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Butchering of Red Deer (Cervus elaphus L.)

– A Case Study from the Late Mesolithic Settlement of Tybrind Vig, Denmark

by TINE TROLLE-LASSEN

INTRODUCTION

Zooarchaeological studies dealing with subsistence practices of hunter-gatherers have, where hunting is concerned, been applied mainly to the procurement of the game. The relative representation and age and sex distribution of the identified species, the hunting season, and perhaps hunting and trapping techniques, to a large degree all reflect hunter decisions. Indirectly, those choices reflect society's needs for food and raw materials. Zooarchaeological studies applied to human decisions concerning game animals *after* the kill have less frequently been studied.

In the present paper, the interim results of a study of the remains of red deer from a Danish Mesolithic settlement, Tybrind Vig, are presented (1). Based on taphonomic analysis, aspects of skinning, butchering, transportation, and food preparation are reconstructed.

THE ARCHAEOLOGICAL BACKGROUND

Tybrind Vig is situated off the west coast of Denmark's second largest island: Funen (fig. 1). Large tracts of southwestern Denmark, which during the Mesolithic were dry land, are today covered by sea as a result of iso- and eustatic movements (Christensen 1982, Strand Petersen 1985a, 1985b, Smed 1986, 1987). The settlement, which in Mesolithic times lay on a cove, is today 200–300 m from the coast under 2–3 m of water (fig. 2). The major part of the actual dwelling area was washed away during prehistoric transgressions, but the remains of a combined rubbish zone and inshore fishing bank in the shallow area outside the settlement are preserved. Systematic sub-marine excavation has been carried out since 1978, and it is estimated that about 20% of the site has been investigated (Andersen 1980, 1985) (2) The unusually fine conditions for preservation of organic material are manifested in the large amounts of preserved animal bones and in exceptional finds of wood, bast, and plant fibres.

The artefact material belongs to the Ertebølle culture dated to 4500–3200 b.c. (C-14 (uncal.)), which represents the latest phase of the Danish Mesolithic. The largest part of the finds so far recovered derive from the later part of this culture phase and are C-14 dated to about 3700–3200 b.c. (uncal.) (Andersen 1984, 1985). Despite the comprehensive archaeological material available for study, knowledge of Ertebølle society is still limited (Andersen 1985: 52, Price 1985: 359). The information we do have suggests a relatively complex hunter-gatherer society with intensive economic exploitation, high implement and facility specialization, permanent settlement supplemented by special sites, exchange between groups, varied decorative art, and distinct regional

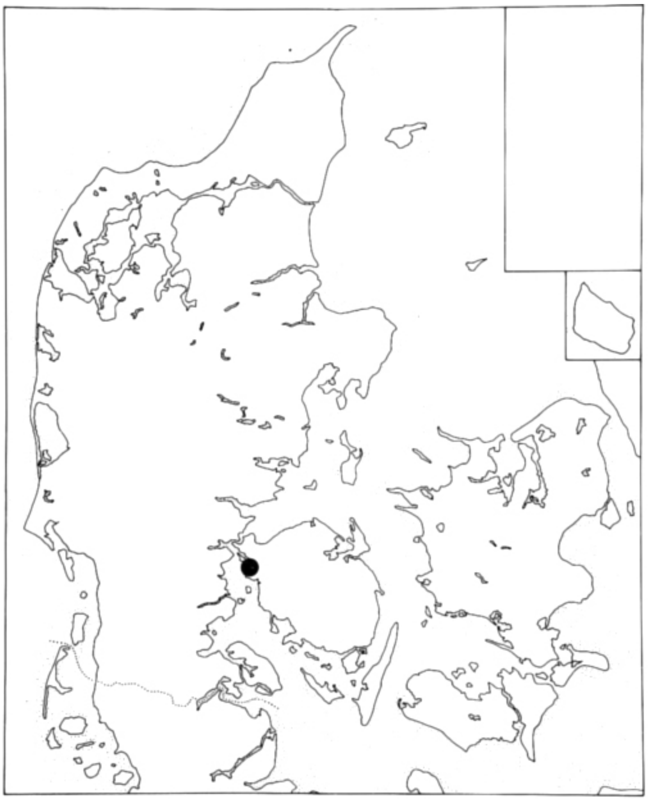


Fig. 1. The geographical location of Tybrind Vig.

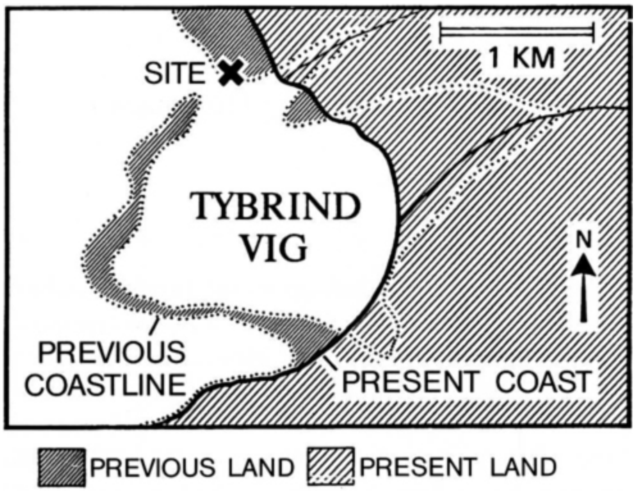


Fig. 2. Map illustrating how the area around the settlement has changed since prehistoric times from a protected cove into the present open bay (after Andersen 1983).

variations (e.g. Albrethsen & Brinch Petersen 1977, Larsson 1980, 1981, 1982, 1983, 1984, Andersen 1981, 1985, Vang Petersen 1982, 1984, Price 1985).

The analyses from Tybrind Vig have revealed occupation during all seasons (Trolle-Lassen 1985). That this was probably of considerable duration – perhaps permanent – is demonstrated in several ways. The abundant artefact and bone material shows that a large number of different activities took place, including a many-faceted economic exploitation. The specific rubbish area, in the form of an off-shore refuse zone, and the presence of a cemetery in connection with the oldest settlement, also suggest prolonged occupation (Binford 1983: 187–190).

The settlement was favourably situated with direct access to the resources of forest, cove, and sea. Amongst extant mammal remains, red deer, roe- deer, and wild pig are best represented in the bone material. Grey seal is slightly less common, while aurochs, wild horse, and various species of whales contribute only a few bones. Bones of fur-bearing animals are present in large quantities: pine- marten, in particular, was exploited (Trolle-Lassen 1986), but remains of polecat, otter, wildcat, and dog are common. There is also one bone from a fox. Bird remains are sparse, whereas there is much to suggest that fishing played a prominent part in the economy (Tauber 1981, Trolle-Lassen 1984, Andersen & Malmros 1985).

Taphonomic effects on skeletal remains of exploited game animals that resulted from prehistoric exploitation of the animals brought to the site have been evaluated. The taphonomic loss has probably been small in the interval between prehistoric deposition and recent times when erosion of the deposits began. The find circumstances suggest that the refuse zone was one of still water and that local vegetation, largely in the form of a reed bed, retained the rubbish (Andersen 1980, 1985, Trolle-Lassen 1984, 1985). The floor of the cove consisted of rapidly accumulating marine gyttja (Andersen 1980, 1985, Smed 1984) into which objects probably sank quickly and were covered by organic material. The marine fauna does not include species that would have affected the composition of the bone assemblage (3), just as the fine state of preservation of the bones shows that diagenesis cannot have caused changes of any consequence.

It was not until the bones were washed free from the find-bearing layers as a result of erosion by the sea that restructuring of the deposits possibly took place. Differential attrition and transport by the current (Gifford 1981) may then have occurred. The effect of these factors on the composition of the Tybrind Vig material is not quite clear but, as a general rule, the chance of a bone being recovered under these circumstances decreases with size and volume.

It is difficult to decide which technique was used to procure red deer for Tybrind Vig. At kill sites, as known from North America, bone assemblages result from a particular hunting and butchering situation. There, both the topography and any observable cultural context often furnish, in themselves, direct evidence of the kind of hunting employed. At a habitation site such as Tybrind Vig, however, the picture is far more complex. The introduced bones were derived from numerous hunting situations that varied with, for instance, terrain, season, and the social structure and needs of the community. Only in rared cases can the settlement context yield direct information about hunting techniques. The many finds of man-size bows in Tybrind Vig, and the many transverse points (Andersen 1985), do suggest, however, that bows and arrows were also used in hunting red deer. This was supported by one coeval and one slightly younger settlement find where the remains of transverse points were found lodged in bones of killed red deer (Noe-Nygaard 1974: 225–229).

Both ethnological sources and present practice show that red deer can be hunted by one or by several hunters (Hahr 1882, Kristoffersen 1974). In Denmark, red deer live in small groups in a relatively confined area and do

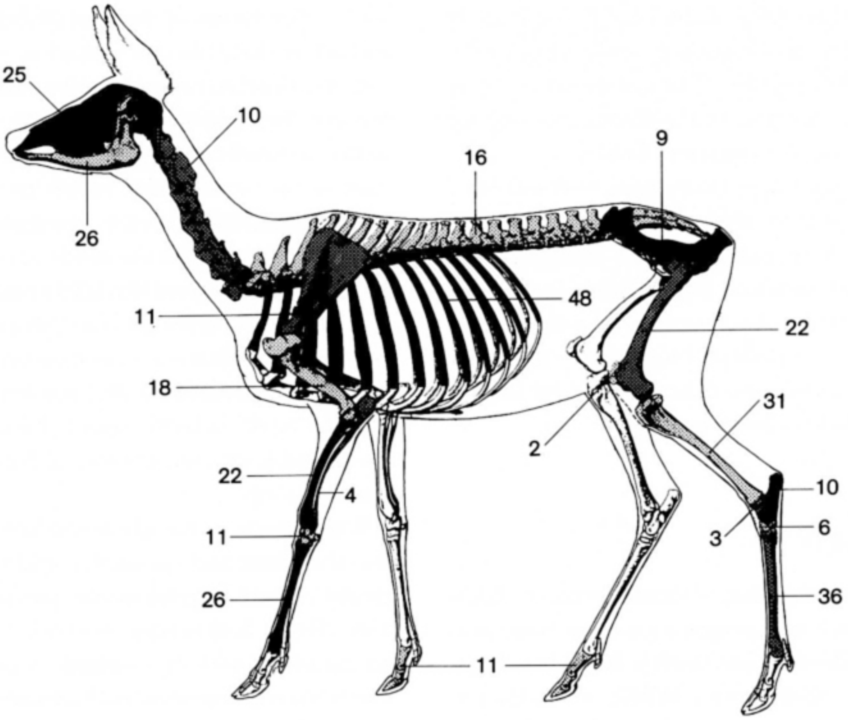


Fig. 3. Red deer skeleton (after Ellenberger *et al.* 1956) showing bones present in the Tybrind Vig material, with the number of fragments indicated.

not undertake major migrations (Valentin-Jensen 1972, Strandgaard 1974). They mainly follow established tracks in the forest and have, at least at the present day, a relatively stable diurnal rhythm. Mesolithic forms of hunting may have involved stalking and covert hunting along the track, or drive, perhaps using ropes to which feathers or other objects were tied (Hahr 1882, Kristoffersen 1974). Pitfalls and snares, as used in trapping elk and reindeer on the Scandinavian peninsula, could also have been used (Selinge 1974, Barth 1981, Ekman 1983). Massive seasonal hunting, which could be interpreted as an expression of communal hunting, was not indicated by analysis of the Tybrind Vig assemblage.

THE RED DEER MATERIAL

390 bone and tooth finds of red deer (*Cervus elaphus* L.) have been recovered from Tybrind Vig, comprising 22.2% of all identified mammal bones and teeth from the locality. In addition, 99 red deer antlers were recovered.

Just under one-third of the bones have a well-preserved surface (32.6%). Almost half are heavily worn, either locally or overall (49.2%). The remainder have been affected to a lesser degree (17.7%).

About one sixth of the bones are almost or completely whole (14.9%). The majority occur in fragmented form, which in most cases has been attributed to prehistoric human activity (85.1%).

Bones from most of the skeleton are represented (fig. 3); only hyoid, caudal vertebrae, and sternum are absent.

At least 14 individuals are represented, 11 of which are older than three months and three younger. Estimation of the minimum number of individuals has taken into account which side of the skeleton and from which part of the bones investigated fragments were derived.

The age determination of jaws, limb bones, and antler shows that red deer of all ages, from newborn up to 15-year-old individuals, were killed (Trolle-Lassen 1985). Calves (0–1 years) are well represented.

Taphonomic factors must have acted uniformly on the lower jaws of all animals older than 3 years, since development and bone density by that age seem to be relatively complete and stabilized. The age distribution in figure 4 shows, therefore, that red deer in the 3-7-year-old age group were more often killed than older individuals.

Seasonal determination from parts of the red deer is given in figure 5 (after Trolle-Lassen 1985). Each line covers one bone, tooth, or antler. The ontogenetic age of the animal is given for each part of the skeleton in months or years and, for antlers, the number of tines.

It is apparent from the bones that calves were killed at all times of the year, as were older animals.

The presence of unshed antler is not as reliable a seasonal indicator as the skeleton, since antler may have been kept as raw material elsewhere and, at a later time, brought to the site to be worked. Uncertainty also surrounds cast antler, since it cannot be known how long it lay on the ground before collection.

ANALYSIS AND RESULTS

Methods of identifying skinning, dismemberment, filleting, transportation, and food preparation from bone material involve the analysis of cut marks, bone breakage, and skeletal element representation. While cut marks unambiguously reflect human activity, that is not the case for bone breakage. In addition to breaks caused by geological agencies, dogs may have worked on the Tybrind Vig material. It is, therefore, necessary to include gnawing by dogs in the analysis and to distinguish between the different patterns of breakage and fragment morphology characteristic of dogs and man, respectively.

The relative frequency with which the different skeletal elements occur may form the basis for evaluating haulage strategy, butchering, further transport, and aspects of food preparation such as extraction of bone grease. However, other forms of human and non-human behaviour also affect skeletal representation.

Many practical considerations affected which parts of a red deer brought down in a hunt were transported to a settlement such as Tybrind Vig, for example, the physical state of the animal (e.g. condition and antler configuration) (Speth 1983, Speth & Spielmann 1983), the possibilities of transport, and the needs of consumers all vary with season. Distance from the kill site to the settlement, size of the animal or animals, the number of animals killed, method of butchering, and number of hunters or bearers are all decisive factors affecting what and how much are brought back. What is selected will also be affected to a considerable extent by cultural factors peculiar to a particular society.

Which parts of the whole red deer skeleton were thrown into the water and, as such, could be recorded archaeologically, would depend on the preceding settlement activities. Here, butchering methods, food, and implement preparation, and the possible removal from the site of meaty parts, together with gnawing of bones by dogs, would determine the make-up of the refuse. How the animal was treated in these contexts would again depend on its physical condition, i.e. age, sex, health, and so on (Speth 1983). Which parts of the refuse ended up in the water would be further determined by factors such as the physical effort involved, the possibility of re-utilization, and how much the part was in the way (Hayden & Cannon 1983: 154). The last factor was determined by, among other things, size, occupation density, intensity of activity, and frequency with which the settlement was used (Binford 1983: 187–190).

