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Mesolithic Hunting in Denmark Illustrated by Bone Injuries Caused by Human Weapons

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Animal skeletons from eight Danish Mesolithic settlements and 14 isolated bog finds have been investigated for injuries caused by hunters. The injuries comprise arrow-pierced limb bones, ribs and vertebrae together with healed and unhealed injuries found on shoulder blades. Special attention has been drawn to the skull lesions on *Sus scrofa* L. Some pathological features in the shoulder blades of the same animal are also discussed for comparison. The sizes and shapes of the injuries in some cases give an indication of the types of weapons that have been used. The proportion of unhealed to healed fractures seems to change during time. This feature may be related to the change to an increasingly stationary mode of life of the hunters.

Introduction

Hunting methods and techniques of prehistoric man can be inferred not only from cave paintings and remains of his weapons but also from injuries on the bones of his prey. These independent lines of evidence lead to the reconstruction of important aspects of the life style and food economy of our ancient predecessors.

Until very few years ago, prehistorians were merely concerned with establishing the bare chronological and geographical framework of their subject. The more advanced had sometimes sent the excavated bone material to a zoologist and asked him for determinations. Nowadays, interest in the biological evidence is increasing and archaeologists want to know more about the ecology of earlier human societies (Clark, 1972).

The most basic necessity for Mesolithic man, as for his modern counterpart, is food. From the refuse heaps of Mesolithic settlements we can discover not only which animals were exploited as a source of food, but also establish an order of preference. From the same refuse heaps it is possible to recover weapons with which the animals may have been killed. However, it is clear that the hunting methods employed cannot be deduced from the weapons alone.

The cave painting from Castellón (Figure 1) (Obermaier, 1924, Plate XIV) offers the synthesis of the relationship between the hunters and the prey. From the painting it is possible to deduce the species of deer hunted, red deer, the weapons with which the deer was hunted, bow and arrow, and the hunting method employed, that of driving a group of animals of both sexes and various ages towards a hide behind which the hunters were probably concealed.

From the settlements it is possible to obtain almost as good information about earlier hunting but it is necessary to use every fragment of information from the material

recovered. The bones not only tell us which species living at a given time were eaten by a particular ethnic group, but the different marks on the bones also give information on the way that the prehistoric community hunted and butchered prey.

This article deals with bone fractures caused by hunting. With this additional source of information it is possible to produce a picture nearly as perfect as that portrayed in Figure 1 of the methods of hunting used by Mesolithic man. From the size and shape of the fractures it is possible to deduce which weapons were used in the hunt and the way in which the hunt took place. Naturally, only a limited number of the various hunting methods employed can be deduced from the bone material; other methods such as net-catching, pit-falls, traps and poison stand little chance of being discovered.

Figure 1. A cave painting from Castellón in Spain synthesizing the relationship between the hunters and the game (after Obermaier, 1924, Plate 14). It shows the hunted animal species, the weapons with which they were hunted and the hunting method applied.

Material

The bone material examined in the present study derives from eight Mesolithic settlements and 11 isolated bog finds in Denmark (Figure 2 and Table 1) dating from the period between pollen zones IV and VIII. The 26 injured bones comprise skulls, shoulder blades, a vertebra, ribs and limb bones originating from five species: *Bos primigenius* (urus), *Cervus elaphus* (red deer), *Sus scrofa* (wild boar), *Capreolus capreolus* (roe deer) and *Cygnus* sp. (swan). Injured bones from the species *Alces alces* (elk) are to be described by Ulrik Møhl, Zoological Museum, Copenhagen, in the near future. The shoulder blades bear more or less rounded, healed and unhealed fractures, whereas ribs, vertebra, limb bones, and skulls are relatively thick bones and in these there is a reasonable possibility of retaining parts of the weapons in the bone matrix. Most of the material is dated by pollen analysis to the pollen zones worked out by Jessen (1920). In some cases no dating by pollen is available and the chronological placing of the bone is based on the implements with which it is found. These implements are assigned to a special period of human culture, and the duration of the different cultures are dated both by pollen and ^{14}C (see Table 1).

With a few exceptions the material is kept at the Zoological Museum in Copenhagen, while a small number are exhibited in the National Museum, Copenhagen.

The material of the wild boar deserves a few further remarks owing to the number of isolated bog finds.

From 34 isolated bog finds, eight skulls of both males and females were found with injuries; five of the skulls are dated to the Boreal time, pollen zone V; three are of unknown age. For most finds only the skulls were recorded and, furthermore, most of them were from the male boar. This also holds true for isolated bog finds of other species of animals. This disparity may be accounted for by the more striking outline of the impressive male skulls in comparison with those of the female, which could lead to a collection bias.

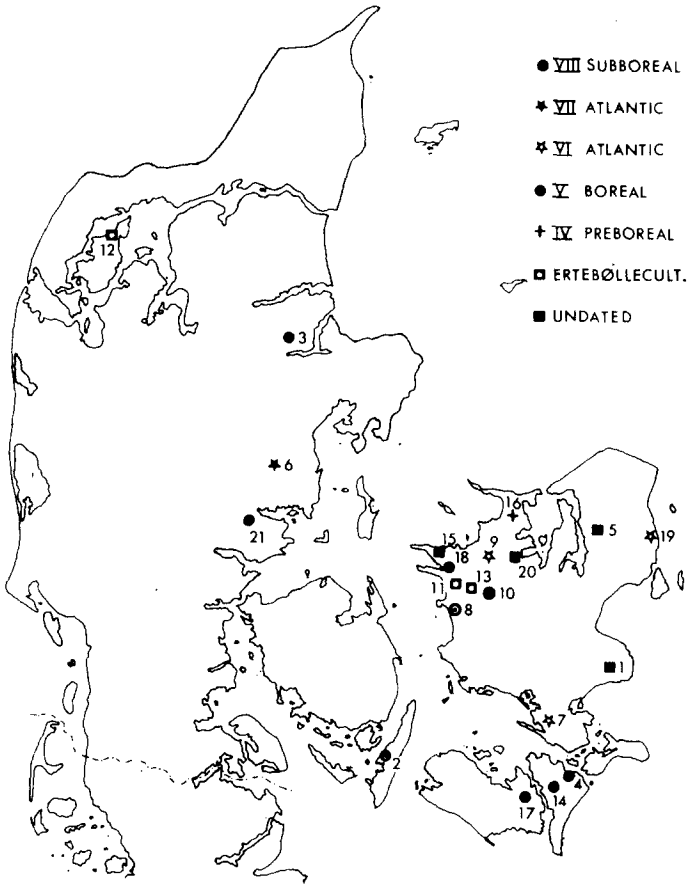

Figure 2. Map showing the distribution and age of the finds. 1, Frøslev mose; 2, Nørre Singelse; 3, Hastrup mose; 4, Stubbekøbing, Søborg mose; 5, Slagslunde; 6, Ringkloster; 7, Sværdborg; 8, Maglemose, Mullerup; 9, Kongemose; 10, Maglelyng; 11, Jordløse; 12, Morsø; 13, Åmoden; 14, 14, Taaderup; 15, Svenstrup; 16, Vig; 17, Grænge mose; 18, Aldersro; 19, Aldersro; 19, Henriksholm; 20, Holbæk, Trønning mose; 21, Fuglekjaer mose, Stenderup.

Finds from settlement deposits comprise three shoulder blades, one dated to the pollen zone V, one to zone VI, and one to zone VII. It was found necessary to illustrate most of the skulls with drawings. This is because they have been treated with wax which darkens the bones and renders them unsuitable for photography.

Bos primigenius Bojanus

(1) *Preboreal period, zone IV*

Locality: Vig, Odsherred, Sjælland (Figure 2). An isolated bog find of a nearly complete skeleton of a bull. The find was published by Hartz & Winge (1906), who showed that two of the ribs had injuries containing flint. One of these ribs shows a healed fracture and slight callus formation around the flint; the other an unhealed fracture. Hartz &

Table 1. The stratigraphic distribution of the total number of injured bones described in this paper

BC ^{14}C Conv.	Pollen zones	Human culture	Genus	Locality	Isolated finds	Settlement finds
	Unknown age		*Sus scrofa*	Trønning mose	X	
			Sus scrofa	Frøslev mose	X	
			Sus scrofa	Slagslunde	X	
			Sus scrofa	Svenstrup	X	
	Subboreal VIII	Tragtbæger culture	*Cervus elaphus*	Maglelyng		X
3200			*Cervus elaphus*	Maglelyng		X
	Atlantic VII	Ertebølle culture	*Cervus elaphus*	Ringkloster		X
			Sus scrofa	Ringkloster		X
			Cervus elaphus	Åmosen		X
			Cervus elaphus	Jordløse		X
4400			*Cervus elaphus*	Jordløse		X
			Cygnus sp.	Henriksholm		X
			Sus scrofa	Sværdborg		X
	Atlantic VI	Kongmose culture	*Capreolus capreolus*	Kongemosen		X
			Capreolus capreolus	Kongemosen		X
			Cervus elaphus	Kongemosen		X
			Cervus elaphus	Kongemosen		X
			Cervus elaphus	Kongemosen		X
6600						
	Boreal V	Maglemose culture	*Sus scrofa*	Maglemose		X
			Sus scrofa	Fuglekjær mose	X	
			Sus scrofa	Nr. Sengelse	X	
			Sus scrofa	Søborg mose	X	
			Sus scrofa	Hastrup mose	X	
7400			*Sus scrofa*	Aldersro	X	
			Bos primigenius	Grænge mose	X	
	Preboreal IV	Klosterlund culture	*Bos primigenius*	Vig	X	

Winge concluded (1906, p. 233) that the urus had been hunted at least twice: it survived the first encounter, but the second time it must have died shortly after it was hit in the rib with the unhealed fracture. Noe-Nygaard (1973) suggested that the shoulder blades probably had been penetrated by a spear, as indicated by the size of the hole in the left blade (max. length = 48 mm; max. width = 38·5 mm).

(2) *Boreal period, zone V*

Locality: Grænge mose, Lolland (Figure 2). Parts of the skeletons of four individuals were found in a bog. Three of the animals were dated to zone V, Boreal time. The find has been published by Andersen & Møller (1946) and Degerbøl & Fredskild (1970, p. 10). A left shoulder blade from an adult individual showed a remarkable fracture in

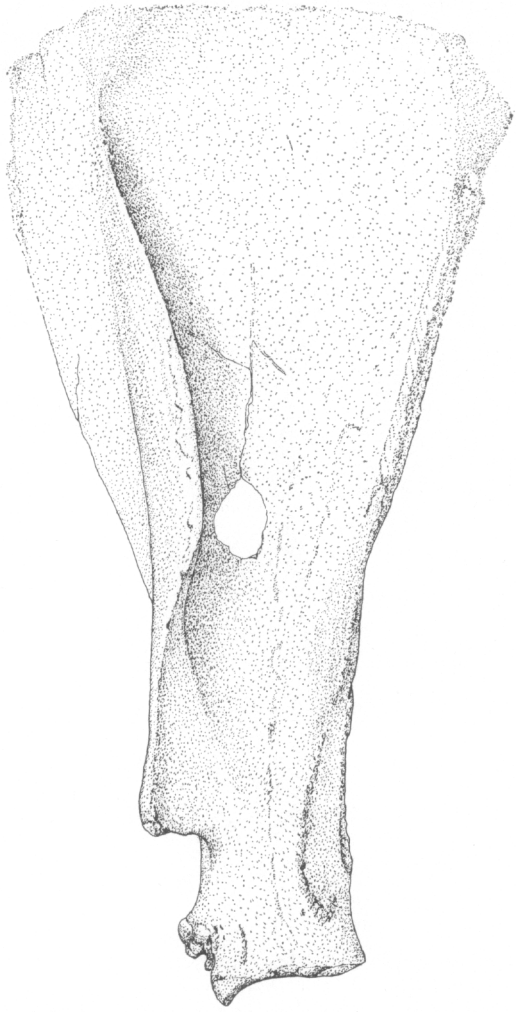

Figure 3. The left scapula of *Bos primigenius* from the locality Grænge mose, Boreal period, zone V, seen from the outside. The blade was penetrated from the inner side. The fracture is unhealed. Length 515 mm.

the lower proximal part of the blade (Figure 3 and Plate 1). The outline of the fracture is oval with a maximum length of 40 mm and the greatest width perpendicular to the length of 28·5 mm. The rim of the fracture shows a lot of scars of flakes of bone on the outer side of the blade, whereas the inner side shows a clear cut rim. There are no visible signs of healing. The perforation is thought to be due to a weapon that passed through the blade from the inner side and as it penetrated the bone, tore splinters of bone from

the outer side (Noe-Nygaard, 1973). The type of weapon used was in all probability a spear; the role it played in the hunt is discussed below.

Cervus elaphus L.

(1) *Atlantic period, zone VI*

Locality: Kongemosen in the Åmose bog, Sjælland (Figure 4). A settlement find excavated by Svend Jørgensen and published in 1956, a left scapula (KS 40/30–39) from a juvenile animal. The coracoid epiphysis is only slightly attached and the size indicates

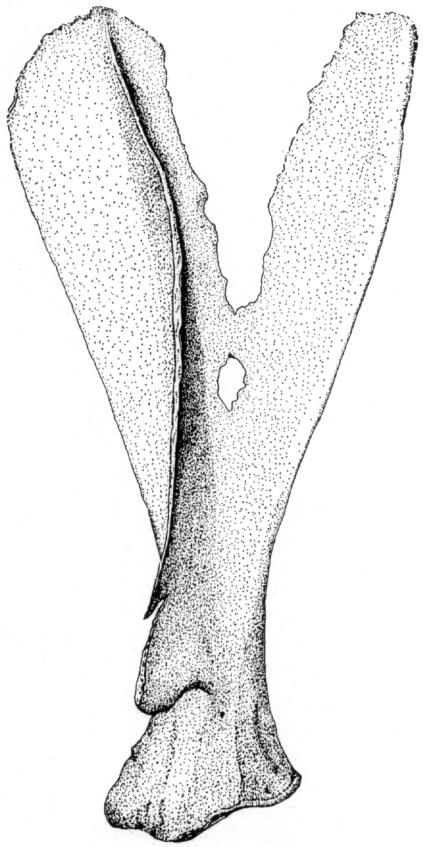

Figure 4. The left scapula of *Cervus elaphus* from the Kongemose site, Atlantic period, zone VI. The blade has been penetrated from the inner side; the fracture is unhealed. Length 200 mm.

a female. There is a fracture in the blade with an unhealed rim (Figure 4 and Plate I). Scars after splintering are seen on the outer side, and small outward-pointing bone splinters are still attached to the rim. There is a small notch in the proximal part of the rim (Plate I).

(2) *Atlantic period, zone VI*

Locality: Kongemosen, the Åmose bog (Figure 2), a settlement find.

A right shoulder blade (KS of 226) from an adult male. On the lower proximal part of the blade an almost circular fracture is to be seen (Figure 5; Plate IIIb1). The rim of the

hole shows no signs of healing, with the outer side covered by many scars from bone splinters; the inner side with a clear cut rim. The size of the hole has a maximum length of 20 mm, and a maximum width of 16·5 mm. The circular shape of the fracture with a little notch in the distal part (Plate IIIb2 and b3), together with the way the splintering scars are arranged, might be used to interpret from which side the weapon penetrated

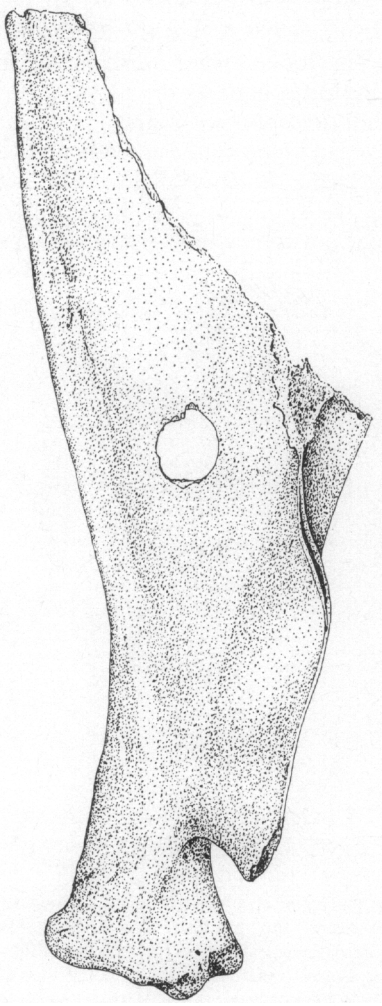

Figure 5. The right scapula of *Cervus elaphus* from the Kongemose site, Atlantic period, zone VI. The blade has been penetrated from the inner side; the fracture is unhealed. Length 248 mm.

the blade. In this case the instrument may have been some sort of harpoon which, either when it entered or as it was wrenched out, broke off part of the rim with its barbs and thus created the little notch. The scars after splintering are more plentiful at the lower distal part, indicating the direction of the penetrating weapon as coming from slightly above and in front of the animal and most likely to have passed right through its body.

