

Cave Bears and Paleolithic Artifacts in Yarimburgaz Cave, Turkey: Dissecting a Palimpsest

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This article addresses the taphonomic issues surrounding artifact–bear associations in Yarimburgaz Cave, northwestern Turkey. Our purpose is to evaluate the circumstances of bone assemblage formation in the Middle Pleistocene deposits of the cave, identifying the agencies responsible for the accumulations and the causes of bone damage before and following deposition. Pleistocene species representation, bone damage, body part representation, and mortality data indicate that cave bear remains in Yarimburgaz are unrelated to hominid use of the same site. None of the observations on the cave bear remains contradicts the expectations developed from modern wildlife accounts of modern bear behavior; these accumulations resulted from mortality normally associated with hibernation over many generations of den use. Nonursid carnivores also played roles in bone collection and/or modification. We conclude that at least three distinct biological processes contributed to the formation of the Middle Pleistocene faunas: hibernating bears, bone-collecting carnivores such as wolves, and hominids in descending order of importance. The Yarimburgaz faunas represent palimpsests or overlays of many short-term depositional events, the close spatial associations of which are explained by slow or uneven sedimentation rates inside the cave. Although occupations by hominids appear to have been ephemeral in nature, hominids ultimately discarded nearly 1700 stone artifacts in Yarimburgaz Cave. The hominids did not discard many ungulate bones in the same circumstances. These observations suggest that hominid foraging efforts focused on resources other than large game while at the cave. © 1996 John Wiley & Sons, Inc.

palimpsest / n, a & v. A manuscript in which later writing is written over an effaced earlier writing; in geology, exhibiting features produced at two or more distinct periods (*The New Shorter Oxford English Dictionary*, 1993 edition:2076).

“For all we know, the archaeological record is just one big palimpsest, incompletely effaced.” (Anonymous archaeologist, 1981)

“**No one escapes his fate.** It might be said that my affair with the cave bear started half a century ago when it was decided to give the child a name that happens to be

Swedish for bear. There were some early difficulties in living up to it, but in time it led to the distinction of a mention in the 'Authors and Subjects' section of the *Journal of Insignificant Research*. Still, the real thing began in the early 1950s. Eager to apply newfangled population ideas on fossil mammals, I was casting about for a statistically respectable sample of some fossil mammal—any fossil mammal . . . It was the cave bear: hundreds and hundreds of teeth and bones.

The fossils told me a great deal about how the bears were put together and how they worked, but the best aspect of it all was that they revealed many other things as well." (Kurtén, 1976:ix-x)

INTRODUCTION

Karstic landscapes have preserved more than their share of Pleistocene faunas, of which hominid fossils and cultural records are only one part. Indeed, our ability to evaluate the circumstances of cave use by premodern hominids depends upon fuller knowledge of the taphonomic history of each site. Far less has been learned by focusing upon human components in isolation.

Bear skeletal remains frequently are found in Paleolithic caves, particularly Eurasian sites whose deposits date to the Middle and Late Pleistocene geologic periods. Thanks in particular to the works of Kurtén (1958, 1973, 1976, 1977; Kurtén and Poulainos, 1981), many investigators now recognize that cooccurrences of human artifacts (or bones) and bear remains in cave deposits may arise from alternating occupations of natural shelters by these species, spaced over decades, centuries or millennia. Water and gravity may also promote stratigraphic associations among historically unrelated materials. Although these concepts are widely acknowledged in principle, much additional work is needed before archaeologists can be confident in their ability to tease apart the many elements of complex faunal records. An effective methodology no doubt requires simultaneous consideration of biological and geological phenomena, in spite of long-standing academic separation of the two fields of study.

This presentation addresses the taphonomic issues surrounding artifact-bear associations in one case study, Yarimburgaz Cave in northwestern Turkey (Figure 1). Yarimburgaz is one of only two Lower Paleolithic cave sites documented in the area between western Asia and central Europe. Part of an extensive karst system in Eocene limestone, Yarimburgaz Cave is situated roughly 15 m above modern sea level on the east side of the lower Sazlidere Valley (Figure 2), which drains into the embayment of the Küçükçekmece Lagoon and ultimately into the Sea of Marmara (Arsebük et al., 1990, n.d.). The cave lies 22 km west of the modern city of Istanbul. It consists of two parallel chambers with separate south-facing entrances (Figure 3), one situated somewhat higher than the other. An interior tunnel connects the two chambers, enlarged in Byzantine times when a chapel was carved into the walls of the upper cave (Özdoğan and Koyunlu, 1986).

The lower chamber of Yarimburgaz Cave extends 600 m into the limestone bedrock (see Figure 2). Deposits within 70 m of the lower entrance are rich in both cave bear remains and Paleolithic artifacts, probably dating to the later

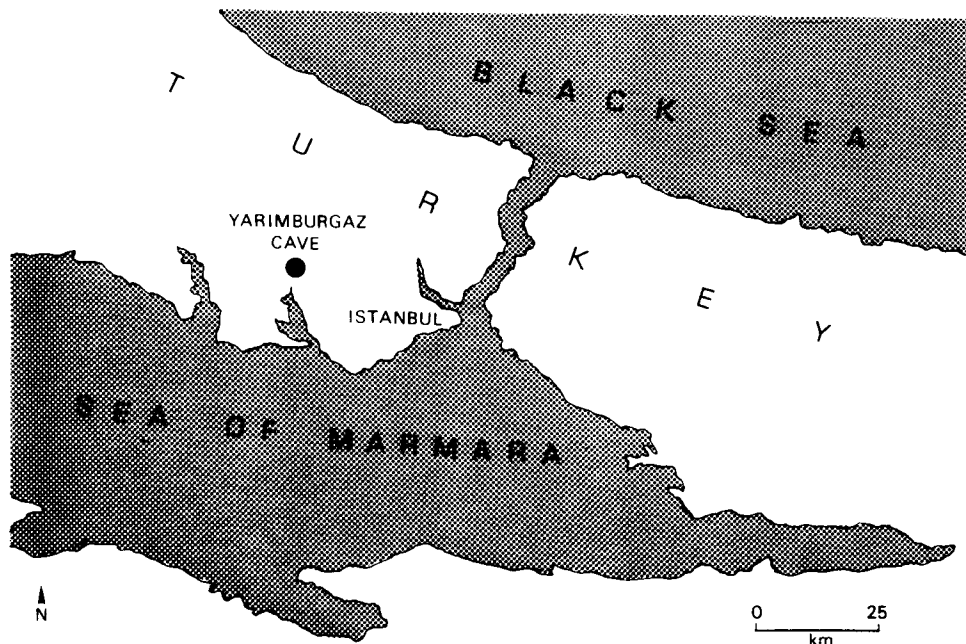


Figure 1. Geographic location of Yarimbürgaz Cave in northwest Turkey, roughly 25 km west of the Bosphorus Strait.

part of the Middle Pleistocene (Farrand, Schwarcz in Arsebük et al., n.d.). Excavations of these deposits, jointly directed by G. Arsebük of the Section of Prehistory of the University of Istanbul and F. C. Howell of the University of California at Berkeley from 1988 to 1990 (Arsebük et al., 1990, 1991; Howell and Arsebük, 1989, 1990; Özdoğan and Koyunlu, 1986), yielded substantial bone and stone artifact assemblages, the latter of which are under study by Kuhn (in Arsebük et al., n.d.; Kuhn, in press).

Reported here are the results from taphonomic analyses of the large mammal remains from the cave, a study undertaken in 1992. Our purpose is to evaluate the circumstances of bone assemblage formation in particular, identifying the agencies responsible for the accumulations and understanding the causes of bone damage before and after deposition. Other aspects of the macrofaunas, including osteometric and mortality data for bears, are presented elsewhere (Stiner in Arsebük et al., n.d.; Stiner, n.d.a, n.d.b).

This study is also, to the extent possible, an investigation of the resource ecology of the hominids and carnivores that once coexisted in northwestern Turkey. Important information about hominid lifeways and ecology surely is manifest by this intriguing, complex case. Only the material from the 1988, 1989, and 1990 excavations at Yarimbürgaz Cave is uniformly Middle Pleisto-

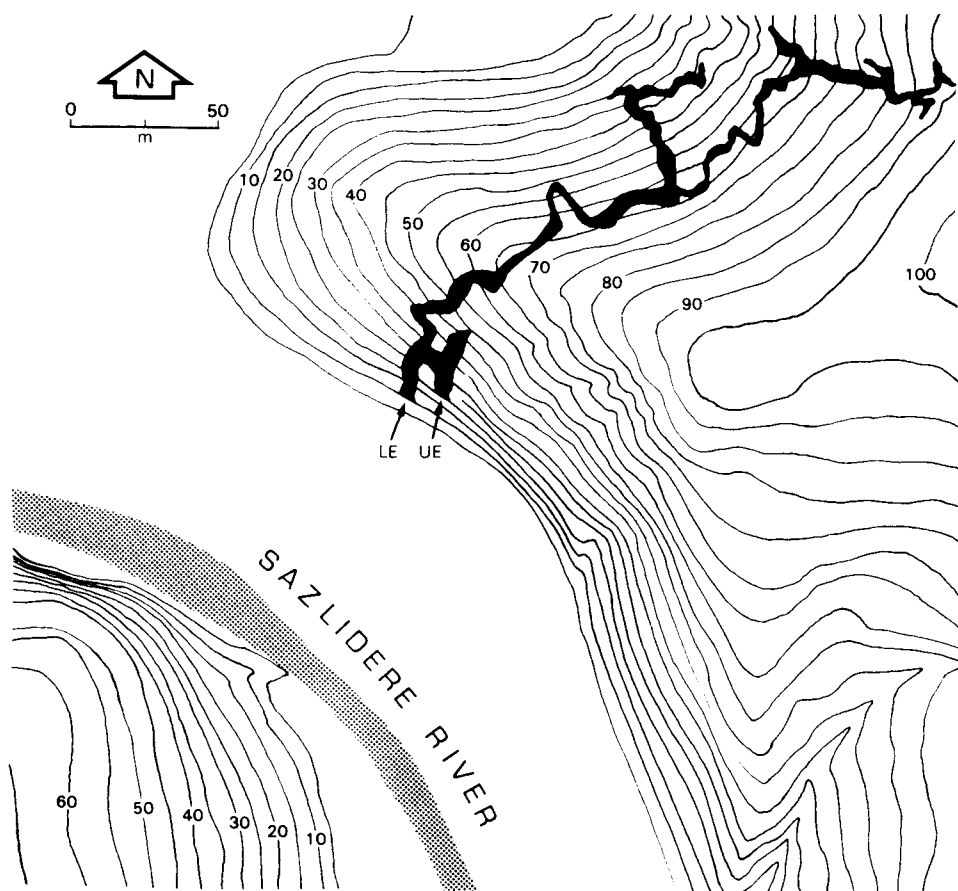


Figure 2. Topographic setting of Yarimburgaz Cave, showing the valley cut by the Sazlidere River and subterranean plans of the upper and lower cave chambers. The Sazlidere flows generally southward into the Küçükçekmece Lagoon and ultimately to the Sea of Marmara: (LE) lower entrance; (UE) upper entrance.

cene in age (probably late Middle Pleistocene) and hence is the focus of consideration. Many other bones and artifacts were recovered during earlier excavation campaigns, but those materials date to later Paleolithic and historic periods and underwent considerable post-depositional mixing, based on the excavators' observations (M. Özbaşaran, 1992, personal communication) and lithic assemblage contents (S. Kuhn, 1992, personal communication).

The bones from Yarimburgaz Cave are in an extraordinary state of macroscopic preservation possibly due to a hyperalkaline sedimentary environment; some of the flint artifacts from the same deposits have not fared nearly as well.

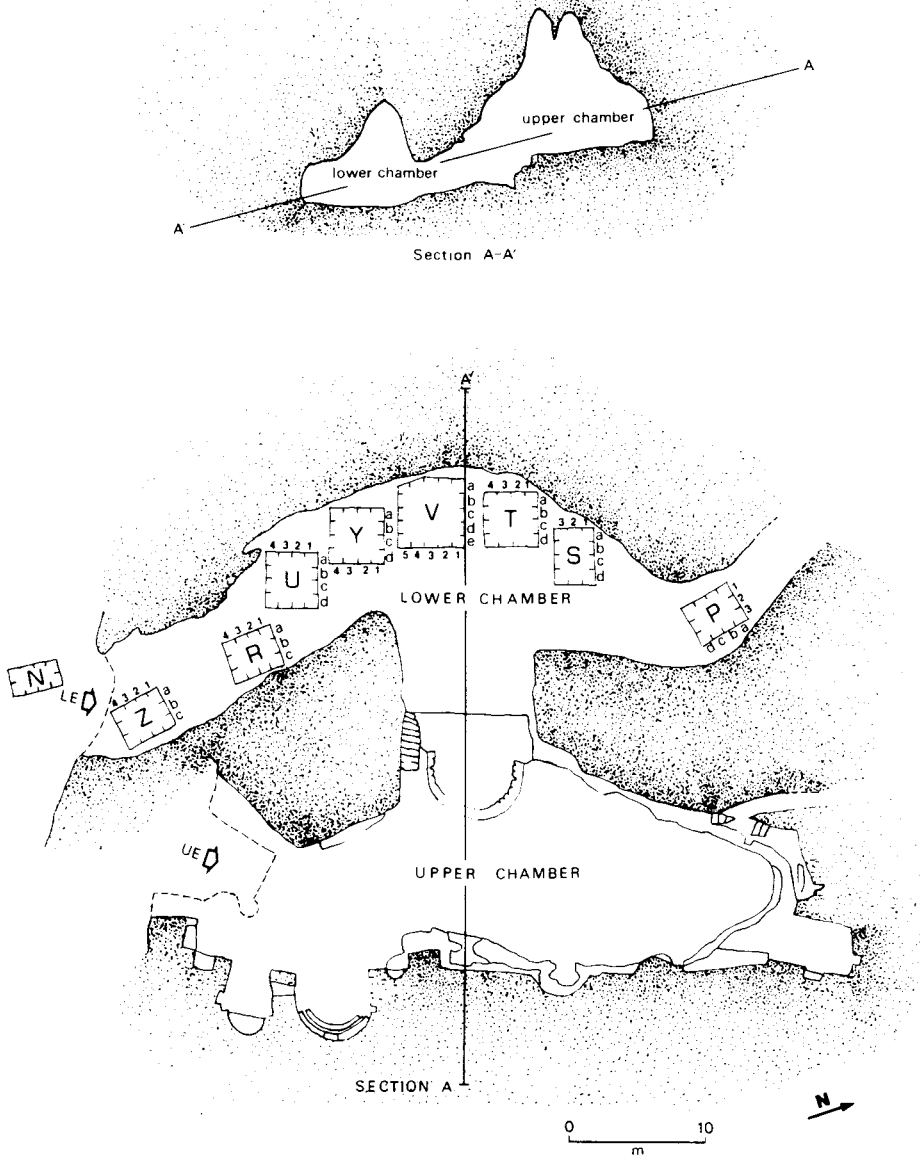


Figure 3. Plan view and cross section of two anterior chambers of Yarimbuzgaz Cave, showing locations of major units excavated in the lower chamber between 1988 and 1990. Each major unit or "trench" consists of multiple 1×1 m squares: (LE) lower entrance; (UE) upper entrance; (---) dripline.

