manipulations include the number of individual specimens (NISP) and the comprehensive minimum number of individuals (cMNI). Klein and Cruz-Urbe (1984) highlight the importance of quantifying the taxonomic abundance stating that a simple presence/absence of a taxon can skew comparisons since there is no way of distinguishing whether a species present in an assemblage illustrates a real or chance occurrence. The easiest and most evident index of species abundance is the number of identified specimens (NISP), the total number of bone fragments assigned to a certain taxon.

The cMNI involves identifying the lowest number of individuals necessary to account for all of the identified bones while considering several, in depth factors (Bunn, 1982). The cMNI's in this study were calculated by sorting, pairing and matching (pair-matching) each element specimen-by-specimen (Adams and Konigsberg, 2004; Cruz-Urbe, 1984; Bunn, 1982). All of the specimens except the ones assigned only to the family Bovidae

were examined as to whether any pieces could be associated with another by considering factors such as size, sex, age and wear. Pair-matching considers one element from a taxon and assesses whether any of the elements could belong to a same individual by comparing the left and right elements (Adams and Konigsberg, 2004). This methodology of accounting for all these variables offers a more precise number of individuals at a site. Determining the minimum number of individuals (MNI) involves calculating the largest number of one bone from a taxonomic group and figuring the minimum number of individuals based solely on the presence/absence of a bone. MNI calculations, however, leave a lot of room for error amongst researchers and they may not be comparable due to the lack of a common methodology (Klein and Cruz-Uribe, 1984). Thus, the more accurate approach requires determining the cMNI for each taxon. Each bovid body size class analysis, however, was undertaken using only the MNI's due to the large sample size and time restraint.

Another important variable aiding in the determination of the primary accumulator entails skeletal part representation. This analytical technique proves extremely salient since the skeletal parts themselves play a large role in determining the bone accumulating agent(s) (Cruz-Uribe, 1991; Marean *et al.*, 2000). This process requires tabulating the total number of each element assigned to a taxon. The examination for this study only involves the bones attributed to the family Bovidae. Each of the bones in this family were further manipulated in that the minimum number of elements (MNE) was also computed. As suggested by Bunn (1982) and Marean and Spencer (1991), this analysis involves summing the most common portion of the long bone i.e. distal, proximal or shaft

fragment in order to determine how many bones are actually represented at a site versus how many bones would be at the site if the skeleton were complete. In other words, this practice illustrates what bones are missing in proportion to the bones that remain at the site.

The carnivore-ungulate ratio was also calculated. According to Cruz-Urbe (1991), studies performed on fossil assemblages from South Africa have shown that carnivores are significantly more abundant at sites accumulated by hyenas than in ones produced by hominids. The carnivore-ungulate ratio involves tabulating the cMNI's of all of the carnivores and illustrating them as relative to the ungulate cMNI.

These methods allow a researcher to see what animals are at Plover's Lake and to gauge an idea about the proportion of animals as well as what bone accumulating agents existed and influenced the site sample assemblage.

4. Results

Quantitative Taxonomic Abundance

Of the 2,107 specimens examined closely, 2,068 could be confidently assigned to at least the family level, in most cases, and to lower taxa levels in the remaining cases. A complete list of the fauna identified for Plover's Lake including their cMNI and NISP are provided in Table 1. Most of the elements analyzed could only be classified to the family Bovidae. The postcranial remains of the family Bovidae are so similar in shape and structure that they cannot be distinguished from each other in a way other than size (Brain, 1981). These comparable parts are the reason why the post crania are designated by body class sizes and cannot be identified into explicit taxa. Despite their abundance in the NISP, the most common species represented was not from the family Bovidae but from the family Procaviidae. Their only member at the site includes *Procavia capensis*, the rock hyrax. The alcelaphine, *Damaliscus dorcas*, is the second most common individual recovered from Plover's Lake followed by the black-backed jackal, *Canis mesomelas*. The three specimens attributed to the Family Hominidae involve one premolar and two molars.

The cMNI's were then tabulated by family and these results are depicted in Figure 2. This graph minimizes the distinctions depicted in Table 1 due to the lack of bovid post crania divisions described previously. The Bovidae are thus the most commonly found family while the Hominidae are the least common at the site.

The MNI's for the body class sizes of the bovids are listed in Figure 3. The most abundant body size found at Plover's Lake is class size II including animals such as *Damaliscus dorcas*, *Antidorcas marsupialis* and the extinct springbok, *Antidorcas bondi*. The skeletal part representation was also considered for the family Bovidae. These results are listed in descending order of survival in Table 2 and graphically represented in Figure 4. The MNE for the skeletal part representations are highlighted in bold in Table 2 while an expanded list of the bovid skeletal parts are also outlined in the same table. The most common skeletal elements found in this sample are isolated teeth making up 57.4% of remains. The next most common elements are phalanges followed by half mandibles. The metacarpals and metatarsals hold the next highest abundance with 34 and 32, respectively and an MNE of 18 each.

The results of the carnivore-ungulate ratio are revealed in Figure 5. The number of carnivores relative to ungulates in this study are 51:123.

Bone surface modification

The sample assemblage from Plover's Lake underwent minimal modification. Only 3.1% of the sample exhibited specific characteristics of bone modification. Figure 6 illustrates the number of elements from each body weight class that have some aspect of bone modification. The graph also conveys exactly what surface damage was identified on the bone fragment. While the total amount of bone modification in the sample is low, the most common damage to the bones came from rodent gnawing. Two bones exhibited hammerstone percussion.

The next illustration, Figure 7, shows the degree of fracture angles divided up by bovid class size. Most of the angles examined were determined to be oblique followed by right and then intermediate. Figures 8 and 9 follow exhibiting the fracture outline and shaft circumference. Overall, the fracture outlines were more intermediate than curved or transverse. In terms of shaft circumference, ~85% of the bones had a complete circumference at some point along its shaft. Few bones with a <1/2 circumference were examined largely due to the fact that some of these pieces were categorized as unidentifiable in the field lab in South Africa. The degree of shaft fragmentation completeness for the family Bovidae is illustrated in Figure 10. In general, most of the specimens examined consisted of less than one fourth of their original length across the body weight classes.

Figure 11 illustrates the number of bovid specimens exhibiting their respective fracture pattern based on bovid size classes. Body size class II holds the most number of fracture patterns, 15. About half of these patterns are longitudinal while the rest consist of irregular perpendicular, saw-toothed, spiral, stepped/columnar and v-shaped. Overall, the most common types of fractures across all body sizes were irregular perpendicular, longitudinal and v-shaped.

5. Discussion

Evidence of hominid presence is confirmed but limited for Plover's Lake Cave based on this sample faunal assemblage. After performing the analysis, I found that these remains exhibited characteristic traits of three accumulators: carnivores, hominids and rodents, in descending order of influence. Most results including NISP of specific macromammals, the carnivore-ungulate ratio, carnivore tooth marks and, possibly, the representation of small hard compact bones at the site suggest a carnivore accumulation. Hominid activity is demonstrated through the skeletal part representation, certain breakage patterns and the existence of percussion marks while rodent influence is distinguished by porcupine gnawing.

Quantitative Taxonomic Abundance

Plover's Lake revealed a variety of ungulates, carnivores and other animals as demonstrated in Table 1. This faunal list illustrates *Procavia capensis*, the rock hyrax, as the most abundant specimen identified to species in terms of both NISP and cMNI. According to Brain (1981), leopards especially prefer hyraxes and consume them in a particular manner. After being devoured by a leopard, the hyrax carcass yields little to no remaining postcrania as well as a chewed off braincase and posterior mandible. Brain (1981) continues by adding that these carnivores worked anteriorly up through the back of the animal cropping off the braincase and ascending mandibular rami to get to the brain and tongue. This methodology leaves behind the unchewable mandible and maxillary parts. Of the 230 specimens in this study, 90% consist of cranio-dental remains. While a limited number of small mammal postcranial remains were able to be

assessed, the extraordinarily high number of cranio-dental remains suggests that carnivores, potentially leopards, were consuming rock hyraxes at Plover's Lake.

The aforementioned cMNI calculations could become even more precise in future studies with the involvement of several manipulations including the most likely number of individuals (MLNI), as defined by Adams and Konigsberg (2004). This estimation involves the previously described pair-matching followed by a calculation solving for the population number using the unnumbered elements (L and R) and the number of matched pairs (P) creating an unbiased estimator (Adams and Konigsberg, 2004). When preservation of a site permits confident pair-matching, this process can illustrate a more accurate number of the actual population that contributed to the recovered assemblage and not an estimation of the number of individuals represented by the recovered assemblage. Due to the fact that this study was published after the assemblage was examined, these beneficial manipulations must be considered for future analysis of this assemblage.