(3) *Atlantic period, zone VI*

Locality: Kongemosen in the Åmose bog (see Figure 2), a settlement find. A left caput humeri (KS 40/32–57) from a juvenile deer with an oblique arrow-head, three quarters buried in the bone (Plate V). The solid bone is fractured indicating that the shot was rather forceful (Figure 6). Neither the crater created by the impact of the arrow-point nor the fracture show any sign of healing, which means that the death of the animal must have taken place very shortly after it was hit by the arrow found in the bone, but the arrow wound itself was not sufficient to cause the death of the deer.

The epiphysis shows no sign of incipient adhesion to the diaphysis and this, considered in relation to size, indicates male as the most likely sex, and gives a reasonable ontogenetic age of the animal of about two years.

The position of the arrow-head in the bone perpendicular to the surface of the epiphysis in the posterior part indicates the direction of the shot. The animal was shot from in front, and, in order to free the epiphysis from the cover of the proximal part of the scapula, the leg of the animal must have been bent in a backwards position.

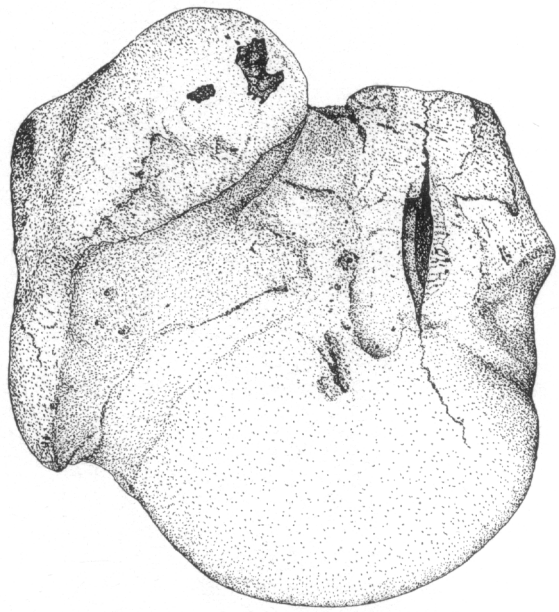

Figure 6. The proximal epiphysis of a left humerus, pierced by an oblique arrow-head; the fracture is unhealed. The Kongemose site, Atlantic period, zone VI. The impact was rather forceful since it has produced a crevice in the bone. Width 65·3 mm.

The arrow-head is an oblique arrow as defined by Mathiassen (1948, pp. 59–60). The tip of the arrow points backwards in the bone with the longest edge buried deepest in the epiphysis (Figure 7a, b). The arrow-head was broken in seven major pieces six of which were still found *in situ* in the bone together with some minute flakes splintered from the point. The very tip of the arrow-point had broken into five pieces, but they lay undisturbed and fixed in the bone and showed the outline of the arrow-head, indicating that the fracturing took place when the arrow hit the bone. The last fragment of the arrow-head is missing. This originated from the shortest sharp edge and was probably placed in a notch in the arrow shaft. This part of the arrow-head now shows a rather blunt edge with small flakes still sitting on the back end, i.e. that closest to the core from which the flake was separated. It may therefore be assumed that as a result of the impact

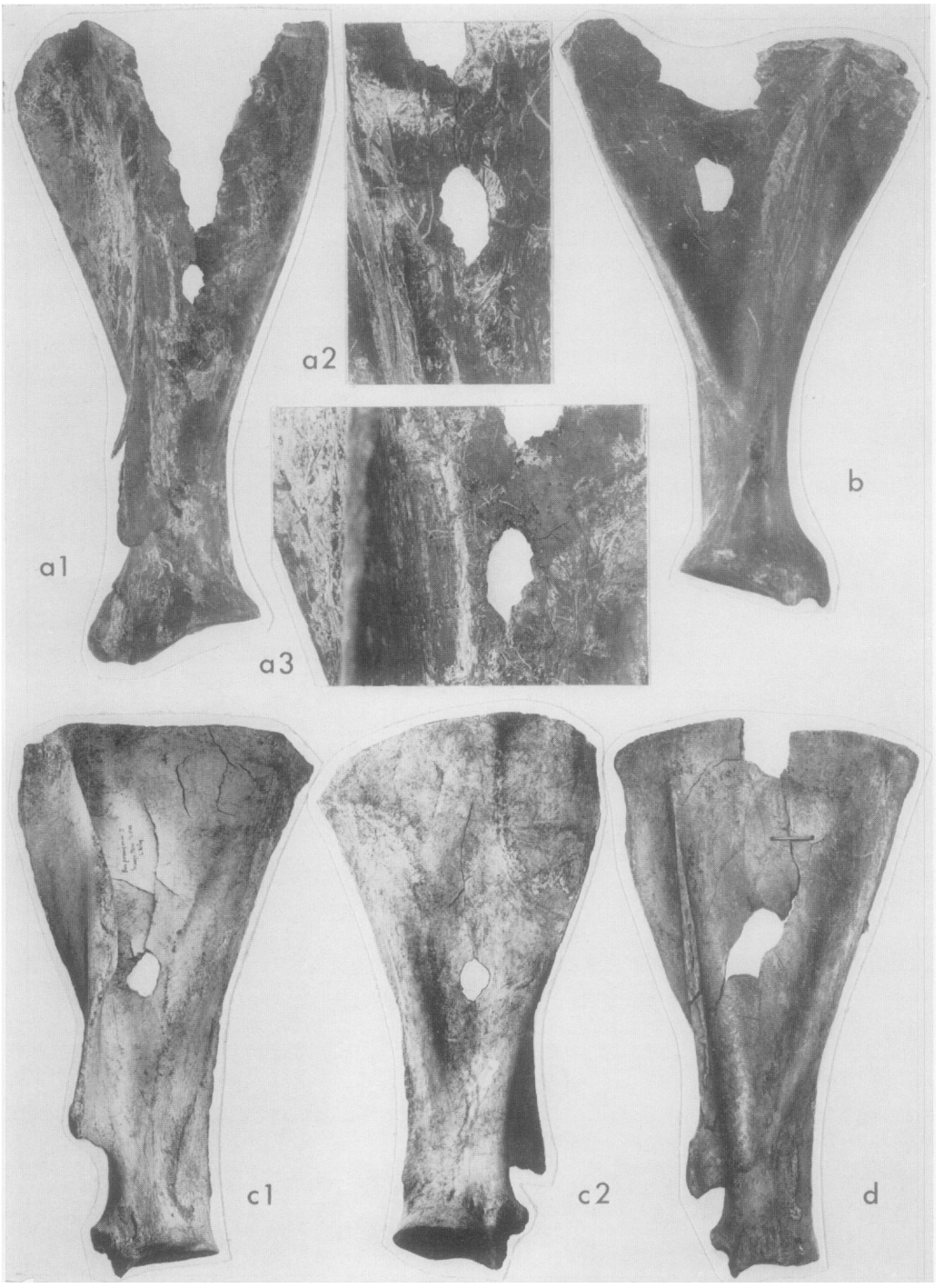

Plate I. a1, The left scapula of *Cervus elaphus* with an unhealed fracture from the Kongemose bog, Atlantic period, zone VI (length 200 mm). a2, The clear cut rim of the inner side of the fracture. a3, The rim of the unhealed fracture shows on the outer side scars after bone splinters. b, The right shoulder blade of *Capreolus capreolus* from the Kongemose bog, Atlantic period, zone VI. The fracture at the centre shows no signs of healing. Length 145 mm. c1, The left shoulder blade of *Bos primigenius* from the Grænge mose bog, Boreal period, zone V. The rim of the unhealed fracture shows on the outer side scars after bone splinters. c2, The rim of the inner side is clear cut. Length 515 mm. d, The left shoulder blade of *Bos primigenius* from Vig, Preboreal period, zone IV. Note the circular shape of part of the fracture. Length 518 mm.

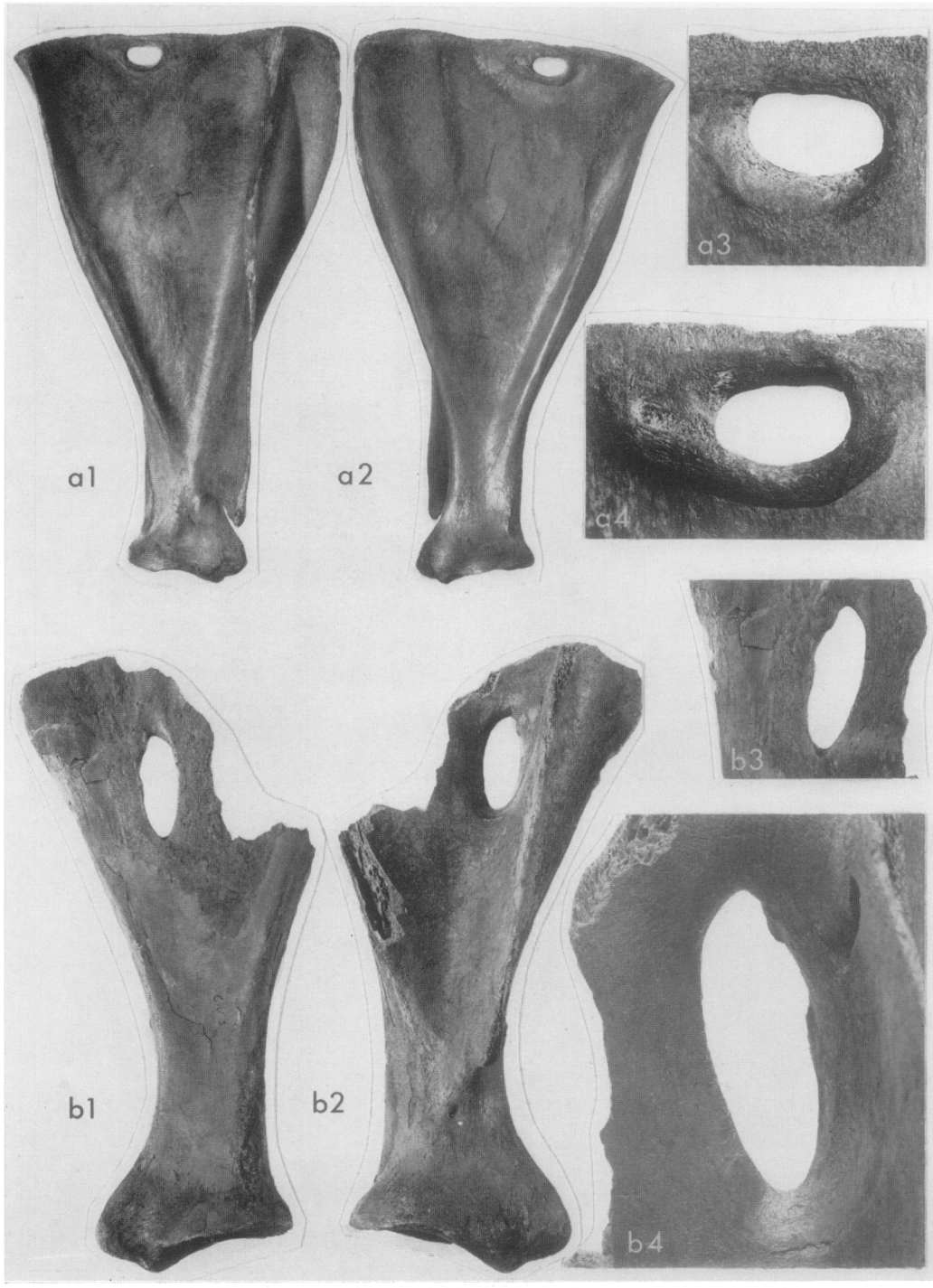

Plate II. a1, The left shoulder blade from *Cervus elaphus* from the Åmose bog near Maglebjerg. The healed fracture shows very little callus formation. Length 235 mm. a2, Inner side of the blade. a3, Outer side of the healed fracture. a4, Inner side of the healed fracture. Note the callus formation around the hole. b1, The shoulder blade from *Cervus elaphus* from the Jordløse bog. The large perforation is smoothly healed. Length 182 mm. b2, Outer side of the blade. b3, The inner side of the fracture. b4, The outer side of the fracture. Note on the right side the two struts.

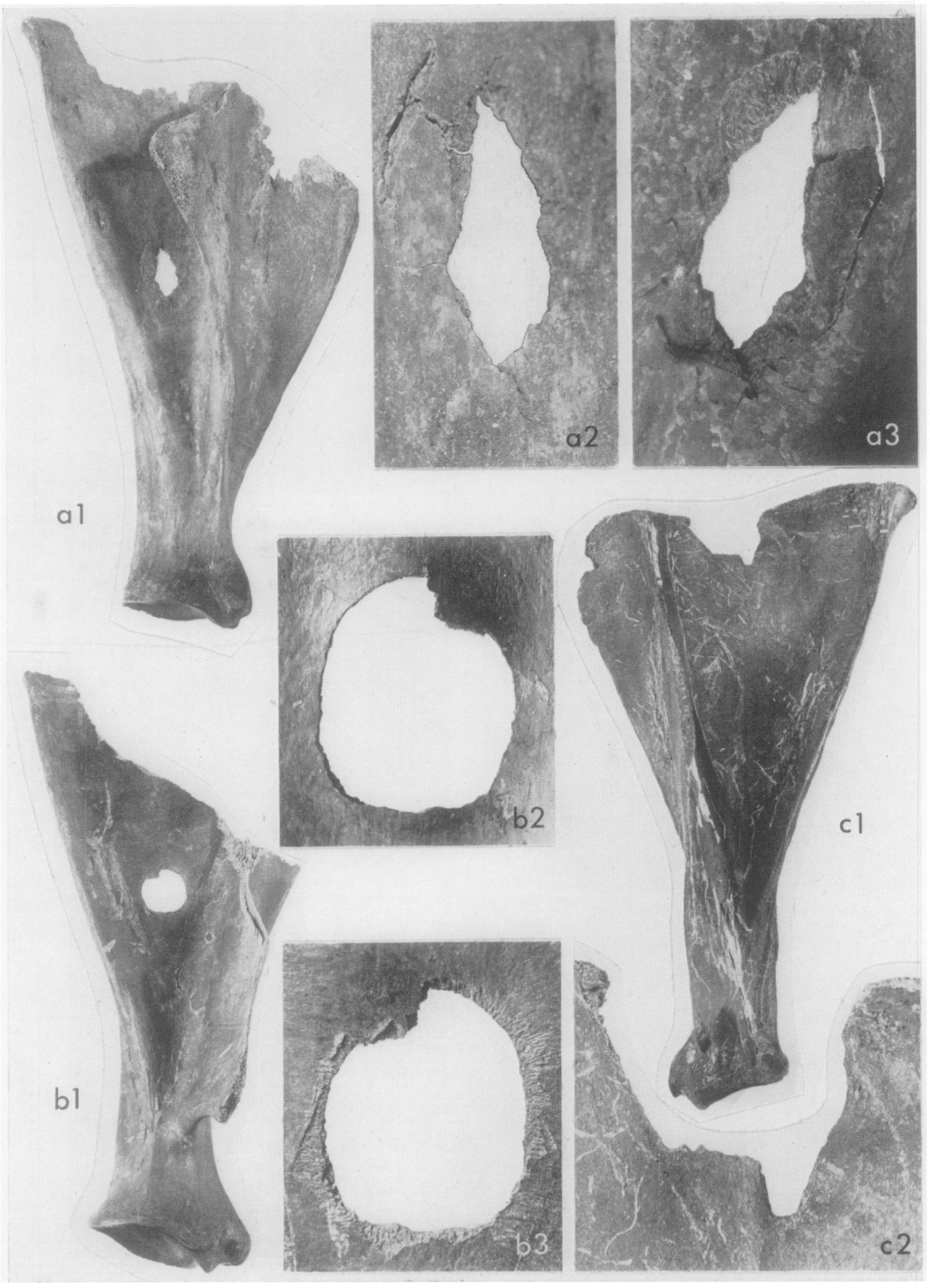

Plate III. a1, External view of the right shoulder blade from *Sus scrofa*. The fracture in the centre shows no healing. It is from Maglemose and dated to the Boreal period, zone V. Length 240 mm. a2, The outer side of the fracture. a3, The inner side of the fracture. Note the scars from bone splinters around the rim. b1, The right shoulder blade from *Cervus elaphus* with an unhealed fracture, from the Kongemose bog dated to Atlantic period, zone VI. Length 248 mm. b2, The inner side of the fracture. b3, The outer side of the fracture with numerous scars after bone splinters. c1, The left shoulder blade from *Capreolus capreolus* from the Kongemose bog dated to the Atlantic period, zone VI. The shoulder blade has a marginal healed fracture. Length 146 mm. c2, The healed fracture.