Table I. Summary of macromammal NISP and stone artifact counts from the 1988, 1989, and 1990 excavations of Yarimburgaz Cave.

a. Macromammal NISP (Bones and Teeth)				
Mammal Group	Tooth NISP	Bone NISP	Composite NISP	Composite NISP (%)
Herbivores	42	109	151	4
Bears	761	3159	3920	93
Other carnivores	33	79	109	3
Total	836	3344	4180	100

b. Paleolithic artifact counts (from Kuhn [n.d.])	
Total lithic artifacts	1674
Modified (retouched) lithic artifacts	602

Note: Composite NISP refers to sum of tooth (articulated and isolated) NISP and bone NISP.

Most of the faunal remains can be identified to genus if not species, because fragmentation is limited.

Framing the Problem

There seldom is a straightforward explanation for the spatial associations of Paleolithic stone artifacts and carnivore bones in natural shelters (Brugal and Jaubert, 1991; Gamble, 1983, 1986; Jenkinson, 1984; Kurtén, 1976; Lindly, 1988; Stiner, 1991a, 1994; Straus, 1982). Slow or variable rates of sediment buildup are typical in caves, potentially allowing materials of different ages to accumulate in the same geological strata. Hence a variety of explanations can be posited for the cooccurrences of artifacts and carnivore bones in the Middle Pleistocene levels of Yarimburgaz Cave.

The taphonomic issues in this case center on how four spatially associated categories of material—bears, stone tools, ungulates, non-ursid carnivores—relate to one another in time. Cave bears constitute 93% of all macromammal specimens recovered (Table Ia), interspersed with 1674 Lower Paleolithic artifacts (Table Ib). Ungulate and nonursid carnivore bones are represented in low frequencies by contrast—4% and 3% of identifiable specimens, respectively—and their distributions seem no less restricted. Ungulate bones modified by hominids exist in the Yarimburgaz collection but are exceedingly rare. It is unlikely that the mammal bones were carried into the cave by water or gravity, although water flowed through the karst during earlier periods (Farrand, 1995; Farrand in Arsebük et al., n.d.).

Because we ultimately are interested in what the hominids may have been doing in Yarimburgaz Cave, the potential bone-collecting and bone-modifying roles of the large carnivores must be evaluated first. It is entirely possible that



Figure 4. Excavated level in Yarimburgaz Cave (trench Y, 1988) showing *in situ* scatter of bear bones and loose limestone rocks.

some or all of these animals were periodic residents. The origins of the herbivore remains are additional points of contention: They almost certainly represent food items of predators and therefore could have been collected by hominids or members of the order Carnivora.

The remains of cave bears (*U. deningeri*) are bountiful and widespread in Yarimburgaz (Figure 4), and an explanation centering on hibernation-related mortality is especially likely. Alternative hypotheses also merit consideration, however. A scenario citing hunting of large carnivores by hominids may seem a less tenable explanation for the cooccurrences of stones and bones in Yarimburgaz Cave, but the possibility requires a proper test. After all, exploitation of bears by humans in later periods is relatively well known, if infrequent overall (Rogers, 1981:69; Bárta, 1989; Stiner, 1990a, 1994).

The scant presence of other carnivore species, such as wolves, lions, spotted hyenas, and caracals, in the Yarimburgaz faunas is an important taphonomic signal in its own right. Some of these predators are known to gather prey bones at den and rest sites (Ewer, 1973; Fentress and Ryon, 1982; Mech, 1970; Fox, 1984; for hyenas, Hill, 1980; Sutcliffe, 1970). Hence their potential roles in bone collecting and/or bone modification must be addressed. As shown below, the influence of large canids at Yarimburgaz Cave was periodically dramatic.

GENERAL METHODS

Conventional zooarchaeological counting units were used to construct a faunal inventory by provenience, taxonomic affiliation, and skeletal anatomy (Grayson, 1984; Lyman, 1994). NISP refers to the *number of identified specimens* in fragmented or whole condition following Grayson (1984). Teeth and bones were recorded separately, accounts of which appear in Appendix 1.

An analysis of species representation is the first step in this taphonomic study, if only because animals that collect bones may die wherever they spend a lot of their time. Bone damage patterns are subsequently examined, primarily in terms of NISP and focusing on the frequencies of superficial damage types (such as burning, tool marks, and gnawing), fracture forms, and weathering. The variable *minimum number of individual* animals (MNI) represented by teeth versus cranial bone is used to evaluate the extent of *in situ* bone destruction caused by various attritional factors (following Stiner [1994:99–103]); this comparison is confined to bears, the most common mammal. The question of *in situ* destruction is explored further through comparisons of numbers of various skeletal elements (*minimum number of elements*, or MNE) and “portion” representation, counting units for which follow Stiner (1991b, 1994). Contrasting body part profiles for ungulates, bears, and other carnivores help illuminate possible differences in the circumstances of accumulation among these major taxonomic groups. Spatial associations of artifacts and the bones of bears, ungulates, and nonursid carnivores are evaluated by comparing relative abundances across provenience units. Finally, bear mortality patterns and body part representation are used to evaluate the hypothesis that the bears of Yarimburgaz Cave represent hibernation-related deaths. The mortality analysis is based on tooth eruption and wear patterns, using a scheme developed for *Ursus* bears (Stiner, n.d.a, 1994:324–327). The presentation concludes with an overview of the taphonomic results, returning to the question of hominid activities at the site.

SPECIES REPRESENTATION

The numbers of identified faunal specimens (NISP) in the 1988–1990 collections from Yarimburgaz Cave are listed separately for teeth and bones in Appendix 1 by trench and geological level. Each tooth is counted as one NISP unit, regardless of whether it is fixed within or isolated from its original bony casing (for discussion and rationale of this procedure, see Stiner [1992:438–439, 1994:69–73]). Most specimens in the Yarimburgaz assemblages are easily identified to species or genus, owing to comparatively low levels of fragmentation. For example, the total *bone* NISP count for bears concords with total *bone* MNE on the order of 81%, and at 86% and 84% for nonursid carnivores and ungulates, respectively (total bone MNE/NISP based on data in Appendixes 1b and 2a–c).

Table 1a shows that most of the mammal remains in Yarimburgaz Cave are

from bears (93%). Cheek tooth measurements (Stiner, n.d.b; Stiner, Tsoukala in Arsebük et al., n.d.) and the relative gracility of certain fused adult bone elements indicate the presence of two species of *Ursus*, one considerably more gracile than the other. The size contrast between the two bear species is well illustrated, for example, by the two fifth metacarpals shown in Figure 5a. The smaller, gracile bear is almost certainly *Ursus arctos*—the brown bear—and appears to have been coeval with the larger type. The large, robust bear species, which constitutes over 99% of all bear remains, is certainly a form of cave bear, probably a comparatively late and large-bodied population of *U. deningeri*. Cheek tooth measurements for the Yarimburgaz cave bears better resemble those for *U. deningeri* than *U. spelaeus* samples from caves in Greece, France, and Germany (Stiner, n.d.b; Stiner, Tsoukala in Arsebük et al., n.d.; esp. Prat, 1988:295; also Argant, 1980; Kurtén, 1973; Kurtén and Poulainos, 1981; Laville et al., 1972; Prat, 1976; Prat and Thibault, 1976; Schütt, 1968). This case effectively extends the geographic range of Pleistocene cave bears defined by Kurtén (1976:61) to include northwestern Turkey (Figure 6).

Whereas only 4% of all bones are from ungulates, the array of species represented by the 151 pieces is extensive, including horse (*Equus caballus*), possibly wild ass (*E. hemionus?*), roe deer (*Capreolus* aff. *süssenbornensis*), fallow deer (*Dama* sp.), red deer (*Cervus elaphus*), giant deer (*Megaloceros* sp.), aurochs (cf. *Bos primigenius*), bison (*Bison* cf. *priscus*), wild pig (*Sus scrofa*), wild goat and/or ibex (*Capra* aff. *aegagrus*, *C.* cf. *ibex*), possibly gazelle (*Gazella* sp.), and an undetermined species of pachyderm. Carnivores other than bears constitute only 3% of the faunal assemblages from all proveniences (NISP = 109) and include large and small cats of the genera *Panthera* (*leo*, possibly also *pardus*) and *Felis* (*caracal* and *sylvestris*), as well as spotted hyena (*Crocuta crocuta*), wolf (*Canis lupus*), fox (*Vulpes* spp.), possibly dhole (*Cuon/Xenocyon?*) and jackal (*Canis aureus?*), and a small mustelid.

The number of genera (N-genera) represented in each assemblage, as defined by level and horizontal excavation unit, is explained principally by differences in assemblage size ($N = 23$, $r = 0.739$, $p < 0.01$). The Middle Pleistocene levels of Yarimburgaz Cave contain many species, but the number of taxa represented is not significantly different across provenience units. Removing bears from the comparison greatly strengthens the relation between N-genera and NISP, however ($N = 23$, $r = 0.904$, $p < 0.001$). This result is not surprising given that the quantity of bear remains exceeds that for all other mammals combined by an order of magnitude.

BEAR BEHAVIOR AND ITS PALEONTOLOGICAL CONSEQUENCES

Despite Kurtén's ample contributions (Kurtén, 1958, 1973, 1976, 1977), research on bears' potential impact on Paleolithic cave site formation has since slowed, though not because all of the questions about bear-artifact associations have been answered. Archaeologists find bear bones in Eurasian cave sites



Figure 5. Gracile and robust bear fifth metacarpals: (a) indicating the presence of two species (*U. deningeri* and *U. arctos*) in the Yarimburgaz Cave deposits; (b) three cortical bone fragments rounded by salivary and/or gut enzymes of a large carnivore (e.g., wolf, hyena, or cat); (c) possible cut marks made by a stone tool on a large ungulate rib shaft fragment.

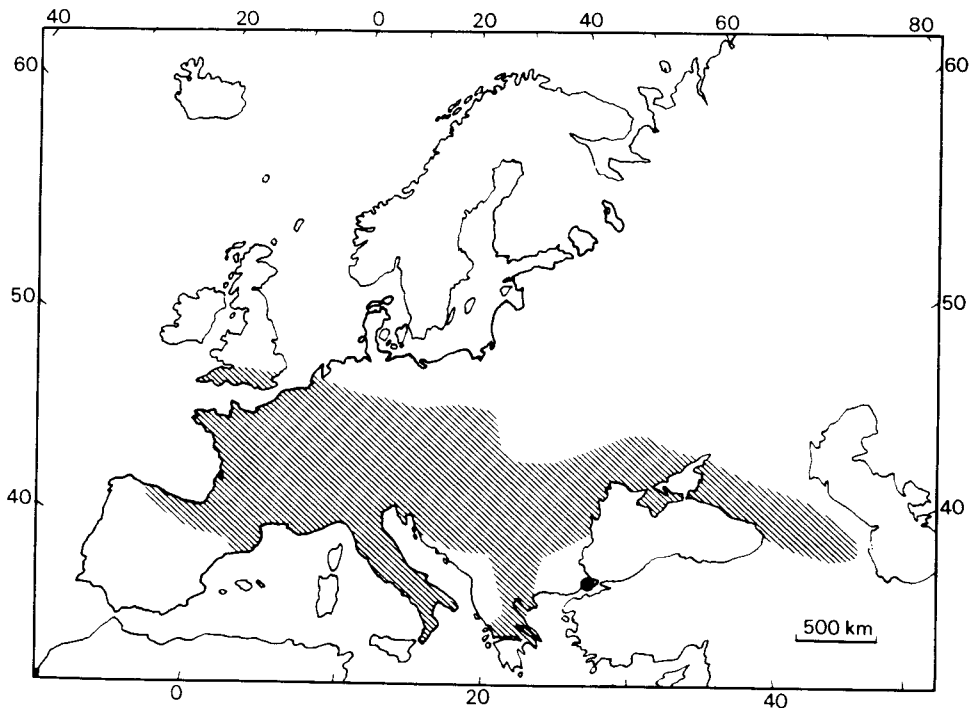


Figure 6. General geographic distribution cave bear sites as reported by Björn Kurtén, and location of Yarimbuzurgaz Cave in northwest Turkey. The shaded area (adapted from Kurtén [1976:61]) represents cave bear populations dating to the Holsteinian interglacial and after, corresponding to the Middle and Late Pleistocene, and therefore should include both *Ursus spelaeus* and the earlier chronospecies *U. deningeri*.

with surprising regularity, yet what we have to say about this phenomenon has gained little additional ground since the 1970s. In order to model the bear's role in the formation of cave faunas—with or without human components—it is necessary first to consider how bears live. The taphonomic question is whether or not bears died inside the cave while hibernating there, and behavioral data on modern brown and black bears can help to build expectations for the “paleontological” consequences of hibernation deaths over the long term.

The hibernation process is perhaps best understood for the American black bear (*U. americanus*), a species still common throughout much of North America (Hellgren et al., 1990; Garshelis and Pelton, 1980; Johnson and Pelton, 1980; Rogers, 1981, 1987). Although brown bears (*U. arctos*) are a distinct species, modern blacks and browns have much in common biologically, including hibernation behavior and its nutritional and reproductive contingencies (Nelson et al., 1980; Tassi, 1983; Murie, 1985; Clevenger, 1990, 1991; Clevenger et al., 1987, 1988; Clevenger and Purroy, 1991). These basic similarities war-

rant certain generalizations about modern representatives of *Ursus* as a group. We further assume on energetic and phylogenetic grounds that the *relations* between dietary and hibernation characteristics of Pleistocene *Ursus* were grossly similar to those of modern *Ursus*. All were omnivorous, for example, and sported multicusped, piglike dentitions, although this morphology reaches its greatest extreme in the cave bears of the Pleistocene (Kurtén, 1958, 1976). The metabolic and reproductive aspects of hibernation in modern *Ursus* are thought to be intrinsic (Watts and Jonkel, 1988; Watts et al., 1987; Hellgren et al., 1990; Johnson and Pelton, 1980; McNamee, 1984:253–257), and, although cave bears are extinct, these qualities are unlikely to have been profoundly different in Pleistocene representatives. The mortality that normally accompanies this adaptation should be comparable as well.