This study would also benefit from another statistical method for the analysis of bone counts from archaeological assemblages. Rogers (2000) approach to the conventional MNI manipulations involves the analysis of bone counts from maximum likelihood (abcmI). This procedure looks at the processes/agents that affect the frequencies of skeletal parts and then uses statistical methods derived from transport and attrition to formulate inferences about bone counts (Rogers, 2000). In other words, Rogers (2000) statistically estimates the proportion of animals within an assemblage accumulated by

different agents, an estimation of the bone damage from the agent and the overall number of animals in an assemblage even with severely damaged assemblages (Rogers, 2000). While this MNI substitution and estimation was not performed in this study, further analyses would benefit from its methodology.

As with most South African faunal assemblages, the Bovidae were the most abundant taxonomic family at Plover's Lake. This preponderance is likely due to several factors. The bovids were a very successful, Pleistocene radiation exploiting many of South Africa's available niches. Additionally, according to Kruuk (1972), carnivores, such as spotted hyenas, have been known to hunt in groups to bring down large prey such as the ungulates found at this site, specifically of body weight classes II and III. Based on Figure 3, the majority of the animals consist of body weight class II followed by body weight class III. Animals of this size, in particular, were likely the most abundant in the external paleo-environment of the cave since they are the best represented in terms of teeth as well as in postcrania. Comparatively, the bovids are large animals with a high return of nutrition when obtained and can, therefore, be a common choice of consumption by both carnivores and hominids. Brain (1981) also discusses how Quaternary sites in southern Africa often yield assemblages that are dominated by bovid remains due to their abundance in the environment.

Plover's Lake consists of more taxonomic families than expressed in this study. In fact, the non-mammal remains were not even able to be examined. The time restriction in the field resulted in this snapshot of specimens. This analysis provides a preliminary

representation of individuals and further studies would definitely be required for a more comprehensive depiction.

Bone Representation

Several factors are taken into consideration when thinking about what bones one expects to find at a site. Brain (1981) highlights the importance of durability in a bone if it is going to survive to become part of the fossil record. Compact bones such as carpals, tarsals and phalanges are usually abundant in hominid assemblages since they lack a sufficient amount of nutritional benefit for any hominid to spend his/her energy in manipulating (Cruz-Uribe, 1991). Also, the non-nutritive, destructive pressures usually inflicted on a skeleton would have less of an effect on the denser bones (Marean *et al.* 2000). According to Cruz-Uribe (1991), these hard bones are rare in hyena assemblages due to their small size and ability to be swallowed whole by the carnivores. Table 2 illustrates a disproportionally high number of phalanges at the site. However, this result can be interpreted in various ways. Pickering (2002) suggests that the rarity of these bones in hyena assemblages is inadequate as a criterion for a hyena accumulator. Through actualistic studies, he emphasizes that while they do ingest these small bones, they also regurgitate or defecate them in close proximity to the cave. Additionally, these bones frequently do not exhibit any signs of digestion. Also, as de Ruiter and Berger (2000) emphasize, the impact of leopards on assemblages is often understated. Leopard behavior does not involve the swallowing of small dense bones, or the ingestion of any bones (Estes, 1991). Finally, Lam (1992) suggests that a preponderance of small compact bones in his hyena assemblage is a result of differential consumption possibly

due to a drought. In these dry conditions, neither carnivores nor scavengers consume an animal completely. Further examination of the bones would be required to determine whether a drought was occurring during this time frame or not, but the possibility exists. Thus, while the relatively high abundance of phalanges shown on Table 2 is not typically indicative of hyena behavior, the support expressed here demonstrated that their presence does not rule out the role of carnivores as accumulators in this case.

As shown in Table 2, the most commonly found animal remains at the site were teeth. Enamel, the hardest substance a body produces, preserves extremely well in the fossil record and is typically the most abundant at a site. Phalanges, an example of a compact bone with little nutritional value, are the next most common bones in terms of NISP correlating with Brain's (1981) assessment of denser bones being preserved more frequently. Half mandibles are another example of compact bone fragments with little nutritional value which is commonly abundant at a site. This abundance coincides with Brain's (1981) results from two villages he studied: Makapansgat and the Kuiseb River Village as well as Pickering's (2004a) study of Sterkfontein Member 4. In both of these studies, the mandibular fragments were extremely common if not the most abundant element after isolated teeth. Brain (1981) concludes that a predictable pattern of survival emerges when bovid skeletons are destroyed regardless of the agent causing the damage. Thus, the abundance of half mandibles does not hold any evidence for an accumulator.

Carnivore-Ungulate Ratio

Cruz-Urbe (1991) and Pickering (2002) consider the carnivore-ungulate ratio as one of the necessary criteria to be assessed when differentiating between a carnivore and hominid assemblage. These authors suggest that remains with more than or equal to 20% of the assemblage consisting of carnivores is a strong indicator of a hyena assemblage. The number of carnivores in the Plover's Lake sample is extraordinarily high. As seen in Figure 5, carnivores consist of a significant part of this assemblage, approximately 29.3%, a number well into the range for a carnivore accumulator. Numerous authors including Brain (1981), Cruz-Urbe (1991) and Pickering (2002) concur that small carnivores in particular are preyed upon for provisioning hyena cubs. Also, Klein *et al.* (1991) concluded that brown hyenas commonly prey upon jackals due to their coincidental meetings at common food sources. Table 1 illustrates the large number of *Canis mesomelas*, the black-backed jackal, as well as the very closely related wild dog, *Lycaon pictus*. This evidence supports the possibility of the cave being utilized as a hyena breeding den.

Bone Surface Modification

Unfortunately, the assemblage contained only 25 specimens that exhibited bone modification that was diagnostic of certain accumulators. This low number holds little statistical significance for the sample and virtually no verification abilities towards agent determination. The paucity of surface damage does not translate to a lack of confirmation for any agent, rather the number merely represents a low level of preservation at the site. Cruz-Urbe (1991) proposes that poor preservation often obscures diagnostic marks such

as tooth marks on assemblages. The bones recognized as cracked, crushed and eroded highlight this preservation status. Regardless, surface damage did occur. While only 1 bone expressed any signs of carnivore tooth mark damage, 2 bones demonstrated hammerstone breakage. This taphonomic indicator confidently places hominids in the cave at some point during this accumulation. Like the lack of tooth marks, the intensity of the occupation is likely understated due to the poor preservation (Cruz-Uribe, 1991). Despite the small number of bones with modification, the fact that rodent gnawing, porcupine in this case, is expressed illustrates their influence on the site's assemblage. Apparently, porcupines played a role at Plover's Lake regardless of recent examinations discounting their involvement as significant bone collectors in other South African cave infills (de Ruiter, pers, comm.). Porcupines transport dry bones with no meat to their lairs and gnaw on them in order to wear down their open-rooted incisors (Estes, 1991). In fact, porcupines often collect more bones than they need or could possibly gnaw making them potentially significant bone collectors (Estes, 1991; Brain, 1981). The existence of the very characteristic porcupine gnaw marks on these bones is the most reliable indication of porcupine influence on the assemblage. Brain (1991) also illustrates that sites considered porcupine lairs exhibit high amounts of porcupine gnawing. While this type of surface damage was the most commonly noted in this study, the small sample size and even smaller number of bones with damage reveals very little information.

While I can confidently state that Plover's Lake Cave remains had some porcupine manipulation, a larger sample size would be required to determine exactly how influential

this animal was in collecting these bones. Despite the fact that experience and research on surface damage familiarity was performed prior to this study, the possibility exists of accumulator marks not being recognized on some fragments.

The breakage pattern of long bones as defined by Villa and Mahieu (1991) also aid in the determination of an agent. Numerous authors suggest that bone breakage patterns can help differentiate between hominid and hyena assemblages. Oblique fracture angles, as seen in Figure 7 are the most abundant in this study and represent fresh, green bone fractures, according to Villa and Mahieu (1991). A carnivore acting as either a hunter or a scavenger would be manipulating the bone before it degreased (Marean *et al.*, 2000; Estes, 1991). Villa and Mahieu (1991) also suggest that transverse fracture outlines are typical of dried bone breaks. Curved fracture outlines result from green fracture breaks. While the highest number of specimens were deemed to have intermediate breaks in Figure 8, it is only by one more specimen than the curved angles. Also, while the intermediate breaks do not exactly include the type of outline defined to support a green bone breakage, these angles hold potential to support them while not countering them.