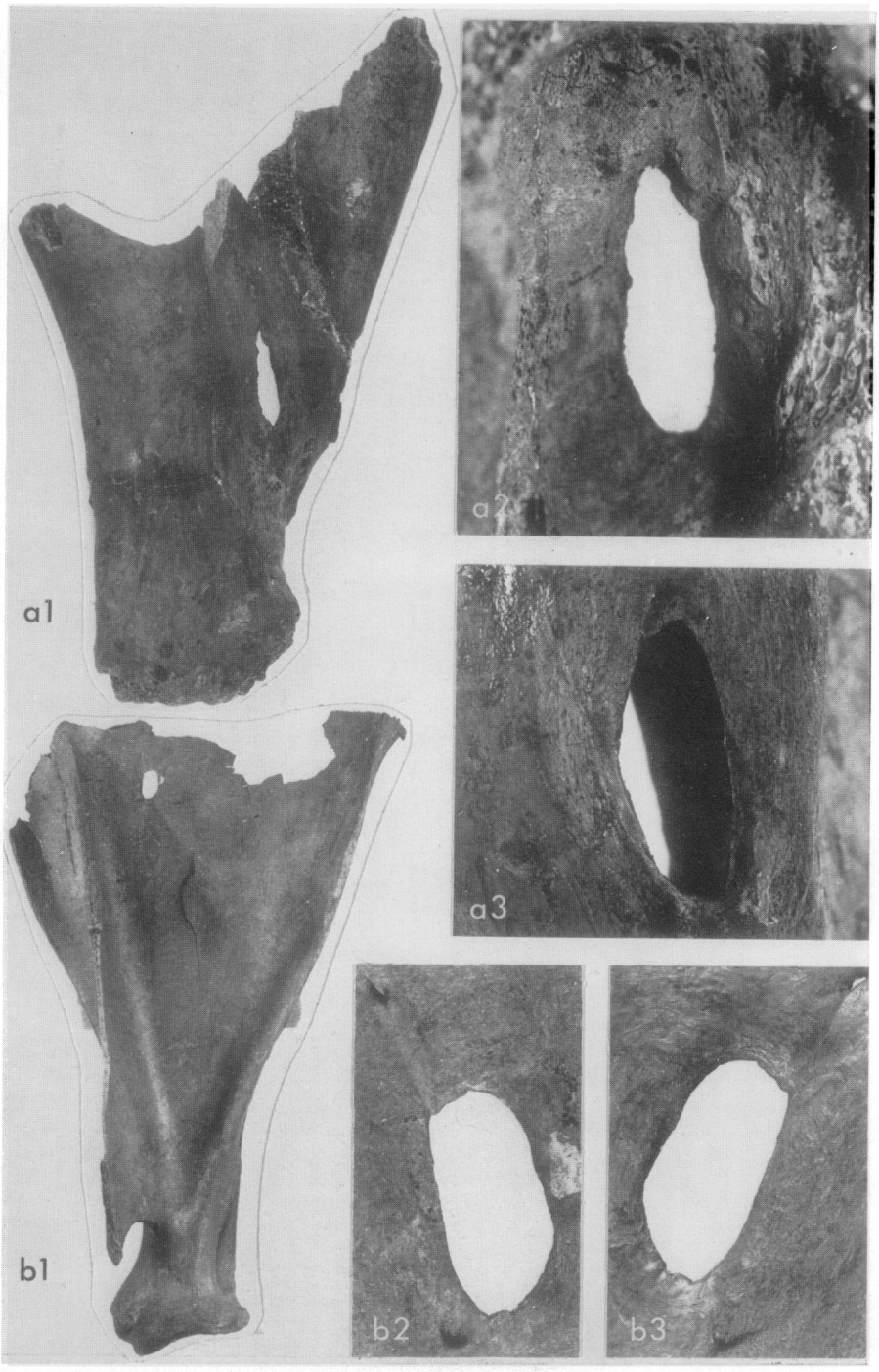

Plate IV. a1, The right shoulder blade of *Sus scrofa* from Sværdborg, Atlantic period, zone VI. The healed perforation is surrounded by strong, uneven callus formation. The joint of the blade has been gnawed by dogs. Length 122 mm. a2, The fracture on the outer side. a3, The fracture on the inner side. b1, The outer side of the left shoulder blade of *Cervus elaphus* from the Jordløse bog, Ertebølle period. The blade has a healed injury; at both ends of the healed fracture a channel can be seen. Length 246 mm. b2, The outer side of the fracture. b3, The inner side of the fracture. Note the two channels in both b2 and b3.

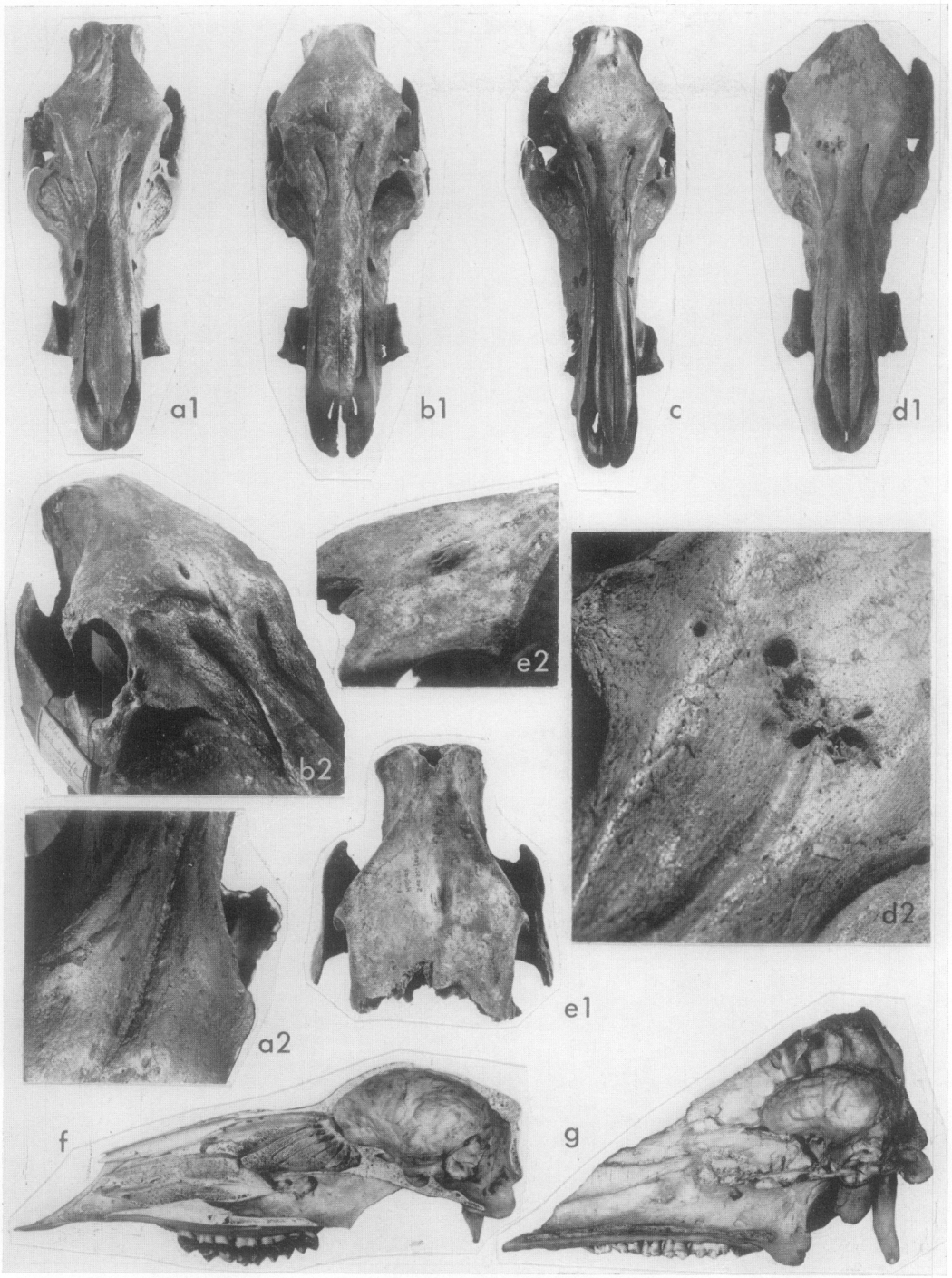

Plate VII. a1, The skull of *Sus scrofa* from the Slagslunde bog, unknown age, with a healed fracture 112 mm long in the frontal bones. Length of the skull from the premaxillaries to the back of the parietal bone: 435 mm. a2, Details of the healed perforation. b1, The skull of *Sus scrofa* from Hastrup mose dated to the Boreal period, zone V. In the right side of the frontal bone there is a healed fracture with a shape indicating that it was caused by an axe. Length *c.* 414 mm. b2, Details of the injury showing the outline. c1, The skull of *Sus scrofa* from Måløv-Knardrup 416 mm. d1, The skull of an old male *Sus scrofa* from Aldersro dated to the Boreal period, zone V. A healed injury in the frontal bone of the right side contains a flint. Length *c.* 396 mm. d2, Note the piece of white flint 1 mm long within the healed injury in the centre. e1, The skull of *Sus scrofa* from Trønning mose. The skull is incomplete and has a healed fracture in the centre of the frontal region. e2, Details of the healed fracture. f, Skull of *Cervus elaphus* sectioned longitudinally to show the thickness of the brain-case. g, A longitudinal section through the skull of *Sus scrofa* to demonstrate the thickness and construction of the brain-case.

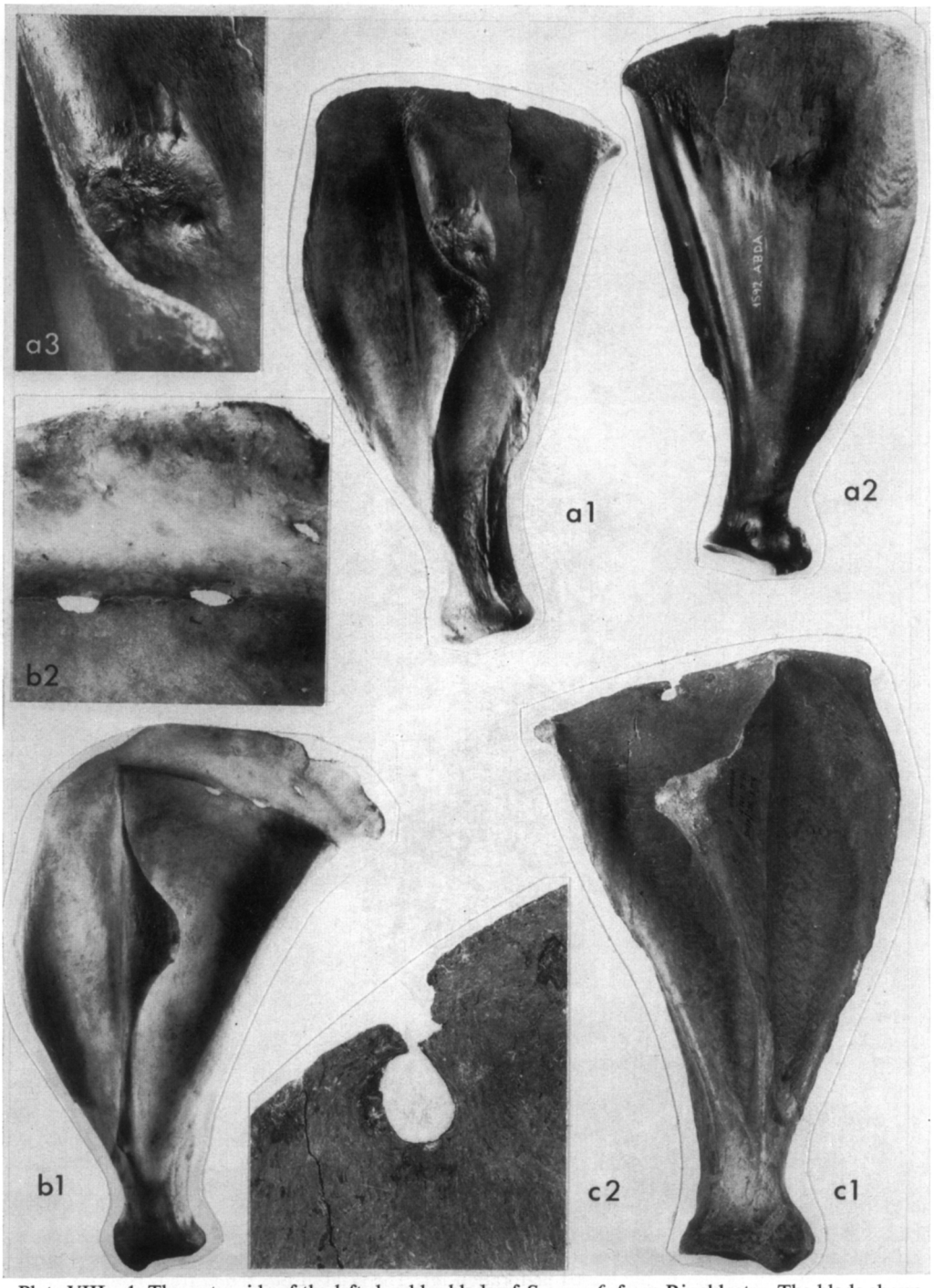

Plate VIII. a1, The outer side of the left shoulder blade of *Sus scrofa* from Ringkloster. The blade shows a healed fracture under the spine. Length 265 mm. Note the two embayments in the border. a2, The inner side of the blade with little callus formation indicating that the weapon hardly penetrated. a3, The callus on the outer side of the blade (×2). b1, A shoulder blade of a modern *Sus scrofa* showing the ceased growth marks in the border zone between bone and cartilage. Length 340 mm. b2, The two pathological perforations (×1). c1, A shoulder blade of *Sus scrofa* from Holmegaard mose dated to the Boreal period, zone V. In the distal edge of the blade there is a round perforation proved to have a pathological explanation. Length 280 mm. c2, Note the nicely healed appearance of the hole (×1). c2, Picture showing the nicely healed hole, thought to have pathological origin.