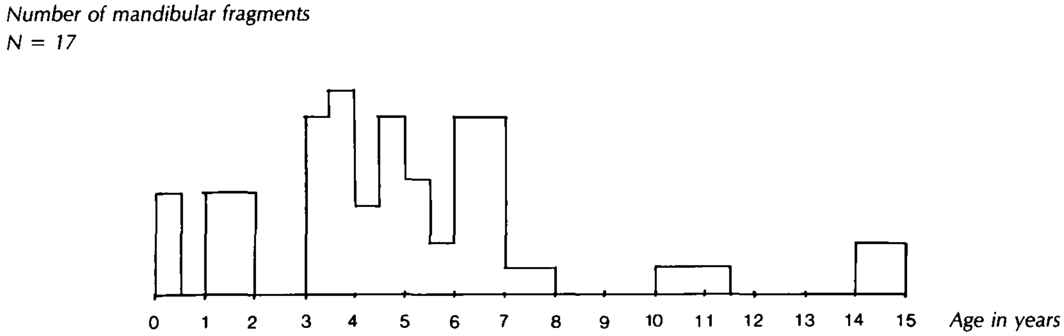


Fig. 4. Age distribution of red deer, based on mandibular fragments.

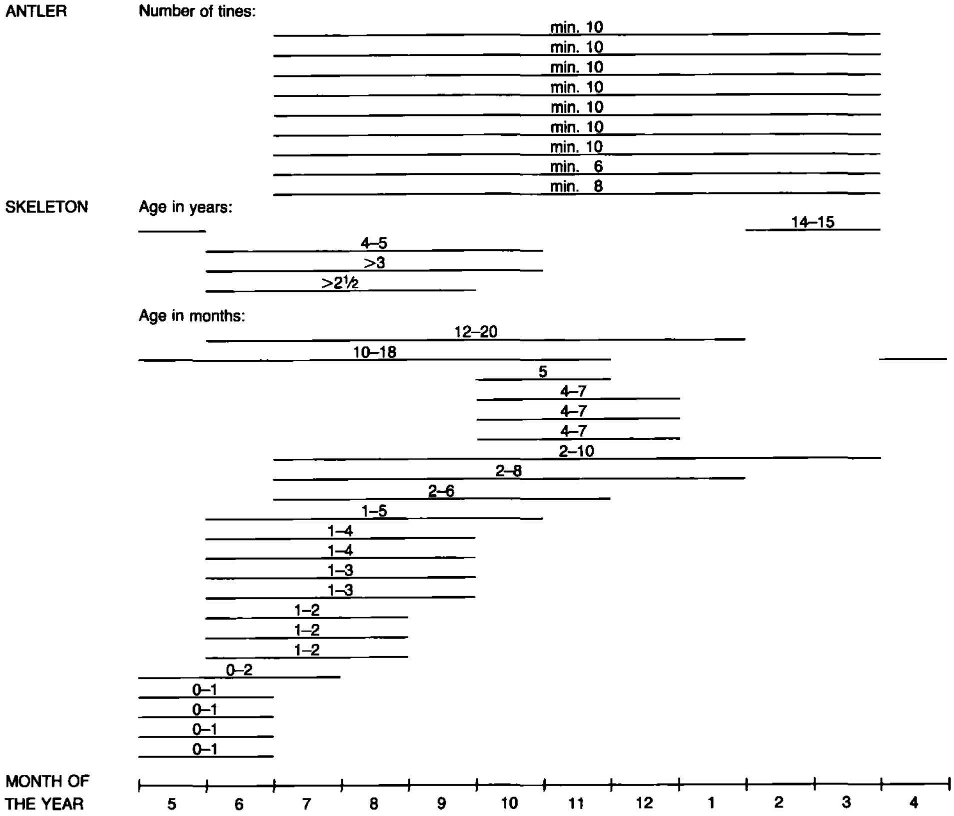


Fig. 5. Season of death determined from skeleton parts.

Cut marks

All bones were scrutinized for cut marks under the microscope at at least five power magnification, and all cuts were recorded on sketches. Interpretation of cut marks and bone breaks was based on: (a) archaeological literature focusing directly on bones and their potential testimony (Møhl 1972, Sadek-Kooros 1972, Wheat 1972, Frison 1973, 1978, Kehoe 1973, von den Driesch & Boessneck 1975, Noe-Nygaard 1977, Myers *et al.* 1980, Binford 1981, Gifford 1981, Zeimens 1982), (b) ethnographic and ethnoarchaeological literature dealing with the treatment of game (Mathiassen 1928, Birket-Smith 1929, Ingstad 1952, Gould 1967, Fletscher & La Flesche 1972, Rogers 1973, Marks 1976, Yellen 1977, Binford 1978), and (c) the experimental skinning of a pine- marten, skinning and butchering of an otter using flint blades, and skinning and butchering of a red deer using flint axes (Trolle-Lassen 1985) (4).

The cut marks on the skeleton reveal their origin during skinning, dismemberment, filleting, and implement manufacture. This may be seen both by which bones exhibit them and in their position on these bones.

Cuts were observed on bones of animals aged about 5 months and older. The uneven surface of all bones of very young calves prevented identification of any marks there.

Use-wear analysis of flint collected from coeval south Scandinavian settlements shows that mainly unretouched blades were used for skinning and butchering (Juel Jensen & Brinch Petersen 1985, Juel Jensen 1986). Blades with an acute edge angle (c. 20°) have, among other things, cut fresh hide and flesh, while blades in which the edge angle is steep (40–55°) have a polish made by working against flesh and bone (butchering) (*ibid.*).

Skinning

Cuts which with considerable certainty may be ascribed to skinning were observed on the vault and on phalanges (cf. Binford 1981: 101–104, 107, Fletscher & La Flesche 1972: 272, Rogers 1973: 22–24). Slightly more ambiguous were cuts on the upper and lower jaws, radius, tibia, and

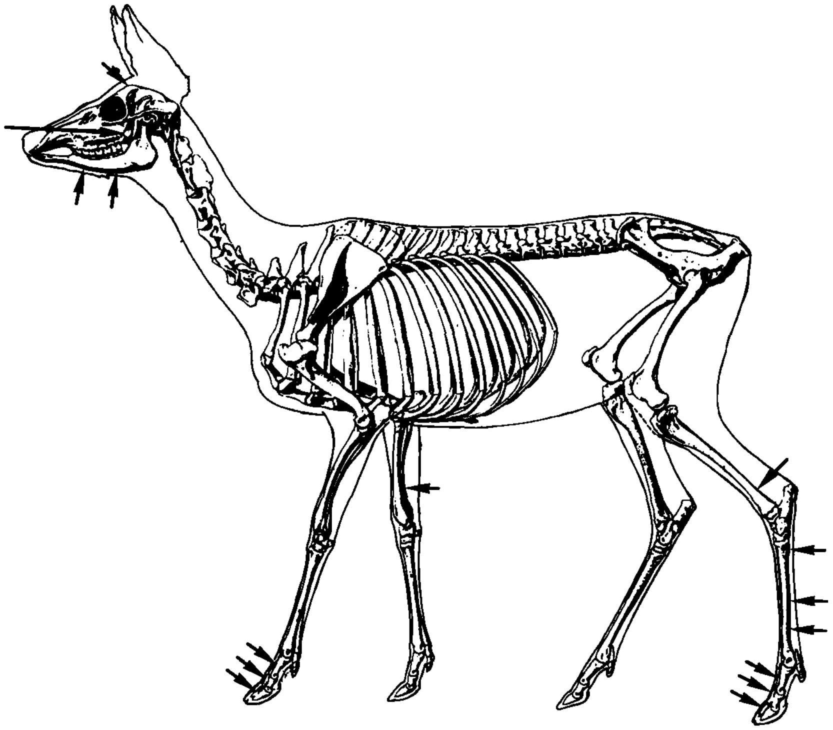


Fig. 6. Red deer skeleton (after Ellenberger *et al.* 1956) showing possible marks of skinning.

metapodials, since these bones acquire cuts during dismemberment or filleting, and the metapodials, because of their use as raw material, also during implement manufacture. The position of possible skinning marks is shown in figure 6.

Half of the eight pieces of *calvaria* with attached antlers exhibited cut marks around the base of the antler, on the burr, and on the vault itself (fig. 7). On the other half, an eroded surface obliterated any such marks.

Three *phalanges* – proximal, medial, and distal – exhibit transverse dorsal cuts (fig. 8). Five other well-preserved phalanges, also representing all types, lacked cuts. Four pieces had an eroded surface.

In both of two fully preserved *maxillae,* oblique and horizontal cut marks were evident on the lateral surface (fig. 9). Some of these may perhaps have been derived from skinning.

Three *mandibles* showed cut marks attributable to skinning (fig. 10). They were all placed latero-basally on the corpus and had an oblique, transverse orientation.

Two distal *radii* exhibited strong and long, respectively, transversal and oblique cuts on the shaft. They were both placed 10–10.5 cm proximal to the most distal point of the bone. Similar transverse marks were seen on two of the six distal *tibiae* with well-preserved surfaces. The cuts are long and cross the shaft 5.5–6 cm proximal to the most distal point on the bone (figs. 11 & 33). They may have been made during skinning (cf. Binford 1981: 107, Højlund 1981: 62, figs. 77–78), but they could have derived from the severing of muscles during filleting.

No metacarpals, but three metatarsals, had annular cut marks possibly due to skinning (fig. 12). In one case, they appeared proximally on the shaft, in another, groups of cuts were found at several places down the distal part of the shaft, and, in a third specimen, there were merely single cuts on the lateral surface of the distal part of the shaft. However, it cannot be ruled out that these marks resulted from preparation for tool-making or, in the proximal case, that they are butchering marks (see below).

On five of the *long bones* of the extremities (radius, metacarpus, femur, tibia, and metatarsus), long, medial longitudinal cut marks were seen. Cuts such as these were also seen on other bone surfaces, and it could not be decided whether they were skinning marks acquired when the hide was cut from the inner side of the limb or whether they were derived from later filleting.

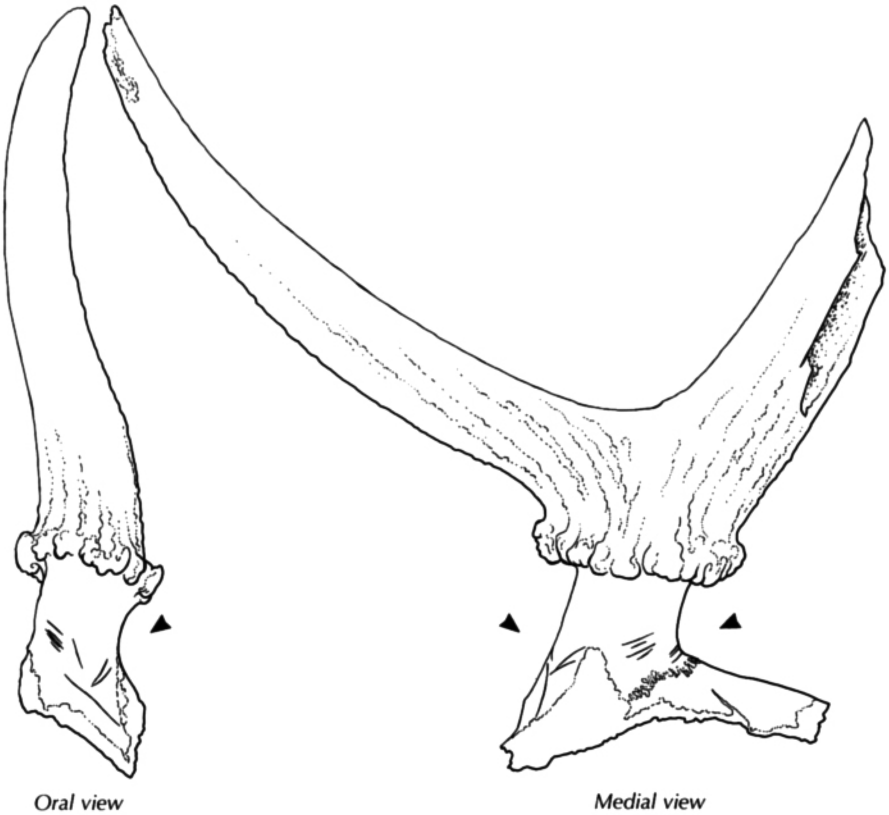


Fig. 7. Skinning marks on the vault around the base of the right antler. 2:5.

Disarticulation

Marks that should presumably be ascribed to cutting through articulations while the carcass was butchered were observed on occiput, atlas, axis, mandible, scapula, humerus, ulna, radius, carpal, metacarpus, pelvis, femur, tibia, malleolus, tarsal, and metatarsus (cf. Binford 1981: 107–126, Rogers 1973: 18–25).

The position of these disarticulation marks is shown in figure 13.

Two oblique cut marks dorso-aboral to the third molar on the *maxilla* may be due not to skinning but to severing of the masticatory muscle, thereby separating the lower jaw from the rest of the skull (fig. 9). No corresponding traces were seen on the mandible.

Two *occipital* regions exhibit cut marks, indicating that the head was cut off between the cranium and the atlas (Rogers 1973: 23–24). Corresponding marks were seen ventrally on one *atlas*. One *axis* with cuts ventrally near the cranial articulation presumably shows that decapitation also occurred with a cut between the atlas and axis, which is the easiest way of doing things (Rogers 1973: 18).

Two sagittal cut marks dorso-medially in the symphysis of a *mandible* were perhaps derived from division of the jaw into right and left halves.

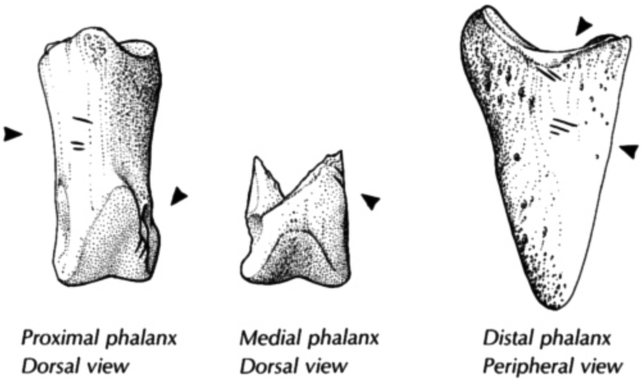


Fig. 8. Skinning marks on phalanges. 3:4.

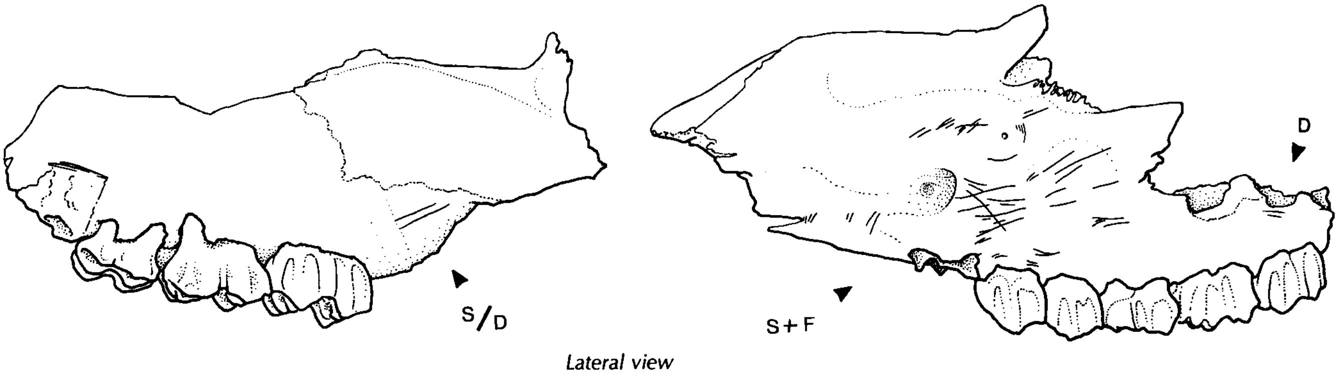


Fig. 9. Filleting marks (F) and possible skinning (S), and dismemberment marks (D) on left maxilla. 1:2.