Immediately following is a brief review of available information on hibernation, foraging behavior, mortality, and cannibalism in modern black and brown bears. Three questions about how the condition and cumulative contents of bear death assemblages may arise are pursued in particular: (1) Do bears normally collect food and bones in dens, such that the remains of bears and their prey might be found together in shelters? (2) What sorts of bear body part profiles and patterns of bone damage occur in hibernation-death situations? (3) Which bear age groups are most commonly affected by hibernation-related mortality?

1. Do bears collect food and bones in dens? Not all predators that inhabit shelters also carry food into them. Rather, predators that rely upon natural or excavated shelters fall into two behavioral categories in this regard: bone collectors and noncollectors. Many of the canids and hyaenids deliberately gather bones at den and rest sites (Ewer, 1973; Fentress and Ryon, 1982; Mech, 1970; Kruuk, 1972), amassing substantial quantities in some cases (Binford, 1981; Hill, 1980). Hominids did essentially the same at residential sites during the Pleistocene, sometimes in caves. Felids may cache food but, when they gather bones in cave systems, it is largely by accident (Brain, 1981).

The story is different for bears. Wildlife accounts show that black and brown bears do not habitually carry food to dens, and they consume little food while preparing their winter beds (McNamee, 1984; Rogers, 1987:23). Black and brown bears typically amass piles of vegetation in hibernation dens (McNamee, 1984:252–253; Murie, 1985:133–135; Rogers, 1987:20–22) but bones other than those of unlucky bears generally are not found. In Cantabria, where brown bears often make use of caves, Clevenger (1991) reports twigs and other plant material in abandoned dens but no bones. In general, bears *avoid* collecting odorous refuse at dens because the location must be kept secret. Sleeping bears are vulnerable to attack despite their great size (Rogers, 1987:53; Ross et al., 1988; Tietje et al., 1986), and food debris can only betray the location of a hibernation den to predators. The only exception to our knowledge is a case reported by Rogers (1987:23) in which a lactating female black bear found a deer carcass near her den after emerging in spring. She dragged the carcass

to the entrance of the den, and fed upon it during the days just prior to abandoning the location. The incident is unusual in Roger's study area, yet raises the possibility that bears might occasionally collect small amounts of bones in or near hibernation sites if they are about to leave them in spring. However, the quantities of nonbear bones that might accumulate in these circumstances are nominal, if perceptible at all, from a paleontological point of view.

2. *What sorts of bear body part profiles and patterns of bone damage occur in hibernation-death situations?* While bears normally do not collect ungulate bones in hibernation dens, bears are very likely to contribute their own remains to the deposits of the shelters they occupy. The hibernation death scenario implies that bears perished *in situ* (or nearby in the cave system), so that complete bear skeletons therefore should be present in the deposits. The bones may not stay in articulatory order, however, because bears renovate bedding areas each year (see references above); the scale of this kind of disturbance hinges on the frequency with which a site is reused. Bears may hibernate in natural caves and fissures in regions where these conveniences are plentiful (Clevenger and Purroy, 1991:113–123; Murie, 1985:133–135) or excavate their own (Rogers, 1981). Limestone caves and fissures are merely better preservation environments for bones, and hence we often encounter the remains of bears in Pleistocene caves.

Mortality rates in modern bears are high toward the end of the hibernation period (Garshelis and Pelton, 1980; Kurtén, 1976; Rogers, 1981, 1987; McNamee, 1984; Stuart, 1982:85). Starvation appears to be the most common cause of hibernation-related deaths in most study areas, especially for cubs and yearlings (Rogers, 1987; and see below). Bears generally do not die in their sleep. Rather, they awaken if their energy stores are depleted and may, as a last resort, make short forays in search of nearby food. It is for reasons such as this that bears sometimes collapse and die in the vicinity of dens.

In addition to nonviolent causes of death, denning bears may be attacked by other predators, including humans. Hunting of these large animals by other predators, especially wolves, people, and other bears, is most feasible while the animal is dormant. Cannibalism within and between bear species may be commonplace during lean years or where population densities are high (Mattson et al., 1992; Ross et al., 1988; Tietje et al., 1986).

Whereas hibernating bears are nearly odorless, a dead bear is not and therefore is likely to attract scavengers once the carcass is abloom. It would be difficult from a taphonomic perspective to distinguish bear deaths resulting from attacks on live, dormant individuals from bodies that were scavenged after death. Attacks may be encouraged by the distress of a starving, wakeful bear, but it must also be recognized that scavengers would be attracted by the odor of a dead bear in the same place. In either case, much gnawing damage by marauding carnivores is expected on bear remains in cave deposits.

3. *Which bear age groups are most commonly affected by hibernation-related mortality?* Hibernation by bears is both a means for supporting exceptionally altricial infants and enduring seasonal scarcity of food plants, invertebrates, and small vertebrates (Clevenger et al., 1992; Ewer, 1973; Garshelis and Pelton, 1980; Rogers, 1981, 1987; Tassi, 1983; McNamee, 1984; Murie, 1985). The success of the hibernation strategy hinges upon food availability during the previous warm season, especially autumn—death patterns in dens are driven principally by starvation. Rather than turning to large prey when plants and invertebrates are no longer available, the bear possesses the metabolic option to drastically reduce its need for energy (Nelson et al., 1980; Hellgren et al., 1990; Johnson and Pelton, 1980; Watts and Jonkel, 1988; Watts et al., 1987). Whereas hibernation may be very important to both sexes in *Ursus* where diets are highly omnivorous, the polar bear (*Thalarctos maritimus*) is a pure carnivore, and hence only pregnant females (and cubs) of this species normally hibernate.

Deaths are especially common toward the close of the hibernation season, when bears are still using dens as short-term foraging hubs. Natural, nonviolent mortality under dire conditions may in turn lead to a gradual, steady rain of bear bones into the sediments of shelters frequented across generations. Because so many deaths occur from starvation and disease, and because young are harbored by female bears in hibernation dens, the juvenile and old adult age groups are preferentially affected by hibernation-related mortality.

Expectations for Paleontological Assemblages

Assuming that the bears in Yarimburgaz Cave represent hibernation deaths, at least four expectations about the distribution, content, and condition of their remains may be forwarded:

Expectation I. Because modern bears normally do not collect food inside hibernation dens, the relative abundances of bear bones and those of other species in cave sediments may not show strong positive spatial correlations to one another, especially with regard to horizontal units. It may *not* be valid to expect a strongly negative relation between the frequencies of bear bones and other mammal remains either, because (a) the geological units recognized by excavators may have formed over long periods of time and/or (b) the bones may become jumbled and reconcentrated subsequently by, among other things, more bed-seeking bears. The expectation therefore is one of spatial independence.

Expectation II. Evidence of intra- and interspecific violence or scavenging is likely to be found on at least some individuals in a large hibernation death assemblage. Adult male bears and wolves are the most common perpetrators in modern settings. On the other hand, nonviolent bear deaths represent scavenging opportunities that few predators could ignore. Considerable gnawing damage on bear carcasses in dens is likely in either case.

Expectation III. Hibernation deaths in caves should result in relatively com-

plete body part representation for bears. The bones may ultimately fall out of articulation, however, because bears typically modify bedding areas by digging and lateral raking with powerful claws. Disturbance of skeletal order in carcasses on or buried just below a cave floor is especially likely if the den area is used again and again. Selective deletion of bear body parts by predators is also possible, but the expectation of complete skeletons, qualified only in terms of density-mediated destruction of bone tissue, is a useful baseline with which to begin the comparisons.

Expectation IV. Starvation, disease, senescence, and occasional cannibalism all may contribute to bear deaths in hibernation dens. A U-shaped age structure (a.k.a. “concave” or “attritional” when plotted in histogram format) therefore should result over many generations of cave use (Kurtén, 1958:4–5; Stiner, 1994:318, n.d.a). This type of mortality pattern characteristically is composed of many juveniles and a smaller complement of old adults; it is nearly devoid of prime-aged adults. The juvenile fraction may be exaggerated further by high infant mortality in the den, although the relatively small litter sizes that are characteristic of bears (Ewer, 1973:306) will suppress this tendency relative to most other den-using carnivore species (Stiner, 1994:316–331).

If we find that bear skeletons in a cave are due to hibernation deaths—places to which bears should not also carry food—then the presence and condition of other macromammal remains in cave deposits are independent and need to be explained by other means. In the case of Yarimburgaz, “other” macromammal remains are primarily from ungulates and nonursid carnivores (see Table Ia, also Appendix 1). The condition of ungulate bones should, at the very least, differ from that of bears. Body part profiles for these taxonomic categories should represent another point of difference, because ungulate remains may have been selectively transported to the cave from procurement spots outside; such a contrast assumes, however, that the effects of *in situ* bone decomposition can be controlled. As for spatial distributions of bears, ungulates, nonursid carnivores, and stone artifacts, it is clear from the outset that no drastic differences exist, although diverse taphonomic histories are suspected. The vertical distributions of these materials depend foremost on sedimentation rates, which appear to have been slow relative to the rates of bone and artifact accumulation. Horizontal distributions may more consistently expose behavioral differences among the various cave occupants under conditions of slow sediment formation (Gargett, 1994; Stiner, 1991a, 1994:150–153).

BONE DAMAGE AND SPATIAL DISTRIBUTIONS OF MATERIALS IN YARIMBURGAZ CAVE

The taphonomic history of the Yarimburgaz faunas is explored three ways in this section. The first procedure attempts to determine how much bone material was lost *in situ* through decomposition of fragile skeletal tissues and/or food processing by consumers. The second procedure focuses on patterns of visible bone damage, including fractures, the forms and frequencies of marks

made by stone tools, and gnawing damage from carnivores and rodents; data for all proveniences are lumped in this analytical step to avoid potentially serious aggregation errors. The final procedure seeks possible differences in the spatial distributions of stone artifacts and ungulate, bear, and nonursid carnivore remains across provenience units in the cave. The relative abundances of these materials are compared using a Pearson's (r) correlation matrix. The animal remains are divided into only three categories—bears, ungulates, and nonursid carnivores—on the grounds that they potentially represent distinct historical entities from a taphonomic point of view.

Bone Preservation as a Function of Skeletal Tissue Density

The question of *in situ* bone loss focuses on how much skeletal material may have disappeared after reaching the cave sediments because of destructive processes such as decomposition and gnawing. The quality of macroscopic preservation for bones recovered from the Middle Pleistocene deposits of Yarimbuzgaz Cave ranges from very good to extraordinary. Substantial molecular transformations almost certainly have taken place, however, judging from the advanced state of fossilization. The great majority of bones and all teeth nonetheless retain the finest natural textures, along with traces of damage inflicted when the tissues were fresh.

The degree of *in situ* bone loss from decomposition or gnawing can be evaluated in gross fashion by comparing the minimum number of individual animals (MNI) derived for two distinct classes of skeletal tissues—tooth and bone—across excavation units. Here the comparison is confined to the skull, because the head is the only transportable unit of the body that is composed of both very hard and very fragile skeletal tissue types. If teeth were deposited in the site, chances are that cranial bones were once there too (i.e., cranium, mandible or both); otherwise the head should be consumed or left where first encountered. Cross-element comparisons, such as between cranial and post-cranial elements, potentially conflate the problem of *in situ* attrition with that of differential transport (Lyman, 1994; Stiner, 1994), something to be avoided in this investigation. The comparison is further confined to bear remains, because they greatly outnumber those of all other mammals and therefore provide the only sample large enough to provide meaningful results in this kind of analysis (but see skeletal portion data below).

If no *in situ* bone attrition has occurred, MNI counts based on teeth and those based strictly on cranial bone for differently-sized assemblages should increase at the same rate. A regression plot of tooth-based and bone-based MNIs (with tooth-based MNI forming the x-axis) therefore should yield a slope of 1 under excellent preservation conditions. The model (Stiner, 1994:100–101) against which cases are evaluated assumes that teeth are denser than any type of bone tissue and therefore have a better chance of being preserved overall. A regression slope that is significantly less than 1 therefore indicates

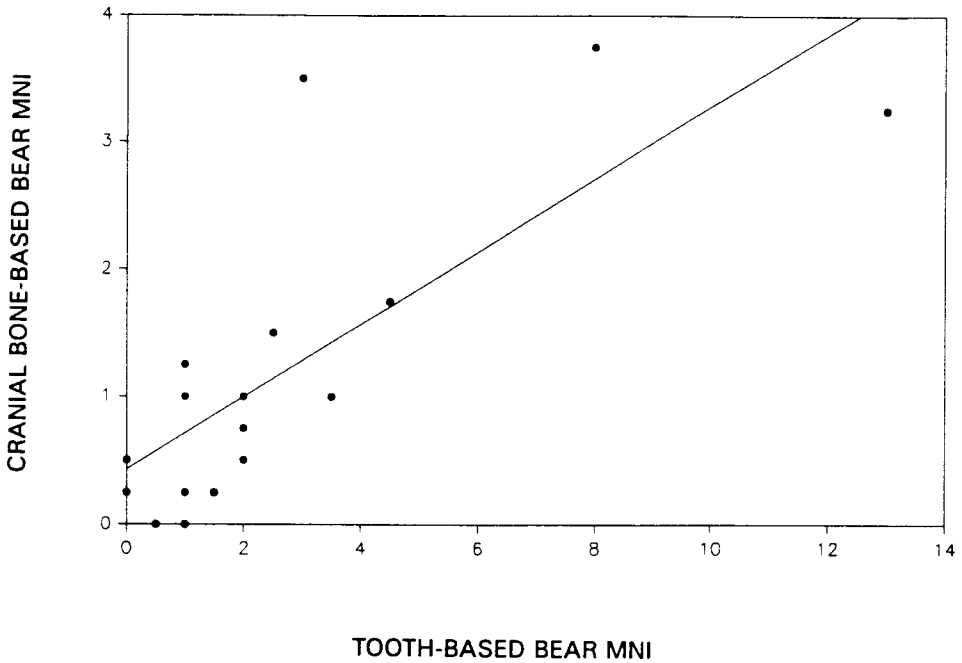


Figure 7. Regression plot of bear MNIs based on teeth to those based on cranial bone landmarks for all Yarimburgaz assemblages containing bear remains. Because mammalian teeth are composed of denser tissues than are bones, a slope value that is less than 1 indicates that some *in situ* bone attrition has occurred. The severity of bone loss increases as the slope decreases (following Stiner [1994]). In Yarimburgaz Cave, tooth-based bear MNI shows a two-fold increase over bear MNI based on cranial bone across assemblages ($n = 18$, y -intercept = 0.431, slope = 0.285, $r = 0.782$, $p < 0.001$). This result testifies to considerable loss of bone identifiability, a phenomenon that probably also affected other mammalian remains in the cave deposits.

that some bone attrition has occurred, the severity of which increases as the slope decreases.