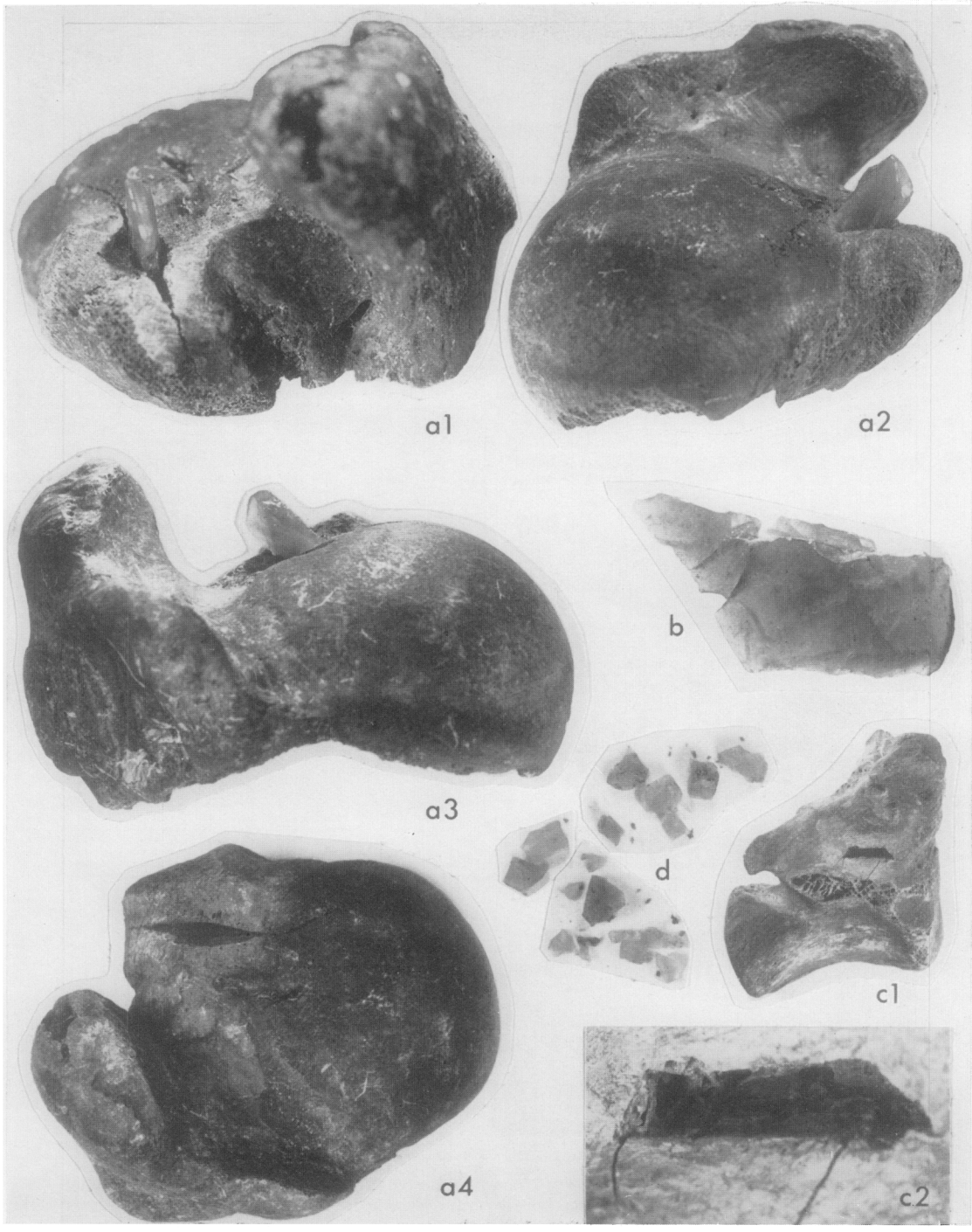

Plate V. a1, The proximal epiphysis of the left humerus of *Cervus elaphus* pierced by an oblique arrow-head. The unhealed fracture is extended as a crevice. Width 63·5 mm. a2, Side view. a3, Front view. a4, The bone viewed from above; note the outline of the fracture. b, The extracted oblique arrow-head. c1, Lumbar vertebra of *Cervus elaphus* from the Ringkloster site, Atlantic period, zone VII. Note the fracture on the arch. A little less than natural size. c2, The fracture (I× 5). Note the trapezoidal outline. d, Some of the extracted splinters of flint.

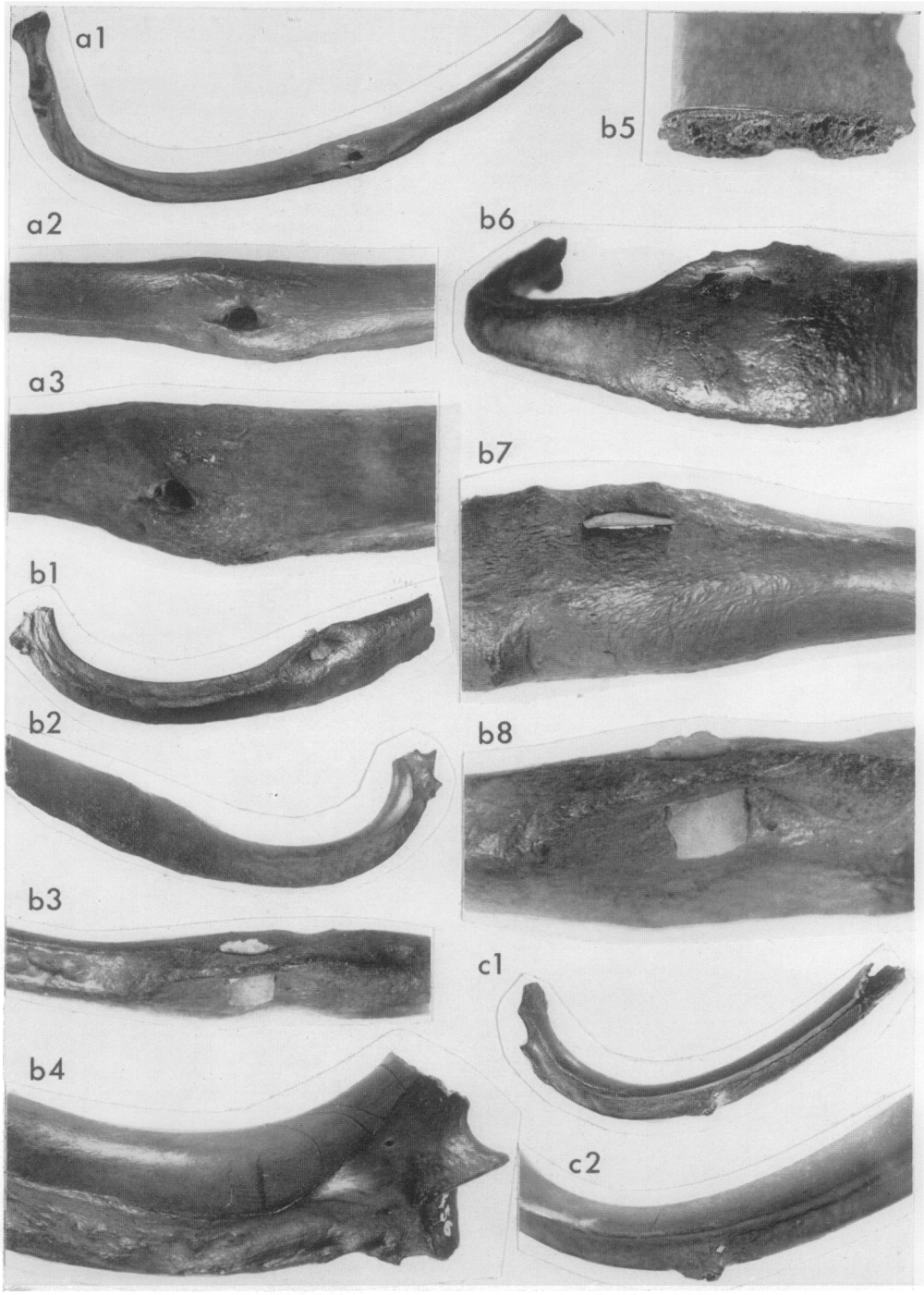

Plate VI. a1, The ninth rib on the left side of *Cervus elaphus* containing small overgrown pieces of flint. Maglelyng complex, Åmosen, dated to Subboreal period, zone VIII. Length 324 mm. a2, The healed injury with callus formation. a3, At the centre of the callus a small fragment of flint *c.* 1 mm long can be seen. b1, The sixth or seventh rib on the right side from *Cervus elaphus*. From the Maglelyng complex dated to Sub-boreal period, zone VIII. The rib has a healed fracture containing a transversal arrow-head. Length 165 mm. b2, The ventral side of the rib. b3, The cranial side of the rib. b4, The joint of the rib. Note the cutting marks on the ventral side. b5, The distal part of the rib. Note the cutting marks. b6, The bone arch under which the arrow-head lay. b7, The arrow fixed under the bone arch. b8, The cranial side of the rib. Note the front edge of the arrow-head, bearing many small scars from chips lost on impact. c1, The upper part of rib no. 9 or 10 from *Cervus elaphus* from Svenstrup, unknown age. The rib contains small pieces of flint on the caudal side. Length 120 mm. c2, The healed injury containing a small piece of flint.

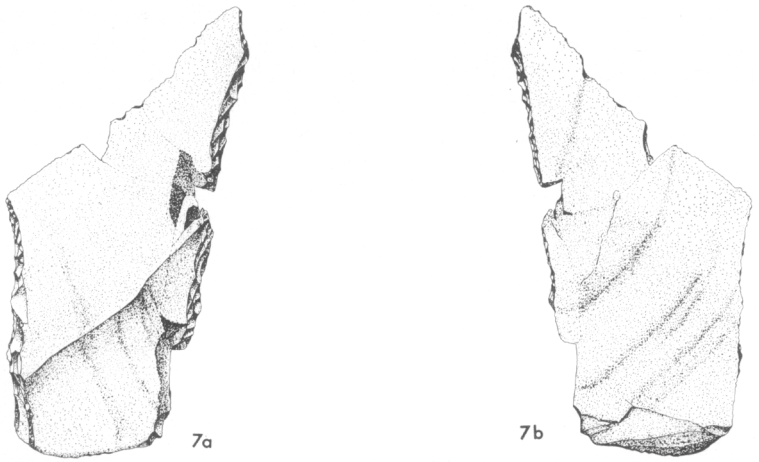

Figure 7. The oblique arrow-head extracted from the left humerus shown in Figure 6 (KS 40/32–57). Notice the number of fragments into which it broke when hitting the bone. a, Outer side; b, inner side. Length 18·5 mm.

on hitting the bone a piece was broken off and was either pressed into the shaft or was lost when the shaft was pulled out. The shaft was not found, probably because it was retrieved for re-use, since shaft making was time-consuming.

From an archaeological point of view, this example is interesting because the position of the arrow-point makes it clear that this oblique arrow has been used as a true arrow-head. The evidence is as good as if the arrow-head were to be found preserved in a wooden shaft as in the case of the shafted transversal arrow-heads described by Troels-Smith (1959) and Brøndsted (1957). This is the second proof of an oblique arrow-head being used as an arrow-tip in Denmark; the first was found in the Klampenborg settlements by E. Westerby (1927), who mentioned (1927, p. 79) an oblique arrow sitting in a small bone fragment. The above-mentioned observations indicate that the oblique arrow-head was probably shafted in the same way as the transversal arrow-head. The asymmetric point probably did not disturb the flight-path of the arrow, as the shaft was rather heavy and the exposed part of the point small.

(4) Atlantic period, zone VII

Locality: Ringkloster, Jylland, a settlement find. *Vertebra lumbalis* from a deer. On the left side of the arch of the bone a trapezoidal hole is to be seen (Figure 8a, b). The shape

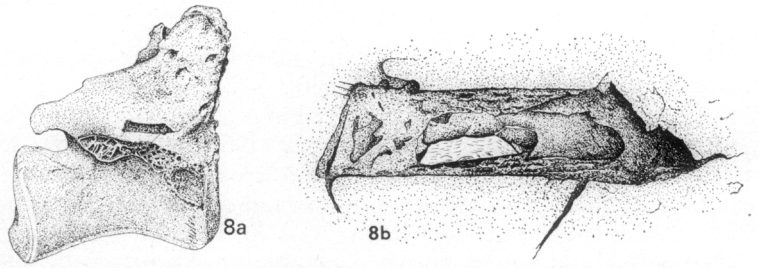

Figure 8. a, Lumbar vertebra of *Cervus elaphus* from the Ringkloster site, Atlantic period, zone VII. On the left side of the arch an unhealed fracture is seen, its outline is that of a transversal arrow-head; *c.* × ½. b, The fracture showing the wedged flint fragments probably derived from the arrow-point; *c.* × 5.

of the fracture is in agreement with the outline of a transversal cut of a transversal arrow-head. The longest parallel line is 10·5 mm, the shortest 8 mm and the distance between the two 2·5 mm. From the hole it was possible to free 20 small sharp-edged flint flakes from the bone matrix, which showed that it was not merely the surrounding earth penetrating into an accidental hole (Plate V c1, c2, d). The outline of the hole together with the flint made it clear that it was made by a transversal arrow. Furthermore, the inside of the hole was very clear cut and with no decomposition of the porous bone matrix. This proves that the arrow-head was removed quite recently which is supported by the lack of earth infilling the hole. The loss of the flint probably occurred during the excavating process.

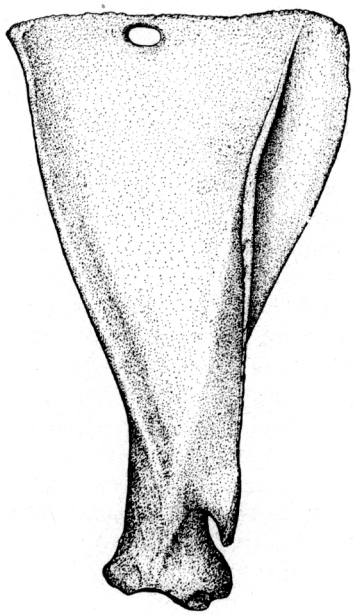

Figure 9. The left scapula of *Cervus elaphus* from the Åmose bog, Ertebølle period. The healed fracture gives no indication of the side from which the weapon has passed. Length 235 mm.

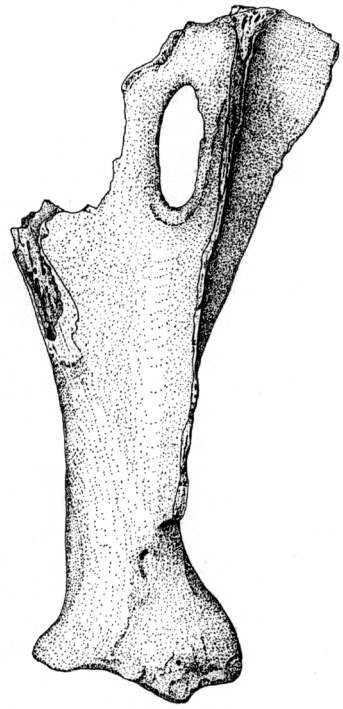

Figure 10. The right scapula of *Cervus elaphus* from the Jordløse bog, Ertebølle period. The large fracture is nicely healed. Note the two extensions of the rim of the fracture towards the upper right. Also see Plate II. Length of the blade 182 mm.

On one of the processes there are four chewing marks, probably the work of a dog. Dog bones have been excavated from the living-site.

A find of a vertebra lumbalis from a deer pierced by a stone arrow is unique from the Mesolithic period in Denmark. Tasnadi-Kubaska (1962, pp. 168–169) mentions a *vertebra lumbalis* from a reindeer pierced by a stone arrow from the Palaeolithic period as coming from the Archaeological Museum in Copenhagen. He quotes the information from Moodie (1923). However, Moodie (1923, Plate 70) states in his plate text that the vertebra in question is "of a young reindeer, neolithic period pierced by a flint arrow-head . . . (after Verneau)". Moodie (1923, pp. 349–350) gives further descriptions of Neolithic injuries and among them mentions the famous skeleton of a urus from Denmark with healed and unhealed injuries in the ribs from the locality Vig together

with a description of the lumbar vertebra mentioned in Tasnadi-Kubaska. The confusion may have arisen through Tasnadi-Kubaska considering the reindeer vertebra to have come from the same locality as the Vig urus, since Moodie mentions no locality for the *lumbar vertebra*.

(5) *Ertebølle period*

Locality: Åmose bog near Maglebjerg. The left scapula of deer found together with remains of pelican in deposits at a settlement. The blade has a healed fracture very close to the rim (Figure 9, Plate IIa1, a2, a3, a4). Healing has taken place without complications and the rim of the fracture is very even. The size of the fracture may indicate that the wound was produced by an arrow. The fracture was not very dangerous to the animal and the arrow has passed somewhere above the vertebral column. Size of fracture 18 × 12 mm.

(6) *Ertebølle period*

Locality: Jordløse bog, Sjælland (C V[3]) (Figure 2). A settlement find excavated by Harald Andersen (1945). The right shoulder blade of an adult deer with a healed fracture (Figure 10, Plate IIb1, b2, b3, b4). The hole has an oval outline 30·5 × 10 mm. The rim of the hole is smooth and even, indicating that healing has taken place without complications. On the inner side of the blade there is a furrow at the distal part of the hole, possibly proving a shot at a low angle from outside and in front of the animal. Close to the spine two struts 10 mm apart are present and show fresh fractures. They may represent the pillars from a bone ridge which has covered a piece of flint but which broke during excavation. Several butchering marks are seen on the spine.