One of the two *scapulae* with a well-preserved distal end showed that parting occurred at the articulation with the humerus (fig. 14). This was confirmed by cuts on the only two proximal *humeri,* both of which are well preserved with fused epiphyses (fig. 15).

Parting had been effected through the joint distal to the humerus, where six more or less well-preserved distal ends of humeri exhibited cut marks (fig. 16). Confirmation was probably found in the only well-preserved proximal end of an *ulna,* where several transverse cuts were seen (fig. 17). Expected corresponding cuts proximally on the radius were not found, but their absence may be explained by attrition and fragmentation of this area of the bone.

The upper and lower parts of the foreleg had been parted in the *carpal region.* No cut marks were seen on the distal end of either the ulna or the radius. Binford, too, found the latter position rare (1981: 126). There was, however, a single transverse cut in the actual articular surface of the radius. The observed cut marks on the proximal carpals were probably derived from disarticulation (fig. 18). Two sets, each of three proximal carpals, exhibited cut marks: one on three and the other on four of the surfaces of the foreleg. One additional intermedium and an accessorium had well-preserved surfaces devoid of cut marks.

One of two *metacarpals* with well-preserved proximal ends had cut marks that can be ascribed to disarticulation or to filleting/scraping. Disarticulation marks were present on one of the two well-preserved distal ends (fig. 19).

Distinct cut marks about the acetabulum on both well-preserved *pelves* indicated separation between the pelvis and femur in this articulation (fig. 20). Corresponding cuts were seen proximally on all three *femora* with well-preserved surfaces (fig. 21).

Only two distal femoral epiphyses, one of which was well preserved, were found in the material. No cut marks attributable to dismemberment were observed. Correspondingly only two proximal tibial epiphyses were found, both of which had eroded surfaces lacking cut marks.

Cuts on tibiae and tarsals testify to separation of the upper from the lower parts of the hind leg. Two of four well-preserved distal ends of *tibiae* with fused epiphyses showed dismemberment marks, while the others were indeterminant (fig. 11). In addition, cut marks were seen dorso-laterally on one of three well-preserved malleoli

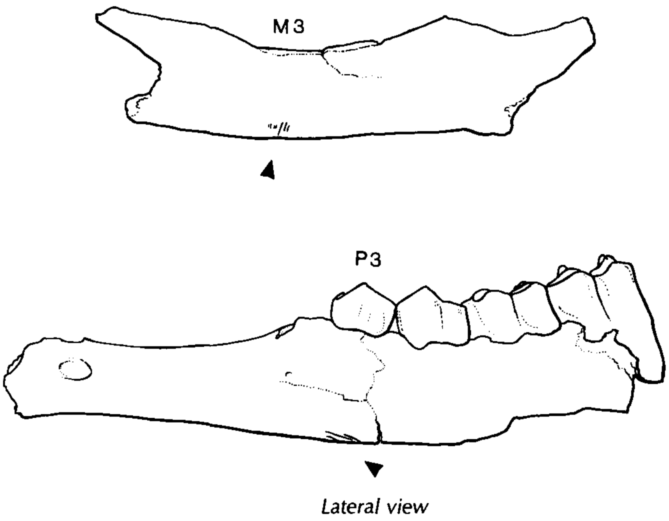
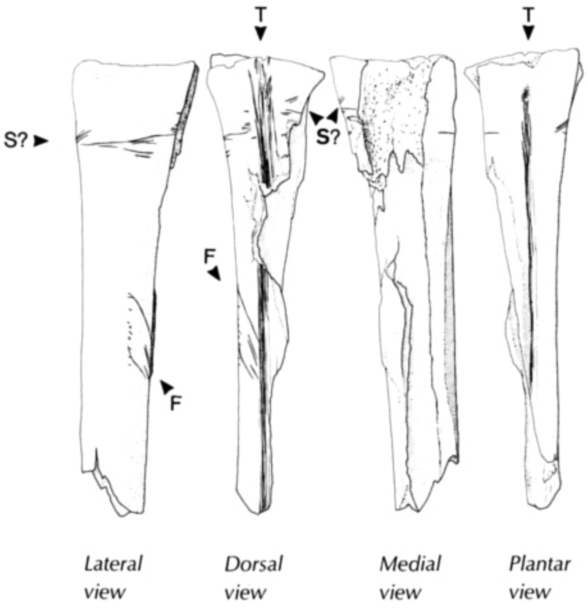


Fig. 10. Skinning marks on left mandible. 1:2.

(fig. 22). All six *calcanei* with undamaged surfaces and all three *astragali* bore distinct disarticulation marks such as those described by Binford (1981: 116–119) (figs. 23 & 24).

Presumably cuts on metatarsus and distal tarsals were caused by separation of these parts. All *centrotarsals* exhibited small, mainly transverse, cut marks, usually on dorsal as well as both lateral surfaces, in one case also on the

Fig. 11. Dismemberment (D), filleting (F), and possible skinning marks (S) on right tibia. C. 1:2



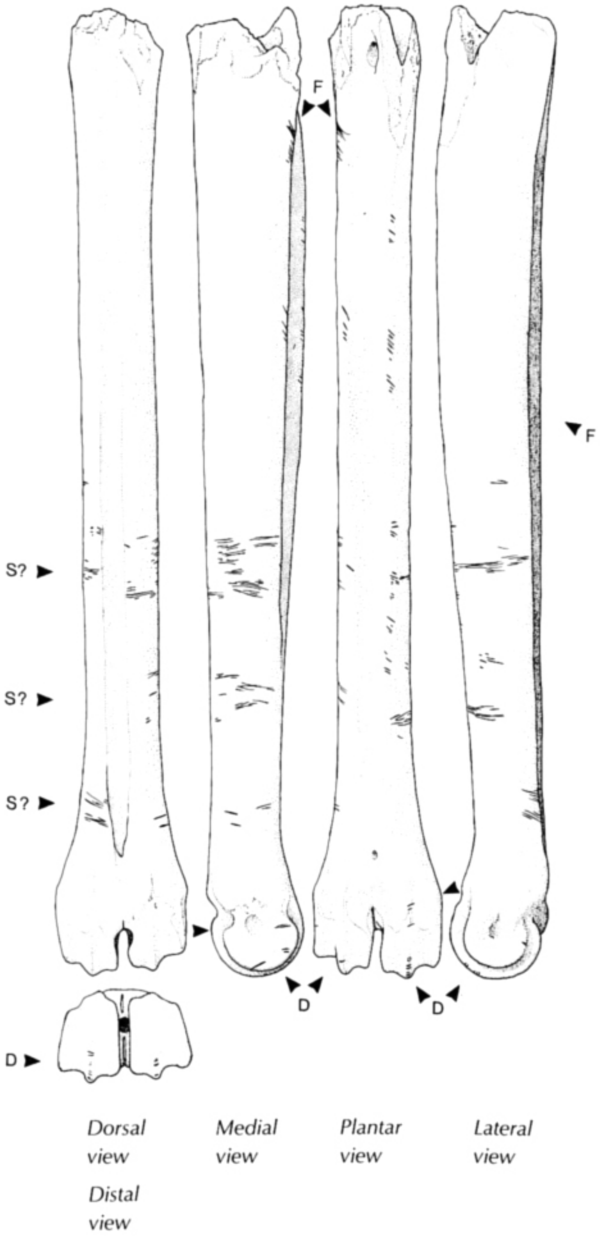


Fig. 12. Cut marks deriving from dismemberment (D), filleting/scraping (F), tool-making (T), and possibly skinning (S) on two right metatarsals. C. 1:2.

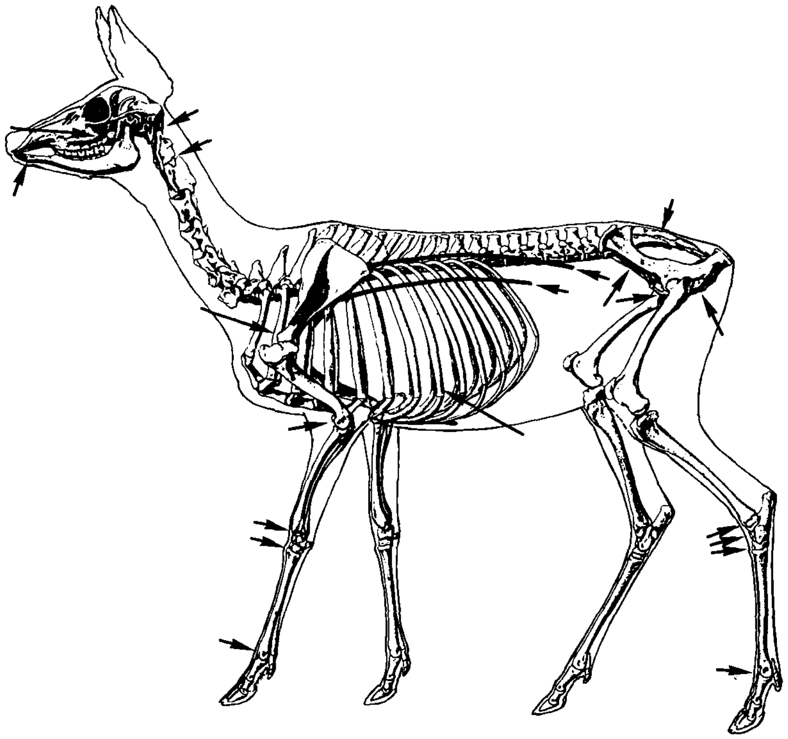
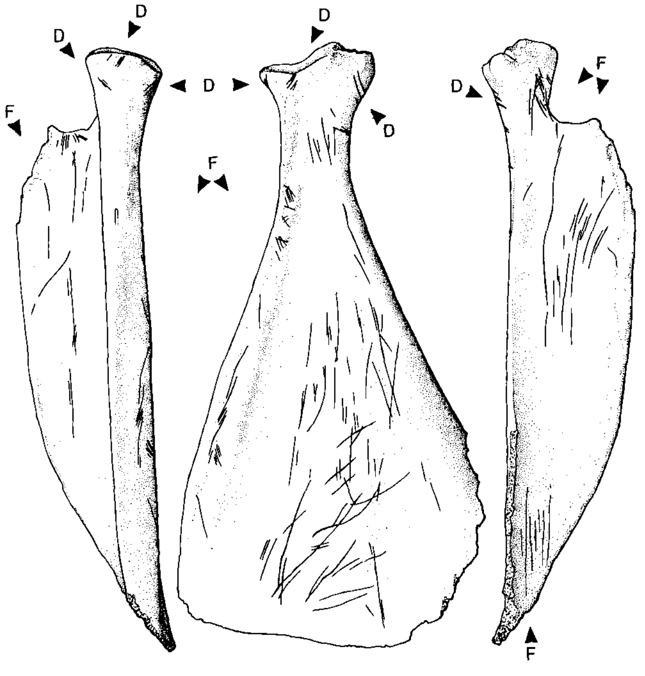
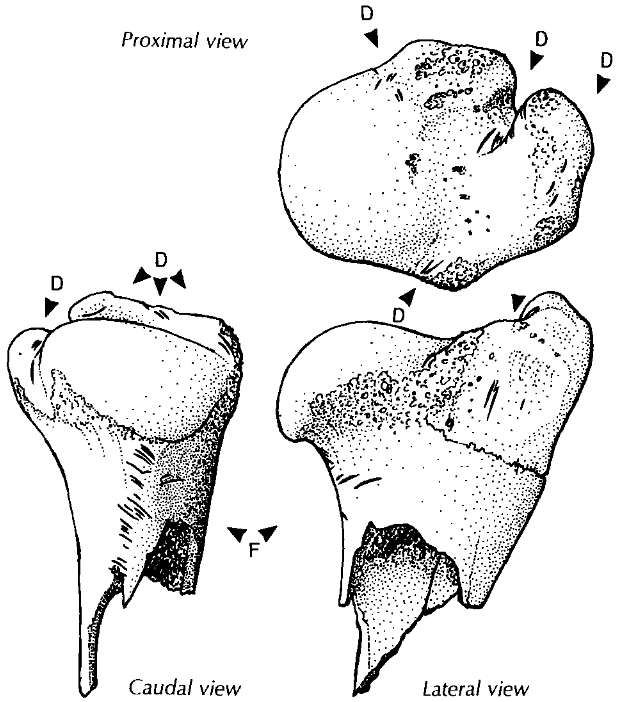


Fig. 13. Red deer skeleton (after Ellenberger *et al.* 1956) showing location of possible marks of dismemberment.



Caudal view *Ventral view* *Cranial view*

Fig. 14. Dismemberment (D) and filleting marks (F) on right scapula. 1:4.



Proximal view

Caudal view *Lateral view*

Fig. 15. Dismemberment (D) and filleting marks (F) on proximal part of right humerus. 1:2.

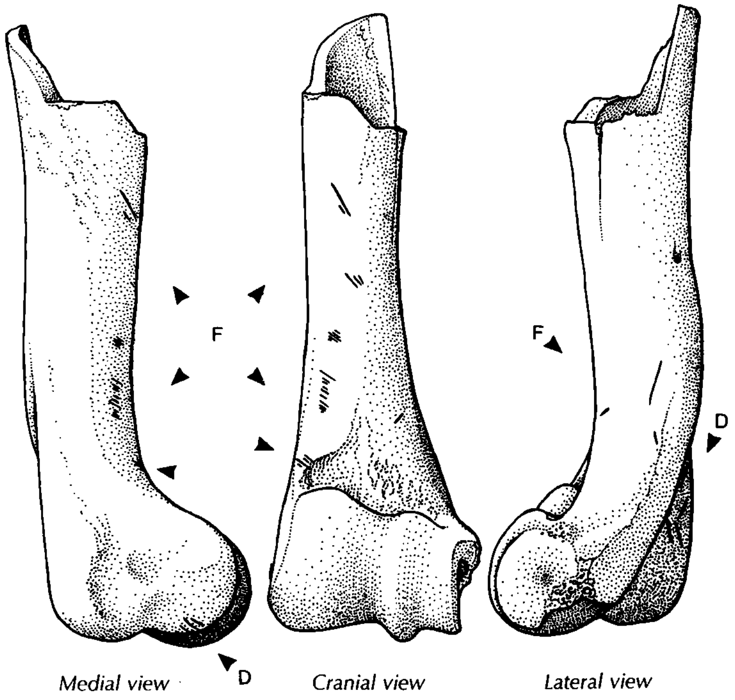


Fig. 16. Dismemberment (D) and filleting marks (F) on distal part of left humerus. 1:2.

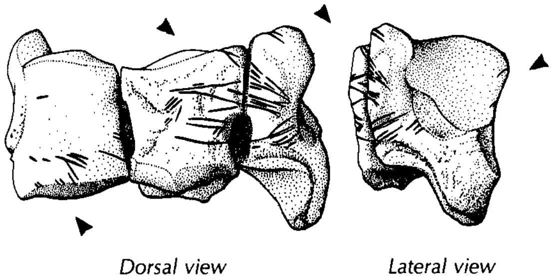


Fig. 18. Dismemberment marks on left carpals. 3:4.