During the taphonomic analysis, the shaft circumference was also examined. Almost all of the bones in this study retained 100% of their shaft circumference at some point on the fragment, as shown in Figure 9. A small number of bones had greater than half and none had less than half of its circumference. This evidence supports a carnivore assemblage. Carnivores are known to chew the ends of long bones and leave the shaft intact (Cruz-Uribe, 1991; Pickering, 2002) while hominids break open the shaft fragments in order to

obtain the marrow. Thus, a complete circumference is more indicative of carnivore manipulation.

This evidence would advocate a carnivore agent more decidedly if associated with an abundance of shaft fragments. Table 2 illustrates the overall lack of shaft fragment abundance in terms of MNE's. When determining whether a shaft has a complete shaft circumference, Villa and Mahieu (1991) explain that the fragment has to have a complete shaft circumference but it can exist anywhere along the bone. This translates to mean that even when a hominid manipulates a bone and produces epiphyseal regions with some shaft fragment remaining, the entry would still yield a complete shaft circumference distinction. Additionally, the degree of shaft fragment completeness typically involved less than $\frac{1}{4}$ of the entire bone. This frequency, illustrated in Figure 8, further leans towards a hominid assemblage since the bone fragments produced from a hominid would consistently be smaller fragments, i.e. less than $\frac{1}{4}$. It is also important to note that preservation also played a role in the shaft fragment completeness. Additionally, students occasionally deemed bone fragments without a complete shaft circumference or smaller pieces of bones as unidentifiable. Again, due to time constraints, the unidentifiable material was not able to be assessed.

The weathering scale used for this study was outlined by Behrensmeyer (1978). Due to either the lack of abundant weathering on the bones in this sample assemblage or the lack of proper recognition of this bone damage, no bones were identified as having been weathered. However, some of the surface damage portrayed in Figure 6 coincides with

some weathering implications outlined by Behrensmeyer (1978). The bones in three of the four body weight class sizes expressed signs of cracking which Behrensmeyer (1978) suggests as signatures of Stage 1 weathering. In this phase, the cracking typically forms longitudinally in the bone which is exactly the case in this study. The bones acknowledged as having cracking portrayed this damage parallel to the bone shaft. The bone showing signs of being eroded probably also underwent some form of weathering though further elaboration would be required to determine what stage.

Skeletal Part Representation

The skeletal part representation holds salient implications for determining agents influencing a site. Typically, an abundance of shaft fragments with no proximal or distal ends are considered an indicator for a carnivore assemblage with the carnivores chewing off the ends of the bones. A hominid assemblage would consist of a lack of shaft fragments in an assemblage but rather the proximal and distal ends of bones due to the hammerstone breakage. Overall, the skeletal part representation in Figure 4 leans more towards a hominid assemblage. Some of the major contributors involve the distal metacarpals, proximal metatarsals and distal humeri. The distal humeri are typically the most abundant or second most abundant element found at a site. Silver (1963) explains how the proximal end of a bovid humerus fuses at ~36 months. In the time prior to the fusion, the epiphysis is attached to the bone by a thin layer of cartilage. The compact, distal end of the humerus fuses at only 12 months thus making this piece of bone very resilient in an assemblage. While studies have shown this compact, durable distal end at carnivore accumulations (Cruz-Urbe, 1991; Swartklip), this part is often not the most

common. The radii shafts are also well represented suggesting the lack of hominid influence, despite the fact that they exist as small fragments. Although shafts like this one exist in the skeletal part representation, the preponderance of proximal and distal ends support the hominid influence.

6. Anthropological Significance

Hominid Influence on Plover's Lake Assemblage

The existence of three hominid teeth and two bones exhibiting hammerstone percussion marks illustrates that hominids did occupy Plover's Lake Cave at some point during the accumulation of this assemblage. In fact, after the sample assemblage for this project was determined, continued excavations produced three, possibly four, more hominid fragments - one of which expressed cut marks (Churchill, pers comm.). Additionally, while not the focus of this study, the excavations have recovered an abundance of Middle Stone Age tools from the site of which research is still in progress (Churchill, pers comm.). This information could lend a different perspective on the primary accumulator for the site, although the findings as well as analysis are in their infancy at this stage.

The described area in the cave where this sample fossil assemblage was extracted covers a rather large area. Due to this fact, determining a carnivore(s) as the primary accumulator involves time averaging the assemblage. Thus, it is unlikely that the sample assemblage assessed here was brought into the cave by one type of accumulator. The possibility exists, therefore, that sections of the assemblage were carnivore accumulated and, supported by hominid induced marks and the abundance of stone tools, sections were the results of hominid occupation occurring in separate time frames. In other words, the admixture of results poses the possibility of hominids occupying the site intermittently with carnivores.

The Plover's Lake Cave area appears to be an ideal place for hominid occupation with an available water source, moderate terrain for hunting or scavenging and easily accessible cave for protection. This idyllic setting begs the question as to why the hominids would leave the site. One obvious conclusion suggests the changing seasons i.e. the hominids were following the mammalian herds. Carnivores having a broader variety of food on which they can prey, are less affected by seasonal changes.

Plover's Lake may have been intensely occupied over a long period, as demonstrated by the abundance of stone tools at the site, but only for brief intervals of time allowing carnivores access to the cave. Examples supporting this theory would include carnivore manipulation of bones that have poor nutritional quality as well as a map of the bones influenced by the hominids and carnivores showing time distinctions between accumulations. While the assemblage requires additional analysis to decipher the nutritional status of the animals preyed upon, this assemblage does hold an abundance of phalanges. As previously discussed, Lam (1992) states how an abundance of small compact bones such as phalanges could be a result of differential consumption possibly due to a drought. He also states that a carcass is not completely consumed by either carnivores or scavengers frequently abandoning the dense, compact bones during environmentally stressful conditions (Lam, 1992). Although these bone accumulations are not carnivore indicative, their type and abundance acts as potential indicators for the dry season. Unfortunately, the maps for Plover's Lake are still being processed (Churchill, pers comm.).

An alternating occupation scheme coupled with a small sample assemblage and poor preservation would lead researchers to understate the involvement of hominids.

Admittedly, this suggestion involves speculative interpretation but the hypothesis allows for a broader picture of the site's formation process accounting for all of the manipulations revealed in the analysis. While these interpretations are enticing, they remain suggestions until more extensive studies can help resolve these issues. The study mandates that further analysis of these remains be performed in order to glean a better understanding of the complete cast of characters and variables that left their taphonomic mark upon Plover's Lake Cave.

Summary

This study reveals that carnivores heavily manipulated this sample assemblage at Plover's Lake Cave. Additionally, the most recent research illustrates that despite the paucity of hominid indicators, hominid involvement in the accumulation of the sample assemblage, based on the existence of percussion marks, specific skeletal part representations and certain breakage patterns, is significant and holds behavioral implications for seasonal occupation.

This paper outlines the episodic factors which have occurred to this sample assemblage from Plover's Lake including the dramatic influence from carnivores as well as significant effects from hominids. Thus, when performing the paleoenvironmental and paleoecological reconstructions on Plover's Lake, one can access this data and not make assumptions about the environment based on accumulator specific criteria. Additionally,

the analyses yielded a detailed database where the effects of the collecting agents can be subtracted from non-nutritive factors. Furthermore, the information from Plover's Lake can become part of the comparative database that may be used by other analysts to determine if similar patterns appear in their study sites.

The results of this faunal identification and taphonomic analysis can aid in the determination of carnivore and hominid accumulators, prevent paleoecological and paleoenvironmental biasing and help understand the behaviors of these ancient bone collectors when investigating a Pleistocene site with a similar assemblage.