(7) *Ertebølle period*

Locality: Jordløse bog, Sjælland (C VII[4]). The left shoulder blade of an adult deer with a healed fracture (Figure 11, Plate IVa2, b1, b3). The find was excavated by Harald Andersen (1945). The healing has taken place without much complication. A small channel (*foramen nutritium*) runs into each end of the fracture, representing nutrition canals for providing extra blood to the healing wound (Sigurd Andersen, pers. comm.). The most pronounced part of the callus formation is situated at the inner side of the blade. This may be attributable to a concentration of the bone splinters here which would thus indicate the course of the weapon as coming from the outer side.

(8) *Sub-boreal period, zone VIII*

Locality: Maglelyng complex, the Åmose bog (Figure 2). National Museum: (NM I, A. 49456 and NM VIII, A. 3587a). A rib with a healed fracture containing a transversal arrow-head (Plate VIb1 to b8). The rib is from the right side, no. 6 or 7 (counted from the cranial end). The bone is from an adult animal, as indicated by the shining hard surface and the well developed attachments for the muscles. Cutting marks are to be seen just under the tuberculum costae. Where the rib is broken distally cuts and sawing traces are to be seen. The rib would normally have had a length of 330–370 mm. The arrow-head lies 128 mm from the head of the rib, i.e. in the proximal end of the bone. The sharp edges of the arrow-head are parallel to the length of the bone. The rib shows a remarkable swelling (callus formation) over a length of 70 mm along the bone. The transversal arrow-head is overgrown by a bonebridge 3·5–5 mm thick. The distance to the caudal edge of the bone is as much as 29 mm. On a normal rib the distance from cranial to caudal edges would be 23 mm, so the breadth of the rib has been extended with 11 mm and the thickness of the rib has increased from 10 to 17 mm. The swollen part is divided by a

narrower area around the middle. The question is whether the swelling was caused by infection due to the intrusion of the transversal arrow-head or whether the swollen part was already there when the arrow hit the bone. The callus formation might be open to another interpretation, e.g. the normal rutting fights between the male deer might result in broken ribs. If the wound had been open there would be a possibility of infection which might have produced the thick callus formation. However, the impact of the arrow

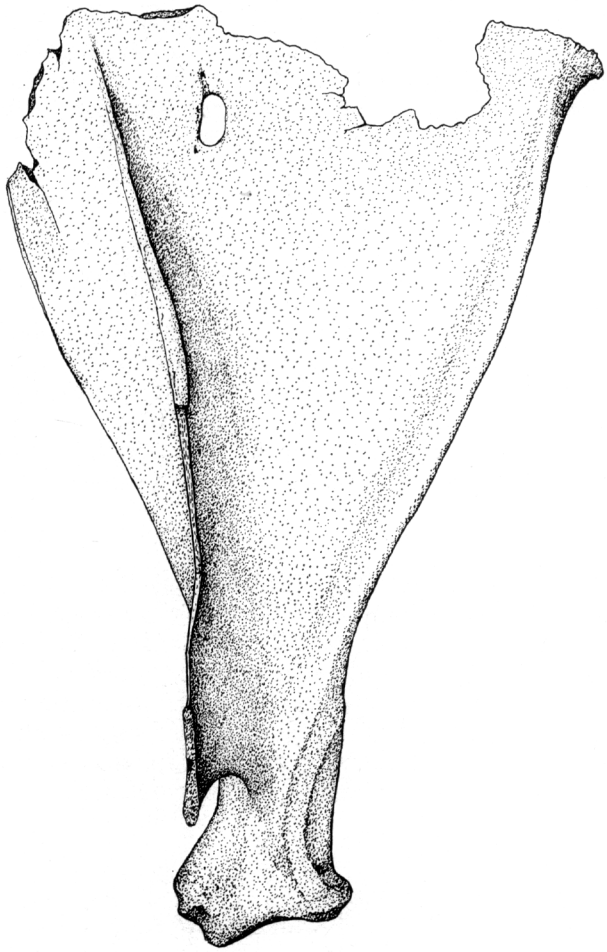

Figure 11. The left scapula of *Cervus elaphus* from the Jordløse bog, Ertebølle period. At both ends of the elongated, healed fracture two channels are seen; they contained blood-vessels leading blood to the lesion. Length of the blade 246 mm.

could have created a fracture such as that in the humerus from Kongemosen (p. 214) and this, together with a heavy infection, might provide an equally reasonable explanation. If the region was not swollen when the animal was hit, the processes of callus formation must have moved the arrow to the position where it is found now, as the arrow is situated outside the outline of the normal rib. The rib is broken again just below the callus formation and this fracture is preceded by cutting marks. This might indicate that the infection was there when the hunter butchered the animal and that the meat around the

wound was unattractive and was cut away. The arrow-head itself is a transversal arrow-head as defined by Mathiassen (1948, p. 60 and Figures 97–104), and the way it is placed shows that it has been used as an arrow, with the longest sharp edge pointing forwards, in this case into the animal. Small scars after splintering are seen along the edge of the arrow-point. These splinters apparently developed when the flint hit the bone. The other sharp edge was probably placed in a groove cut in the end of the arrow-shaft, as seen on the piece from Ejsing (Brøndsted, 1957), but seems to be incomplete and rather blunt. Some flakes have probably been broken off this edge by the impact of the arrow and are missing, as postulated in the case of the oblique arrow-head from Kongemosen. On this piece from Maglelyng a small flake is still sitting on the arrow-head, but rendered visible only because air has penetrated underneath it. There is some black, glue-like material still attached to part of the arrow-point which could be dried birch resin (cf. Troels-Smith, 1961).

(9) *Sub-boreal period, zone VIII*

Locality: Maglelyng complex in the Åmose bog, Stenmagle, Sjælland (Figure 2). (National Museum NM I 787/62 and NM VIII 3587G). The left rib no. 9 containing small pieces of flint overgrown with callus, from a deer. The total length of the rib is 324·1 mm and the injury lies 166 mm from the joint of the rib (Plate VIa1, a2, a3). The healing of the fracture has taken place without many complications although a slight thickening of the bone has taken place. The three flint fragments are situated at the inner side of the rib. There seems to be a channel within the mid-point of the healed fracture, which might have conducted blood to the healing wound. The animal survived this first shot but the hunter killed it later as indicated by a number of cutting marks concentrated around the injury. A pollen analysis of the sediment around the bone carried out by B. Fredskild (unpublished internal report Nationalmuseet, Dept. of Natural Science VIII A 3587G) dates the bone to the beginning of zone VIII around the A-Land occupation (Troels-Smith, 1960).

(10) *Unknown age*

Locality: Svenstrup, Borup, Ramsø Herred, Sjælland (Figure 2). The upper part of rib no. 9 or 10 from an adult hind. The rib contains small pieces of flint in the caudal side. The flint has caused infection and the callus formation has developed a bone knob (Plate VIc1, c2). The injury was slight and healed. The flint arrow glanced off the rib but left a minute flint flake embedded within the bone. The mode of death of the animal is unknown; cutting marks on the bone appear to be modern. For further description see Steenstrup (1871).

Sus scrofa L.

(1) *Boreal period, zone V*

Locality: Aldersro, Kalundborg, Sjælland, 15 May 1879 (Figure 2). An isolated bog find of an old male boar. In both the skull (Plate VIId1 and d2) and the elbow joint there are splinters of flint to be seen. The fractures which the splintered flint-point has caused are healed. For further description, see Steenstrup (1880, p. 136) and Winge (1904, p. 247).

(2) *Boreal period, zone V*

Locality: Hastrup mose, Randers, Jylland, 6 August 1872 (Figure 2) (Steenstrup's letters), Winge (1904, p. 245). The skull of an old wild boar, male, found in layers of calcareous tufa. The skull is nearly complete, lacking only the two canine teeth (Plate VIIb1 and b2). In the right side of the frontal region there is a healed fracture to be seen which,

judging from the shape, was caused by a hack with an axe. There is very little callus formation and no openings lead into the brain cavity. The scar has a length of at least 42 mm and is 12 mm broad, but it is not very deep, the axe seems to have slipped and slid down the frontal and thereby caused a relatively superficial injury.

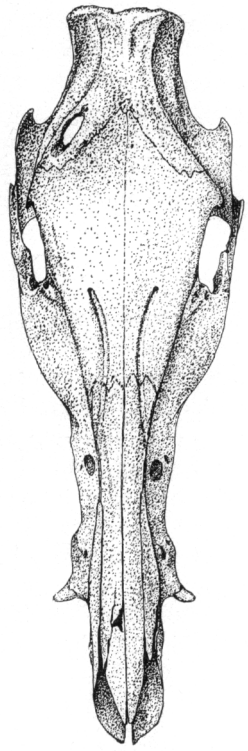

Figure 12. The skull of a young female of *Sus scrofa* from the Søborg mose, Boreal period, zone V. The fracture in the right side of the forehead is healed and a slight deformity around the lesion is visible. The length from the premaxilla to the back of the parietal is 371 mm.

(*3*) *Boreal period, zone V*

Locality: Søborg mose, Stubbekøbing, Falster, 4 September 1940 (Figure 2). The skull of a young female wild boar (Figure 12); the sutures between the cranial bones are still open, and m^3 is not yet visible. In the right parietal there is an elongated healed fracture, surrounded by some callus formation; the scar has a length of 43 mm and is 14 mm broad. The healing does not seem to have taken place for a long time, since the rim of the fracture is very uneven and porous. Part of the right side of the parietal bone and the right squamous bone are swollen and it looks as if the injury caused infection in the brain cavity. This might very well have led to the death of the animal a month or two after it had received the blow.

(*4*) *Boreal period, zone V*

Locality: Maglemose near Mullerup, Sjælland. A settlement excavated 17 November 1900. A right shoulder blade (J^{II} 10^2) from an adult individual which, to judge from the

size, was a female. The proximal lower part of the blade has an elongated fracture of which the rim shows no signs of healing (Plate IIIa1, a2, a3). The outline of the hole is disturbed by later fractures, probably caused by the excavating process. On the outer side of the blade the rim is clear-cut with no splintering, whereas the inner side of the blade around the hole shows a lot of scars after splintering. The size of the hole has a maximum length of 18 mm, and a maximum width of 8 mm. It is rather small, and is therefore likely to have been made by an arrow, which has passed from the outside at a very low angle, as indicated by the position of most of the splinters.

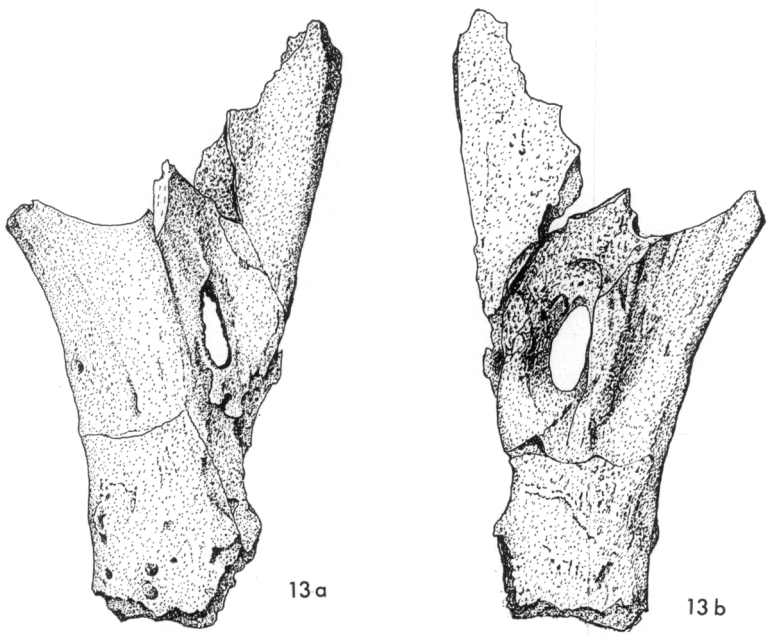

Figure 13. The right scapula of *Sus scrofa* from Sværdborg (1943), Atlantic period, zone VI. The healed perforation is surrounded by a strong, uneven callus formation. The joint of the scapula has in part been gnawed away by dogs. a, Outer side of the blade; b, inner side of the blade.

(5) *Boreal period, zone V*

Locality: Fuglekjær mose near Stenderup, 28 January 1880 (Figure 2). A bog find of a cranium belonging to a young male wild boar; m^3 has not yet penetrated the jawbone over its full length. The calvarium is nearly complete, only lacking the nasals and premandibulars. In the right, frontal bone there is a healed fracture which to judge from its shape was caused by a hack with an axe. The length of the fracture is 37 mm (Figure 15). The skull was mentioned by Winge (1904, p. 245) and has another oval fracture with an unhealed rim, but owing to the preservation technique it is impossible to tell whether the fracture is a modern one or whether it dates from the time when the animal was killed. The healed fracture is surrounded by bulbous callus formation, probably as a result of an infection in the wound. The bottom of the fracture is perforated and communicates with the brain cavity.

(6) *Boreal period, zone V*

Locality: Nørre Sengelse near Rudkøbing, Langeland, 31 May 1866 (Figure 2). A single bog find of the calvarium of a wild boar, male, lacking its two canine teeth (Figure 18).

The nasals and left jugal bone are partly broken. In the right part and in the middle of the frontal there are several healed fractures, the majority of which are lying along a straight line 66 mm long. Though healed, several of the fractures still enter up to 5 mm into the brain case. There is very little callus formation to be seen, so the healing seems to have been rapid and without complications.

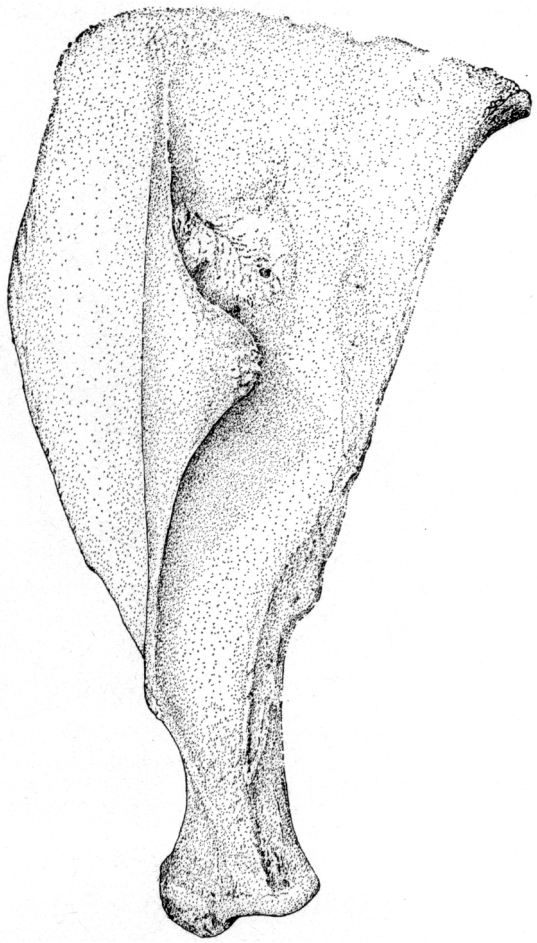

Figure 14. The left scapula of *Sus scrofa* from Ringkloster, Atlantic period, zone VII. The callus formation under the spine shows that heeling of the lesion has taken place. Length 265 mm.

(7) *Atlantic period, zone VI*

Locality: Sværdborg 1943, Sjælland (Figure 2) an inland settlement supposed to be younger than Sværdborg II (Gitte Henriksen, pers. comm., 1974) dated by Jørgensen (1972). A right scapula from an adult animal, Sværdborg 1943-LV, A1 (Plate IVa1, a2, a3) (Figure 13a, b) with a healed perforation 16 × 9 mm surrounded by a strong callus formation. *Processus coracoideus* and most of the joint have been chewed away, presumably by dogs. On the proximal part of the bone several chew marks from canine teeth are to be seen, and dog bones have also been found at the settlement. The callus formation is mainly found on the inside of the scapula; this fact could be explained by an enclosed

infection between the ribs and the blade with little possibility for the pus to escape. The infection was probably caused by irritation by the small pieces of bone around the hole. The greater amount of these splinters occurs at the side of the bone where the weapon has left, in this case the inner side. This indicates that the direction of penetration was from the outside through the bone.