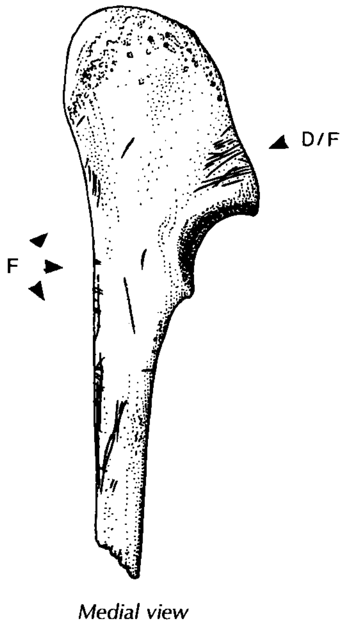


Fig. 17. Filleting (F) and possible dismemberment marks (D) on proximal part of left ulna. 1:2.

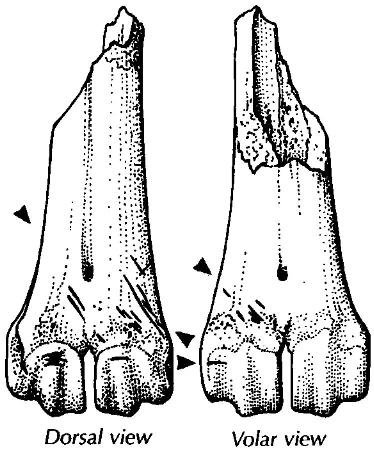


Fig. 19. Dismemberment marks (D) on distal part of left metacarpus. 1:2. D ►

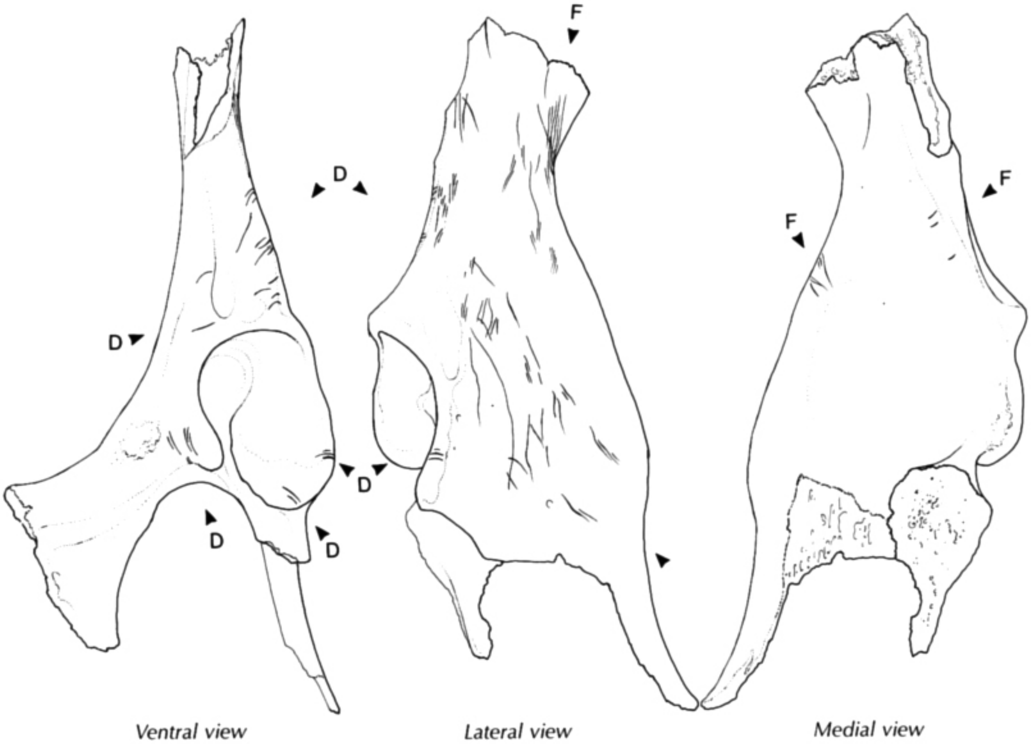


Fig. 20. Dismemberment (D) and filleting marks (F) on left pelvis. 1:2.

plantar aspect (fig. 25). The two latero-intermediate *cuneiforms* both had small, oblique cut marks on the dorsal surface. Three of the five well-preserved proximal ends of *metatarsus* exhibited cut marks that may be attributed to disarticulation (fig. 26).

Cuts distally on the metatarsus, both on the barrels and on the surfaces just above the epicondyle, probably reflect the cutting off of the phalanges (fig. 12). Such traces were seen on three of the eight well-preserved pieces.

Filleting and Scraping

Cuts that may result from the filleting or scraping away of flesh or periosteum, or both, were observed on maxilla, vertebra, cervical, scapula, humerus, ulna, radius, metacarpus, pelvis, femur, tibia, metatarsus, and costa (see Binford 1981: 126–36).

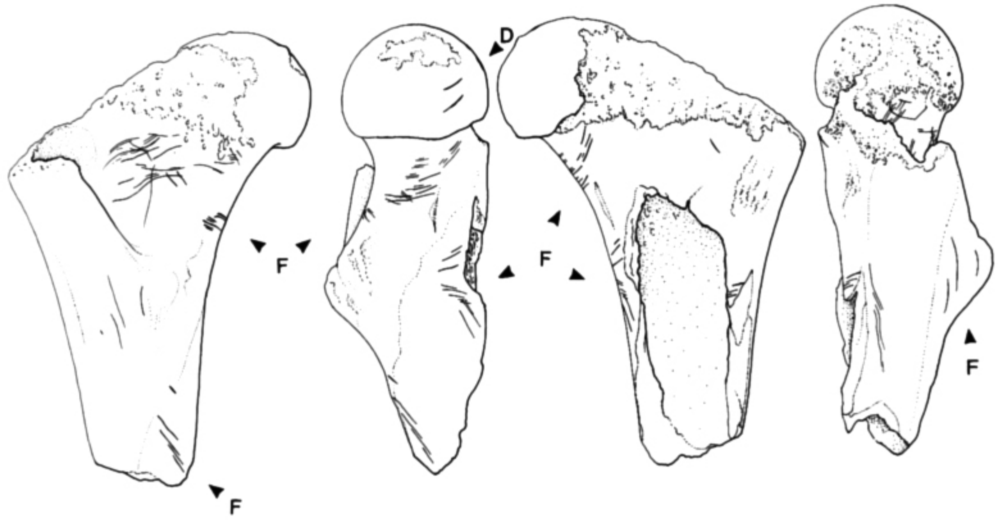
The Nunamiut Eskimo usually carefully scrape and clean the shafts of long bones before extracting the marrow (Binford 1981: 150–159). It is reported that the !Kung Bushmen cut off large lumps of flesh remaining after biltong-making before extracting marrow (Yellen 1977: 292–293). The breaking of the bone followed a specific pattern for each (*ibid.*), and the blows must, therefore, fall precisely, which presumably required that the bones be well cleaned. The cutting and scraping away of meat are also found among Cree Indians (Rogers 1973: 21–22, 25). A similar cleaning of the bones could have preceded their utilization as raw material in prehistoric tool-making.

Flesh had been scraped from the *cranium* in the region of the cheek (fig. 9). The same process is presumably reflected in cut marks observed dorsally on two *cervical vertebrae,* no. 5 or 6 (fig. 27).

Extensive filleting cuts were seen on all three preserved *scapulae* (fig. 14) and likewise on all pieces of *humerus,* where the surface had not been eroded away (fig. 15).

Cuts stemming from filleting, but perhaps also from scraping caused by activities with other purposes, were seen on *ulnae* (fig. 17) and on a large number of *radius* pieces (figs. 28 & 29). Corresponding scraping cuts of different kinds were seen on the shafts of three *metacarpals* (fig. 30).

The parts of the *pelvis* which, according to Binford, primarily display filleting cuts (1981: Fig. 4.36), were not observed in the Tybrind Vig material, which comprises

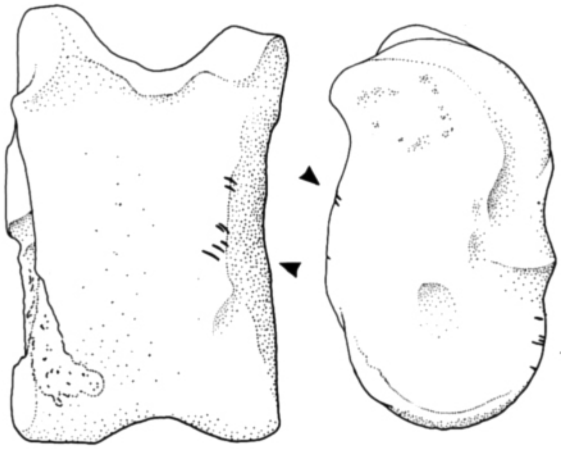


Caudal view Medial view Cranial view Lateral view

Fig. 21. Dismemberment (D) and filleting marks (F) on proximal part of left femur. 1:2.

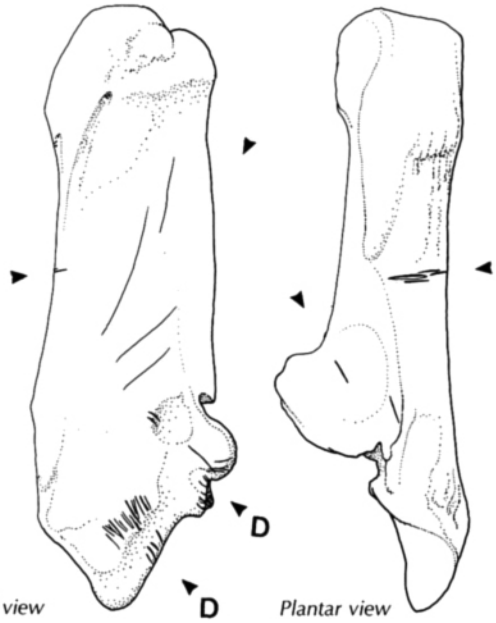
Lateral view

Fig. 22. Dismemberment marks on right malleolus. 1:1.



Plantar view Medial view

Fig. 24. Dismemberment marks on left astragalus. 1:1.



Lateral view Plantar view

Fig. 23. Dismemberment marks (D) on right calcaneus. 5:7.

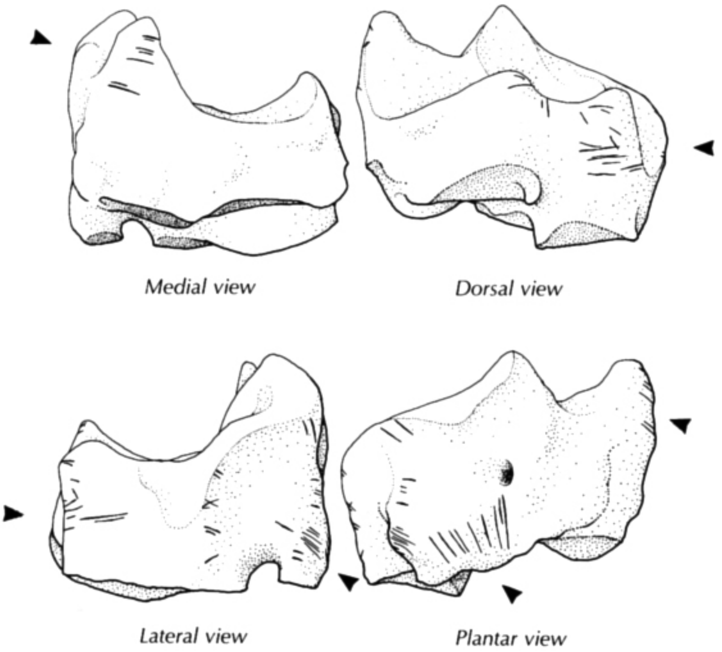


Fig. 25. Dismemberment marks on left centrotarsal. 1:1.

little more than the acetabulum and the area around it. In the existing fragments, a number of cut marks were observed, however, whose presence is best attributed to this activity (fig. 20). *Femora* had many cut marks which, in accordance with Binford, are interpreted as filleting marks (figs. 21 & 31).

Cut and scraping marks on *tibiae* presumably were derived from filleting and perhaps other scraping activity

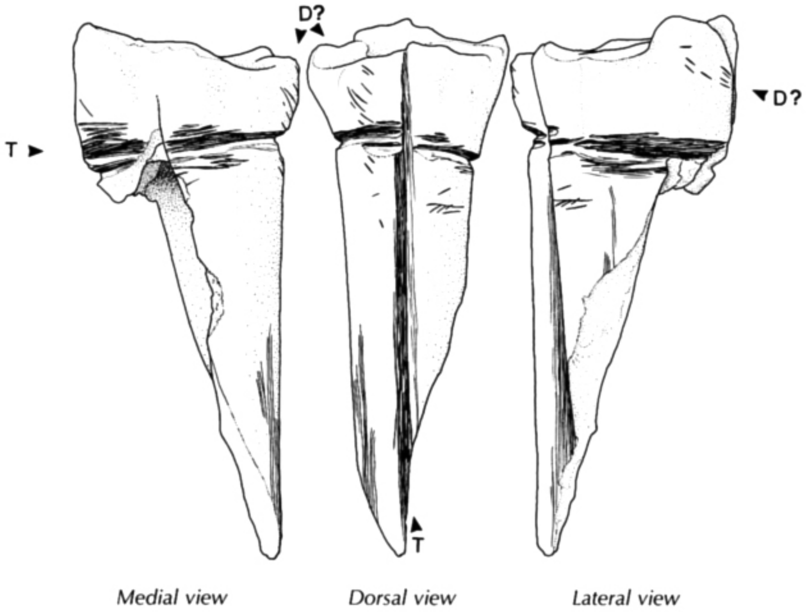


Fig. 26. Marks of dismemberment (D) and tool-making (T) on proximal part of left metatarsus. 3:4.

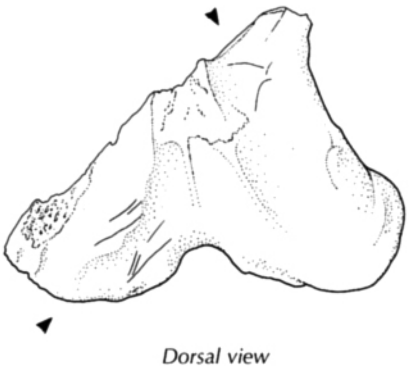


Fig. 27. Filleting marks on cervical vertebra. 2:3.

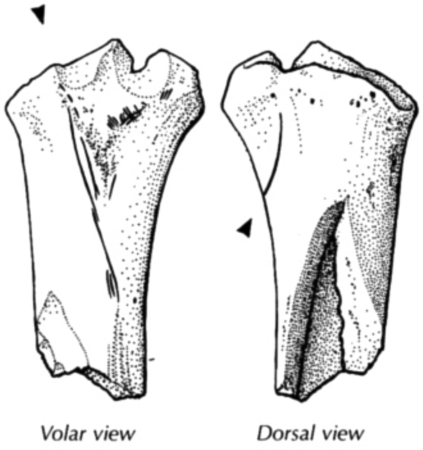


Fig. 28. Filleting marks on proximal part of right radius. 1:2.

(figs 32. & 33). Corresponding cuts of different types were seen on the shafts of four *metatarsals* (fig. 12).

Longitudinal or transverse cut and scraping marks on the inner *rib* faces were most likely derived from the cutting and scraping away of flesh (fig. 34). Marks of this kind, which were unambiguously recorded in 11 cases, were observed only on the mid- and ventral parts of the ribs, not on dorsal ends.