Figure 7 compares bear MNIs for 18 proveniences in the cave, organized by horizontal unit (see Figure 3) and geological level. A complete regression yields a slope of 0.285 ($n = 18$, y -intercept = 0.431, $r = 0.782$, $p < 0.001$). Only the P2 assemblage diverges significantly from the regression line; oddly, the MNI based on cranial bone slightly exceeds MNI based on teeth in this assemblage. Removing the R1 assemblage from consideration significantly improves the overall relation between tooth and cranial bone MNI (slope = \emptyset .436).

These results show that some bone loss relative to teeth has taken place for bear remains in Yarimburgaz Cave. Bear MNI based on teeth increases roughly twice as fast as MNI based on cranial bone landmarks, a conclusion that probably also loosely applies to other, scantier mammal remains. The degree

Table II. Comparison of MNE and MNI counts for small dense bones, long limb bones, and cheek teeth of Yarimburgaz bears from all proveniences combined.

Bear Skeletal Element Type	MNE	MNI ^a
Small dense elements		
Scapholunate (carpal)	33	17
Pisiform (carpal)	29	15
Patella (kneecap)	22	11
Astragalus (tarsal)	40	20
Calcaneum (tarsal)	24	12
Long limb bone elements		
Scapula	26	13
Humerus	31	16
Radius	26	13
Ulna	28	14
Femur	22	11
Tibia	29	15
Fibula	30	15
Cheek teeth		
P ⁴	28	14
M ¹	37	19
M ²	30	15
P ₄	38	19
M ₁	59	30
M ₂	74	37
M ₃	64	32

^a MNI here calculated simply by dividing MNE by 2, with right and left sides combined and value rounded to the next highest whole number.

of *in situ* bone attrition in Yarimburgaz Cave is impressive, though considerably less so if set in broader paleontological perspective (Stiner, 1994:100–103).

This point is explored further in Table II, which compares minimum numbers of skeletal elements (MNE) and MNI (MNE/2) for various small dense and large limb bones of bears. Here the data for all proveniences are pooled, and right and left sides are summed. The small dense elements are two types of carpals, the kneecap, and two types of tarsals. Some of the counts of small dense bones exceed those for large limbs, but the MNIs are broadly analogous overall; for example, the MNI for bear humeri is 16 using this particular counting scheme, whereas the highest tarsal MNI is 20, both of which are much lower than the MNIs based on bear lower molars (e.g., M₂ MNI = 37).

Table III quantifies skeletally unique “portions” for major limb elements of the bears to see if there are any differences in the frequencies of distal, diaphyseal, and proximal portions. The data show that (a) many specimens represent complete or nearly complete skeletal elements and (b) of those broken, shafts

Table III. Summary of "portion" counts (subset of NISP) for major limb elements of Yarimburgaz bears from all proveniences combined.

Portion Type	Limb MNEs for Bears						
	Scapula	Humerus	Radius	Ulna	Femur	Tibia	Fibula
COMPLETE ^a	7	3	11	10	7	12	8
PROXIMAL ^b	1	7	11	15	5	10	2
DISTAL ^c	13	8	16	10	6	5	16
DIAPHYSIS ^d	8	15	3	? ^e	6	6	5

^a COMPLETE = complete or nearly complete specimen.

^b PROXIMAL = fragment that includes some or all of the proximal epiphysis only.

^c DISTAL = includes some or all of the distal epiphysis only.

^d DIAPHYSIS = fragment in which some or all of the limb shaft cross-section is intact only.

^e ? = no data; short cross-sections could have been mistaken for rib fragments.

Note: Differential bone density distributions in bear skeletons are not known. On the whole, shafts are no more likely to be preserved than epiphyses in fragmented material, and, with the exception of scapula and fibula, no distinct bias toward one or other of the ends (epiphyses) is apparent. Bears (massive plantigrades) seem to be robust all over. Also, portion counts presented here are not appropriate for direct calculation of MNE, because portion categories partly overlap (with respect to unique landmarks needed to count and control for counting same element twice or more). See instead Appendix 2 for bone MNE data.

are no more likely to be preserved than one or both limb ends (epiphyses). With the exception of the scapula and fibula, no distinct bias toward one or the other of bear limb bone ends is apparent. No accounts of differential bone density in the bear skeleton have been published to our knowledge, but one can be certain that the distribution differs from that of ungulates in some fairly significant ways (see Binford, 1978, 1981; Binford and Bertram, 1977; Lyman, 1984, 1991). For example, proximal bear humeri are nearly as common as distal ends, and proximal bear tibias are actually much more abundant than distal ends; neither observation is typical of ungulate faunas in archaeological or paleontological sites, because *in situ* attrition tends to reduce the number of proximal ends in these skeletal elements of ungulates.

Relatively speaking, the bones from Yarimburgaz Cave are in good shape. Certainly, the conditions of fossilization were very favorable. But something was eating away at the bones beforehand, while the tissues were still fresh and edible. There is much evidence of gnawing by both carnivores and rodents (documented below), suggesting that some fragile bone tissues, such as thin flat and trabecular types, could have been partly or wholly destroyed by biological agencies soon after prey death. The causes of fresh bone destruction can be determined from macroscopic surface damage and fracture forms.

Bone Damage Caused by Hominids, Carnivores, and Rodents

The Yarimburgaz faunas contain only small quantities of herbivore bones, and, among them, only a few fragments (two "probable" and two "possible")

Table IV. Frequencies of carnivore and rodent gnawing damage on ungulate, bear, and other carnivore remains, expressed at a percentage of bone NISP.

	Ungulates	Bears	Other Carnivores ^a
Bone NISP (N observations)	117	3129	67
Gnawed by large carnivore (%)	23	10	18
Gnawed by rodent (%)	6	11	1

^a Primarily canids and bears, but possibly also *Panthera*, *Felis*, or *Vulpes* in some instances.

cases) display cut marks from Paleolithic stone tools (Figure 5c). The marks are relatively small, ranging between 0.5 and 2.0 cm in length and occurring on ungulate rib and limb shaft fragments. None of these specimens is also gnawed.

Although absence or scarcity of cut marks does not, in itself, preclude the possibility that hominids also collected the unmarked herbivore bones, other types of bone damage pose some important contradictions to this hypothesis. There is no evidence of burning whatsoever, nor are any of the breakage patterns exclusively attributable to hominids. Cone fractures (*sensu* Binford, 1978; Potts, 1982) occur on 16 cortical limb bone specimens, mostly of ungulates. Both hominids and large carnivores are physically capable of generating large cone fractures, although hominids tend to produce them in higher frequencies (i.e., usually well in excess of 6% of bone NISP) (Stiner, 1991a:110; 1994:106, 130–132). The frequency of cone fractures in the Yarimburgaz faunas is quite low ($\leq 1\%$), which is more consistent with carnivore agencies than with stonewielding, marrow-hungry hominids. Cone fracture diameters vary between 1.0 and 6.0 cm, and eight of these cooccur with gnawing damage from large carnivores. None of the bear or nonursid carnivore bones shows signs of tool marks. A few specimens were instead scarred by excavators' tools, but this recent damage is quite obvious.

Many of the bones from Yarimburgaz Cave have been chewed (Table IV). The perpetrators were wolf-sized or larger carnivores, judging from the diameters and shapes of *deep* tooth punctures and general chewing patterns (Binford, 1981; Haynes, 1983; Stiner, 1990a, 1994). Some tooth puncture diameters help narrow the probable range of carnivore agencies, provided that the punctures in bone are deep and the distinct shapes and alignments of teeth are expressed. Some 59 measurable punctures were recorded, mostly in trabecular (spongy) tissue; only those deeply embedded in bone were considered. Nearly all of the puncture diameters fall between 0.3 and 0.5 cm, and most are attributable to carnivores of intermediate body size. The deep imprints of canid premolars and lower first molars are unmistakable in some instances (Figures 8[a–b] and 9[b–c]).

Four young bear bones display exceptionally large punctures, ranging between 0.7 and 0.8 cm in diameter, the arrangements of which best match partial anterior dental arcades of adult bears. Figures 10 and 11(a) illustrate



Figure 8. Bear remains: (a) carnivore gnaw marks and salivary rounding on bear innominate, probably by large canids; (b) arch of canid tooth punctures on bear thoracic vertebra, probably by wolf; (c) infant bear, rabbit, deer antler, and other bone fragments scarred by digestive acids, probably when passed through the gut of a large canid.

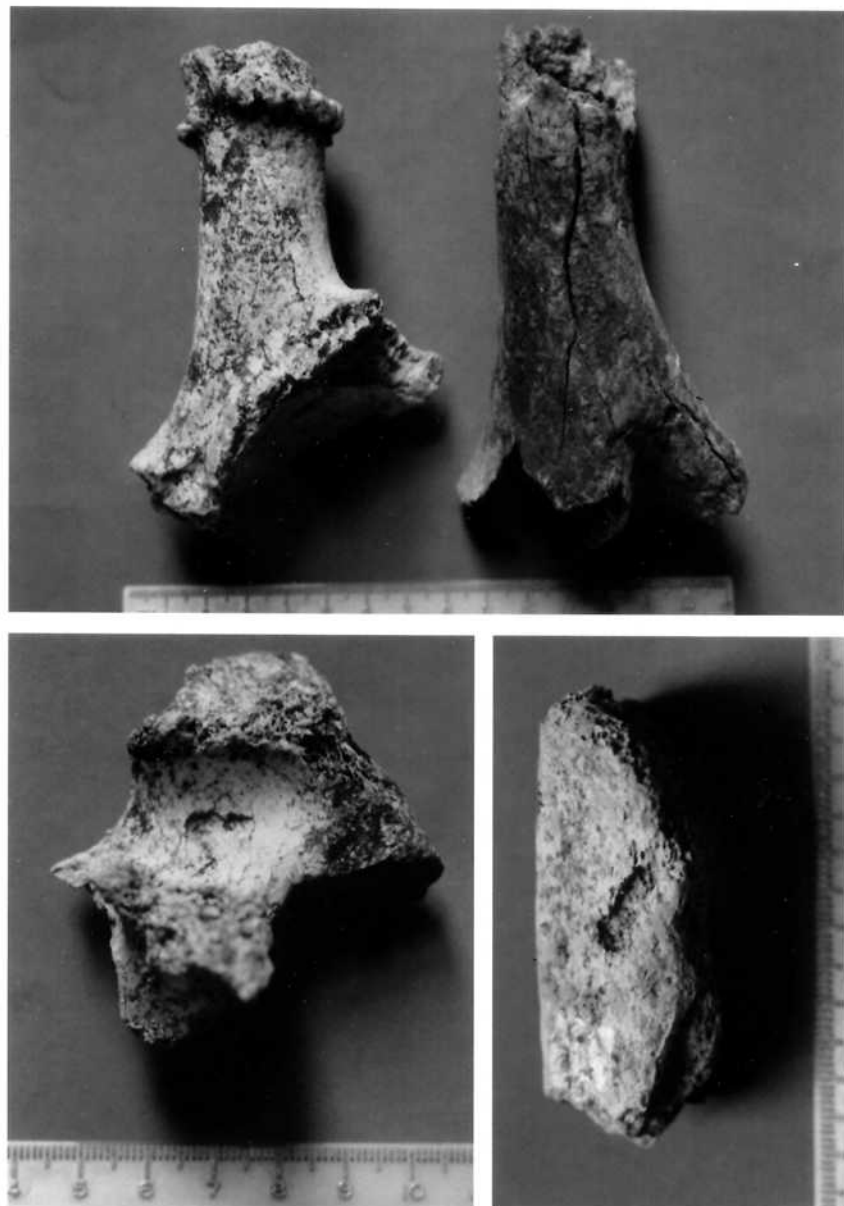


Figure 9. (a) Deer antler base (unshed) and humerus gnawed by large carnivores, probably canids but hyena-caused damage is also possible; (b, c) characteristic canid cheek tooth punctures in bear vertebrae.



Figure 10. Example of cannibalism by adult bears on crania of twin bear cubs found together: (a) the brain cavities were accessed through the occipitals and the faces were eaten away; (b) there is a large puncture, probably from an adult bear canine, in the left frontal portion of one cranium.



Figure 11. Bear remains: (a) young bear frontal bone fragment punctured by the incisors of a large adult bear; (b) first phalanges extensively gnawed by small rodents, suggesting that the bones lay on the ground surface for some time before being buried in sediment.

some rather tragic examples of infant bear crania apparently punctured by the canines of adult bears. Evidence of cannibalism or scavenging by bears on other bears is much less common in the Yarimburgaz faunas than damage caused by nonursid carnivores.

Some infant bear bones digested by larger carnivores were defecated inside Yarimburgaz Cave (Figure 8c); these remains tend to cooccur with hare bones, also marred by digestive acids. The largest concentration of fecal bone was found in the U1 excavation unit, but other instances, presumably representing once-coherent pellets, occur in units U0, S2, S4, and T4. The bones could not have been passed by cats or hyenas, as the degree of etching by gut acids is too subtle. The general pattern of breakage, the average fragment size (mode = 1.4 cm, range = 0.6–5.2 cm, NISP sampled = 173), and the quality of etching damage in the fecal bone samples are most typical of large canids (Schmitt and Juell, 1994; Stiner, 1994:168–171), although our interpretation suffers from the lack of comparative data on modern bear scats. Perhaps also significant is the fact that etched bones (Figure 8[c]), rounded bone tablets (Figure 5[b]), and gnawed antlers and horns (as in Figure 9[a]) tend to cluster in the units named above.

Table IV shows that carnivore gnawing is twice as frequent on ungulate (23%) and nonursid carnivore bones (18%) than it is on bear bones (10%). Moreover, gnawing damage is much more common on ungulate bones than are marks from hominids' tools (roughly 2%). The gnawing frequencies on ungulate and nonursid carnivore bones compare favorably with those observed in Pleistocene wolf and spotted hyena dens of Italy, wherein gnawing damage

on bones varies greatly but averages around roughly 22% and 30% for wolf and hyena dens, respectively (Stiner, 1994). The lower frequencies of gnawing on bear remains isolate them from all other large mammals in the cave.