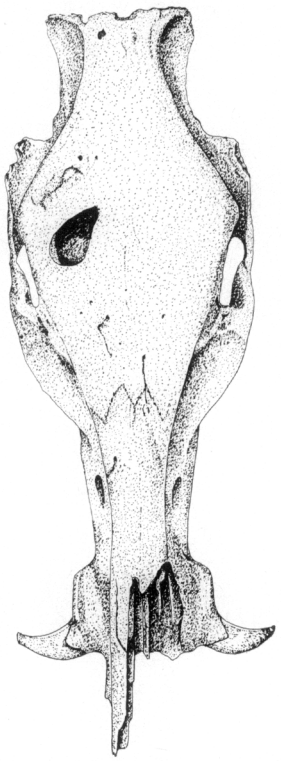

Figure 15. The skull of *Sus scrofa* from Fuglekjær mose, Boreal period, zone V. Towards the right side of the head two lesions are seen; it is not possible to tell the age of the open fracture owing to the preservation technique used. The outline of the healed lesion indicates that an axe may have been used as a weapon. Length of the skull 410 mm from the premaxilla to the back of the parietal.

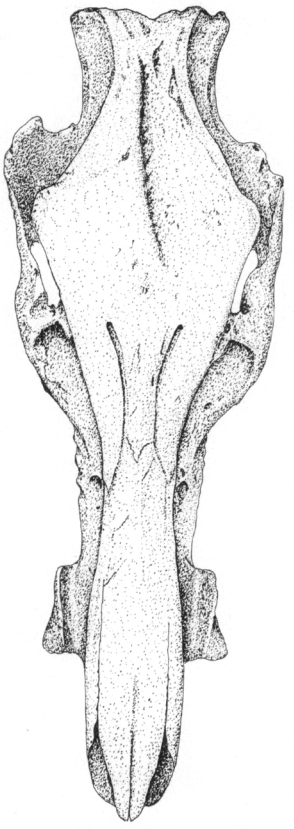

Figure 16. The skull of *Sus scrofa* from Slagslunde bog, unknown age. In the middle of the frontal bones there is a 112 mm long healed lesion. Length from the premaxilla to the back of the parietal is 435 mm.

(*8*) *Atlantic period, zone VII*

Locality: Ringkloster, Jylland (Figure 2). A left shoulder blade from a wild boar found at a settlement shows clear callus formation under the spine (Figure 14, Plate VIIIa1, a2, a3). A radiograph proved that no foreign object was lodged in the bone matrix. The callus formation seems to be the result of slightly difficult healing of a fracture, which has not gone all the way through the bone. Whether this fracture actually was caused by a human weapon or whether it derives from rutting fights between males is impossible to tell; it is well known that the males use the shoulder region as a shield in such contents. This

explanation is favoured by the minor nature of the wound; an arrow would most likely have completely penetrated the bone. From the same locality a vertebra was found showing clear marks from a transverse arrow-head which has penetrated deeply into the bone. The people at the settlement obviously used bows and arrows.

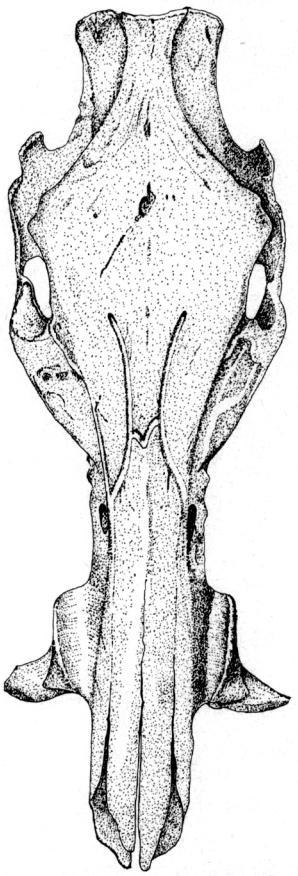

Figure 17. The skull of *Sus scrofa* from Frøslev mose, unknown age. A healed lesion in the middle and to the right in the frontal bones can be seen. Length from the premaxilla to the back of the parietal 457 mm.

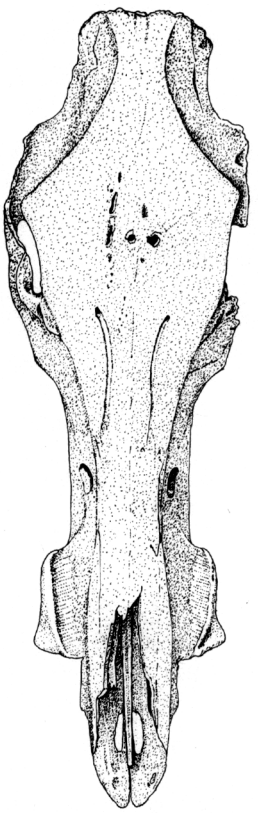

Figure 18. The skull of *Sus scrofa* from Nørre Sengelse, Boreal period, zone V. In the middle of the parietal and the frontal bones a series of small healed fractures are observable. They may be the result of a splintering of a flint weapon which hit the bone. Length 440 mm from the premaxilla to the back of the parietal.

(9) *Unknown age*

Locality: Slagslunde, Sjælland (Figure 2). A single bog find of a cranium of an old male wild boar (Plate VIIa1 and a2; Figure 16). The teeth show prolonged wear. The skull is nearly complete, lacking the two canine teeth. In the middle of the parietal and the frontal bones a deep furrow ploughs into the bone matrix. The wound shows healing, and at the distal part of the 112 mm long scar some callus formation is to be seen. The injuries might have been caused by a man-made weapon though it might possibly derive from rutting fights. This is discussed further below.

(10) Unknown age

Locality: Frøslev mose, Sjælland, 15 May 1857 (Figure 2). The calvarium of a large male wild boar (Figure 17). The animal is well grown, but not old, judging by the degree of wear of the teeth. The cranium is nearly complete. In the centre and towards the right side of the frontal region there is a 55 mm long, narrow scar which widens out in the upper 15 mm. The injury has healed nicely and only very little callus formation is to be seen. The injury has not reached very far into the brain bone, and cannot have been a serious threat to the animal's survival. The possibility that the fracture is due to a hunting failure is discussed below.

(11) Unknown age

Locality: Trønning mose, Tuse near Holbæk, Sjælland (Figure 2). Part of the skull of a female wild boar (Plate VIIe1 and e2). In the frontal region there is a healed fracture with the dimensions 30 · 15 mm.

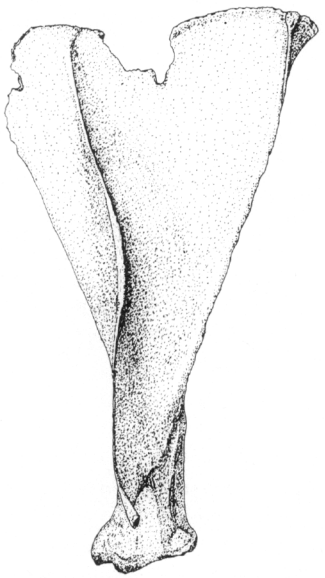

Figure 19. The left scapula of *Capreolus capreolus* from the Kongemose bog, Atlantic period, zone VI. The distal marginal fracture shows in certain parts a healed rim, most distinctly in the small and narrow embayment. Length of the blade 146 mm.

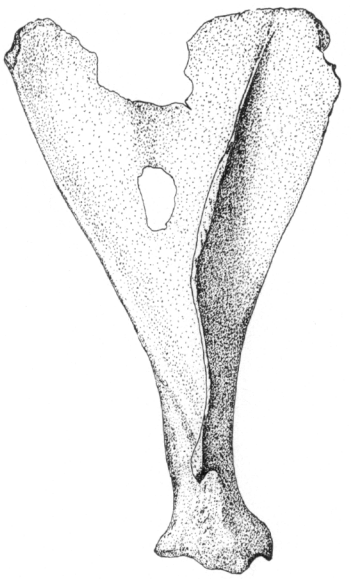

Figure 20. The right scapula of *Capreolus capreolus* from the Kongemose bog, zone VI. The rim of the centrally placed penetration scar shows no signs of healing. Length 145 mm.

Capreolus capreolus L.

(1) Atlantic period, zone VI

Locality: Kongemosen in the Åmose bog (Figure 2). A scapula (KS 31/37–50) from the left side of an adult animal was found at the Kongemose settlement. The fracture is placed at the edge of the blade and shows healing in certain parts of the rim (Figure 19, Plate IIIc1 and c2). Other parts of the rim have been broken recently so the original shape of the fracture cannot be seen. There is a notch in the healed part of the rim. The callus formation is more pronounced at the inner side of the blade. There is no clear evidence to show from which side the weapon hit the animal. As the rim shows healing the animal must have escaped its pursuers, and the position of the wound at the edge of the blade

would not have been very dangerous to the animal, the weapon probably having passed above the vertebral column. There are some cutting marks on the neck of the blade.

(2) Atlantic period, zone VI

Locality: Kongemosen in the Åmose bog (Figure 2). A find from the settlement Kongemosen. The right scapula with an oval hole in the middle (KS 37/31–7) from an adult individual (Figure 20, Plate Ib). Maximum length = 15·9 mm, maximum width = 9 mm. The rim of the fracture shows no signs of healing. The scars produced by splintering are on the outer side, most densely distributed on the distal rim of the hole. This indicates that the weapon struck the inner side of the blade with a slightly upward thrust.

Cygnus sp.

Atlantic period, zone VI

Locality: Henriksholm, Vedbæk, Sjælland (Figure 2), settlement find. A humerus from a swan with a transversal arrow-head lodged just below the caput humeri.

Discussion

The bone material from *Sus scrofa* falls into two major groups, the finds from settlements, consisting mainly of shoulder blades, and the isolated bog finds composed of fairly complete skulls. To the first group belong three fractured shoulder blades, one from zone V (Plate IIIa1, a2, a3), one from zone VI (Plate IVa1, a2, a3), and one from zone VII (Plate VIIIa1, a2, a3); the two last mentioned carry healed injuries, the first was unhealed. The placing of the unhealed fracture falls within the area covered by unhealed fractures in Figure 22. The fractures on two of the blades almost certainly were caused by human hunting weapons. The cause of the third fracture which was nicely healed is, as previously mentioned, uncertain. From the material described above it can be concluded that the bow and arrow was used in hunting the wild boar.

The second group comprises the skulls of which five are from zone V and three of uncertain age. They all carry more or less severe fractures in the parietal and frontal bones. The eight fractures are healed with little callus formation. The injuries are of very different shape; some elongated holes, some rounded and some deeply ploughed furrows. In common for all the injuries is the character of the wounds, except perhaps for one, and their location in the same part of the skull (Figure 21). Several explanations may be considered: (1) rutting fights; (2) sacrifice; (3) hunting.

In order to find out if rutting fights normally cause fractures on the skull of the wild boar, 20 modern wild boar skulls, all males, were examined. Only one showed a small fracture resembling parts of the fracture found on the Frøslev mose skull, but it was much less pronounced and the origin of the fracture was unknown. The wild boar, furthermore, uses its shoulder region as a shield to protect itself against the sharp and dangerous canine of the lower jaw of its adversary. The holes on the subfossil skulls vary greatly in size and shape. This would not be expected if canine teeth were the cause of them all; moreover, the deepest part of the injuries is always situated at the upper part of the fracture, thus indicating that the blow was directed downwards from above. Finally the skulls belong to both sexes. These facts all lead to the conclusion that most of the fractures did not derive from rutting fights.

Against the hypothesis of sacrificial origin for the injuries it can be stated that in the cases where limb bones were collected together with the skulls there was no marrow splitting and no special arrangement of the skeleton. Furthermore, the injured animals have all survived and escaped a possible sacrifice; it can hardly have been a frequent event.

that the sacrificial animal broke loose and escaped the rites. Furthermore, the skulls are derived from quite different cultural groups covering a time span of at least 2000 years. Sacrificial killing is therefore unlikely.

Most likely the fractures are a result of hunting by human beings. The variation in outline of the fractures, and the fact that flint splinters have been found in the bone matrix (the boar from Aldersro) strongly support this.

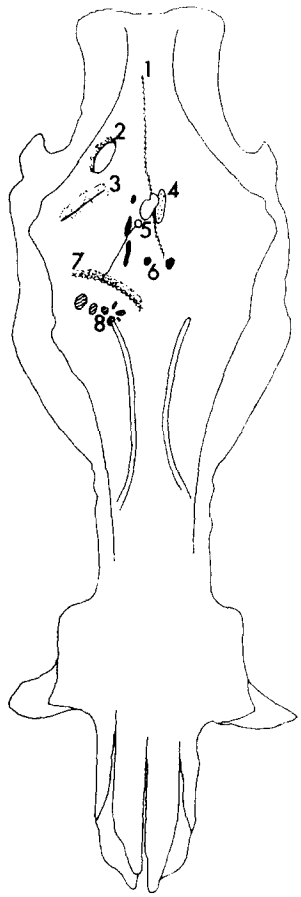

Figure 21. Positions and sizes of all the fractures found on the wild boar skulls superimposed onto a standard skull. Notice the variation in outline of the injuries and their position.

Nevertheless, it is striking that all the fractures are healed and thereby indicate that the hunter did not get his prey. On the other hand one can never tell how many wild boars the hunter actually caught. The captured animals will now be found as considerably fragmented refuse at the various settlements, and only the ones that escaped will have a chance to be preserved as more or less complete skeletons in bogs as a result of natural death, death sometimes caused by the infections introduced through the wounds they received. This could be so with the female boar from Søborg mose.

The walls of the brain case of a pig are much thicker than those of a deer (Plate VII f. g), and it is obviously not a reasonable place to strike if the intention is to kill the animal. The brain case of a wild boar is about five times as thick as that of a deer although

it is not solid bone, but rather two bone layers with transverse walls and cavities in between them. The hunters at that time undoubtedly knew where to hit the animal in order to kill it, and yet these unsuccessful attempts have been made. The explanation might be sought in the aggressive nature of the wild boar, especially if wounded. If disturbed the animal will turn round and attack its pursuers with its knife-sharp canine teeth. If the animal is too close there will be no time for bow and arrow. The hunter will take his spear or axe, knife or even a stone to defend himself. As the head of the animal would be turned against the man the blow will hit it somewhere in the face. The blow might distract the animal so the hunter can escape, or on the contrary make the animal more furious and the multilation or death of the man would result. The size and shape of some of the fractures provide evidence that different weapons have been used.

Some of the injuries have an outline which suggests a hack with an axe; some indicate that the weapon slipped and scraped a furrow in the bone; and some are holes as if a spear had been employed. The fractures are all placed in the right side of the head (Figure 21). This probably indicates that the blow has been delivered at an attacking animal, as it will turn the side of the head to the enemy to be able to use the canine teeth.

A greater variety of methods have been employed in hunting wild boar during historical times than in deer hunting. The boar is shortsighted and has poor hearing. This allows the hunter to stalk close to the animal and permits the use of close combat weapons such as an axe, short spear, and knives. On the other hand the animal is dangerous and if wounded it will turn its head towards the attacker in order to get a clear sight of him. During the attack, the boar moves the lower jaw sideways, thus presenting a canine tooth which it runs upwards into the victim. In the Medieval period a short, double-edged spear was the preferred weapon, specially employed in wild boar hunting. Nets were often used together with the spear to hunt the wild boar, or the animal was held by strong dogs so as to allow the hunter to come near and to use his spear (Brusewitz, 1968, p. 138; Lindner, 1937, 1940). Pit-falls have been employed in many periods and so has the bow and arrow.

It is difficult to tell what type of weapon Mesolithic man used in hunting the wild boar, but we have evidence for bow and arrow, probably spear, and an axe-like implement. The hunting methods employed were probably both long distance shooting with bow and arrow by groups, and single man participation for close-range hunting with short-range weapons.

The wild boar normally lives peacefully together with roe deer, and is not as territorially restricted as the deer. The non-gregarious way of living and the dangerous behaviour of the animal might give an indication as to why wild boar remains seldom dominate in the refuse heaps from the Mesolithic settlements in Denmark, although suitable biotopes were plentiful at that time.

On a shoulder blade of *Sus scrofa* from Holmegårds mose (15 December 1922) a rounded perforation was observed at the border zone between the cartilage and the bone (Plate VIIIc1 and c2). The bone was from a settlement dated to the Boreal period, zone V. At first it was thought to be a healed injury, but comparison with 10 modern wild boar shoulder blades revealed that all of them had one or two more or less rounded perforations resembling the one found on the blade from the Holmegårds mose. This suggested that the holes had a pathological explanation, and were probably caused by a short cessation in growth in this zone between bone and cartilage.