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Appendix

Table 1: Faunal Representation

Order	Family	Tribe	Genus	Species	Common Name	Total	cMNI
Artiodactyla	Bovidae					971	
Artiodactyla	Bovidae	Alcelaphini				4	1
Artiodactyla	Bovidae	Alcelaphini	<i>Connochaetes</i>	<i>taurinus</i>	Blue Wildebeest	8	4
Artiodactyla	Bovidae	Alcelaphini	<i>Damaliscus</i>	<i>dorcas</i>	Bontebok	138	12
Artiodactyla	Bovidae	Alcelaphini	<i>Damaliscus</i>	<i>niro</i>	Extinct Bontebok	1	1
Artiodactyla	Bovidae	Alcelaphini	<i>Med Alcel</i>	<i>sp.</i>		92	6
Artiodactyla	Bovidae	Alcelaphini	<i>Megalotragus</i>	<i>sp.</i>		1	1
Artiodactyla	Bovidae	Antilopini				4	1
Artiodactyla	Bovidae	Antilopini	<i>Antidorcas</i>	<i>bondi</i>	Bonds Springbuck	64	7
Artiodactyla	Bovidae	Antilopini	<i>Antidorcas</i>	<i>marsupialis</i>	Springbuck	34	6
Artiodactyla	Bovidae	Antilopini	<i>Antidorcas</i>	<i>sp.</i>		24	8
Artiodactyla	Bovidae	Bovini	<i>Syncerus</i>	<i>caffer</i>	African Buffalo	4	3
Artiodactyla	Bovidae	Hippotragini	<i>Hippotragus</i>	<i>sp.</i>		3	2
Artiodactyla	Bovidae	Neotragini				1	1
Artiodactyla	Bovidae	Neotragini	<i>Raphicerus</i>	<i>campestris</i>	Steinbuck	1	1
Artiodactyla	Bovidae	Neotragini	<i>Raphicerus</i>	<i>sp.</i>		1	1
Artiodactyla	Bovidae	Peleini	<i>Pelea</i>	<i>capreolus</i>	Rhebok	2	1
Artiodactyla	Bovidae	Reduncini	<i>Redunca</i>	<i>arundinum</i>	Reedbuck	1	1
Artiodactyla	Bovidae	Reduncini	<i>Redunca</i>	<i>fulvorufula</i>	Mountain Reedbuck	6	4
Artiodactyla	Bovidae	Tragelaphini				1	1
Artiodactyla	Bovidae	Tragelaphini	<i>Taurotragus</i>	<i>oryx</i>	Eland	2	2
Artiodactyla	Bovidae	Tragelaphini	<i>Tragelaphus</i>	<i>strepsiceros</i>	Greater Kudu	4	4
Artiodactyla	Suidae					2	1
Artiodactyla	Suidae		<i>Phacochoerus</i>	<i>africanus</i>	Common Warthog	3	2

Table 1: Continued

Order	Family	Tribe	Genus	Species	Common Name	Total	cMNI
Carnivora						30	24
Carnivora	Canidae					69	14
Carnivora	Canidae		<i>Canis</i>	<i>mesomelas</i>	Black-backed Jackal	103	8
Carnivora	Canidae		<i>Lycaon</i>	<i>pictus</i>	Wild Dog	4	2
Carnivora	Canidae		<i>Otocyon</i>	<i>megalotis</i>	Bat-eared Fox	3	2
Carnivora	Canidae		<i>Vulpes</i>	<i>chama</i>	Cape Fox	23	4
Carnivora	Felidae					11	3
Carnivora	Felidae		<i>Felis</i>	<i>lybica</i>	African Wild Cat	2	1
Carnivora	Felidae		<i>Panthera</i>	<i>pardus</i>	Leopard	5	1
Carnivora	Hyaenidae		<i>Crocuta</i>	<i>crocuta</i>	Spotted Hyena	2	1
Carnivora	Hyaenidae		<i>Hyaena</i>	<i>brunnea</i>	Brown Hyena	11	4
Carnivora	Mustelidae		<i>Aonyx</i>	<i>capensis</i>	African Clawless Otter	4	1
Carnivora	Mustelidae		<i>Ictonyx</i>	<i>striatus</i>	African Polecat	3	1
Carnivora	Mustelidae		<i>Mellivora</i>	<i>capensis</i>	Honey Badger	1	1
Carnivora	Viverridae					25	3
Carnivora	Viverridae		<i>Atilax</i>	<i>paludinosus</i>	Marsh Mongoose	2	1
Carnivora	Viverridae		<i>Cynictis</i>	<i>penicillata</i>	Yellow Mongoose	1	1
Carnivora	Viverridae		<i>Galerella</i>	<i>sanguinea</i>	Slender Mongoose	2	1
Carnivora	Viverridae		<i>Genetta</i>	<i>tigrina</i>	Blotched Genet	6	3
Carnivora	Viverridae		<i>Mungos</i>	<i>mungos</i>	Banded Mongoose	1	1
Carnivora	Viverridae		<i>Suricata</i>	<i>suricata</i>	Meerkat	1	1
Hyracoidea	Procaviidae		<i>Procavia</i>	<i>capensis</i>	Rock Hyrax	230	23
Indet Mammal						39	11
Lagomorpha	Leporidae		<i>Lepus</i>	<i>sp.</i>		90	8
Perissodactyla	Equidae		<i>Equus</i>	<i>burchelli</i>	Burchell's Zebra	45	5
Primates	Cercopithecidae		<i>Cercopithecus</i>	<i>aethiops</i>	Vervet Monkey	1	1
Primates	Cercopithecidae		<i>Papio</i>	<i>sp.</i>	Baboon	1	1
Primates	Hominidae					3	1
Rodentia	Hystriidae		<i>Hystrix</i>	<i>africaeausustralis</i>	South African Porcupine	20	9

Table 2. Skeletal Part Representation

Skeletal Element	NISP	MNE derivation (in bold)	MNE
sacrum	1	sacrum	1
pelvis	3	acetabulum	3
maxilla	5	half maxilla	5
ulna	9	ulnar head	8
		proximal ulna	1
scapula	10	glenoid fossa	8
		spine	2
horn core	12	horn core	12
rib	14	rib shaft fragment	12
		rib head	2
humerus	17	distal humerus	9
		humerus shaft	5
		humeral head	3
tibia	17	distal tibia	10
		tibia shaft	6
		proximal tibia	1
femur	18	femur shaft	6
		distal femur	5
		femoral head	4
		proximal femur	3
radius	23	radius shaft	12
		proximal radius	7
		distal radius	4
vertebra	24	thoracic vertebra	9
		lumbar vertebra	7
		caudal vertebra	5
		cervical vertebra	2
		vertebra indet.	1
metatarsal	31	proximal metatarsal	18
		distal metatarsal	7
		metatarsal shaft	6
metacarpal	35	distal metacarpal	18
		proximal metacarpal	10
		metacarpal shaft	7
mandible	37	half mandible	36
		mandibular condyle	1
phalanges	134	1st phalanx	46
		2nd phalanx	46
		3rd phalanx	42
isolated tooth	723		

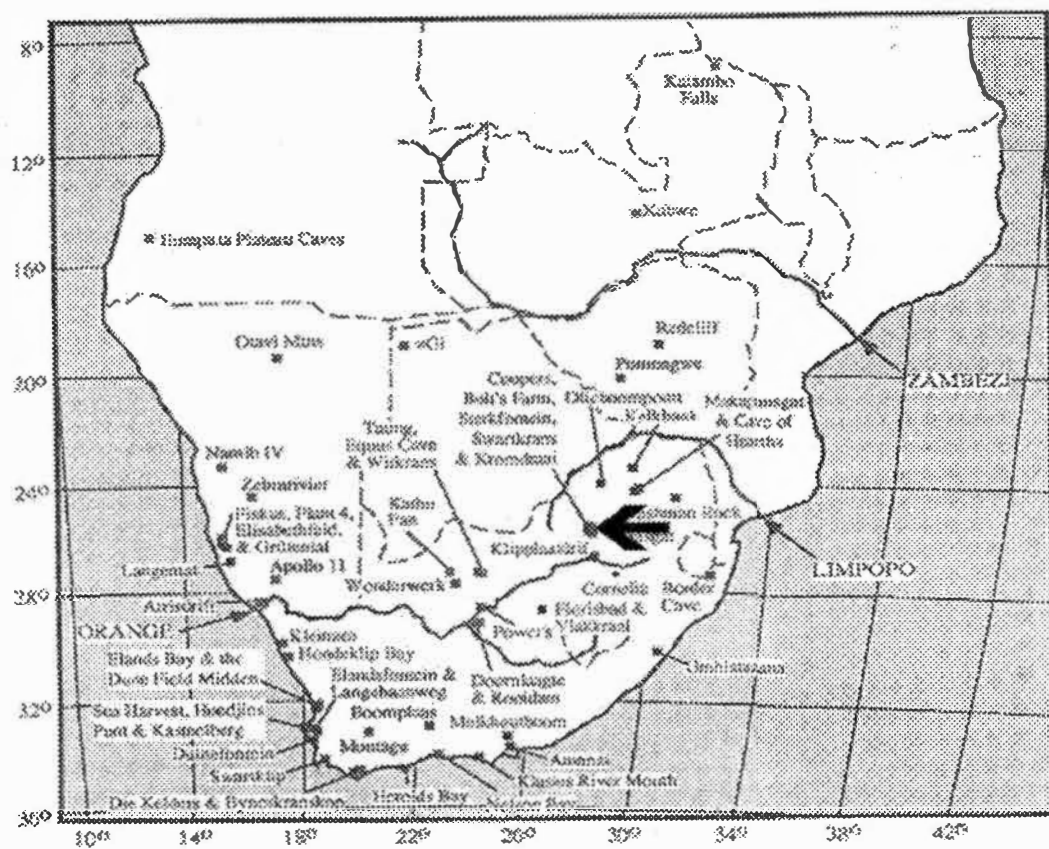


Figure 1. Map of Plover's Lake Cave Location
(adapted from Klein 1991: p. 72)