Potential collectors of herbivore remains in Yarimburgaz Cave are large canids, possibly also cats and hyenas, and, of course, hominids. Large canids (wolves?) appear to have played especially significant roles. Nonursid carnivores either transported many or most of the ungulate bones to the cave, or created scavenging opportunities for hominids, the spoils of which retained marks made by the primary feeders. Similar frequencies of both ungulate and nonursid carnivore remains in the deposits seem to argue against the latter interpretation. This fact, along with the nature of damage to the ungulate bones, instead suggest that large canids (and possibly hyenas at times) used the cave as a den or rest site, to which they carried food. They may have eaten whatever they encountered when they first arrived as well.

Damage from gnawing rodents (Figure 11[b]) is more prevalent on remains of bears than on any other large mammals (Table IV). The rodents were vole-sized species, based on the width of the tooth grooves. Rodent gnawing is most common on bear phalanges and metapodials in excavation units S0-3 (10%), U0 (67%), U0b (40%), and U1 (65%), and the damage is especially severe on the phalanges. Whereas rodents had little impact on other types of bones, MNE counts for bear phalanges suggest that rodents worked from the exposed tips of the paws inward (proximally). Rodents took the greatest toll on the distal phalanges: MNE counts for first through third phalanges should be equal under good preservation conditions but in fact decline catastrophically below the first phalanx element (MNE = 384, counts for the second and third are 213 and 204, respectively). Because the terminal phalanges of bears tend to be quite large, size-dependent bone recovery techniques by archaeologists cannot explain the above-noted discrepancy. Rodents may have been attracted to the bear bones while they were still rich in minerals and fat; the marrow cavities of the bear phalanges often were breached by the gnawing rodents. Gnawing apparently began where hard tissues were naturally exposed.

The frequencies of carnivore and rodent gnawing show essentially inverse distributions (see Table IV). The high incidence of rodent gnawing on bear bones in particular may reflect differing conditions of accumulation for bear carcasses than for body parts of other large mammals, reinforcing the possibility that the causes of ungulate and nonursid carnivore bone accumulations are not directly linked to those for the bear bone accumulations. Because rodents would be sensitive to foot traffic, digging, and the risk of being eaten, rodent activities evidenced by their feeding on bones should be inversely proportional to the periodicity of predator activity cycles in the cave.

Weathering data also expose possible differences in the circumstances of accumulation among ungulates, bears, and nonursid carnivores. Consistent with situations in other Mediterranean caves (Stiner, 1990a, 1994), weathered bones are comparatively rare in the Yarimburgaz faunas overall (1% of total

Table V. Frequencies with which medullary cavities of major limb bones^a of bears, nonursid carnivores, and ungulates from all proveniences combined were breached by gnawing carnivores or hammer-wielding hominids, presumably to extract marrow.

Type of Mammalian Remains	Total MNE	MNE for Complete Specimens	MNE for Fragmented Specimens	Percentage with Medullary Cavity Opened (%)
Bears	108	33	75	69
Nonursid carnivores	6	2	4	67
Ungulates	11	1	10	91

^a Major limb bones considered are humerus, radius, femur, and tibia, because these were judged to possess substantial medullary cavities potentially rich in marrow and therefore worthy of extraction efforts by large mammalian consumers.

Note: The frequency with which medullae were opened is calculated as follows: Total MNE count for the four limb bone elements considered subtracted by the MNE count for complete or nearly complete specimens. This yields a derived MNE count for fragmented specimens, which is then converted to a percentage of total MNE. Counts for the four major limb elements are combined due to small sample sizes for ungulates and nonursid carnivores.

mammal bone NISP) and the damage tends to be very mild when it occurs. But weathering damage is found only on bear bones, suggesting that bear carcasses lay exposed on the cave floor for longer periods than the remains of any other large mammal species. Rare types of damage—as weathering damage certainly is in this case—may only be apparent in relatively large samples, but ungulate and other carnivore remains are not so few in Yarimburgaz Cave as to suppress all chances of finding this kind of damage.

The condition of bear, ungulate, and nonursid remains can also be compared in terms of the frequency with which medullary cavities of major limb bones were opened by large consumers (Table V), presumably to extract marrow. Only the humerus, radius, femur, and tibia are considered, because these skeletal elements contain substantial medullary cavities. It is interesting that the frequencies with which long bones of bears and other carnivores were opened are 69% and 67%, respectively, whereas the limb bones of ungulates were breached by gnawing or hammer-wielding consumers 91% of the time. The crudity of this comparison notwithstanding, it is clear that the major limb bones of ungulates were more consistently opened by all consumers. The fate of carnivore remains of any sort was more variable, with the medullary cavities of bones left whole or nearly whole approximately 30% of the time. Although any mammal can be food to another, bears and nonursid carnivores appear to represent a different economic, and therefore taphonomic, category than do the ungulates in Yarimburgaz Cave.

Spatial Associations among Mammalian Groups and Stone Artifacts

Bear bones are widespread among the trenches and levels of Yarimburgaz Cave, and they generally cooccur with stone artifacts in the gross sense. The

Table VI. Pearson correlation matrix of the abundances of bears, other carnivores, and ungulates (NISP) and lithic artifacts across proveniences of Yarimburgaz Cave.

a. All assemblages (N assemblages = 31)				
	Bears	Other Carnivores	Ungulates	Lithic Artifacts
Bears	—			
Other carnivores	0.810	—		
Ungulates	0.793	0.812	—	
Lithic artifacts	0.652	0.654	0.360 ^a	—
b. Assemblages in which both lithic and bear abundances are greater than 0 (N assemblages = 17)				
Bears	—			
Other carnivores	0.750	—		
Ungulates	0.722	0.754	—	
Lithic artifacts	0.627	0.625	0.264 ^a	—

^a Ungulate NISP and lithic artifact abundances show the poorest correlations among proveniences.

close spatial associations between bones and stone artifacts can be somewhat deceiving in caves, however, where sediments may build up slowly. Only the horizontal distribution of material in Yarimburgaz Cave holds much promise for evaluating the nature of the spatial associations, and even in this regard we may not be justified in expecting any sort of clean separation among material classes.

Table VI compares lithic artifact and faunal abundances (NISP) across provenience units, using a Pearson's correlation matrix. The large mammal remains are grouped into three broadly defined taxonomic categories as before: bears, nonursid carnivores, and ungulates. Stone artifacts represent the fourth class of material whose distribution is at issue, the only sort unequivocally traceable to hominid activities in the cave.

Table VIa presents results for all assemblages, whereas Table VIb compares only those that happen to contain both bear bones and lithics. There are no negative correlations in the matrixes, meaning that no class of material is clearly segregated from any other in the cave deposits. The matrixes nonetheless expose some surprising patterns: (a) Bear, nonursid carnivore, and ungulate abundances show stronger positive correlations to one another than any of them show to lithics; (b) the distributions of stone artifacts show the poorest relation to herbivores. Given that the few tool marks found in the Yarimburgaz assemblages occur only on ungulate bones, it is strange that this mammal group would show the weakest spatial correlation to artifacts overall, especially since large areas of the cave were excavated. A comparison of assemblages in which bear NISP and lithic artifact abundances exceed zero (Table VIb) does not alter the results much, except to diminish the spatial relation between

lithics and ungulates further. Nor are discernible differences found in the distributions of artifacts, carnivores or ungulates relative to the lower cave entrance versus deep interior (see Figure 3).

The spatial comparisons qualify the other taphonomic observations in important ways. While it is true that a few tool marks occur on the bones of some herbivores, gnawing frequencies and the spatial arrangements of lithics and bones in the cave prohibit any sort of wholesale attribution of the ungulate remains to hominids. The main collectors of herbivore body parts in the cave probably were carnivores of intermediate to large body sizes (especially wolves?), with only minor contributions by hominids.

As for human activities, the taphonomic data suggest that the discard of stone tools and debris in the cave was not contingent upon processing game there. Hominids dropped nearly 1700 Paleolithic artifacts in Yarimburgaz Cave, yet only a tiny fraction of the 151 ungulate skeletal fragments show any indications of hominid processing. Faunal remains normally are the only kinds of food refuse preserved in early hominid sites, tempting investigators to conclude that human economic activities centered on the use of game. Yarimburgaz does not seem to uphold this view. Rather, Yarimburgaz presents a situation in which hominid presence is unequivocally evidenced only by lithic artifacts, whereas traces of carnivore activities predominate among the bone assemblages. Hominids were attracted to this cave, perhaps time and again, but their purpose for being there is not made obvious by the bones.

BODY PART REPRESENTATION FOR BEARS, UNGULATES, AND NONURSID CARNIVORES

The possibility that the bear remains in Yarimburgaz Cave have different origins than those of nonursid carnivores and ungulates can be examined in terms of body part representation. The taphonomic histories of the three categories of mammals should vary according to whether their parts were usually carried to the cave by a consumer or the bones simply represent occupants' deaths in residence. Consumers' processing techniques and/or natural decomposition may bias body part profiles further, though perhaps not enough to obscure the contrast sought here.

A situation of *no transport* is implied by the bear hibernation death scenario: If the animals died in place, then all or nearly all of their bones should be present in the cave deposits. Skeletal completeness should be undermined only by *in situ* decomposition or gnawing in this kind of situation, both of which tend to affect fragile spongy bone tissue such as in vertebrae and femurs (Binford and Bertram, 1977; Brain, 1981; Lyman, 1984, 1991, 1994). In contrast to the expectation for bear remains, we may assume that the deer, horse, wild cattle, and other ungulates represented in the cave deposits perished elsewhere; these bones either represent food items carried to the cave by predators or concentrated in natural depressions by gravity and water. In Yarimburgaz Cave, the prevalence of gnawing damage and rare instances of cut marks on

the ungulate remains point to predators as the primary collectors of the bones. Anatomical representation for ungulates therefore should be rather different from that for bears. The situation for nonursid carnivores might provide another point of contrast.

The analyses of body part representation compares the minimum number of skeletal elements (MNE) in the assemblages by trench and geological level (data in Appendix 2). MNE is determined for each type of skeletal element (e.g., rib, femur, or humerus) based on the most common portion of that element present. Right and left sides are summed if applicable. The counting procedure employs a variety of unique morphological features ("portions" or "landmarks") per element, because the goal is to maximize the MNE estimate. No *a priori* rule is set about which landmark to count; the most common one is allowed to emerge from the data. For example, cranial MNE can be determined from occipital condyles, petrous bones, incisors, or intact bony maxillae (teeth are never used for this purpose). Likewise, tibia MNE can be determined from the anterior, posterior, lateral, or medial sides of the proximal or distal epiphysis, or from the main nutrient foramen. Most elements of the mammalian skeleton are composed of more than one class of bone tissue, creating the possibility of differential preservation among the many portions that constitute an element. The counting procedure described above avoids most problems caused by differential preservation by considering as many different portions as can be recognized. It should be clear, however, that no MNE value promises that all portions of an element are present in the assemblage.

In order to compare body part representation for bears and ungulates, it is necessary to standardize the MNE counts in terms of one complete skeleton. The comparisons to follow are further simplified by grouping elements into nine anatomical regions (following Stiner, 1991b): (1) horns/antler if present in a species, (2) head, (3) neck, (4) axial column below the neck and including the pelvis, (5) upper forelimb, (6) lower forelimb, (7) upper hindlimb, (8) lower hindlimb, and (9) feet. Observed MNEs are summed for each region and divided by the expected frequency for that region in a single complete animal (OBS/EXP), yielding an estimate of MNI by region (Table VII). Inequities in body part representation are thus easily compared in bar charts, because perfectly complete body part representation would be indicated by bars of equal height for all anatomical regions.

Figure 12(a) shows the standardized body part profile for bears from all proveniences of Yarimburgaz Cave; anatomical region 1 is empty because it is reserved for horns/antlers. The head is slightly better represented than other anatomical regions, despite our having calculated its number strictly from bone tissues. Values for the upper and lower forelimbs, lower hindlimbs, and feet of the bears are nearly comparable to that for the head, however, and it is significant that all of the elements in these anatomical regions are comparatively dense and therefore more resistant to *in situ* destruction. Because the neck and axial column are composed of greater amounts of fragile trabeculae,

Table VII. Standardized MNI values by anatomical region for bears, all ungulates, and other carnivores.^a

Anatomical Region	Region Code	Standardized MNI ^b		
		Bears	All Ungulates	Nonursid Carnivores
Horn/antler	1	—	4.0	—
Head	2	21.0	1.7	0.5
Neck	3	12.3	0.3	0.1
Axial (ribs, pelvis, vertebrae)	4	11.3	0.2	0.1
Upper forelimb	5	14.2	1.7	0.7
Lower forelimb	6	18.4	1.3	0.9
Upper hindlimb (femur)	7	11.0	0.5	0.5
Lower hindlimb	8	17.4	2.5	1.2
Feet	9	13.4	1.2 ^c	0.2

^a Values for bears and ungulates plotted in Figure 12.