Distribution of shot-holes

The positions and sizes of all the measurable perforations considered to be shot-holes found on the Mesolithic shoulder blades have been superimposed onto a standard blade (Figure 22b). It emerges clearly that while unhealed fractures are strongly concentrated

in one area, the healed fractures are scattered over the entire blade. The concentration of the unhealed fractures might be the result of the severity of wounds within this part of the animal. However, some of the supposed unhealed fractures may have resulted from mechanical postmortal distortion which might have developed particularly in the thinner areas of the blade (Noe-Nygaard, 1973). Figure 22a shows the contrasting distribution of holes considered by Rust (1937a, *b*, 1943) to be shot-holes on reindeer shoulder blades from the Palaeolithic settlement at Stellmoor, similarly superimposed onto a standard shoulder blade. In the case of the reindeer, there are no healed fractures and all the unhealed fractures have a random distribution over the whole blade. As the shoulder blade of a reindeer is at least as fragile as that of red deer and roe deer, this indicates that the concentration of the unhealed fractures on blades from the Mesolithic material is not due to mechanical fracturing.

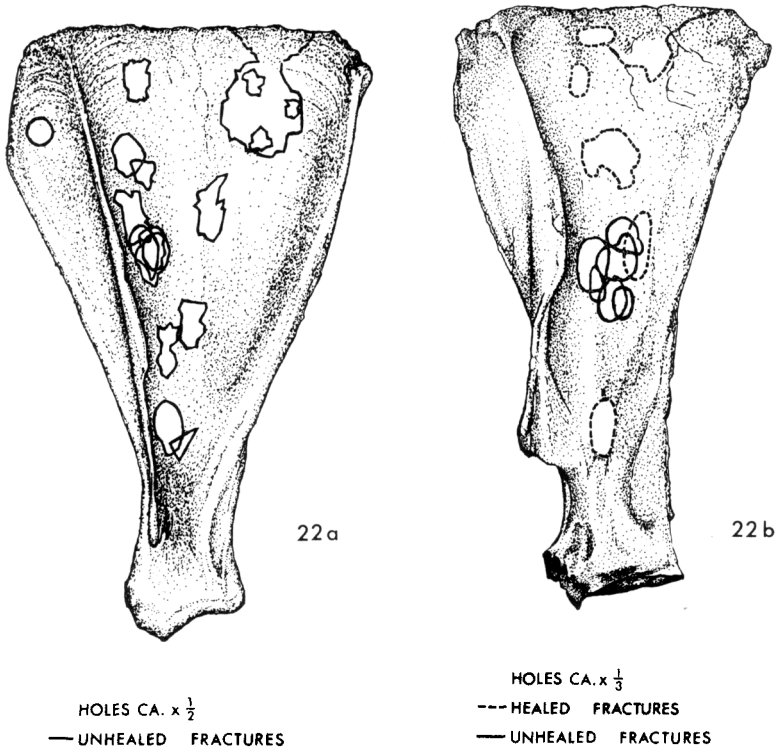

Figure 22. a, Positions and sizes of all the fractures considered by Rust (1943) to be shot-holes, superimposed onto a standard blade. Note the scattered distribution of the fractures, all of which are unhealed (drawing by Bente Surlyk). b, Positions and sizes of all fractures found on the Mesolithic scapulae superimposed onto a standard blade. Note the concentration of the unhealed fractures (drawing by Bente Surlyk).

Figure 23 shows the skeletons of different prey animals with the relative positions of the vital organs such as lungs and heart. The heart is situated deep in the body and behind the shoulder blade; however, its position in relation to the shoulder blade may change with movements of the animal. The best place to aim in order to cause instant death is just behind the shoulder blade where the chance to hit the heart or a large blood vessel just above the heart is greatest and where there is no bone to hinder the passage

of the weapon. A shot at the throat and the lung is also considered fatal. Bows and arrows were used in the great bison hunts performed by the Red Indians in North America. It was the practice of these hunters to aim behind the blade at the moment the front leg was stretched forward, thereby exposing the maximum space between the ribs when the possibility of penetrating undisturbed through the animal was greatest (McHugh, 1972).

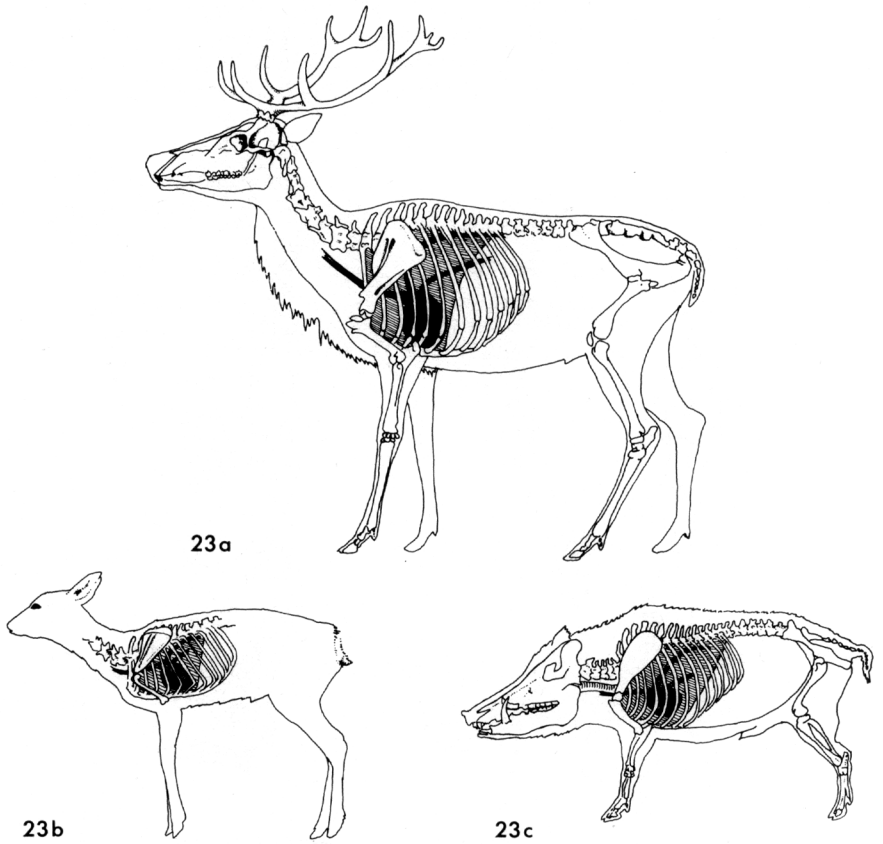

Figure 23. Drawings of some of the most important game animals with the vital organs such as heart and lungs placed in their correct position in relation to the skeleton. a, *Cervus elaphus*. b, *Capreolus capreolus*, drawn after a dissected animal in Röken (1972). c, *Sus scrofa*, modified after Snethlage (1967). (Drawings by Bente Surlyk.)

Returning to the unhealed fractures, it is obvious that one can never tell if these wounds were actually mortal, or if the animal died from other injuries which were never recorded on the bones. It is even possible that the shots through the blades should be regarded as failed shots aimed at the vulnerable place behind the blade. Such a failure would have resulted if the bow were misfired a fraction of a second too early. Nevertheless, it is noteworthy that the unhealed fractures are unquestionably concentrated. This may be explained by the fact that this central area of the blade is thin and covers vital organs which if hit would cause instant death or paralysis, such as the throat artery, the lungs, and the spinal cord.

Healed fractures grouped around the upper border of the blade (Figure 22b) are easily explained. The animals survived since no vital organs lie underneath this part of the blade.

On the reindeer shoulder blades from Stellmoor there are only unhealed fractures as mentioned above, and these are randomly distributed. There is no obvious anatomical difference in the shoulder blades of the reindeer and those of the other deer. It would therefore be reasonable to conclude that the different distributional patterns (Figures 22a, b) should rather have resulted from the employment of different hunting methods for reindeer and Mesolithic game animals owing to dissimilarity in mode of life.

The reindeer live in huge herds. Clark (1967, 1972) suggested that Palaeolithic man moved around with these herds on which he was entirely dependent for materials for housing, clothing, tools, and particularly food. If this hypothesis is correct then the capture of the animal would have presented no problems. The technique was probably

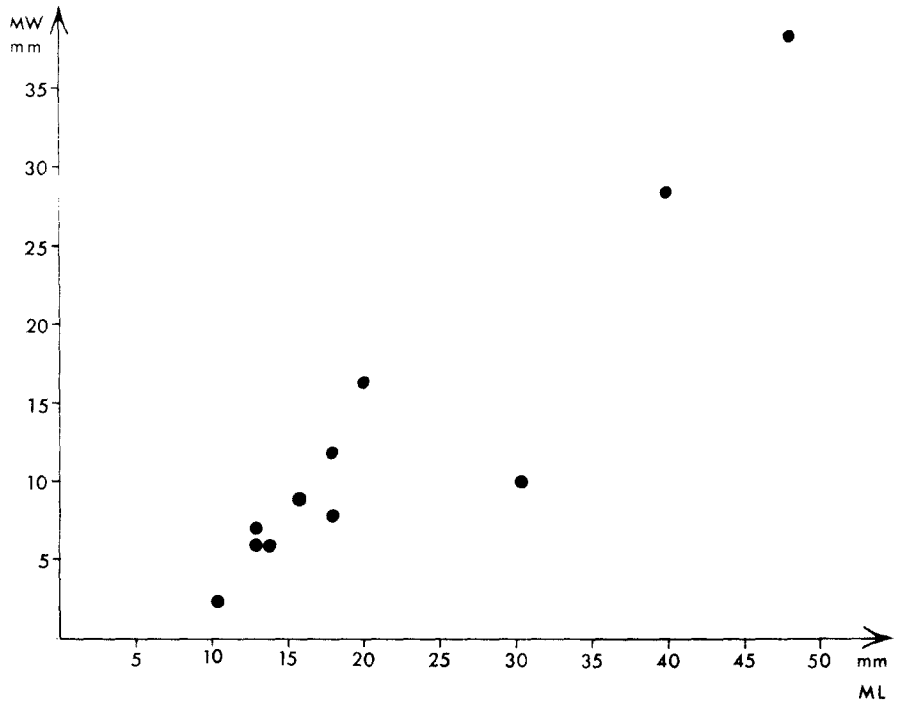

Figure 24. Sizes of perforations in the Mesolithic bone material from Denmark. ML, Max. length; MW, max. width.

to wedge off a small group of animals from the main herd and slaughter all of them. In this the hunters may have used game fencing which would make it possible to shoot at the animals from several directions. Advantage would undoubtedly have been taken of natural factors such as thin ice and deep snow which restrict the rate of movement of the reindeer herds (Troels-Smith, 1956) and would have permitted the hunters to approach the animals more closely and thus fire arrows repeatedly at the same animal.

In North American bison hunting large herds were eradicated by killing every individual in smaller groups which were isolated by the hunters. Often a man covered with a bison hide was sent into the large herd in order to isolate a smaller group and drive it away from the others. In this type of hunting, precision shooting was of minor importance, and few of the hunted animals had a chance of survival.

On the other hand, the Mesolithic game animals, red deer, roe deer, urus, elk, and the wild boar lived in smaller herds and all occurred in forested areas in contrast to the open tundra environment of the reindeer. The Mesolithic hunters probably concentrated on the individual animal, finding, tracking, chasing and killing it. Both battue and hunting with tracking hounds were probably practiced, but the forest could give shelter to a wounded animal, thus greatly increasing the need for precision shooting.

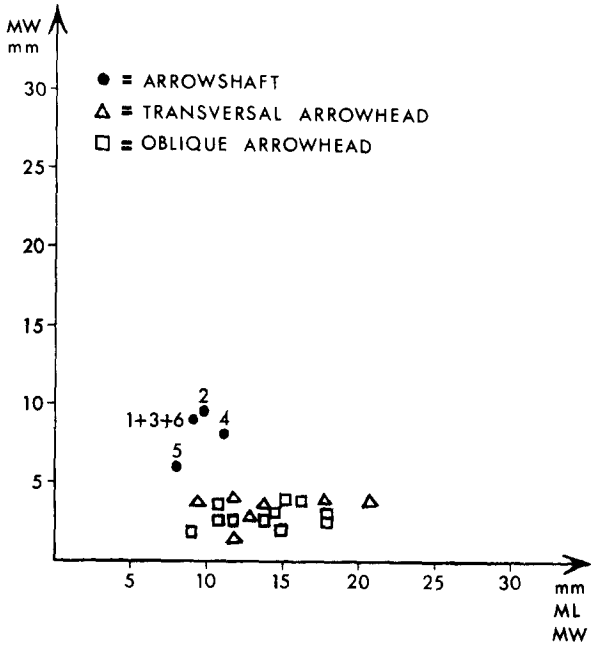

Figure 25. The dimensions of some of the transversal and oblique arrow-heads and shafts from the Danish Mesolithic. ML, Max. length; MW, max. width. 1, Eisig (Brøndsted, 1957); 2, Vinkel (Troels-Smith, 1961); 3, Løshult (Malmer, 1969); 4, Åmosen (Troels-Smith, 1960); 5, Åmosen (Troels-Smith, 1960); 6, Holmegaard (Becker, 1945).

The weapons

The size and the outline of the fractures give good indications of which weapons have been used. In Figure 24 the maximum length of the fractures has been plotted against the maximum width. Most of the fractures have a maximum length of 15–20 mm while a few reach a length two to three times this size. Figure 25 shows the maximum length and width of some transversal and oblique arrow-heads together with the wooden arrow-shafts described by Troels-Smith (1959, 1961), Becker (1945), Malmer (1969) and Brøndsted (1957). A comparison of Figures 24 and 25 shows that the dimensions of the holes and the arrows are more or less the same, which strongly suggests that the injuries were caused by arrows. However, the weapons responsible for the larger holes still remain to be accounted for. Figure 26 illustrates the sizes of the perforations together with the sizes of some of the larger Mesolithic weapons such as barbed points, harpoons (Andersen, 1971), flint-edged spears (Jørgensen, 1956), wooden lances (Becker, 1945), and large oblique and transversal arrow-heads (Westerby, 1927; Petersen, 1973). Some of the harpoons from the Ertebølle period described by Andersen (1971) and the large flint arrows possess dimensions suitable for producing the large perforations. The flint-edged spears and the wooden lance described by Becker (1945) are only of the same

size as transversal and oblique arrow-heads. It is impossible to say for certain which sort of weapon made which specific hole, but it is obvious that both arrows and spears were used. Whether the spear was a simple wooden implement with fire-hardened point (Clark, 1967; Tasnadi-Kubacska, 1962, p. 168; Warren, 1911, 1950; Adam, 1951) or whether the point was made of antler or flint, cannot be stated. It should be mentioned that in the bison hunts in North America, special, broad-bladed arrows were used to cause maximum bleeding with the aim of exhausting the animals. Furthermore, it is told that a good marksman was able to shoot right through one bison and to hit and mortally wound the one running next to it (McHugh, 1972).

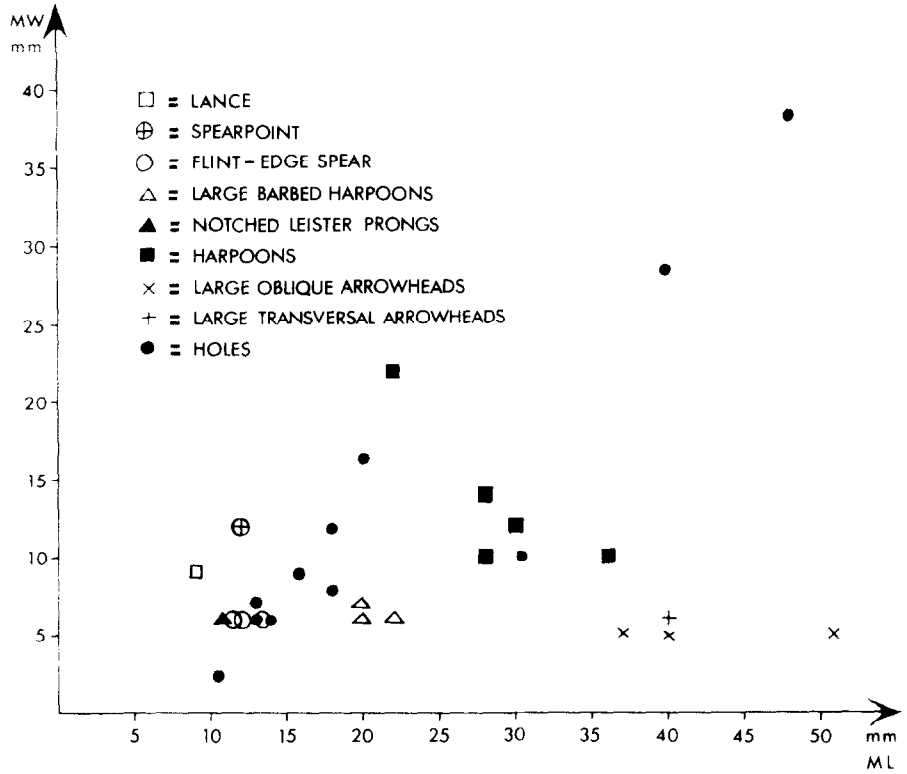

Figure 26. Size comparison of the possible weapons and the perforations in reindeer shoulder blades from Stellmoor. Re-measurements of Rust's material by the author. ML, Max. length; MW, max. width.