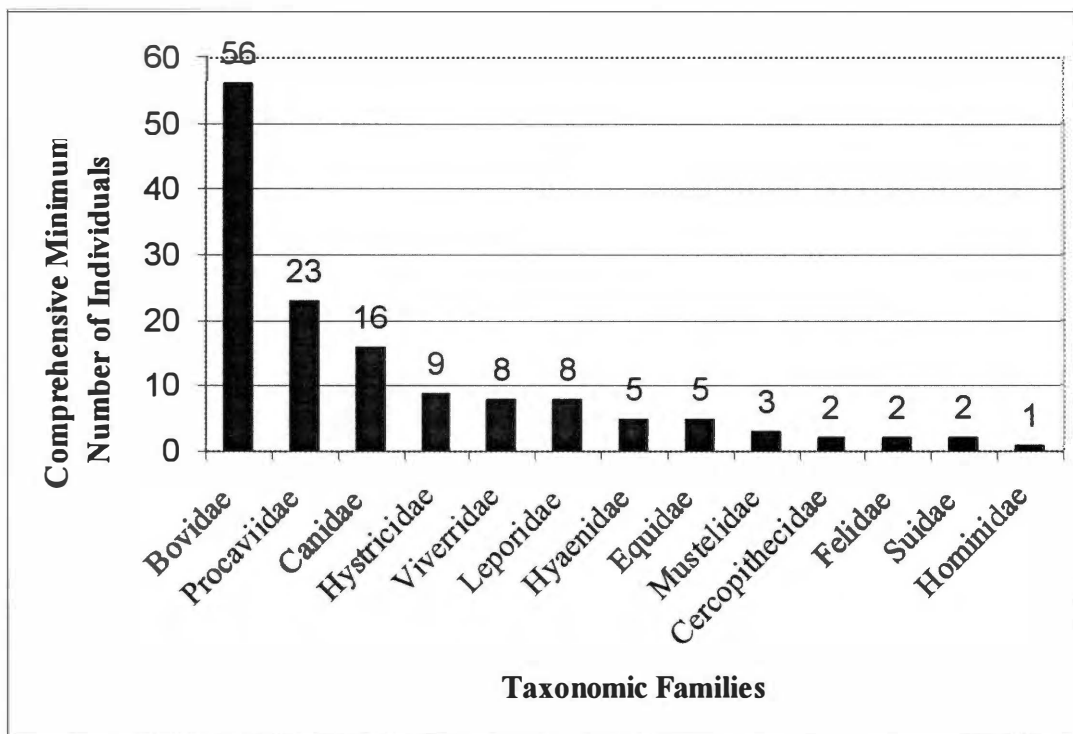


Figure 2. Taxonomic Families at Plover's Lake

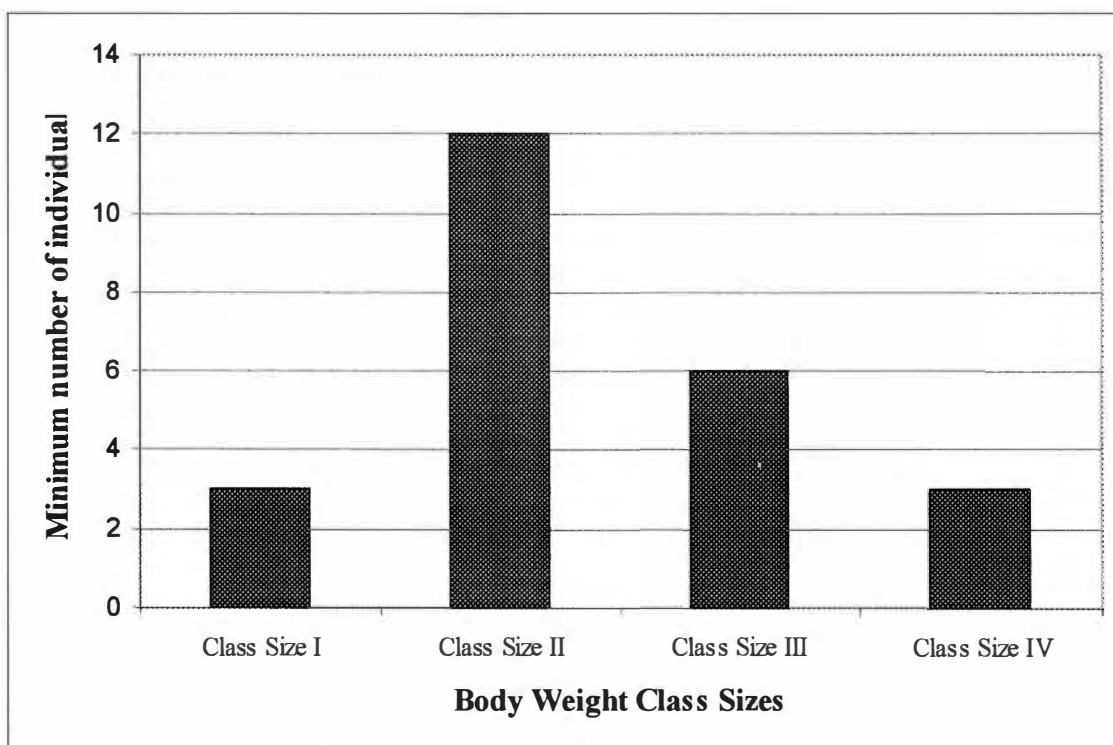


Figure 3. Bovid Weight Class Distribution

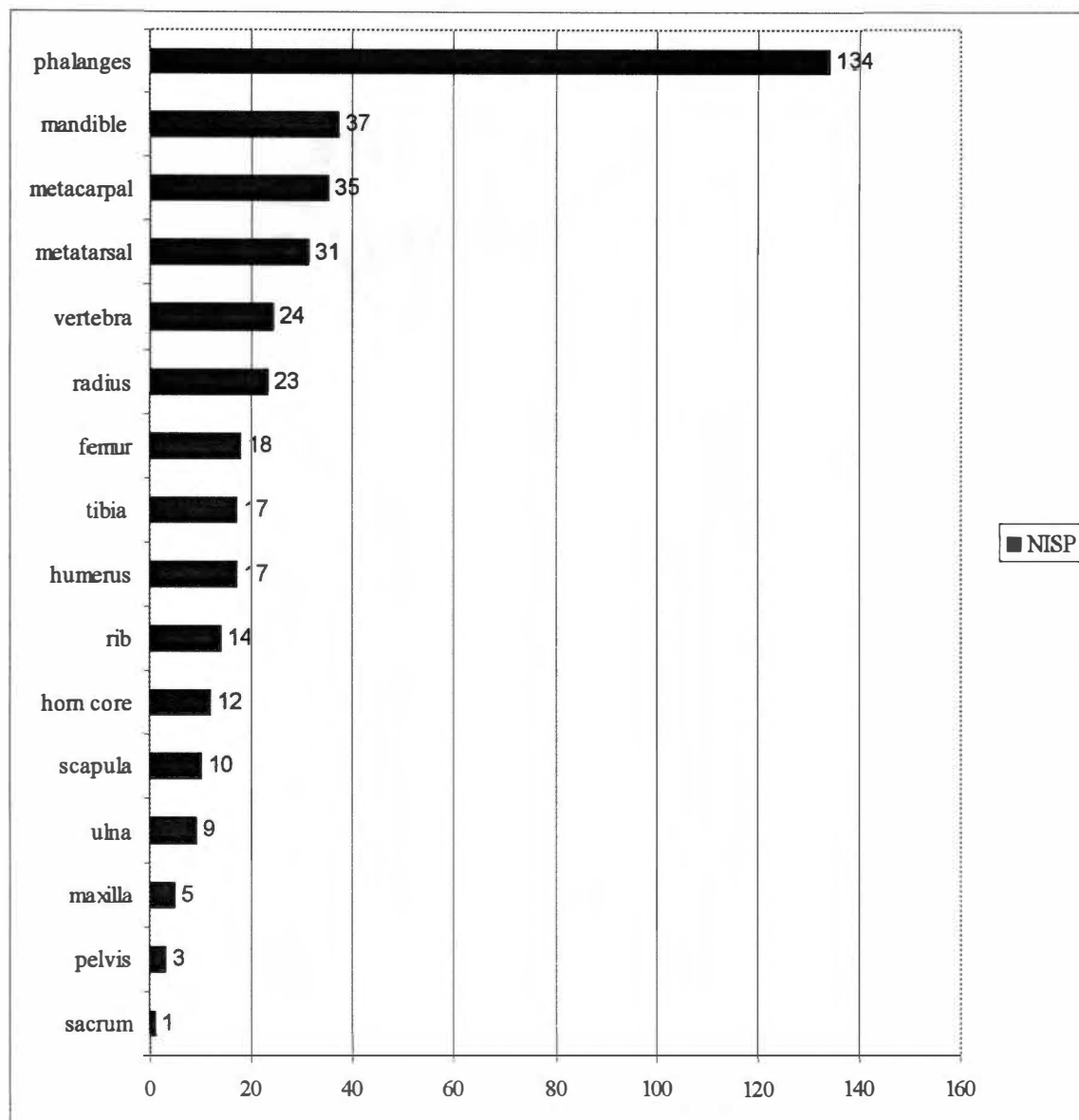


Figure 4. Skeletal Part Representation

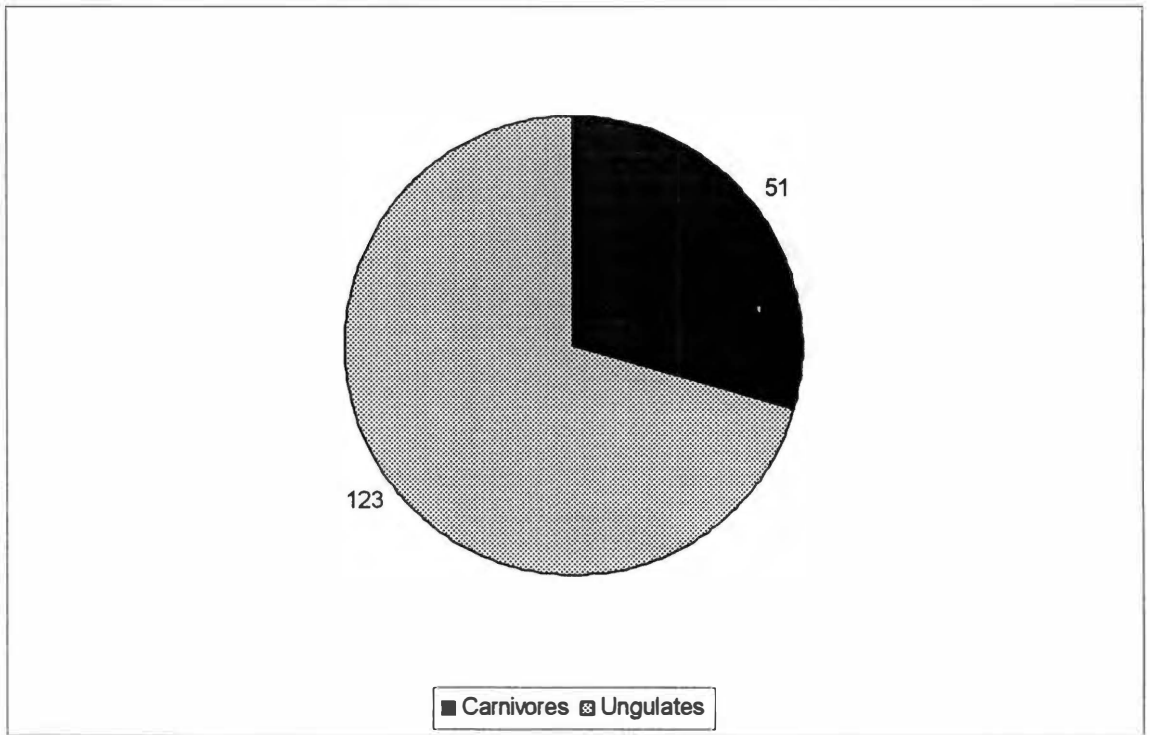


Figure 5. Carnivore-Ungulate Ratio

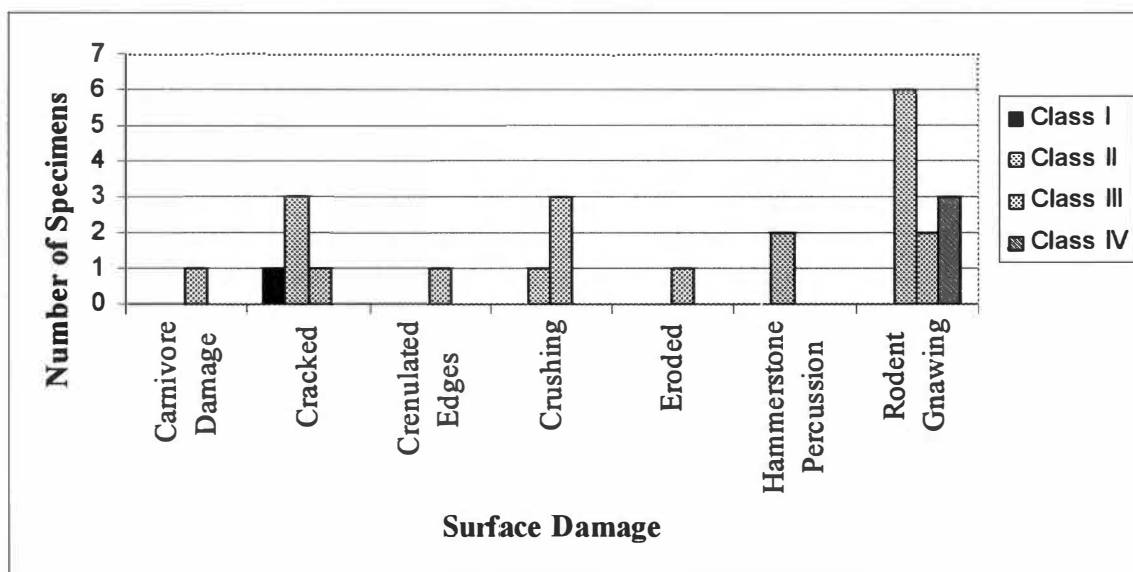


Figure 6. Amount and Type of Surface Damage

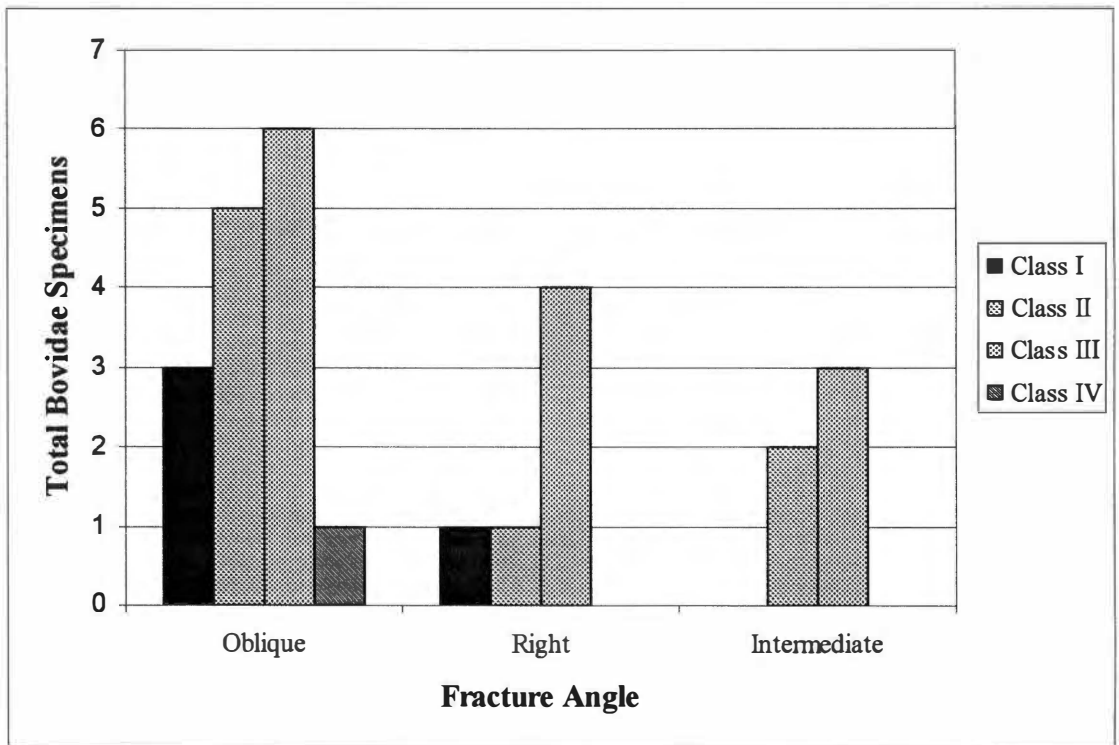


Figure 7. Type of Fracture Angle