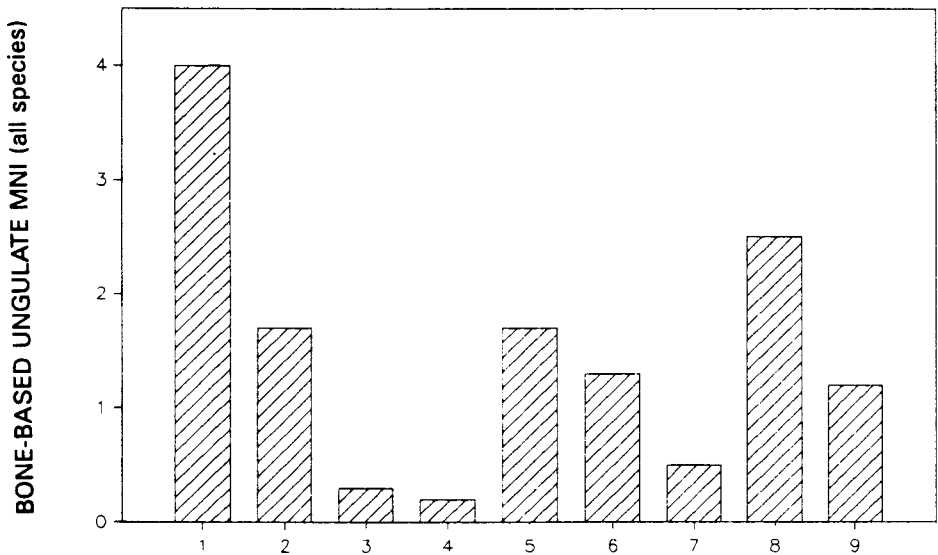
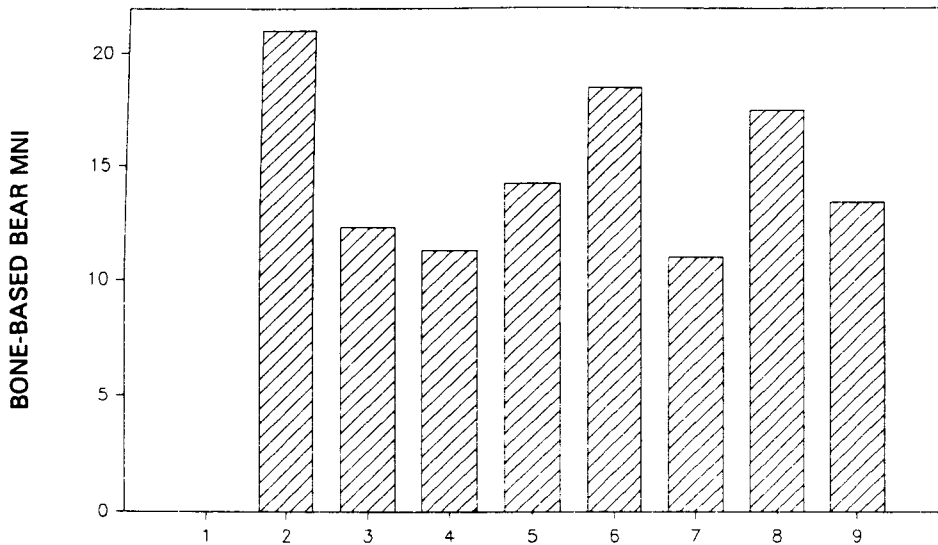
^b Standardized MNI is calculated by summing observed MNE (OBS) for each anatomical region and dividing it by the expected (EXP) frequency for that region (Stiner [1991b:461] for carnivores, [1994: Table 9.4, p. 244]). Small bone elements such as the hyoid, baculum, fibula, carpals, patella, and most tarsals are not figured into the above calculations because they generally are not, in themselves, food packages worth transporting. Basic bone MNE counts are listed in Appendix 2.

^c The expected value for this region is adjusted to compensate for natural differences in the numbers of toe bones in artiodactyls and perissodactyls.

as is the femur, it is not surprising that bones from these areas of the body are somewhat less well represented. The general conclusion to be drawn from Figure 12(a) is that body part representation for bears is relatively complete overall, consistent with the idea that the bears died while hibernating inside Yarimburgaz Cave.

Figure 12(b) shows the composite pattern of body part representation for ungulates, wherein all species from all proveniences are combined. The body part profile is very uneven across the nine regions of the body. Horns and antler (region 1) constitute the leading value—they are far more plentiful than expected. Small sample size could be to blame, but this kind of pattern, which includes shed as well as unshed antler, is also common in known carnivore den assemblages (Stiner, 1991a, 1991b). Horn and antler parts in Yarimburgaz Cave consistently associate with the spatial distribution of “mouthed” bone tablets (see Figure 5[b], cortical bone fragments severely rounded by salivary enzymes), and some of the horn and antler parts are gnawed (Figure 9[a]), lending support to the possibility of large canids or hyenas as the collectors.

Heads, upper and lower forelimbs, lower hindlimbs, and feet of ungulates occur in general anatomical balance, whereas neck and axial vertebrae and femurs are quite rare, considerably fewer than is observed for bear remains. Although the latter set of elements are also the most likely to be lost to gnawing and other destructive forces, bears and larger ungulates have similarly sized bones, which should be similarly affected by *in situ* decomposition overall. Yet,



ANATOMICAL REGIONS

- 1 - horn/antler
- 2 - head
- 3 - neck
- 4 - axial
- 5 - upper forelimb
- 6 - lower forelimb
- 7 - upper hindlimb
- 8 - lower hindlimb
- 9 - feet

Figure 12. Standardized (OBS/EXP) body part profiles for (a) bears and (b) ungulates from all proveniences of Yarimbuzg Cave. Note that all bars would have equal heights if the paleontological body part profile perfectly matches that for the complete living skeleton.

body part representation for ungulates is significantly less complete. Differential transport of the ungulate body parts by carnivores may also partly explain the absence of neck and axial bones (anatomical regions 3 and 4). While anatomical profiles in cave faunas generally are not reliable means for identifying collector agencies (Stiner, 1991b:463–465, 474), the prevalence of horn and antler in the ungulate profile in particular contradicts patterns observed in hominid-collected cave faunas prior to the Upper Paleolithic period (Stiner, 1991b:467–468).

Standardized anatomical data for nonursid carnivores are also presented in Table VII but are not plotted. This group consists primarily of lions, wolves, foxes, and caracals. The incidence of lower hind limb bones is inordinately high; otherwise the body part profile is relatively even. The profile for nonursid carnivores contrasts most with that for the bears; Spearman's r correlation coefficients between all possible pairs of skeletal part frequencies show that these taxonomic groups are the least similar ($S_r = 0.602$, $p = 0.114$). Ignoring the empty cell for horn/antler, the profiles for the nonursid carnivores and the ungulates are most alike ($S_r = 0.855$, $p = 0.007$). It is worth noting that cannibalism and interspecific violence among carnivores generally is on par in modern situations with prey consumerism as regards damage to carcasses. To summarize, the anatomical data indicate that the circumstances of accumulation for bear bones were different (relatively more independent) of those for other large mammals in Yarimburgaz Cave.

BEAR MORTALITY PATTERNS AND THE HIBERNATION DEATH HYPOTHESIS

Bear cheek teeth from Yarimburgaz Cave were classified into consecutive age categories, based on the degree of tooth development and occlusal wear (methods and age scoring diagrams in Stiner [n.d.a]; or see Stiner [1994] for M_1 and M_2 only). The eruption and wear correspondences for bear cheek teeth are developed from intact dentary rows in the Yarimburgaz collection, supplemented by Stiner's observations for *U. spelaeus* and *U. arctos* from Italian caves and by those of Dittrich (1960) and Torres (1988). Although the complete age-scoring system employs nine categories, these are collapsed to three here—juveniles, prime adults, and old adults. By converting the frequencies of individuals in each of the three age categories to percentages of total tooth element MNI, cases can be plotted on a triangular graph, the axes of which range from 0 to 100% (Figure 13[a]).

The three age groups together span the maximum potential lifetime and correspond to major changes in physiology and behavior in the life histories of bears (Stiner, 1994; for other mammals, Stiner, 1990b). The hypothetical lifetime begins with formation of the milk teeth where represented in the dentary arcade and ends with complete destruction of permanent cheek tooth crowns. The amounts of time represented by the age categories are not equal, nor is this condition necessary for the analysis to follow. This approach to

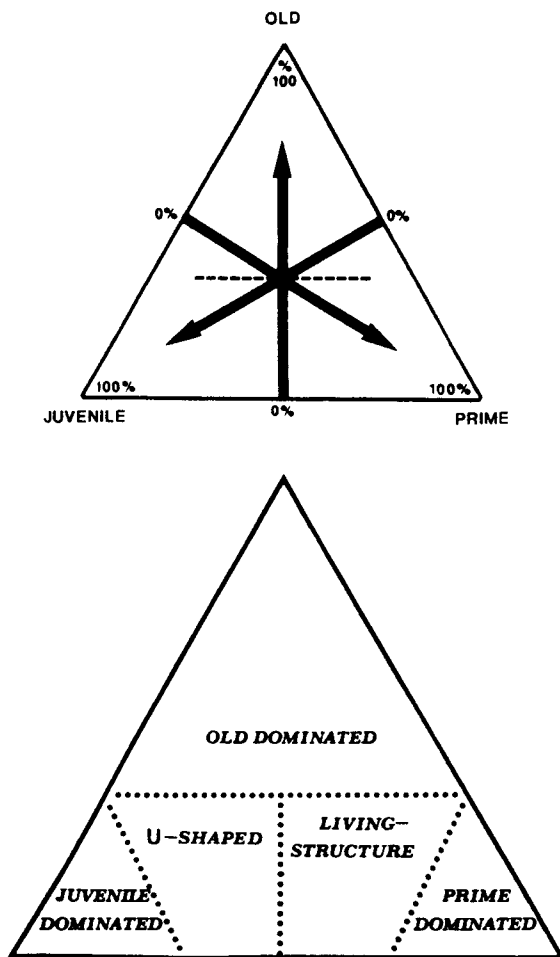


Figure 13. Triangular diagram (a) defining the three age axes and (b) relating areas of the graph to general classes of mortality patterns and their characteristic ranges of variation (from Stiner [1990b]).

mortality analysis emphasizes the normal ranges of variation surrounding a number of classic age structure models (Stiner, 1990b, 1994), providing a conservative and relatively objective means for evaluating prehistoric patterns.

Five kinds of mortality patterns, resulting from numerous causes (disease, malnutrition, predation), may be distinguished in natural conditions (Caughley, 1966, 1977; Lyman, 1987; Stiner, 1990b, 1991c, 1994). Figure 13(b) shows the variation normally associated with each idealized model in real life (from Stiner, 1990b:318). Most important to this discussion are the

Table VIII. Mortality models for and results on bears based on six different cheek tooth elements and collapsed into three age categories.a. Mortality Models, Using Three Age Cohorts^a

Model	Percent in Each Age Category		
	Juvenile (%)	Prime Adult (%)	Old Adult (%)
Living-structure mortality	34	45	21
U-shaped (classic attritional) mortality	59	22	19
Juvenile-biased mortality	71	29	0

b. Mortality Data for Yarimburgaz Bears, Using Three Age Cohorts^b

Tooth Element	Number of Age-Scored Teeth	MNI ^c	Juvenile (%)	Prime Adult (%)	Old Adult (%)
P ⁴	37	19	62	35	3
M ¹	43	25	58	19	23
M ²	36	20	67	14	19
M ₁	65	35	48	40	12
M ₂	79	44	61	29	10
M ₃	62	39	56	29	14

^a Note: See Stiner (1990b, 1994:292–295, 316–330) for bases of these idealized models. The values representing each of the three models do not include information on normal variation associated with them.

^b The illustrated eruption and occlusal wear age scoring scheme is presented in Stiner (n.d.a) (see also Stiner [1994:324–327] for M₁ and M₂ only).

^c Here MNI is based on the most common side (right or left).

two areas in the lower central zone of the graph, labeled U-shaped and living-structure patterns respectively (following Caughley [1977] on mammals; for bears specifically, Rogers [1987], Bunnell and Tait [1981], Eberhardt et al. [1986], and McCullough [1981]). Each corner area of the graph represents a strong bias toward the age group designated.

As explained above, the prediction for bear assemblages originating from hibernation-related deaths is a U-shaped age structure pattern, the typical combined outcome of malnutrition, disease, senescence, and infant mortality in an animal with a naturally low reproductive rate. Juveniles and old adults will predominate in hibernation den assemblages, whereas adults in their prime will be uncommon or absent.

Table VIII presents age frequency data for the bears from all excavation units of Yarimburgaz Cave. Six cheek tooth elements (P⁴, M¹, M², M₁, M₂, and M₃) are considered in order to cross-check the results plotted in Figure 14. The age structure indicated by each type of tooth fulfills the prediction of U-shaped mortality: Some old and many young individuals are present, but there are very few prime adults. By way of comparison, Kurtén (1958) reports U-shaped mortality for *U. spelaeus* based on the large assemblages from Odessa, as does Wiszniowska (1982) for Bacho Kiro in Bulgaria, and Andrews and Turner

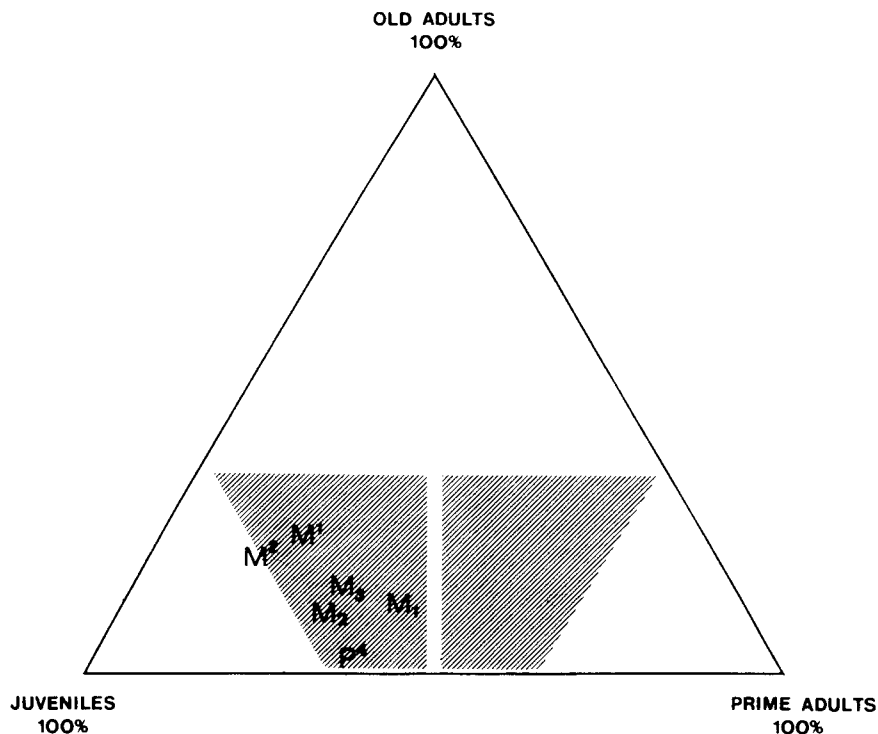


Figure 14. Triangular plot of bear mortality patterns in Yarimbuzgaz Cave, based on six different tooth elements (P^4 , M^1 , M^2 , M_1 , M_2 , M_3). Results for all cheekteeth indicate a classic U-shaped mortality pattern.

(1992) obtained broadly similar results for *U. deningeri* from Westbury in Great Britain.

Details of the mortality results vary somewhat among cheek tooth elements, however. The pattern derived for the M_1 lies close to the living-structure boundary in Figure 14, and the pattern evident from the P^4 is poor in old adults due to its forward position in the maxilla and minimal potential for wear overall. The location of M^2 near the juvenile-biased boundary is less cause for concern because carnivore death patterns in denning contexts often trend in this direction (Stiner, 1994:316–317). It may be significant that the upper and lower molars of the bears form separate groups on the graph, but all yield essentially the same answer—U-shaped (attritional) mortality.