Bone breakage

The breakage pattern, fragment morphology and secondary features of the bones showed that human agencies, and not carnivores (for example, dogs), were responsible for the fragmentation (Binford 1981, Gifford 1981). Fragments of long bones were thus found either as isolated epiphyses or as split shafts. Epiphyses with attached shafts occurred only occasionally, and secondary features in the form of marks made by blows showed that the breaks result from human activity.

On a tenth of the bones, marks from the gnawing of scavengers, presumably dogs, were seen (table 1). The gnawing observed can, however, be ruled out as a cause of breaks in the sturdy, thick-walled long bones of the red deer: it is too weak and its marks were concentrated at the epiphysis and not, or only to a lesser degree, around the break.

Ethnographic sources report that normally only a few bones, such as ribs and perhaps pelvis and vertebrae, were snapped or broken in connection with butchering (Birket-Smith 1929: 139–141, Fletscher & La Flesche 1972: 272–274, Rogers 1973: 18, Yellen 1977: 280ff., Binford 1978: 50, 62–63, 94–97, 142–144, Binford 1981: 87ff.). An exception is secondary butchering of frozen carcasses. In that situation, it is not possible to sever the tendons of the joints, and the limbs, for example, have to be further sundered by a break in the centre of the shaft of long bones (Binford 1978: 50). Such a technique is unnecessary in a mild climate such as that which prevailed in Danish Atlantic times. The overchopped and broken bones most

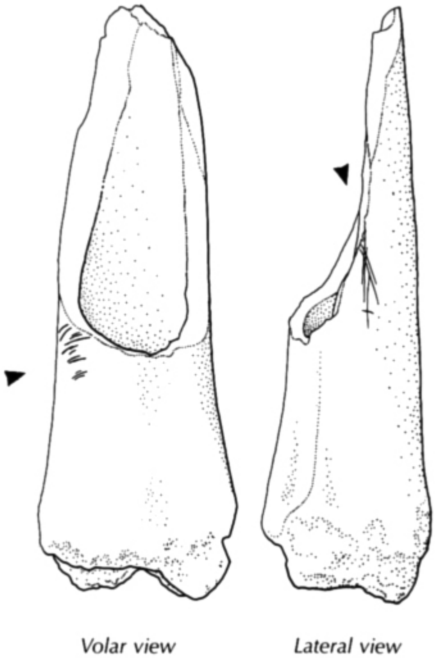


Fig. 29. Filleting marks and possible scraping marks on distal part of right radius. 2:3.

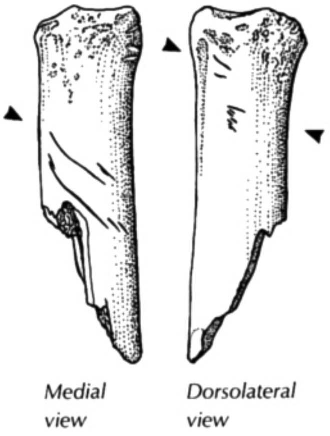


Fig. 30. Cleaning marks on proximal part of left metacarpus. 1:2.

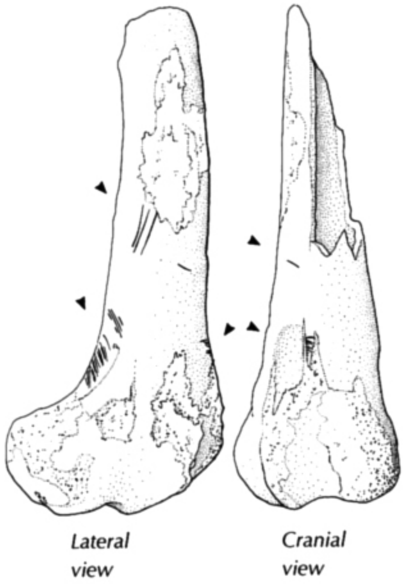


Fig. 31. Filleting marks on distal part of right femur. 1:2.

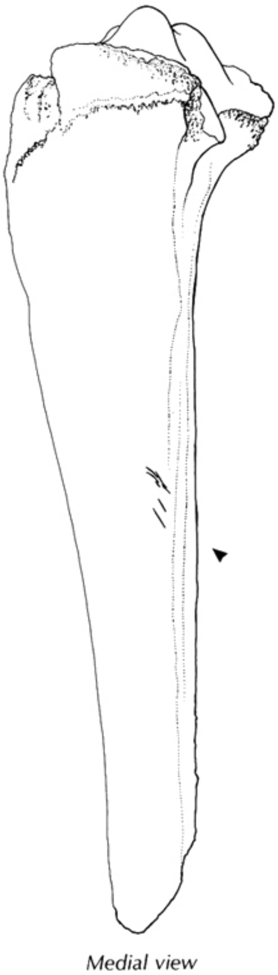


Fig. 32. Filleting marks on proximal part of right tibia. 1:2.

often resulted from food preparation and tool-making, respectively.

Bone breakage associated with food preparation might serve the following ends: (a) reducing the size of the meaty bone pieces, allowing boiling or roasting to occur in a smaller pot or smaller pit, (b) extracting marrow or brain mass, (c) rendering bone grease, and (d) production of bone juice. The rendering of bone for grease and bone juice are both activities which, for the Nunamiut Eskimos and the Mistassini Cree Indians, took place *after* marrow extraction (Rogers 1973: 25, Binford 1978: 157, 164). The raw material consists of the epiphyses of long bones, entire tarsals, and for bone juice also whole carpals and ribs (Binford 1978: 32–38, 164–165). In the course of the process, the bones are effectively crushed, resulting in a greater or lesser degree of pulverization, depending on the hardness of individual bones (Binford 1978: 158, 164–165). In the following, only large bone fragments, such as epiphyses and shaft splinters of long bones, will be discussed, and the production of bone grease and liquor will, therefore, not be touched on in this section.

Dismemberment

The breaking of bones probably during dismemberment was observed in pelvis and ribs.

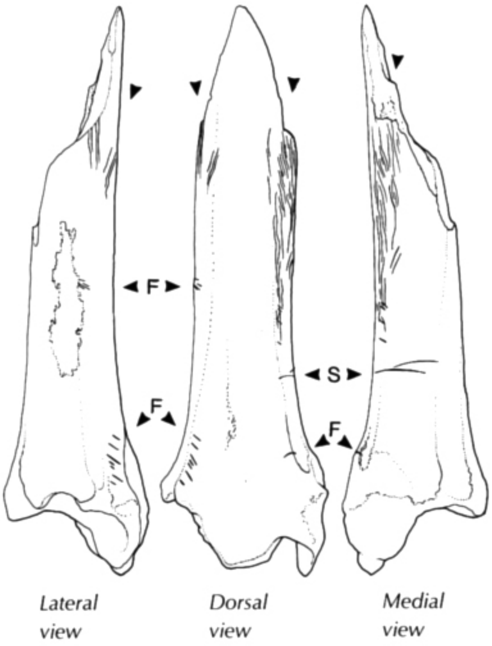


Fig. 33. Filleting marks (F), and possible skinning (S) and scraping marks on distal part of right tibia. 1:2.

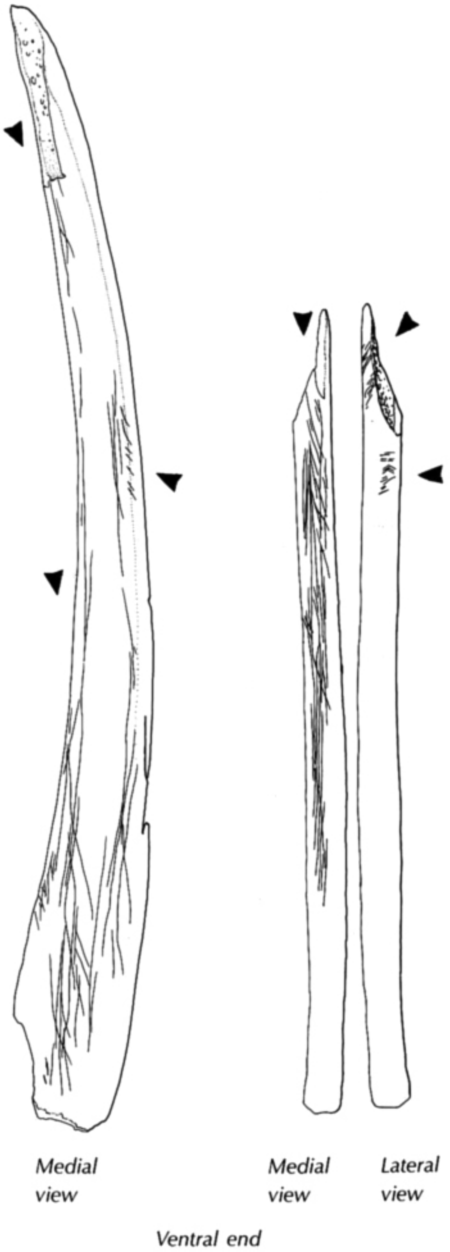


Fig. 34. Scraping marks on the inner side of right ribs. 1:2.

All seven *pelvis* pieces were derived from the area around the acetabulum (fig. 35). Right and left halves had probably been parted or broken in the sagittal plane through the symphysis. Considering the conditions of preservation, it is not reasonable to ascribe this pattern to natural agencies after the bone was discarded. Dog gnawing is seen not on the pubis, but caudally on the ischium, where the transverse ramus and tuberosity were usually gnawed away (table 1). According to Binford, it is precisely these two parts, in addition to the dorsal rim of the tuberculum pubis, to which carnivores are partial (1981: 66–67). A first sacral vertebra reveals that the sacrum had been chopped down the middle. Lengthwise division of the pelvis is known from the Bushmen, where it is often split to ease transportation of the kill (Yellen 1977: 283). Nor is the phenomenon altogether uncommon in connection with caribou (Binford 1981: 67–69).

Half caribou pelvis were often broken through at the neck of the ilium (Binford 1981: 69). This seems also to have occurred during dismemberment of red deer from Tybrind Vig where three of the five larger pelvis pieces exhibited a clean break lacking evidence of dog- gnawing, while two were relatively eroded and recently broken.

Rib fragments may be classified into four categories according to their anatomical position and size: (a) dorsal pieces, without the head, (b) mid-pieces, (c) combined mid- and ventral pieces, and (d) ventral pieces.

The dorsal pieces showed that the rib- slab was broken at the neck, the heads remaining attached to the spine (fig. 36) (Rogers 1973: 18, Yellen 1977: 283, Binford 1981: 113). It is apparent from the dorsal, mid, and mid-ventral

Bone	Bones permitting identification	Gnawed	
	n	n	% of identifiable
Cranium	5	1	20.0
Mandibula	10	1	10.0
Vertebrae cervicales	9	1	11.1
Costae	21	2	9.5
Scapula	2	2	100.0
Humerus	12	8	66.7
Radius	16	3	18.8
Carpal	8	3	37.5
Metacarpus	16	5	31.3
Pelvis	3	2	66.7
Femur	13	2	15.4
Tibia	18	1	5.6
Calcaneus	8	6	75.0
Metatarsus	20	6	30.0

Table 1. Frequency of dog-gnawing on different types of red deer bones.

pieces that a deliberate break was also made across the slab more ventrally (fig. 36). The break had apparently been prepared by scoring deeply across the ribs in line with the intended break. These cut marks were too deep to be interpreted as filleting marks. In most cases, namely 11 out of 14, the cut had been scored from the outside, after which the inner side had been broken over, as shown by its scarred or serrated appearance (fig. 37). In only three cases was the opposite pattern, in which the incision had been laid from the inside, seen (fig. 37). The anterior ribs (up to and including no. 3 at least) had not been subjected to this scoring and breaking. Corresponding observations were made in the material from Præstelyngen where the phenomenon was likewise interpreted as deliberate dismemberment (Noe-Nygaard 1977: 228–229). Although more superficial cuts were not observed in the dorsal rib area, one must assume that the fillet was cut away early in the process (Rogers 1973: 18). After this, the rib-slab was broken from the backbone and a more ventral break made by cutting deeply into the bone. The purpose of breaking the ribs was to separate the filleted dorsal part from the still meaty mid- and ventral part.

A rib with strong, transverse, lateral scoring on the ventral end may reflect removal of the sternum (Fletscher & La Flesche 1972: 272–273, Binford 1981: 113). A systematic breakage pattern among ventral rib fragments was not ascertained, and such fragmentation can thus not be attributed to deliberate cultural activity. This is supported by the presence of ten large rib pieces, each of which comprised the entire portion from the ventral end to the point where the dorsal part begins.

Marrow Extraction

The purpose of breaking mandibles, long bones, phalanges, and vertebrae was apparently, first and foremost, the extraction of marrow. The long bone shafts of the newborn animals and young calves 0–3 months old were complete. As early as an age of about 6–10 months, marrow had been extracted from the long bones. The presence of a complete jaw half from a 5-month-old calf shows that marrow was not extracted from mandibles of animals in this age group.

The *mandibles* were breached for marrow extraction, as has been recorded for Bushmen and Eskimos (Yellen 1977: 292, Binford 1978: 149–150). Most of the breaks formed a particular pattern, certain features of which are reminiscent of that described for the material from the coeval locality of Præstelyngen (Noe-Nygaard 1977: 225–226).

At least five pieces showed breaking across the corpus, aboral to the 2nd and 3rd molars (as at Præstelyngen) (fig. 38). The bases may have been broken off in slightly different ways: just under the molars and obliquely up through the diastema (as at Præstelyngen), somewhat further down on the corpus and basal to the incisors, or even more basally so that only the bottom margin of the jaw was broken off.

Fig. 35. Two left pelvis halves with dismemberment breaks across the neck and longitudinally through the symphysis. Parts of the ischium have been gnawed away by dogs. Ventral view.

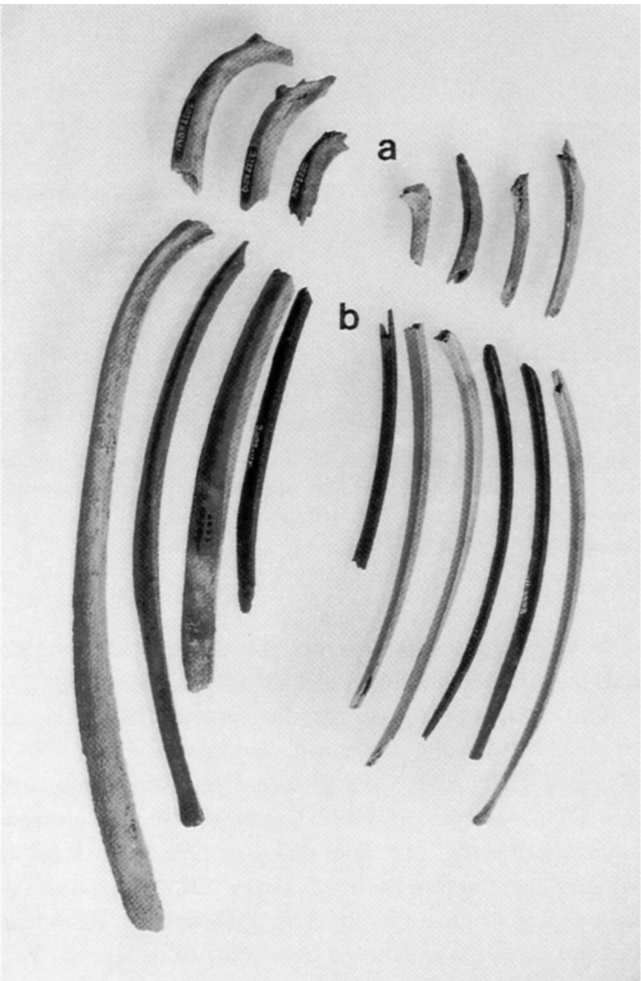


Fig. 36. Anatomical arrangement of rib fragments showing that the rib-slab has been deliberately broken at two places: (a) at the neck, leaving the heads attached to the spine, and (b) somewhat more ventrally.