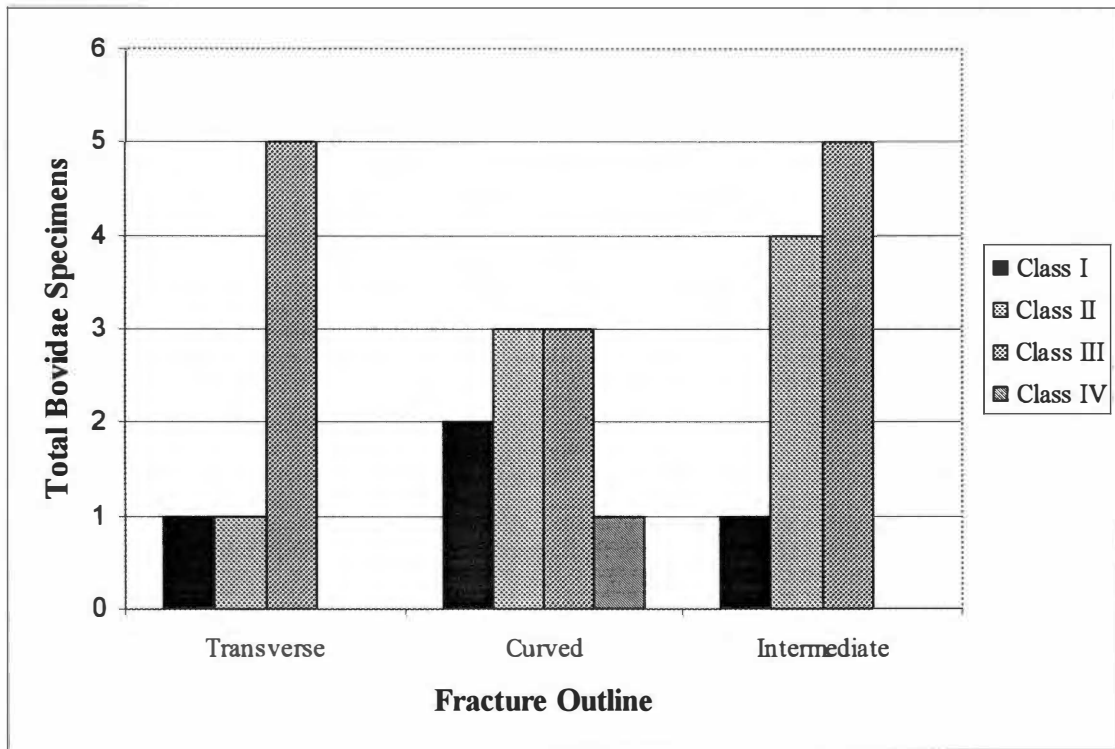


Figure 8. Type of Fracture Outline

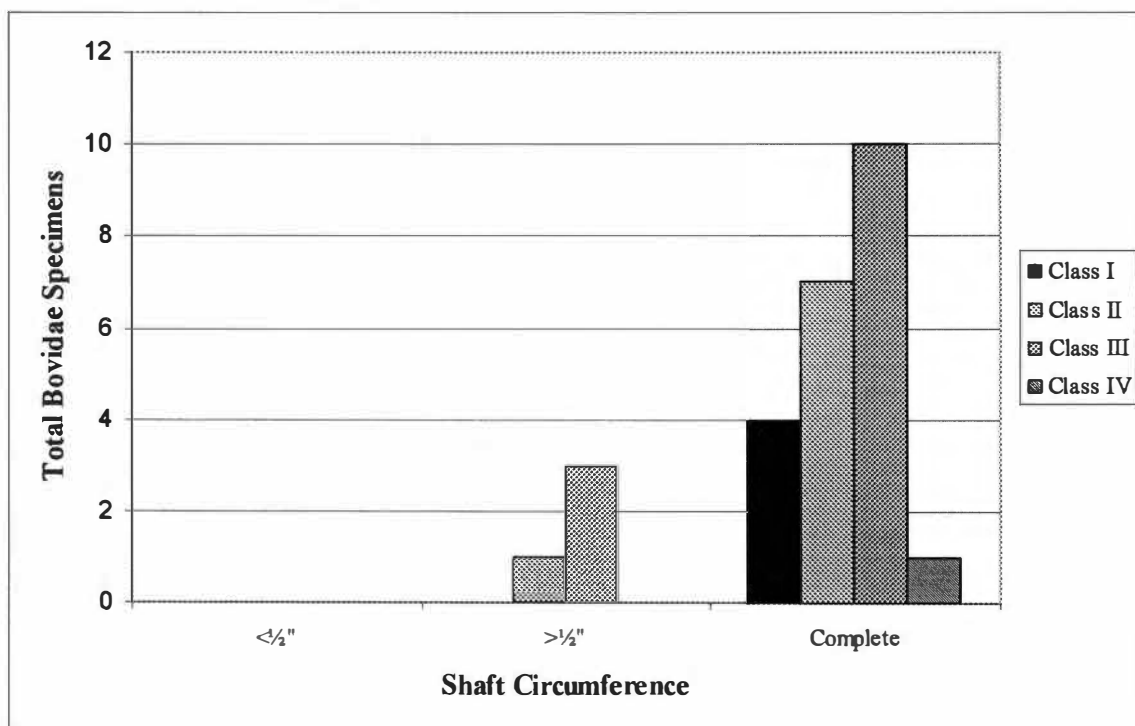


Figure 9. Amount of Shaft Circumference

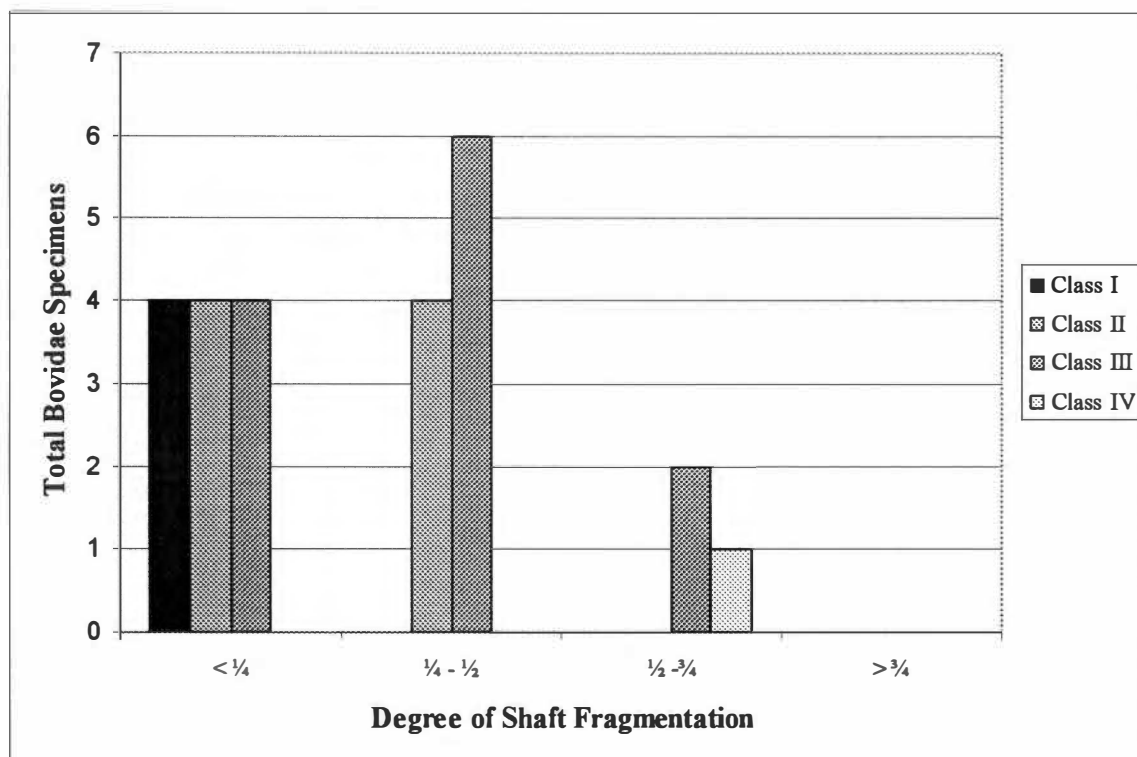


Figure 10. Amount of Shaft Fragmentation

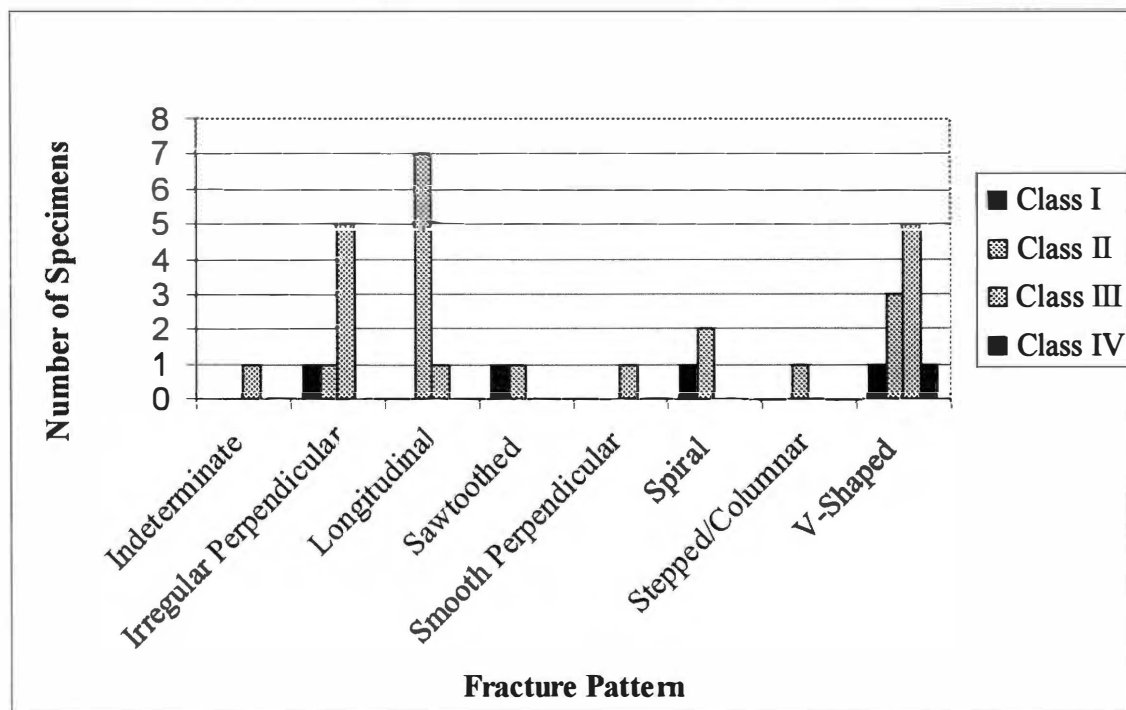


Figure 11. Amount and Type of Fracture Pattern

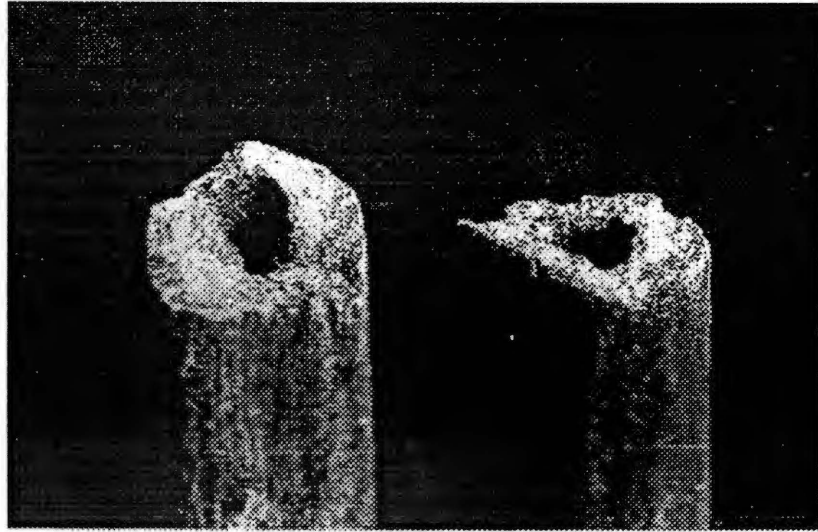


Figure 12. Right Fracture Angles
(adapted from Villa and Mahieu 1991: p.35, Figure 5)

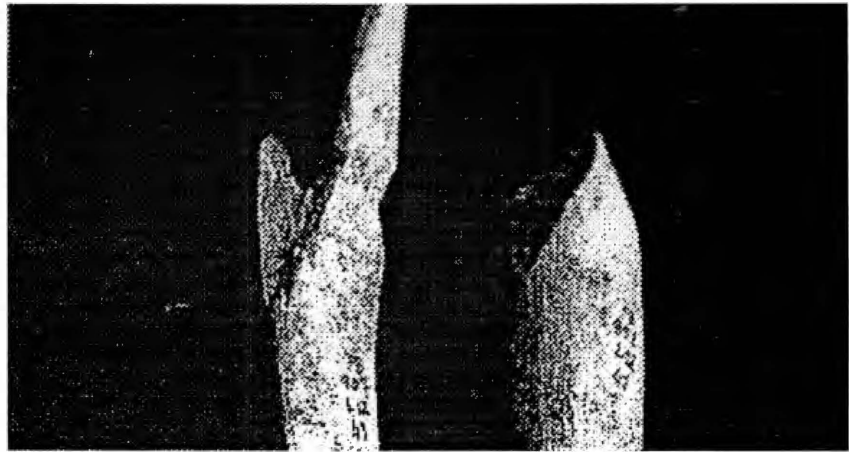