The mortality data for the Yarimbuzgaz bears are entirely consistent with the hibernation scenario. The age structure of these bears is exactly what one would expect to result from starvation, disease, and predation on denning bears. Wildlife accounts show that frail or small individuals may be attacked

by predators, and the carcasses of dead bears would certainly be scavenged. The bears of Yarımburgaz Cave show considerable gnawing damage by carnivores and rodents. The taphonomic evidence, body part representation, and mortality data together point to hibernation deaths as the cause of the bear bone accumulations in the cave. No aspect of the faunal data falsifies this interpretation.

CONCLUSIONS

Yarımburgaz Cave is of obvious importance for establishing the depth of human antiquity in Turkey. It is not a simple or clear-cut archaeological case, however. Stone artifacts are plentiful in the Middle Pleistocene levels, testifying unequivocally to hominid presence there. But most of the damage on macromammal remains in the cave is from intermediate- and large-sized carnivores, and to a lesser extent from small rodents. Yarımburgaz presents a situation in which just a few bones modified by hominids are stratigraphically intermixed with many gnawed bones, and stone artifacts cooccur with the remains of bears, wolves, lions, wild cats, caracals, and foxes.

Materials of apparently diverse origins show positive spatial correlations to one another in the cave sediments, although much stronger relations are apparent between the distributions of carnivore and ungulate remains than between ungulate bones and stone artifacts. Some of these peculiar observations can be understood by taking into account the influence of geological processes. The most important force behind the apparent stratigraphic associations of these disparate materials, and the biological processes responsible for them, was slow or uneven rates of sediment accumulation over time. The bone and tool assemblages in Yarımburgaz Cave represent palimpsests of many relatively short-term depositional events, most of which were causally independent. Some of the material may have been locally redistributed later by the digging and scraping that is typical of bed preparation by bears.

The taphonomic analyses of the bones reveal that three distinct biological processes contributed to the formation of the Middle Pleistocene macrofaunas in the lower chamber: hibernating bears, bone-collecting carnivores such as wolves, and hominids in descending order of importance. The cave served as a hibernation site for many generations of bears; age structure, skeletal representation, and damage patterns for bear remains all are consistent with hibernation-related mortality. Weathering and rodent gnawing damage, both of which are largely confined to bear remains, suggest that the skeletons of the bears lay exposed on the cave floor for longer periods than other types of macromammal remains. Bear bones suffered fewer disturbances on the average, consistent with the hibernation death scenario. We conclude that bear deaths had nothing to do with hominids use of the same place.

Wolves and perhaps certain other nonursid carnivores brought most of the ungulate bones into the cave, not hominids or bears. Although the bone damage patterns point most consistently to large canids, cannibalism by adult (probably

male) bears is also apparent in a few cases. Of the carnivore species known to collect bones in modern shelters, wolves and foxes are most prevalent in the Yarimburgaz collection. Deposition of predators' remains alongside prey is a normal occurrence in the dens of bone-collecting carnivores (Brain, 1981; Horwitz and Smith, 1988).

The apparent independence of hominid, ursid, and nonursid carnivore components in Yarimburgaz Cave also has implications for reconstructions of Paleolithic hominid ecology. Hominids spent sufficient amounts of time in the cave to generate substantial quantities of stone artifacts, but the quantities of bones discarded by the hominids were small, a situation that contrasts with many later Paleolithic shelter sites. Low rates of herbivore bone accumulation relative to artifacts may suggest that hominids' foraging efforts focused on resources other than large game while they occupied the cave (for related discussions, see Stiner and Kuhn [1992:327-328, 332] and Stiner [1994]).

The complexity of the Yarimburgaz case indicates other general features of premodern hominid ecology as well. The farther back in time one searches, the greater likelihood of encountering evidence of alternating use of places by humans and large carnivores, and in these early time ranges, it usually is difficult to distinguish purely archaeological from purely paleontological faunas. The fact that Yarimburgaz Cave was frequented by such a disparate array of predators suggests that hominid occupations were relatively ephemeral. It is likely that visits to the cave by these species were widely scattered in time, and that any prospective occupant's claims on the shelter hinged primarily upon a low risk of interference. Hominids' and carnivores' interests in natural shelters overlapped only in the general sense, consistent with the evidence from other Lower and early Middle Paleolithic records in the Mediterranean region and elsewhere (Gamble, 1983; Kurtén, 1976; Stiner, 1992, 1994). In this regard, Yarimburgaz testifies to rather different patterns of coexistence between hominids and large carnivores than was typical of later periods (Binford, 1983; Clark, 1981; Gamble, 1986; Brugal and Jaubert, 1991; Stiner, 1990a, 1993, 1994).

The Yarimburgaz faunas constitute an invaluable paleontological sample of Pleistocene cave bears in addition to informing us about hominid-carnivore ecological relations. Although fossilization is well advanced, their remains are relatively well preserved from a macroscopic point of view. This case therefore presents the possibility not only for understanding the circumstances of bone and artifact assemblage formation in one Paleolithic cave but also a way to develop and refine the taphonomic methods needed to cope more effectively with palimpsests of hominid and carnivore components so often encountered in Paleolithic sites.

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Appendix 1a. Tooth NISP by Macromammal Taxon and Provenience (Trench and Geological Stratum).

Taxon	P1	P2	R0	R1	R2	R6	S1	S4	T1	T2	T3	T4
Equus	—	—	—	—	—	—	—	—	—	—	—	1
Capreolus	—	—	—	—	—	—	—	—	—	—	—	—
Indet. deer	2	—	1	3	—	—	2	—	—	—	1	2
Dama	9	—	—	—	—	—	—	—	—	—	—	—
Cervus	—	—	—	4	—	—	—	—	—	—	—	1
Bos/Bison	—	—	—	—	—	—	—	—	—	—	1	—
Sus	—	—	—	—	—	—	1	—	—	—	—	—
Hippopotamus	—	—	1?	—	—	—	1?	—	—	—	—	—
Capra	—	—	—	1	—	—	—	—	—	—	—	—
Indet. carnivore	1	—	—	1	—	—	—	—	—	—	—	1
Crocota	—	—	—	—	—	—	—	—	1?	—	—	1?
Felis	—	—	—	1	—	—	—	—	—	—	1	—
Canis/Cuon	1	—	—	—	—	—	—	—	—	—	—	1
Vulpes	1	—	—	—	—	—	1	—	—	1?	—	1
Panthera	2	—	—	1	—	—	—	—	—	—	—	1
Ursus	90	32	1	281	8	1	3	32	14	28	20	139
Mustela	—	—	—	1	—	—	—	—	—	—	—	1
Total by provenience	106	32	3	293	8	1	8	32	15	29	23	149
Taxon	U1	Y0	Y1	Y1a	Y1b	Y5	Z3	Total by Taxon				
Equus	—	—	—	—	—	—	—	1				
Capreolus	3	—	—	—	—	1	—	4				
Indet. deer	1	—	1	—	—	—	—	13				
Dama	—	—	—	—	—	—	—	9				
Cervus	—	—	1	—	—	—	—	6				
Bos/Bison	1	—	—	—	—	—	—	2				
Sus	—	—	—	—	—	—	—	1				
Hippopotamus	—	—	—	—	—	—	—	2?				
Capra	2	—	—	—	—	—	1	4				
Indet. carnivore	—	—	—	—	—	—	—	3				
Crocota	—	—	—	—	—	—	—	2?				
Felis	1	—	—	—	—	—	—	3				
Canis/Cuon	6	—	—	—	—	—	—	8				
Vulpes	4	—	2	—	—	—	—	10				
Panthera	—	—	—	—	—	—	—	4				
Ursus	23	18	7	51	13	—	—	761				
Mustela	—	—	—	—	—	—	1	3				
Total by provenience	41	18	11	51	14	1	1	836				

Note: NISP is the number of identifiable specimens. Data represent provenienced material only.

Appendix 1b. Bone NISP by Macromammal Taxon and Provenience (Trench and Geological Stratum).

Taxon	P1	P2	R0	R1	R2-3	R5-6	S0-3	S4	T0-1	T2	T3	T4
Large mammal ^a	29	14	1	102	—	3	6	29	31	116	17	119
Medium mammal ^b	—	—	—	1	—	—	—	—	—	—	—	2
Small mammal ^c	—	—	—	—	—	—	—	—	—	3	1	1
Equus	1	—	—	2	—	—	—	1	—	3	—	1
Capreolus	1	—	—	—	—	—	—	—	—	3	—	3
Indet. deer	3	—	—	2	—	—	—	4	—	4	2	3
Dama	3	—	—	—	—	—	—	—	—	—	—	—
Cervus	4	—	—	9	—	—	1	3	—	1	—	2
Megaloceros	—	—	—	—	—	—	—	1?	—	—	—	—
Bos/Bison	—	—	—	—	—	—	—	—	—	—	—	—
Sus	—	—	—	—	—	—	—	—	—	—	—	—
Capra	—	—	—	—	—	—	—	—	—	—	—	—
Small ungulate	—	—	—	—	—	—	—	—	—	1	—	—
Medium ungulate	1	—	—	—	—	—	—	—	—	—	1	1
Large ungulate	2	1	—	1	—	—	—	—	—	9	2	1
Pachyderm	1	4	—	—	—	—	—	—	—	—	—	—
Indet. carnivore	2	—	—	1	—	—	—	—	—	—	—	—
Crocota	—	—	—	—	—	—	—	—	—	—	—	—
Felis	1	—	—	1	1	—	—	1	—	—	—	3
Canis	1	1	—	4	—	—	—	3	—	—	—	2
Cuon/Xenocyon	1?	—	—	3?	—	—	—	—	—	—	—	—
Vulpes	—	—	—	—	—	—	—	2	—	—	—	—
Panthera	4	2	—	4	—	—	—	1	3	1?	—	10
Ursus	279	199	1	550	20	3	94	156	48	164	41	381
Mustela	—	—	—	—	—	—	—	—	—	—	—	—
Total by provenience	333	221	2	680	21	6	101	201	82	305	64	529
Taxon	U0	U0b	U1	U < 5	Y0	Y0b	Y1	Y1a	Y1b	Y1c	Y4	Y5
Large mammal ^a	5	4	13	—	—	4	—	29	—	—	26	—
Medium mammal ^b	—	—	1	1	—	—	—	—	—	—	—	—
Small mammal ^c	—	—	2	1	—	—	1	—	—	—	—	—
Equus	—	—	—	—	—	—	—	—	—	—	—	—
Capreolus	—	—	2	—	—	—	—	—	—	—	—	—
Indet. deer	2	3	—	—	—	—	—	—	—	—	—	—
Dama	—	1	—	—	—	—	—	—	—	—	—	—
Cervus	—	2	—	—	—	—	—	1	—	—	—	—
Megaloceros	—	—	—	—	—	—	—	1	—	—	—	—
Bos/Bison	—	2	—	—	—	—	—	—	—	—	—	1
Sus	1?	1	—	—	—	—	—	1	—	—	—	—
Capra	—	—	—	—	—	—	—	—	—	—	—	—
Small ungulate	1	—	—	—	—	—	—	—	—	—	—	—
Medium ungulate	—	—	—	—	—	—	—	—	—	—	—	—
Large ungulate	—	—	—	—	—	—	—	1	—	—	—	—
Pachyderm	—	—	1	—	—	—	—	—	—	—	—	—

(Continued)

Appendix 1b. (Continued)

Taxon	U0	U0b	U1	U < 5	Y0	Y0b	Y1	Y1a	Y1b	Y1c	Y4	Y5
Indet. carnivore	—	—	2	—	—	—	—	1	—	—	—	—
Crocota	—	—	—	—	—	—	—	—	—	—	—	—
Felis	1	—	—	—	—	—	2	—	—	—	—	—
Canis	—	—	1	—	1	—	—	—	—	—	—	—
Cuon/Xenocyon	—	—	—	—	—	—	—	—	—	—	—	—
Vulpes	—	—	3	—	—	—	2	—	—	—	—	—
Panthera	—	—	—	—	—	—	—	—	1	—	—	—
Ursus	267	6	167	—	11	4	9	182	18	3	4	—
Mustela	1	—	—	—	—	—	—	—	—	—	—	—
Total by provenience	278	19	192	2	12	8	14	216	19	3	30	1
Taxon	Z2	Z3	Z4	Z5	Total by Taxon							
Large mammal ^a	—	—	—	—	548							
Medium mammal ^b	—	—	—	—	5							
Small mammal ^c	—	—	—	—	9							
Equus	—	—	—	—	8							
Capreolus	—	—	—	—	9							
Indet. deer	—	—	—	—	23							
Dama	—	—	—	—	4							
Cervus	—	—	—	—	23							
Megaloceros	—	—	—	—	2							
Bos/Bison	—	—	—	—	3							
Sus	—	—	—	—	3							
Capra	—	1	—	—	1							
Small ungulate	—	—	—	—	2							
Medium ungulate	—	—	—	—	3							
Large ungulate	—	—	—	—	17							
Pachyderm	—	—	—	—	6							
Indet. carnivore	—	—	—	—	6							
Crocota	—	—	—	—	0							
Felis	—	—	—	—	10							
Canis	—	—	—	—	13							
Cuon/Xenocyon	—	—	—	—	4							
Vulpes	—	—	—	—	7							
Panthera	—	—	—	—	26							
Ursus	1	1	1	1	2611							
Mustela	—	—	—	—	1							
Total by provenience	1	2	1	1	3344							

^a Mostly bear remains.

^b Mostly ungulates.

^c Mostly other carnivores.

Note: Small ungulate remains may include *Capreolus*, *Sus*, and possibly *Gazella*; medium ungulate remains may include *Dama*, *Cervus*, and *Megaloceros*; large ungulate remains may include *Equus*, *Bos*, and *Bison*. NISP is the number of identifiable specimens. Data represent provenienced material only.

Appendix 2a. Bear bone MNE by skeletal element and provenience.