Besides the dentigerous fragments, four basic pieces of varying size and a single fragment of the oral part of the jaw broken at the diastema were recorded. Four jaw fragments did not fit the pattern described.

Different indications revealed that the long bones had been broken, first and foremost, to obtain marrow. For the !Kung Bushmen and perhaps the Omaha Indians, this is the only, and for the Nunamiut Eskimo and Mistassini Cree, apparently the primary reason for breaking bones (Fletscher & La Flesche 1972: 274, Rogers 1973: 25, Yellen 1977: 292–293, Binford 1978: 144ff.).

Yellen reports that the Bushmen try to make the break so that the marrow can be extracted as entire and unsullied (by bone splinters) as possible, and that different bones are treated in different ways (1977: 293). It has also been established, both from the explanation of the !Kung and direct observation, that random breakage is *not* the rule (*ibid.*).

Neither Bushmen nor Eskimo prepare long bones in a meaty condition, but they fillet them first. Bushmen make biltong from the first meat to be cut off, and boil the rest. The pieces of bone are also added to the stew after marrow removal (*ibid.*). The Eskimo do not put broken bones in their stew, but can sometimes heat the bones in it, preparatory to extracting marrow (Binford 1978: 145–146).

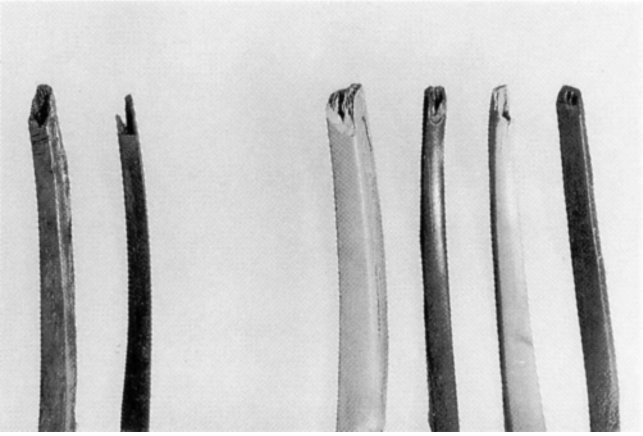


Fig. 37. The broken ends of six rib fragments, inner aspect. Medial view. The two pieces on the left have been cut from the inner side; the four on the right have marks from cutting on the outside and from snapping on the inside.

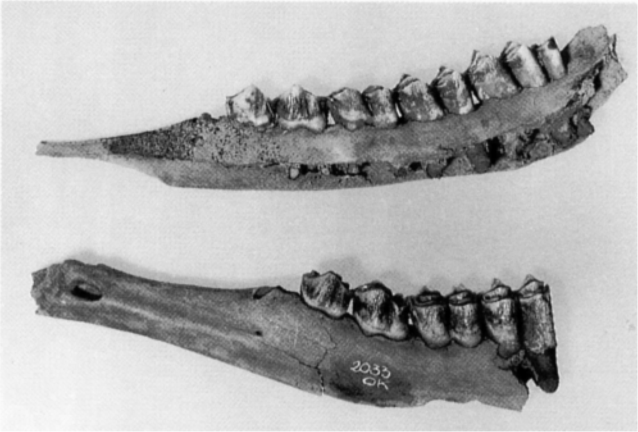


Fig. 38. Dentigerous fragments of marrow-broken left lower jaws. Lateral view.

Among the bone implements, the metapodials were the only long bones that were utilized as raw material.

The breakage pattern for the *humerus* (19 pieces) is reminiscent of that described for Præstelyngen (Noe-Nygaard 1977: 226). The proximal end was broken off just distal to the cancellous tissue where the marrow cavity begins (fig. 39). The distal end was struck off at varying distances up the shaft, either just proximal to the articulation or near mid-shaft (fig. 39). In most cases, the marrow cavity was exposed over most of its length. The shaft was apparently split into at least two parts.

The breakage pattern for the *radius* (26 pieces) did not resemble that observed for the Præstelyngen material (*ibid.*). In most cases, both the proximal and distal ends were struck off (figs. 28–29), after which the shaft was split into two or more pieces. More rarely, the bone was apparently struck across the middle, after which the resulting pieces were split, perhaps followed by another break at the junction of shaft and epiphysis.

The breakage pattern for the *femur* (23 pieces) differed from that at Præstelyngen, six or more instead of four fragments per bone (*ibid.*) resulting. The proximal end was struck off just distal to the cancellous bone (fig. 21); the head and the large trochanter were separated. The distal end was struck off, apparently usually without or with only a little of the shaft. The shaft was struck across the middle, and these pieces were then most often split lengthwise. Four pieces differed in being more intact.

The breakage pattern for the *tibia* (35 pieces) likewise differed from that observed at Præstelyngen; instead of four pieces per bone, six or more were produced (*ibid.* and p. 228). The proximal end was struck off just distal to the spongiosa. The distal end was struck off a short way up the shaft (figs. 11 & 33). The shaft was struck across the middle and split into at least two proximal and at least two distal pieces. Six larger, and thus less broken, pieces deviated from this pattern, but in all cases, the marrow was easily accessible.

Although seven pieces with unequivocal signs of toolmaking were excluded, fragmentation of the *metapodials* (73 pieces) gave a confused picture which presumably reflects a combination of marrow extraction and toolmaking. When extraction of marrow was the primary end, the breakage pattern seemed to accord with that observed for the femur and tibia, and thus different from that observed at Præstelyngen (Noe-Nygaard 1977: 226, 228). Both epiphyseal ends were struck off (figs. 19 & 30), and the shaft was broken across and split lengthwise into at least four pieces.

All five proximal *phalanges* and two out of the four medial phalanges were broken for marrow (fig. 8). The Nunamiut Eskimo boil caribou feet into a stew and, if food is limited, or marrow bones (long bones) are not immediately available for the meal, the proximal and medial phalanges are broken for marrow at mid shaft (Binford 1978: 148), which results in a break exactly like those observed for the Tybrind Vig material. The two distal phalanges were complete and unbroken (fig. 8).

Two almost whole *cervical vertebrae* (an axis and a 5th vertebra) were found, while the remaining 14 pieces,

Fig. 39. Proximal fragments of right and distal fragments of left marrow-broken humeri. Lateral and dorsal views.

Fig. 40. Several marrow-struck cervical vertebrae, ventral aspect. On the left are body fragments and on the right parts of the arch.

which are merely fragments, represented the whole cervical segment of the spine. The body and the arch were in all cases separated (fig. 40), which agrees with the Præstelyngen material (Noe-Nygaard 1977: 228).

Five body pieces were chopped through near the middle in the transverse dorso-ventral line (fig. 40) and one is whole. The vertebral processes were, in some cases, broken off the arch. The left dorsal part of the atlas was found as a chopped-off fragment. The breaks did not seem to be the result of dismemberment, such as described by Yellen (1977: 284), who reports that the Bushmen chop the cervical part of the spine down the middle into two parts to make transport home easier. The fragmentation patterns rather suggest the extraction of marrow for eating, as known from Omaha Indians' exploitation of bison (Fletscher & La Flesche 1972: 272). The vertebral column of neither the large antelope nor the caribou is used for its marrow, the yield being considered too small (Yellen 1977: 292, Binford 1978: 149).

The other ten pieces of both *thoracic* and *lumbar vertebrae* were most fragmented and eroded, and a pattern of breakage could not be distinguished. It can be mentioned, however, that among the former is a specimen that has opened epiphyses in which the spinal process is intact, in contrast to the Præstelyngen material (Noe-Nygaard 1977: 227–228). Also, among the lumbar vertebrae, a cranial body part was seen which was parted in the transverse dorso-ventral plane, while another vertebra was divided sagitally.

Tool-making

Bone breakage possibly related to the manufacture of implements was observed on the skull, the scapula, and the metapodials.

Nine proximal *antler* pieces attached to a frontal element were recorded. The cranium was clearly chopped to free the antler (fig. 7) (Rogers 1973: 23–24). Apart from this method sparing the whole antler in the first instance, it should also be the easiest way of removing it, if the purpose is merely to part it from the skull (Binford 1981: 109).

In two cases, breaks observed on the *scapula* may be derived from prehistoric human activity, the spine having been chopped off. This phenomenon should presumably be ascribed to tool-making, a similar break having been seen in material from the coeval settlement of Ringkloster in connection with the production of bone discs from scapula bone (Andersen 1975: 70–72).

Besides seven *metapodials* with unambiguous traces of tool-making, several types of fragments may be associated with this activity (5). For example, proximal pieces, split mediolaterally, are thought to be waste from the production of long bone points fashioned from the caudo-medial or caudo-lateral ridge. In contrast are epiphyses attached to the plantar part of the whole split shaft that are probably blanks for awls, bone points, or the like (fig. 41). At least six fragments exhibited cuts that may be attributed to tool manufacture. Thus, there were many, fine, long, parallel cuts along the length of the shaft, usually in the dorsal or plantar groove (fig. 12).

Utilization of the Skull

Skull parts comprising both face and neurocranium were not found. *Facial* fragments consist of parts of maxilla, one of which still has an attached nasal bone, a piece of zygomatic arch, and numerous loose teeth. It could not be established whether these parts were deliberately separated, but the state of preservation of the bones of other species represented, such as pine- marten and polecat, in conjunction with ethnographic observations (Rogers 1973: 23–24, Yellen 1977: 291–292, Binford 1978: 150–151), suggest that that was the case. Fat can be obtained from the nose and from behind the eyes, and breacking the cranial cavities provides a strong soup when the skull is boiled (Ingstad 1952: 127, Binford 1978: 151).

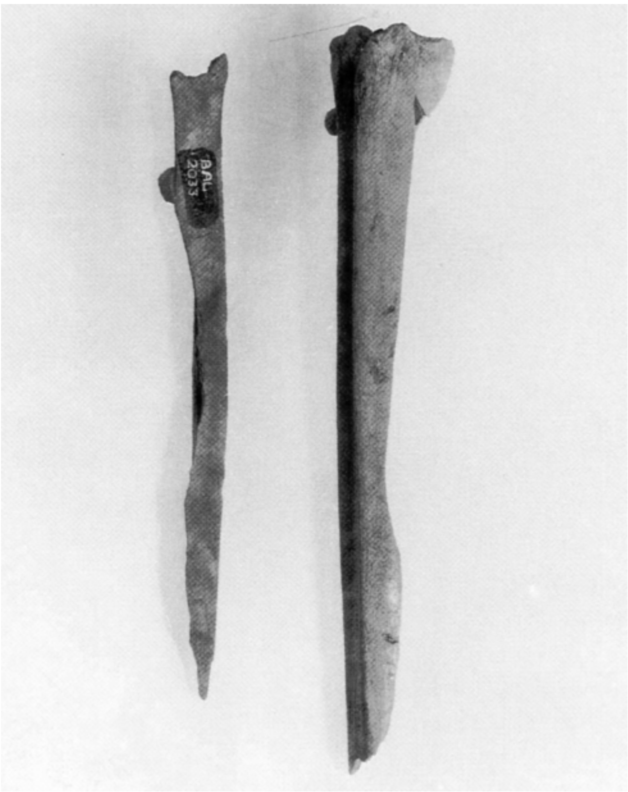


Fig. 41. On the left, a bone point fashioned from a left metatarsus and on the right an (unsuccessful?) unfinished piece for a similar implement fashioned from a right metatarsus. Lateral view.

In addition to the earlier mentioned frontal pieces with attached antler, the *neurocranium* was represented by seven fragments. Contrary to the case with the facial skeleton, distinct marks from blows were seen on bones of the cranium, and it was deliberately opened by humans. By a series of blows on the vault, the rear part was chopped away and then broken into left and right halves and perhaps into still smaller pieces, as indicated by half of one occipital condyle. This fragmentation facilitated extraction of the brain for eating or hide preparing, as known from extant populations (Ingstad 1952: 127, Fletscher & La Flesche 1972: 273, Rogers 1973: 23–24, 29, Yellen 1977: 292, Binford 1978: 151).

Skeletal representation

As mentioned earlier, bones were found from the greater part of the skeleton, with only the hyoid, caudal vertebrae, and sternum absent. Estimates based on the man-

Part	Number of fragments						Number of bone units						Representation %	
	found			expected			found			excepted				
	sin	dex	indet.	sin	dex	indet.	sin	dex	indet.	sin	dex	indet.	fragment	bone unit
Dentes			11											
Cranium	9	3	1			88			3			11	14.8#	27.3
Mandibula	13	8	3	44	44		11	5		11	11		27.3	72.7
Hyoideum									0			11	0	0
Atlas			1			22			1			11	4.5	9.0
Axis			3			33			3			11	9.0	27.3
Vertebrae cervicales			12			165			5			55	7.2	9.1
Vertebrae thoracales			5			286			3			143	1.7	2.1
Vertebrae lumbales			5			132			4			66	3.8	6.1
Vertebrae sacrales			2			66			2			44	3.0	4.5
Vertebrae coccygis			0			121			0			121	0	0
Costae	25	19	4			869			19			286	5.5	6.6
Sternum									0			11	0	0
Scapula	6	7		27.5	27.5		4	6		11	11		23.6	45.5
Pelvis	5	3	1	33	33		5	3		11	11		13.6	36.4
Humerus	8	11		44	44		7	4		11	11		21.6	50.0
Radius	12	13		44	44		2	5		11	11		29.5	31.8
*Ulna**	3	3		22	22		1	3		11	11		13.6	18.2
Carpalia	10	1		55	55		10	1		55	55		10.0	10.0
Matacarpus III/IV	11	8	14	see Mp			5	6		11	11			50.0
Femur	15	8		66	66		8	3		11	11		17.4	50.0
Patella		2		11	11			2		11	11		9.1	9.1
Tibia	15	20		66	66		5	5		11	11		26.5	45.5
Fibula	1	2		11	11		1	2		11	11		13.6	13.6
Astragalus	1	2		11	11		1	2		11	11		13.6	13.6
Calcaneus	5	5		11	11		5	5		11	11		45.5	45.5
Other tarsalia	3	5		33	33		3	5		33	33		12.1	12.1
Matatarsus III/IV	17	18	9	see Mp			7	7		11	11			68.2
Metapodium III/IV	28	26	26	110	110		12	13	2	22	22		36.4	61.4
Phalanx p.			5			176			4			88	2.8	4.5
Phalanx m.			4			132			4			88	3.0	4.5
Phalanx d.			2			88			2			88	2.3	2.3
Sesmoides			1											

Uncertain figure.

* Some fragments fused with radius.

Table 2. Representation of skeletal parts of red deer older than 3 months (at least 11 individuals).

dible indicate that at least 11 animals older than 3 months are represented. This information was used in producing table 2, together with results from the breakage pattern analysis.