Figure 13. Oblique Fracture Angles
(adapted from Villa and Mahieu 1991: p.35, Figure 5)

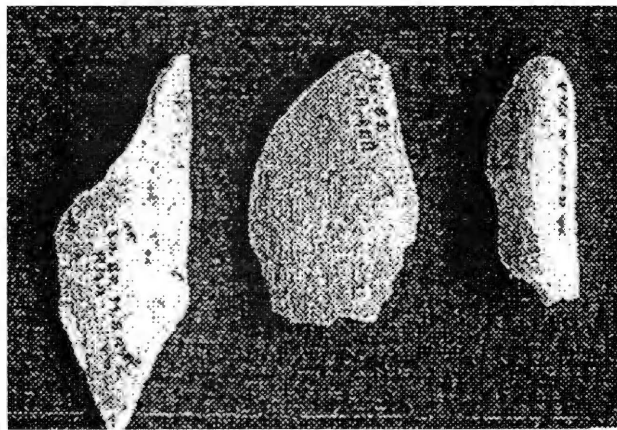
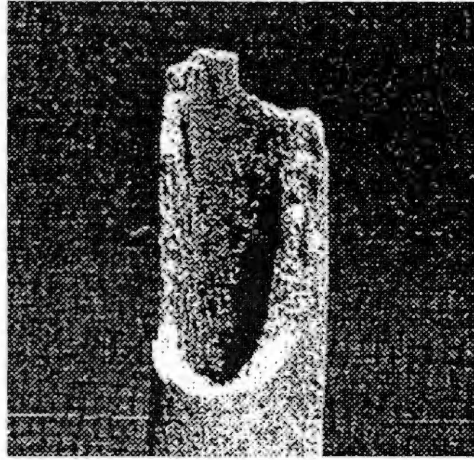


Figure 14. Curved Fracture Outlines
(adapted from Villa and Mahieu 1991: p.35, Figure 7)

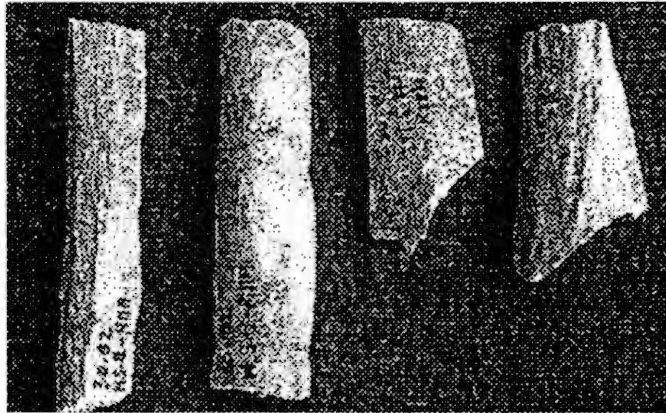


Figure 15. Transverse Fracture Outline
(adapted from Villa and Mahieu 1991: p.35, Figure 7)

Vita

Juliet Krueger Brophy was born in Grayslake, Illinois, on 20 September 1980. She was raised in Ingleside, Illinois and attended Big Hollow School for both grade school and junior high school. She graduated from Carmel High School, Mundelein, Illinois, in 1998. After high school, she attended the University of Michigan, Ann Arbor and graduated with a Bachelor of Science in Biological Anthropology. She received a Master of Arts degree from the University of Tennessee, Knoxville in anthropology and is currently applying to graduate schools to pursue her doctorate.

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