Bone Element	P1	P2	R0	R1	R2	R3	R5	R6	S0	S1	S2	S3
Hyoid	1	—	—	3	—	—	—	—	—	—	—	—
Half cranium (L or R)	3	10	—	~4	1	—	—	—	—	—	—	—
Half mandible (L or R)	4	4	1	9	—	—	—	—	—	—	—	—
Atlas vert	3	—	—	~5	—	—	—	—	—	—	—	—
Axis vert	3	1	—	~4	—	—	—	—	—	—	—	—
Cervical vert	5	1	—	8	—	1	—	—	—	—	4	—
Thoracic vert	9	4	—	14	1	—	—	—	—	—	1	—
Rib	11	10	—	34	2	—	1	—	3	2	1	—
Lumbar vert	6	2	—	11	2	—	—	—	—	—	—	—
Sacral vert	2	1	—	3	1	—	—	—	—	—	—	—
Innominate (1/2 pelvis)	~3	~2	—	11	—	—	—	—	—	—	1	—
Caudal vert	2	5	—	8	—	—	—	—	1	—	—	—
Sternal segment	2	1	—	3	—	—	—	—	—	—	—	—
Scapula	3	1	—	~11	—	—	—	—	—	—	—	—
Humerus	3	3	—	~11	—	—	—	—	—	—	—	—
Radius	2	2	—	1	1	1	—	—	—	—	—	—
Ulna	1	1	—	10	1	—	—	—	—	1	—	—
Metacarpal	13	13	—	37	2	—	—	—	—	3	1	—
Femur	1	3	—	~6	—	—	—	—	—	—	—	—
Tibia	4	2	—	6	1	—	—	—	—	—	1?	—
Patella	3	1	—	11	—	—	—	—	—	1	—	—
Astragalus	8	4	—	11	—	—	—	—	—	3	—	—
Calcaneum	1	2	—	6	—	—	—	—	—	2	—	—
Fibula	5	4	—	9	—	—	—	—	1	—	—	—
Metatarsal	29	13	—	31	—	—	—	—	1	8	—	—
1st phalanx	53	24	—	61	2	—	—	1	4	11	2	1
2nd phalanx	24	26	—	32	—	—	—	—	—	6	1	—
3rd phalanx	26	16	—	34	1	—	—	—	—	7	—	—
All sesamoids	4	18	—	4	—	—	—	—	—	12	—	—
Metapodial	15	4	1	15	1	—	—	2	—	1	—	—
Carpals/tarsals	15	18	—	57	1	—	—	—	—	11	—	—
Indet. vertebra	2	1	—	~45	—	—	—	—	—	2	1	—
Os penis	1	—	—	1	—	—	—	—	—	1	—	—
Total by provenience	267	197	2	516	17	2	1	3	10	71	13	1
Bone Element	S4	T0	T1	T2	T3	T4	U0	U0b	U1	Y0	Y0b	
Hyoid	2	—	—	2	—	5	—	—	—	—	—	
Half cranium (L or R)	2	1	2	2	4	6	—	—	1	2	—	
Half mandible (L or R)	4	1	1	2	1	9	—	—	—	2	—	
Atlas vert	1	—	—	—	2	2	—	—	—	—	—	
Axis vert	2	—	—	1	—	1	—	—	—	—	—	
Cervical vert	5	—	1	7	1	1	1	—	—	—	2	
Thoracic vert	6	—	2	3	—	13	—	—	—	3	—	
Rib	~24	—	13	~40	5	64	27	1	17	—	—	
Lumbar vert	6	—	—	1	—	6	—	—	—	—	—	
Sacral vert	—	—	—	1	1	—	—	—	—	—	—	
Innominate (1/2 pelvis)	1	—	—	3	—	8	—	—	—	—	—	
Caudal vert	4	—	—	1	—	3	2	—	3	—	—	

(Continued)

Appendix 2a. (Continued)

Bone Element	S4	T0	T1	T2	T3	T4	U0	U0b	U1	Y0	Y0b
Sternal segment	1	—	—	—	—	7	1	—	2	—	—
Scapula	1	—	—	4	~1	3	—	—	—	—	—
Humerus	2	—	2	3	1	4	—	—	1	1	—
Radius	1	1	~1	3	1	6	—	1	—	—	—
Ulna	—	—	—	4	—	4	—	—	1	1	—
Metacarpal	5	—	2	12	4	20	25	1	9	—	1
Femur	1	—	1	3	1	6	—	—	—	—	—
Tibia	1	—	1	1	—	7	—	—	1	—	—
Patella	—	—	—	—	1	—	1	—	1	—	—
Astragalus	3	—	—	—	—	3	—	—	2	—	—
Calcaneum	1	—	—	—	1	4	2	—	1	—	1
Fibula	—	—	—	1	1	4	1	—	2	—	—
Metatarsal	9	—	—	10	2	18	15	1	5	—	—
1st phalanx	11	—	6	26	4	36	78	1	44	2	—
2nd phalanx	9	—	4	9	4	23	43	—	27	—	—
3rd phalanx	7	—	3	14	1	28	27	—	25	—	—
All sesamoids	—	—	—	2	1	4	3	—	6	—	—
Metapodial	4	—	3	~4	1	9	16	—	3	—	—
Carpal/tarsal	6	—	2	19	4	34	24	1	14	—	—
Indet. vertebra	~11	—	~4	~9	~2	~20	—	1	1	—	~2
Os penis	—	—	—	1	—	2	—	—	—	—	—

Total by provenience	130	3	48	188	44	360	266	7	166	11	6
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Bone Element	Y1	Y1a	Y1b	Y1c	Y4	Z2	Z3	Z4	Z5	Total by Element
Hyoid	—	1	—	—	—	—	—	—	—	14
Half cranium (L or R)	—	2	—	—	~2	—	—	—	—	42
Half mandible (L or R)	—	2	2	—	—	—	—	—	—	42
Atlas vert	—	3	—	—	—	—	—	—	—	16
Axis vert	—	1	1	—	—	—	—	—	—	14
Cervical vert	—	2	1	—	—	—	1	—	—	41
Thoracic vert	—	10	1	—	—	—	—	—	—	67
Rib	~5	~40	3	—	~11	—	—	—	1	315
Lumbar vert	—	6	1	—	—	—	—	—	—	41
Sacral vert	—	—	—	—	—	—	—	—	—	9
Innominate (1/2 pelvis)	—	—	—	—	—	1	—	—	—	30
Caudal vert	—	—	1	—	—	—	—	—	—	30
Sternal segment	—	—	—	—	—	—	—	—	—	17
Scapula	1	—	—	—	—	—	—	1	—	26
Humerus	—	—	—	—	—	—	—	—	—	31
Radius	—	5	—	—	—	—	—	—	—	26
Ulna	—	4	—	—	—	—	—	—	—	28
Metacarpal	1	12	—	1	—	—	—	—	—	162
Femur	—	—	—	—	—	—	—	—	—	22
Tibia	—	4	—	—	—	—	—	—	—	29
Patella	—	3	—	—	—	—	—	—	—	22
Astragalus	—	5	1	—	—	—	—	—	—	40
Calcaneum	—	2	1	—	—	—	—	—	—	24
Fibula	—	2	—	—	—	—	—	—	—	30

(Continued)

Appendix 2a. (Continued)

Bone Element	Y1	Y1a	Y1b	Y1c	Y4	Z2	Z3	Z4	Z5	Total by Element
Metatarsal	—	7	—	1	—	—	—	—	—	150
1st phalanx	—	16	1	—	1	—	—	—	—	385
2nd phalanx	—	5	1	—	1	—	—	—	—	215
3rd phalanx	—	12	2	1	1	—	—	—	—	205
All sesamoids	—	2	—	—	—	—	—	—	—	56
Metapodial	—	4	—	—	—	—	—	—	—	83
Carpal/tarsal	—	18	1	—	1	—	—	—	—	226
Indet. vertebra	~3	1	—	—	1	—	—	—	—	106
Os penis	—	—	—	—	—	—	—	—	—	6
Total by provenience	10	169	17	3	18	1	1	1	1	2550

Note: MNE is the minimum number of each type of skeletal element, based on the most common portion or unique anatomical "landmark"; counts are mutually exclusive across categories. Cranial MNE is based exclusively on bone tissues (not teeth), and is computed in terms of right (R) and left (L) halves. Metapodials are counted using the proximal end, and carpal/tarsal MNE excludes the astragalus and calcaneum. No value presented in the table promises that whole elements are represented in the assemblages. Data represent provenienced material only.

Appendix 2b. Ungulate (all species) bone MNE by skeletal element and provenience.

Bone Element	P1	P2	R1	S0	S4	T2	T3	T4
Horn core	—	—	—	—	—	—	—	—
Antler	—	—	2	—	2	~1	~1	—
Half cranium w/antler	—	—	—	—	1	—	—	—
Half cranium (L or R)	2	—	1	—	1	—	—	—
Half mandible (L or R)	1	—	—	—	—	—	—	—
Atlas vert	—	—	—	—	—	—	—	—
Axis vert	1	—	—	—	—	—	—	—
Cervical vert	—	—	—	—	—	—	—	~1
Thoracic vert	—	—	—	—	—	—	—	—
Rib	1	—	—	—	—	5	1	—
Lumbar vert	—	—	1	—	—	—	—	—
Sacral vert	—	—	—	—	—	—	—	—
Innominate (1/2 pelvis)	—	1	1	—	—	—	—	—
Caudal vert	—	—	—	—	—	—	—	—
Sternal segment	—	—	—	—	—	—	—	—
Scapula	—	—	—	—	—	1	—	—
Humerus	—	—	—	—	1	1	—	2
Radius	—	—	—	—	—	1	1	1
Ulna	—	—	—	—	—	—	—	—
Metacarpal	—	—	1	—	—	1	—	1
Femur	—	—	—	—	~1	—	—	—
Tibia	—	—	1	—	—	—	1	—
Patella	—	—	—	—	—	—	—	—
Astragalus	1	—	1	1	2	—	—	2
Calcaneum	—	—	2	—	—	—	—	1
Metatarsal	1	—	1	—	—	1	—	—
1st phalanx	4	—	1	—	—	3	1	—

(Continued)

Appendix 2b. (Continued)

Bone Element	P1	P2	R1	S0	S4	T2	T3	T4
2nd phalanx	—	—	2	—	—	1	—	1
3rd phalanx	—	—	—	—	—	—	—	1
All sesamoids	—	—	—	—	—	2	—	—
Metapodial	—	—	—	—	1	—	—	—
Carpal/tarsal	1	—	—	—	—	—	—	1
Total by provenience	12	1	14	1	9	17	5	11
Bone Element	U0	U1	U<5	Y1a	Y5	Z3	Total by Element	
Horn core	—	—	—	1	—	—	1	
Antler	—	—	—	—	—	—	6	
Half cranium w/antler	—	—	—	—	—	—	1	
Half cranium (L or R)	—	~1	—	—	—	—	5	
Half mandible (L or R)	—	—	—	—	—	1	2	
Atlas vert	—	—	—	—	—	—	0	
Axis vert	—	—	—	—	—	—	1	
Cervical vert	—	—	—	—	—	—	1	
Thoracic vert	—	—	—	—	—	—	0	
Rib	—	—	—	—	—	—	7	
Lumbar vert	—	—	—	—	—	—	1	
Sacral vert	—	—	—	—	—	—	0	
Innominate (1/2 pelvis)	—	—	—	—	—	—	2	
Caudal vert	—	—	—	—	—	—	0	
Sternal segment	—	—	—	—	—	—	0	
Scapula	—	1	—	—	—	—	2	
Humerus	—	—	—	1	—	—	5	
Radius	—	—	—	—	—	—	3	
Ulna	—	—	—	—	—	—	0	
Metacarpal	—	—	—	—	—	—	3	
Femur	—	—	—	—	—	—	1	
Tibia	—	—	—	—	—	—	2	
Patella	—	—	—	—	—	—	0	
Astragalus	—	—	—	—	—	—	7	
Calcaneum	1	—	—	—	—	—	4	
Metatarsal	2	1	—	—	—	—	6	
1st phalanx	1	4	~1	1	—	—	16	
2nd phalanx	—	2	—	1	1	—	8	
3rd phalanx	—	—	—	—	—	—	1	
All sesamoids	—	—	—	—	—	—	2	
Metapodial	—	2	—	—	—	—	3	
Carpal/tarsal	—	—	—	—	—	—	2	
Total by provenience	4	11	1	4	1	1	92	

Note: Ungulate species are summed together in this anatomical comparison because too few of each taxon are represented to warrant species by species analyses of body part representation. MNE is the minimum number of each type of skeletal element, based on the most common portion or unique anatomical “landmark”; counts are mutually exclusive across categories. Cranial MNE is based exclusively on bone tissues (not teeth), and is computed in terms of right (R) and left (L) halves. Metapodials are counted using the proximal end, and carpal/tarsal MNE excludes the astragalus and calcaneum. No value presented in the table promises that whole elements are represented in the assemblages. Data represent provenienced material only.

Appendix 2c. Nonursid carnivore^a bone MNE by skeletal element and provenience.

Bone Element	P1	P2	R1-2	S4	T1-2	T4	U0	U1	Y0	Y1-1b	Total by Element
Half cranium (L or R)	—	—	1	—	—	—	—	—	—	—	1
Half mandible (L or R)	—	—	—	—	—	—	—	1	—	—	1
Cervical vert	—	—	—	—	—	—	—	1	—	—	1
Thoracic vert	—	—	1	—	—	1	—	—	—	—	2
Lumbar vert	1	—	1	—	—	—	—	—	—	1	3
Scapula	—	—	—	—	—	—	—	1	—	—	1
Humerus	—	—	—	—	—	—	1	1	—	—	2
Radius	1	—	1	—	—	—	—	—	—	—	2
Ulna	—	—	1	—	1	—	—	—	—	2	4
All carpals	—	—	—	1	—	4	—	—	—	1	6
Metacarpal	3	—	1	—	—	—	—	1	—	—	5
Femur	—	—	—	1	—	—	—	—	—	—	1
Tibia	—	—	—	—	—	—	1	—	—	—	1
Astragalus	—	—	—	—	—	1	—	—	—	—	1
Calcaneum	—	1	1	—	—	—	—	—	—	—	2
All other tarsals	—	—	—	—	1	1	—	—	—	—	2
Fibula	—	1	1	—	1	1	—	—	—	1	5
Metatarsal	2	—	1	—	—	4	—	—	1	2	10
1st phalanx	—	1	1	3	—	—	—	—	—	—	5
2nd phalanx	—	—	—	1	—	3	—	—	—	—	4
3rd phalanx	1	—	—	1	—	—	—	—	—	—	2
All sesamoids	2	—	—	—	—	—	—	—	—	—	2
Metapodial (indet.)	—	—	2	—	1	1	—	1	—	—	5
Total by provenience	10	3	12	7	4	16	2	6	1	7	68

^a Mostly lion and secondly wolf, followed by other carnivore taxa.

Note: MNE is the minimum number of each type of skeletal element, based on the most common portion or unique anatomical "landmark"; counts are mutually exclusive across categories. Cranial MNE is based exclusively on bone tissues (not teeth), and is computed in terms of right (R) and left (L) halves. Metapodials are counted using the proximal end, and carpal/tarsal MNE excludes the astragalus and calcaneum. No value presented in the table promises that whole elements are represented in the assemblages. Data represent provenienced material only.

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