In table 3, the representation of individual bones is shown according to the frequency in which they occur. There is nice agreement between the number of fragments of a specific bone and the frequency with which a bone element occurs, supporting the assumption that the order is characteristic of the material. Only a few bones (marked with an asterisk) occupy different positions in both columns. The radius was, on account of an easily identified shaft, relatively overrepresented among the fragments. The femur was perhaps for the opposite reason

Fragment		Bone unit	
Good, > 20%	%	*Good, > 40%*	%
Calcaneus	45.5	*Mandibula*	72.7
Metapodia	36.4	*Metapodia*	61.4
*Radius**	29.5	*Humerus*	50.0
Mandibula	27.3	*Femur**	50.0
Tibia	26.5	*Scapula*	45.5
Scapula	23.6	*Tibia*	45.5
Humerus	21.6	*Calcaneus*	45.5
Medium, 10–20%	%	*Medium, 10–40%*	%
*Femur**	17.4	*Pelvis*	36.4
Cranium	14.8#	*Radius**	31.8
Pelvis	13.6	*Cranium*	27.3
Ulna	13.6	*Axis**	27.3
Malleolus	13.6	*Ulna*	18.2
Astragalus	13.6	*Malleolus*	13.6
Other tarsalia	12.1	*Astragalus*	13.6
Carpalia	10.0	*Other tarsalia*	12.1
		Carpalia	10.0
Poor, < 10%	%	*Poor, < 10%*	%
Patella	9.1	*Patella*	9.1
Vertebrae	1.7–9.0	*Vertebrae*	2.1–9.1
Costae	5.5	*Costa*	6.6
Phalanges	2.3–3.0	*Phalanges*	2.3–4.5
Hyoideum	0	*Hyoideum*	0
Vertebrae coccygis	0	*Vertebrae coccygis*	0
Sternum	0	*Sternum*	0

* Bones not occupying the same position in both columns.

See Table 2.

Table 3. Representation of skeletal parts of red deer, with bones ranked by frequency of occurrence at Tybrind Vig (based on Table 2).

slightly underrepresented, while the axis, due to easy recognition of the characteristic knob, is well represented.

It is apparent from table 2 that 12.9% of the expected number of bones and 11.1% of the expected number of fragments were present. A loss of at least 87–89% could, thus, be directly observed. This accords with findings from other investigations at similar places (Noe-Nygaard 1979, Aaris-Sørensen 1983). The actual loss was much greater and could presumably be reconstructed only under very favourable find conditions. Below, attention will be focused on the relative loss, i.e. the quantitative ratio of skeletal remains present.

Transport Home

The bone assemblage from Tybrind Vig so far suggests that the entire deer was usually brought back home. In the first instance, nearly all parts of the skeleton were present, including small and distal bones like the phalanges and, in the second instance, large bones with relatively little utilization value, such as mandible, calcaneus, and axis, frequently occurred (table 4). This agrees with the Mistassini Cree treatment of moose and caribou where the whole animal is brought home and entirely utilized (Rogers 1973: 20–21, 39).

Disarticulation

The presence of small hoof bones in the discarded material is probably an expression of methods used to cut up the carcass. There are, thus, several examples of hoof bones being thrown together into the water, presumably still articulated by tendons. A collection may, for example, consist of the three proximal carpal bones, the two

Bone	%	Bulk Density	Marrow	Grease	Meat	Food
Group I						
Mandibula	72.7	0.57	6	13	31	44
Metatarsus	68.2	0.51	91	30	11	27
Metacarpus	50.0	0.53	64	29	5	11
Humerus	50.0	0.32	29	51	29	40
Femur	50.0	0.32	41	63	100	100
Scapula	45.5	0.36	6	8	45	43
Tibia	45.5	0.40	68	47	26	56
Calcaneus	45.5	0.64	21	47	11	32
Average	53.4	0.46	41	36	32	44
Average excl. metapodia	51.5	0.44	29	38	40	53
Range		0.32–0.64	6–91	8–63	5–100	11–100
Group II						
Pelvis	36.4	0.27	8	29	49	48
Radius	31.8	0.43	55	35	15	24
Cranium	27.3	–	–	–	–	
Axis	27.3	0.16	1	13	10	10
Ulna	18.2	0.37	–	–	14	27
Malleolus	13.6	–	–	–	–	–
Astragalus	13.6	0.47	1	32	11	32
Other tarsali	12.1	0.39	1	30	11	32
Carpal	10.0	–	–	–	–	–
Average	21.1	0.35	13	28	18	29
Range		0.16–0.47	1–55	13–35	10–49	10–48
Group III						
Patella	9.1	–	–	–	–	–
Vertebrae cerv.	9.1	0.19	1	17	37	36
Vertebrae thor.	2.1	0.24	1	12	47	46
Vertebrae lumb.	6.1	0.29	1	15	33	32
Costae	6.6	0.40	1	8	52	50
Sacrum	4.5	0.19	–	–	49	40
Phalanx p.	4.5	0.42	30	33	2	14
Phalanx m.	4.5	0.25	22	25	2	14
Phalanx d.	2.3	0.25	1	14	2	14
Vertebrae coccygis	0	–	–	–	–	–
Sternum	0	0.22	1	26	66	64
Average	4.4	0.27	7	19	32	34
Range		0.19–0.42	1–30	8–33	2–66	14–64

*including the tongue.

Table 4. Representation of red deer bone units in relation to bulk density and food value.

distal tarsals, and the proximal part of the metatarsal, or the distal and medial phalanges. In cases where the animal was dismembered differently, and those bones separated from one another, they were perhaps on account of their small size not thrown into the water; among other things, the isolated bones are easier for dogs to manage.

Utilization of the Long Limb Bones

The separation of long bone epiphyses was not equal. There are various reasons for such a differential presence in rubbish. The food value of the bones and the utilization associated with it partly explain the pattern observed. The juncture at which the epiphyses fuse with the shaft, reflecting the size and mineralization of the pieces, seems,

Bone	Fused and isolated epiphyses	Fused and isolated epiphyses and isolated diaphyses	Approximate time of epiphyseal fusion
Metacarpus p.	7	10	7 months
Metatarsus p.	10	10	7 months
Humerus d.	9	10	1½–2½ years
Radius p.	8	8	1½–2½ years
Tibia d.	7	9	2½–3½ years
Metacarpus d.	8	9	3½–5 years
Metatarsus d.	13	13	3½–5 years
Average	8.9	9.9	2½ years
Average excl. metapodia	8	9	2½ years
Range	7–13	8–13	–
Radius d.	4	5	4½–6½ years
Tibia p.	4	4	4½–6½ years
Femur p.	5	8	4½–6½ years
Femur d.	2	2	4½–6½ years
Humerus p.	5	5	4½–6½ years
Average	5.0	4.8	4½–6½ years
Range	2–5	2–8	–

*Complete obliteration of the epiphyseal line.

Table 5. Occurrence of long bone epiphyses related to approximate time of epiphyseal fusion.

however, to have a more general effect on the distribution. The representation of the epiphyses relative to timing of fusion will, therefore, be examined first.

In table 5, bones of individuals older than approximately 6 months were presented in the order in which epiphyses fuse. The first column gives the number of detached and fused epiphyses. The second column includes shaft pieces from the epiphysis end in question. It was apparent from that that the number of earlier fused ends was on average around ten, whereas the average figure for the later fused is just less than five. According to the skeletal part representation (tables 2–4), metapodials were the most frequently occurring long bones, which was presumably due to their being kept more carefully after dismemberment because of their role as a raw material for implement production. When metapodials were omitted from analysis in order to eliminate the effects of toolmaking, the representation of early fused epiphyses fell to nine. Apart from the proximal femoral epiphysis, there thus seemed to be a connection between the incidence of epiphyses and the time at which each fused. Epiphyses that fused at a late stage were underrepresented in relation to those that fused early, perhaps because unfused ends occurred in smaller units (one or more epiphyses and a diaphysis end) and exhibited a lower degree of mineralization than did fused epiphyses.

Skeletal representation can also reflect differential utilization of carcass and skeleton parts, manifested, for instance, by removal from the site of particular parts having high food value, or in differential crushing in the course of food preparation. This illustrates the importance of food value as a selective factor.

In connection with butchering and food preparation in which the crushing of bone was involved, the bulk density of the bone will also be important, that, too, relating to the resistance of the bone to destruction (Gifford 1981): compact bone parts are better able to withstand destruction than low-density pieces. This applies in general, of course, whether destruction is brought about by biological or geological agencies.

The unequal food value and bulk density of the various parts of the game animal thus result in individual bones being used and destroyed with different intensity and effect by both men and dogs. Also of taphonomic importance is the direct relationship between bulk density and food value, as demonstrated by Lyman (1985: 228–231). Thus, compact bone parts have low food and nutritional value, whereas low-density bones tend to have high value.

Bone	Fused and isolated epiphyses	Bulk density	Marrow	Grease	Meat	Food	Gnawed	
							n*	%
Metatarsus d.	13	0.46	100	43	11	24	6	54.5
Metatarsus p.	10	0.55	82	18	11	30	5	20.0
Humerus d.	9	0.39	28	28	29	37	6	83.3
Radius p.	8	0.42	44	38	15	27	4	0
Metacarpus d.	8	0.49	67	42	5	10	5	40.0
Metacarpus p.	7	0.56	62	17	5	12	5	40.0
Tibia d.	7	0.50	93	26	26	47	5	20.0
Average	8.9	0.48	68	30	15	27		36.8
Average excl. metapodia	8.0	0.44	55	31	23	37		34.4
Range	7–13	0.39–0.56	28–100	17–43	5–29	10–47		0–83.3
Femur p.	5	0.36	34	27	100	100	4	50.0
Humerus p.	5	0.24	30	75	29	43	4	50.0
Radius d.	4	0.43	66	33	15	22	4	25.0
Tibia p.	4	0.30	44	69	26	65	2	0
Femur d.	2	0.28	49	100	100	100	1	100.0
Average	4	0.32	45	61	54	66		45.0
Range	2–5	0.24–0.43	30–66	27–100	15–100	22–100		0–100.0

*Number of bone fragments permitting identification of gnawing, if present.

Table 6. Occurrence of long bone epiphyses related to bulk density, food value, and dog-gnawing.

In table 6, the column with detached and fused epiphyses was arranged in order of frequency. The bulk density, marrow, grease, meat, and total food value were given for each bone (after Lyman 1985: 227, table 2, partly referring to Binford 1978). Estimates of bulk density have been provided for two North American species of deer (*Odocoileus hemionus* and *O. virginianus*) and are believed to be of general validity for artiodactyls (Lyman 1985: 226ff.). The food values given refer to caribou, but comparisons with sheep show that the artiodactyl pattern is relatively uniform (Binford 1978: 13–58, 72–75). The percentage representation of dog-gnawed bones is also given. Eroded bones for which the presence of dog- gnawing cannot be evaluated were omitted from this column.

In agreement with the already demonstrated connection between the incidence of an epiphysis type and the timing of its fusion, the five last fusing epiphyses were seen to be the most poorly represented. At the same time, these bone parts had much greater food value than those with a higher incidence in the material. This was due to the high meat and grease value of the group, whereas the marrow value was actually generally somewhat lower than in the other group. A possible reason for the observed pattern could, therefore, be the transport of unfilleted meat away from the settlement. Only the femur, however, has a significant meat value that justifies this interpretation. Another reason for these epiphyses rarely being discarded could be that grease extraction crushed them. Judging by the grease values for the various bones, this would apply to the proximal part of the humerus, proximal part of the tibia, and distal part of the femur. These very parts are the ones with the lowest bulk density and, therefore, are the easiest to crush.

Both food value and bulk density must also be factors of importance to understanding which bones dogs prefer to gnaw and which they can destroy. No pattern was, however, apparent from the percentage distribution of gnawed bones (table 1). Part of the explanation for this is no doubt that dogs had access to the original bone material only after site inhabitants had already utilized it and drastically reduced its palatability.

Several factors in prehistoric behaviour seem to have contributed to the low representation of certain epiphyses. It is presumably of importance that these particular epiphyses were those which fuse later and which will, therefore, occur in several smaller parts and with a lower degree of mineralization in site deposits. They have also relatively high meat and grease value, and their density is generally low. This means that both men and dogs would, to a greater degree, both be interested in and able to crush these very epiphyses, and that dogs can devour them completely, while man would not find them a nuisance and would not, therefore, have cause to throw them into the cove. Although the metapodials might be imagined to deviate from the illustrated pattern because of their special role as potential raw material, that was, in fact, not the case, perhaps because it was the cannon bone shaft that was most often used for making tools.

Interpretation of the Total Skeletal Representation

All bones in table 4 were ranked according to the frequency with which they occurred in the faunal material, and their bulk density and trophic value were also stated (after Lyman 1985). For the long bones, the mean value for both the proximal and distal end was given.

From the food values given, it was not immediately possible to identify patterns that may be connected with transport away from the site or food preparation. The utilization of tarsals, carpals, and ribs for the extraction of bone grease and juice, as described for the Nunamiut Eskimo (Binford 1978: 32–38, 164–165), was not apparent from skeletal representation data. A low occurrence of ribs is more likely to be due to small fragment size as an effect of the dismemberment method described above.

An actual direct relationship between the representation of a bone and its compactness or fragment size seemed to be generally present. That a bone was poorly represented may thus be due to low density, small fragment size, or both. Low density implies that the bone was easier to break and crush. The fragment size could affect the frequency with which a particular type of bone was thrown out and on the chance of its being recovered by archaeological excavation. Since prehistoric behaviour involved bone breaking associated with the cutting up of the carcass, food preparation, and the manufacture of implements, all of which affected the size of fragments, these activities must have affected skeletal representation differentially.

The composition of the studied refuse was consistent with the settlement having been occupied at many seasons and, thus, perhaps for long periods, and with both intensive and varied activities. Thus, several quite small bone pieces were represented, including some from other species, and a large amount of antler (which neither rots nor smells) was cast away.

CONCLUSION

This paper has presented data and interpretations pertaining to the exploitation of red deer by prehistoric hunters. A reconstruction was attempted of the material aspects of haulage, butchering, and food preparation.

Apparently whole animals were usually brought back to the settlement. Individuals of all ages from newborn up to 15 years were killed. Whether skinning and primary dismemberment occurred at the kill site first, or later at the settlement, could not be determined from the bone material alone. Ethnographic observations suggest, however, that animals as large as the Danish subfossil red deer were cut up before transportation away from the kill site (Fletscher & La Flesche 1972: 271–275, Rogers 1973: 18–20, 35–37, Marks 1976: 121–122). The means of transport then available was probably important (Binford 1978: 48). Possibly the prehistoric hunters, like the Mistassini Cree, used canoes for transporting the butchered game. Among the finds from Tybrind Vig was an almost whole, 10-m-long dug-out and the remains of a similar but somewhat larger canoe (Andersen 1983, 1985).

There were several examples where the skin was cut free around the base of the antler (see fig. 6) during skinning of the deer. Apparently the skin was freed from the rostrum by cutting around this, after which a cut was presumably made in the ventral mid-line and out along the inside of the four limbs. Sometimes even the fingers and toes were skinned out using a transverse cut. In other cases, the skin was probably cut across more proximally around the cannon bone or right up on the shank.

Dismemberment has been carried out both by parting through the articulations and by breaking bones (fig. 13). Decapitation was effected with a cut above the first or second vertebra of the neck. The lower jaw was probably separated from the rest of the skull by cutting the masticatory muscle, and it was then divided at the symphysis.

The foreleg was divided into at least five parts, consisting of each of the four long bones (the metacarpal or radius/ulna perhaps with the carpals still attached) and the phalanges. The carpals may have been cut off as one or two units, and the phalanges possibly separated from one another, for example, before marrow extraction. The hind leg was correspondingly partitioned into at least six parts, one of which included all the tarsals or only the proximal ones. Parting through the femoro-tibial articulation was not documented, but it probably occurred.

The pelvis, including the sacrum, was split down the middle and the pieces further reduced in size by breaking at the neck of the ilium. The brisket was presumably removed, and the ventral end of the ribs sometimes touched by the knife. Presumably, after the cutting away of the fillet, the rib- slab, from and including the fourth rib, was broken away just below the chin. A more ventral break, prepared by cutting across the ribs, was then made.

Parts of the dismemberment process could not be immediately identified. Thus, no cut marks were found indicating partitioning of the chine, but the sparse occurrence of vertebral fragments, among other things, shows that this took place. The many breaks on the vertebrae are thought, first and foremost, to have been made in conjunction with marrow extraction (see below); but the possibility that certain of the recorded breaks had occurred in the process of dismemberment could not be ruled out.

Filleting, and the scraping away of flesh from head, neck, shoulder, rump, fore and hind legs, and the whole of the ventral rib portion, were documented. Some of the observed cut marks presumably originated during the cleaning of long bones preparatory to marrow extraction, and, in the case of cannon bones, also to tool-making. After the large muscles were cut from the bone, any small lumps of meat and periosteum that remained were probably cut and scraped off.

The type and size of skull fragments showed that breaking of the skull did not solely serve to free the antlers. The extraction of the brain for food or skin preparation, and possibly the removal of fat from the nose and behind the eyes, also occurred.

The mandibles, long bones, phalanges, and vertebrae were apparently, first and foremost, broken for marrow extraction. Only the cannon bones showed a breakage pattern reflecting both marrow extraction and utilization in tool-making. The extraction of bone grease and juice in a form requiring crushing of epiphyses of long bones, and of tarsals, carpals, and ribs, could not be unequivocally demonstrated, since the low representation of, for example, the actual epiphyses of the long bones may result from other causes. That bone grease and juice were used in one way or another seems likely, however.

No evidence of selective removal from the settlement of meaty parts was forthcoming. The observed skeletal part representation, combined with calculated food values for the individual bones, did not suggest that that was the case.

Comparative studies of butchering practice have been suggested by Wiessner (1982) as one of several means by which knowledge may be gained about the social aspects of production in a given society. Among the means available to groups of hunter-gatherers for reducing subsistence risks, sharing and storage were mentioned. It was argued that, in societies that primarily depend on sharing as a risk-reducing factor, a greater regularity in butchering practice is to be expected, whereas less regularity is to be expected for those that depend on storage (Weissner 1982: 174). Settlement refuse (the later archaeological material) usually occurs, however, in consumption units and not in original butchering and sharing units (Binford 1984: 249). Detailed analyses of bone assemblages, by which attempts are made to isolate butchering practices, must, therefore, precede comparative studies of butchering variability. It may also be possible, when bone evidence is considered alongside other archaeological evidence, that social relations connected with the later stages of food preparation can be inferred and interpreted.

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NOTES

1. The results presented in this paper are based on parts of an unpublished dissertation for a master's thesis submitted to the Institute of Prehistoric Archaeology, Aarhus University, in 1985. See Trolle-Lassen (1985). The manuscript was presented as a "precirculating paper" at the World Archaeological Congress, Southampton 1986.
2. The archaeological excavation was carried out by S. H. Andersen, Institute of Prehistoric Archaeology, Aarhus University.
3. Enquiries about possible marine predators were kindly answered by J. Just, University Zoological Museum, Copenhagen, and V. H. Jacobsen, Danish Fisheries and Marine Exploration, Charlottenlund.

4. L. B. Nielsen, Museum of Natural History, Aarhus, took part in the experiments on fur animals. P. Lassen, Jægersborg Dyrehave, Copenhagen and P. Rasmussen, The National Museum, Copenhagen, participated in the experiment on red deer.
5. See illustrations of bone implements in Andersen (1980, 1985).

REFERENCES

Aaris-Sørensen, K. 1983: An example of the taphonomic loss in a Mesolithic faunal assemblage. In *Animals and archaeology* 1, J. Clutton-Brock & C. Grigson (eds), 243–247. *BAR International Series* 163.

Albrethsen, S. E. & E. Brinch Petersen 1977: Excavation of a Mesolithic cemetery at Vedbæk, Denmark. *Acta Archaeologica* 47, 1–28.

Andersen, S. H. 1975: Ringkloster, en jysk indlandsboplads med Ertebøllekultur. *Kuml* 1973–74, 11–108.

– 1980: Tybrind Vig. Foreløbig meddelelse om en undersøisk stenalderboplads ved Lille Bælt. *Antikvariske Studier* 4, 7–22.

– 1981: Ertebøllekunst. Nye østjyske fund af mønstrede Ertebølleoldsager. *Kuml* 1980, 7–59.

– 1983: En stenalderbåd fra Tybrind Vig. *Antikvariske Studier* 6, 162–172.

– 1984: Tybrind Vig. *Current Archaeology* 93, 314–317.

– 1985: Tybrind Vig. A preliminary report on a submerged Ertebølle settlement on the west coast of Fyn. *Journal of Danish Archaeology* 4, 52–69.

Andersen, S. H. & C. Malmros 1985. Madskorpe på Ertebøllekar fra Tybrind Vig. *Aarbøger for nordisk Oldkyndighed og Historie* 1984, 78–95.

Barth, E. K. 1981: Rein og elg, livsviktige ressurser gjennom årtusener. *Fauna* 34, 150–161. Oslo.

Binford, L. R. 1978: *Nunamiut ethnoarchaeology.* New York: Academic Press.

– 1981: *Bones: ancient men and modern myths.* New York: Academic Press.

– 1983: *In pursuit of the past.* London: Thames & Hudson.

– 1984: Butchering, sharing and the archaeological record. *Journal of Anthropological Archaeology* 3(3), 235–257.

Birket-Smith, K. 1929: The Caribou Eskimos. *Report of the Fifth Thule Expedition 1921–24.* Copenhagen.

Christensen, C. 1982: Stenalderfjorden og Vedbækbopladserne. *Nationalmuseets Arbejdsmark* 1982, 169–178.

Driesch, A. von den 1976: A guide to the measurement of animal bones from archaeological sites. *Peabody Museum, Bulletin* 1. Cambridge.

Driesch, A. von den & J. Boessneck 1975: Schnittspuren an Neolithischen Tierknochen. *Germania* 53, 1–23.

Driver, f. 1986: Precirculating paper at The World Archaeological Congress, Southampton 1986.

Ekman, S. 1983: *Norrlands jakt och fiske.* Norrländska Skrifter no. 11. Umeå: Två Förläggare.

Ellenberger, W. H. Baum & H. Dittrich 1956: *An atlas of animal anatomy for artists.* New York: Dover Publications.

Fletscher, A. C. & F. La Flesche 1972: *The Omaha tribe.* New York: Johnson Reprint Corporation.

Frison, G. C. 1973: The Wardell Buffalo Trap 48SU301: communal procurement in the Upper Green River Basin, Wyoming. *Anthropological Papers of the Museum of Anthropology, University of Michigan* 48.

– 1978: *Prehistoric hunters of the High Plains.* New York: Academic Press.

Gifford, D. P. 1981: Taphonomy and paleoecology: a critical review of archaeology's sister disciplines. In *Advances in archaeological method and theory* 4, M. B. Schiffer (ed.), 365–438. New York: Academic Press.

Gould, R. A. 1967: Notes on hunting, butchering, and sharing of game among the Ngatatjara and their neighbours in the West Australian Desert. *Kroeber Anthropological Society Papers* 36, 41–66.

Hahr, Th. 1882: *Handbok för Jägare och Jagtvänner.* Andra Bandet. Stockholm: P. A. Norstedt.

Hayden, B. & A. Cannon 1983: Where the garbage goes: refuse disposal in the Maya Highlands. *Journal of Anthropological Archaeology* 2, 117–163.

Højlund, F. 1981: The deposit of sacrificed animals at the entrance to the tomb chamber. In *The Maussolleion at Halikarnassos.* The Sacrificial Deposit, K. Jeppesen, F. Højlund & K. Aaris Sørensen (eds). Jutland Archaeological Society Publications, 15, vol. 1, 21–89. Aarhus: Aarhus University Press.

Ingstad, H. 1952: *Nunamiut.* Oslo: Gyldendal Norsk Forlag.

Juel Jensen, H. 1986: Unretouched blades in the Late Mesolithic of South Scandinavia: a functional study. *Oxford Journal of Archaeology* 5(1), 19–33.

Juel Jensen, H. & E. Brinch Petersen 1985: A functional study of lithics from Vænget Nord, a Mesolithic site at Vedbæk, N.E. Sjælland. *Journal of Danish Archaeology* 4, 40–51.

Kehoe, T. F. 1973: The Gull Lake site: a prehistoric bison drive site in southwestern Saskatchewan. *Milwaukee Public Museum, Publications in Anthropology and History* no. 1.

Kristoffersen, F. 1974: Jagt på kronvildt. In *Nyt dansk Jagtleksikon V,* A. Weitemeyer & F. Hansen (eds), 1376–1381. Copenhagen: Branner & Korch.

Larsson, L. 1980: Stenaldersjägernas boplats och gravar vid Skateholm. *Limhamniana* 1980, 13–39. Malmö.

– 1981: En 7000-årig sydkustboplats. *Limhamnia* 1981, 17–46. Malmö.

– 1982: Skateholmsprojektet. Nya gravar och ett nytt gravfält. *Limhamniana* 1982, 11–41. Malmö.

– 1983: Skateholmsprojektet. Jägere – Fiskare Bönder. *Limhamniana* 1983, 7–40. Malmö.

– 1984: Skateholmsprojektet. På spåren efter gravsedsförändringar, ceremoniplatser och tama rävar. *Limhamniana* 1984, 49–84. Malmö.

Lyman, R. L. 1985: Bone frequencies: differential transport, *in situ* destruction, and the MGUI. *Journal of Archaeological Science* 12, 221–236.

Marks, S. A. 1976: *Large mammals and a brave people: subsistence hunters in Zambia.* Seattle: University of Washington Press.

Mathiassen, T. 1928: Material culture of the Igluik Eskimos. *Report of the Fifth Thule Expedition 1921–24.* Copenhagen.

Myers, T. P., M. R. Voorhies & R. G. Corner 1980: Spiral fractures and bone pseudo-tools at paleontological sites. *American Antiquity* 45(3), 483–490.

MØHL, U. 1972: Animal bones from Itivnerg West Greenland. *Meddelelser om Grønland* 191(6), 5–23.

NOE-NYGAARD, N. 1974: Mesolithic hunting in Denmark illustrated by bone injuries caused by human weapons. *Journal of Archaeological Science* 1, 217–248.

– 1977: Butchering and marrow fracturing as a taphonomic factor in archaeological deposits. *Paleobiology* 3(2), 218–237.

– 1979: Problems in quantification of archaeo-zoological material caused by differences in butchering and marrow fracturing techniques. In *Archaeozoology,* M. KUBASICZ (ed.), 109–119. Szczecin: Agricultural Academy.

PRICE, T. D. 1985: Affluent foragers of Mesolithic southern Scandinavia. In *Prehistoric hunter-gatherers,* T. D. PRICE & J. A. BROWN (eds), 341–363. New York: Academic Press.

ROGERS, E. S. 1973: The quest for food and furs: the Mistassini Cree 1953–54. *National Museums of Canada, Publications in Ethnology* 5. Ottawa.

SADEK-KOOROS, H. 1972: Primitive bone fracturing: a method of research. *American Antiquity* 37(3), 369–382.

SELINGE, K. G. 1974: Fangstgropar. *Fornyardaren* 12. Jämtlands Läns Museum.

SMED, P. 1984: Submarine stenalderbopladser i Danmark. Del I. *Meddelanden från Marinarkeologiska Sällskapet* 1984(2), 35–41. Stockholm.

– 1986: Registrering af undersøiske stenalderbopladser. *Fortidsminder* 1986, 35–67.

– 1987: *Registrering af submarine fortidsminder* – A registration and investigation of submerged archaeological sites. Skov- og naturstyrelsens havbundsundersøgelser. Copenhagen.

SPETH, J. D. 1983: *Bison kills and bone counts.* Chicago University Press.

SPETH, J. D. & K. A. SPIELMANN 1983: Energy source, protein metabolism, and hunter-gatherer subsistence strategies. *Journal of Anthropological Archaeology* 2(1), 1–31.

STRANDGAARD, H. 1974: Kronvildt. In *Nyt dansk Jagtleksikon V,* A. WEITEMEYER & F. HANSEN (eds), 1356–1373. Copenhagen: Branner & Korch.

STRAND PETERSEN, K. 1985a: The Late Quaternary History of Denmark. *Journal of Danish Archaeology* 4, 7–22.

– 1985b: Det sydfynske arkipelag. Dets geologiske udvikling med særlig hensyntagen til havnivaeuændringer og den marine mollusk fauna. In J. SKAARUP: *Yngre stenalder på øerne syd for Fyn,* 15–27. Meddelelser fra Langelands Museum 1985. Rudkøbing.

TAUBER, H. 1981: 13 C evidence for dietary habits of prehistoric man in Denmark. *Nature,* vol. 292, no. 5821, 332–333.

TROLLE-LASSEN, T. 1984: A preliminary report on the archaeological and zoological evidence of fish exploitation from a submerged site in Mesolithic Denmark. In *2èmes Rencontres* D'Archéo-Ichthyologie, N. DESSE-BERSET (ed), 133–143. Paris: C.N.R.S.

– 1985: *En zooarkæologisk analyse af Ertebøllebopladsen Tybrind Vig, primært baseret på knogler af pelsdyr og kronhjort.* Unpublished dissertation, Institute of Prehistoric Archaeology, University of Aarhus, Aarhus.

– 1986: Human exploitation of the pine marten (*Martes martes* (L.)) at the Late Mesolithic settlement of Tybrind Vig in western Funen. *Striae* 24, 119–124. Uppsala.

– 1987: Human exploitation of fur animals in Mesolithic Denmark – a case study. *Archæozoologia* I(2), 85–102.

VALENTIN-JENSEN, P. 1972: Krondyr. In *Danmarks Dyreverden* 10, H. HVASS (ed.), 217–238. Copenhagen: Rosenkilde & Bagger.

VANG PETERSEN, P. 1982: Jægerfolket på Vedbækbopladserne. *Nationalmuseets Arbejdsmark* 1982, 179–189.

– 1984: Chronological and Regional Variation in the Late Mesolithic of Eastern Denmark. *Journ. Dan. Arch.* 3, 1984, pp. 7–18.

WHEAT, J. B. 1972: The Olsen-Chubbuck site: a paleo-indian bison kill. *Society for American Archaeology, Memoir* 26.

WIESSNER, P. 1982: Beyond willow smoke and dog's tails: a comment on Binford's analysis of the hunter-gatherer settlement systems. *American Antiquity* 47, 171–178.

YELLEN, J. E. 1977: Cultural patterning in faunal remains: evidence from the !Kung Bushmen. In *Experimental archaeology,* D. INGERSOLL, J. E. YELLEN & W. MACDONALD (eds), 271–331. New York: Columbia University Press.

ZEIMENS, G. M. 1982: Analysis of postcranial bison remains. In *The Agate Basin site,* G. C. FRISON & D. J. STANFORD (eds), 213–240. New York: Academic Press.