Figure 27 shows a comparison of the dimensions of possible weapons and sizes of perforations in the shoulder blades from the Palaeolithic material from Stellmoor (Rust, 1943). The sizes of most of the holes and the dimensions of the weapons are of the same magnitude, except for a few fractures larger than any recorded weapon from the site including the barbed points. It is possible that a wooden spear has been used of which nothing is preserved. It is, anyway, clear that there, as in the Danish Mesolithic material, at least two types of weapons have been employed.

One case has left us an idea of how the hunting was performed. The urus from Vig had both an unhealed fracture caused by penetration of a spear through the shoulder blade and an unhealed fracture due to flint arrows in the rib (Noe-Nygaard, 1973). The

arrows were probably used to exhaust the animal by loss of blood whereafter the spear was applied.

Many of the injured bones have been gnawed by dogs; there are records of dog bones from the settlements. It is therefore reasonable to suggest that dogs took part in the hunt, tracking and holding the prey animal. In primitive hunting it is most important to stalk as close as possible to the animal in order to be sure of a hit and so as not to waste too many arrows. Barnes *et al.* (1971, 1973) describe an elk from the Allerød interstadial with numerous injuries probably caused by barbed points, some of which were found resting on the skeleton.

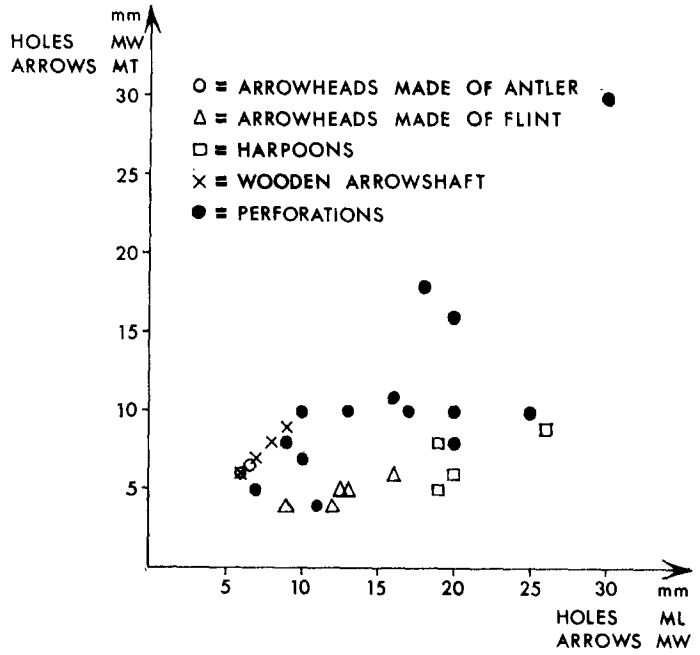

Figure 27. Size comparison of some of the possible weapons and their corresponding perforations in the Mesolithic bone material. MT, Max. thickness; MW, max. width. ML, max. length. 1, Lance (Becker, 1945); 2, Lance (Becker, 1945); 3, Spear point (Becker, 1945); 4, Flint edge spear (Jørgensen, 1957); 5, Flint edge spear (Jørgensen, 1957); 6, Flint edge spear (Jørgensen, 1957); 7, Flint edge spear (Jørgensen, 1957); 8, Large barbed harpoon (Maglemose culture) (Mathiassen, 1948); 9, Large barbed harpoon (Maglemose culture) (Mathiassen, 1948); 10, Large barbed harpoon (Maglemose culture) (Mathiassen, 1948); 11, Notched leister prongs (Maglemose culture) (Mathiassen, 1948); 12, Notched leister prongs (Maglemose culture) (Mathiassen, 1948); 13, Harpoon (Ertebølle culture) (Andersen, 1971); 14, Harpoon (Ertebølle culture) (Andersen, 1971); 15, Harpoon (Ertebølle culture) (Andersen, 1971); 16, Harpoon (Ertebølle culture) (Andersen, 1971); 17, Harpoon (Ertebølle culture) (Andersen, 1971); 18, Large oblique arrow-head (Brinch Petersen, pers. comm.); 19, Large oblique arrow-head (Mathiassen, 1948); 20, Large oblique arrow-head (Mathiassen, 1948); 21, Large transversal arrow-head (Ertebølle culture) (Westerby, 1927).

Multiple shooting as an indicator for the mode of life of Mesolithic man

It is remarkable how many of the bones described here bear healed fractures. Of the 21 examined pieces, excluding the 8 skulls of wild boar, 11 showed healed fractures. The perforated bones with healed and unhealed fractures are distributed among the different periods as follows. Zone IV: 1 healed, 3 unhealed (same animal); zone V: 2 unhealed;

zone VI: 2 healed, 4 unhealed; 1 zone VII: 5 healed, 1 unhealed; zone VIII: 2 healed; 1 healed of unknown age.

Most of the bone material derives from settlement refuse heaps. The bones bear traces resulting from marrow splitting, while cutting, sawing and hack marks are scattered all over the surfaces. This shows that the animals probably had been butchered at or near the settlement and that it is no accident that the animal was there. Neither is their occurrence at settlements a result of sacrifice, but they are unmistakably left-overs after meals.

Bones with healed fractures must belong to animals which have been hunted at least twice with a minimum period of 2–3 months between the two last hunts, to permit the injury to heal up. On the other hand, perforated bones showing no healing provide no more evidence than that the animals have been hunted at least once. Since the material at the settlements is represented by single bones or fragments of bones and not by complete skeletons, estimates of the number of hunts in which the animal has been injured are absolute minima. Relatively complete skeletons are unfortunately rare, but they indicate that fractures due to former hunts may be recovered from different bones belonging to the same skeleton (Hartz & Winge, 1906; Noe-Nygaard, 1973). Regrettably it is never possible to re-assemble the isolated bones in a refuse heap and reconstruct skeletons and thereby compound their history. Furthermore, none of the injuries received in the soft tissue are recorded although these may be as fatal as those registered on the bones.

It appears that the relative proportion of healed to unhealed fractures changes during time with very few healed in the Maglemosian period and many healed fractures from the later part of the Ertebølle period. In 1972 the Palaeolithic bone material from Stellmoor (Rust, 1943) was re-examined by the present author, but none of the perforated bones showed any sign of healing. From Denmark bones belonging to the zones IV, V, and VI are here regarded as one group in which there are three healed and seven unhealed fractures, or 30% healed injuries. From the zones VII and VIII, regarded as the other group, there are seven healed and one unhealed, or 87% healed fractures. The tendency seems clear enough although conclusions are hampered by lack of material. The possibility of sampling bias cannot be completely ruled out until a re-examination of a larger quantity of bone material from the Mesolithic period has been undertaken.

The overall high percentage of healed fractures might thus be due to the fact that the healed fractures are easier to discover on account of the more or less pronounced callus formation around the perforation. Unhealed fractures would be obliterated by the marrow splitting process, so that the one type of fracturing will prevent the recognition of the other type. The mere fact that the injuries are found on 13 shoulder blades, five ribs, one vertebra and yet on only one limb bone could be interpreted as evidence for marrow splitting as a biasing factor in the selection of the bones recorded, as these are the bones which are least suitable to the marrow splitting process. They either contain no attractive marrow or if they do contain marrow it is not necessary to break the bones to gain access to it.

On the other hand the distribution of the perforations on the various bones might equally well reflect the knowledge of the prehistoric hunter as to the best region to aim at to wound the animal fatally; this region is near the shoulder blades and in the upper part of the rib-cage. In any case, the marrow splitting process offers a poor answer as to why the proportion of the healed to unhealed fractures changes during time. A more reasonable explanation could be sought in the hunters' way of living in relation to the biology of the various prey animals.

In the material from Stellmoor, consisting almost entirely of reindeer bones, there are no visible signs of multiple shooting. Clark (1967, p. 64) presumed that the people from

the Hamburg Culture moved around with the reindeer herds to the habits of which they had adapted themselves. Clark (1972, p. 20) reckoned with a reasonable hunting group of 20–40 persons including women and children following herds of 10,000 reindeer. They were totally dependent on these animals for food, clothes and as a source of material for their implements. The 20–40 persons would need around 20–40 kg meat/day, and in a year they would consume 7300–14,600 kg of meat to cover their calory consumption. One animal weighs about 125 kg, but only 50–60 % can be eaten (White, 1953) which implies eating around 120–240 animals/year. In addition, more animals have presumably been shot to obtain skins and antlers, but in herds of tens of thousands and with the method of hunting discussed above, the likelihood of re-shooting the same animal on different occasions is very small.

Contrary to this, the material from the Danish Mesolithic shows that red deer and roe deer together with the urus, the wild boar and the elk constituted the prey animals, and their biology is in many respects entirely different from that of the reindeer. They gather in small herds and are associated with the forest.

In the earlier part of the Mesolithic, zones IV to VI, we find a low re-shooting percentage which is probably due to the nomadic life characteristic of pure hunters in areas with reasonable supplies of game.

In zone VII it is generally assumed that the forest was very dense (Iversen, 1967; Troels-Smith, pers. comm.). The available game was less than in the more open Boreal and early Atlantic forest. The number of hunting families is assumed to have been small (Petersen, 1972).

In zones VII and VIII red and roe deer were the dominant game. Both species are territorial animals, especially the roe deer. The bucks are very sedentary for more than two years and the females for more than one year, and some of the bucks keep their territory for the rest of their lives (Strandgård, 1972). Red deer are less sedentary but even so the same animals can be found within a limited area year after year (Ingebrigsten, (Petersen, 1972).

It seems that the deer were recaptured at a high rate and the blades with healed fractures all belong to adult animals, which are the more sedentary animals. It is thus reasonable to presume that it was the same hunting group which encountered the animals on more than one occasion, which leads to the conclusion that the hunters must themselves have adopted a rather sedentary way of living within a certain territory. Lack of means of communication except along the rivers due to the thick forest, and the sparse game, would have led to increased shooting pressure, which would have improved the chances for encounter. The lack of game meat might have forced late Mesolithic man to accept agriculture as a means of survival. We have evidence that cultivated wheat and domesticated animals first appeared at the end of zone VII. The agricultural way of living fits well with the already presumed adoption of a more settled mode of life by late Mesolithic man.

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References

Adam, K. D. (1951). Der Waldelefant von Lehringen, eine Jagdbeute des diluvialen Menschen. *Quartär* **5**, 79–92.

Andersen, A. & Møller, K. (1946). Fund af urokse (*Bos taurus urus* L.) i Grænge Mose på Lolland. *Danmarks geoligiska Undersølgelse* IV.

Andersen, S. H. (1971). Ertebøllekulturens harpuner. *Kuml* 73–125.

Barnes, B., Edwards, B. J. N., Hallam, J. S. & Stuart, A. J. (1971). Skeleton of a Late Glacial elk associated with barbed points from Poulton-le-Fylde, Lancashire. *Nature* **232**, 488–489.

Becker, C. J. (1945). En 8000-aarig stenalderboplads i Holmegaards Mose. *Fra Nationalmuseets Arbejdsmark* **1945**, 61–72.

Brusewitz, G. (1968). *Jagt. Jægere, vildt, våben og jagtmetoder fra de ældste tider til vore Dage*. Copenhagen: Hasselbalch.

Brøndsted, J. (1957). *Danmarks Oldtid. 1. Stenalderen*. Copenhagen: Gyldendal.

Clark, J. D. G. (1954). *Star Carr—an early Mesolithic site at Seamer near Scarborough, Yorkshire*. Cambridge.

Clark, J. D. G. (1967). *The Stone-Age Hunters*. London: Thames and Hudson.

Clark, J. D. G. (1972). Star Carr—a case study in bioarchaeology. *Module* **10**, 42 pp.

Darling, F. (1969). *A Herd of Red Deer*. Oxford: Oxford University Press.

Degerbøl, M. & Fredskild, B. (1970). The urus (*Bos primigenius* Bojanus) and the Neolithic domesticated cattle (*Bos taurus domesticus* Linné) in Denmark. *Biol. Skr. dan. Vid. Selsk.* **17**.

Hallam, J. S., Edwards, B. J. N., Barnes, B. & Stuart, A. J. (1973). The remains of a Late Glacial elk associated with barbed points from Hish Furlong near Blackpool, Lancashire. *Proceedings of the Prehistoric Society* **39**, 100–128.

Hartz, N. & Winge, H. (1906). Om uroxen fra Vig. Såret og dræbt med flintvåden. *Årb. Nord. Oldk. Hist.* **1906**, 225–236.

Ingebrigsten, O. (1924). Hjortens utbredelse i Norge. *Bergens Naturvidenskabelige række* **6**.

Iversen, J. (1967). Naturens udvikling siden sidste istid. *Danmarks Natur* **1**, 345–445.

Jessen, K. (1920). Moseundersøgelser i det nordøstlige Sjælland. *Danmarks geoligiska Undersølgelse* **II** (34).

Jørgensen, S. (1956). Kongemosen. Endnu en Åmose-boplads fra ældre Stenalder. *Kuml* 23–40.

Jørgensen, S. (1972). Bog geology and pollen analysis. In (Petersen E. Brinch, Ed.), A Maglemose hut from Sværdborg Bog, Zealand, Denmark. *Acta Archaeologica* **XLII**, 52–59.

Kristoffersen, F. (1971). *Jagt på Nordens hjortevildt og andre klovbærende arter*. Nyt Nordisk Forlag: Arnold Busck.

Lindner, K. (1937). *Die Jagd der Vorzeit*. Berlin und Leipzig: Geschichte des Deutschen Wiederwerks.

Lindner, K. (1940). *Die Jagd im Frühen Mittelalter*. Berlin: Walter de Gruyter & Co.

Malmer, M. (1969). Die Mikrolithen in dem Pfeil-Fund von Loshult. Mhulm 1966–1968 Lund, 249–255.

Mathiassen, T. (1948). *Danske oldsager*. 1. *Ældre Stenalder*. Copenhagen.

McHugh, T. (1972). *The Time of the Buffalo*. New York: Alfred A. Knopf.
Moodie, R. L. (1923). *Paleopathology*. Urbana: University of Illinois Press.
Noe-Nygaard, N. (1973). The Vig Bull. New information on the final hunt. *Bulletin of Geological Society of Denmark* **22,** 244–248.
Obermaier, H. (1924). Fossil man in Spain. VII. Palaeolithic Art. *The Hispanic Society of America*, pp. 210–264.
Petersen E. Brinch, (1972). A Maglemose hut from Sværdborg Bog, Zealand, Denmark. *Acta Archaeologica* **42,** 43–77.
Rust, A. (1937*a*). *Das Altsteinzeitliche Renntierjägerlager Meiendorf*. Neumünster: Wachholtz.
Rust, A. (1937*b*). *Vor 2000 Jahren Eiszeitliche Renntierjäger in Holstein*. Neumünster: Wachholtz.
Rust, A. (1943). *Die Alt-und Mittelsteinzeitlicher Funde von Stellmoor*. Neumünster: Wachholtz.
Röken, B. O. (1972). Skott mot rådjur. *Svensk Jagt* **1,** 22–26.
Snethlage, K. (1967). *Das Schwartzwild*. Paul Parey Verlag.
Steenstrup, J. (1871). Kjæmpe-oxens (*Bos primigenius* Boj.) samtidig med landets ældre fyrreskove—og om flintskjærver, indvoxne i dyreknokler som minder om Stenalderens forfølgelser af de vilde dyr. *Kong. dan. Vid. Forhandl.* **3,** 1–10.
Steenstrup, J. (1880). Nogle i året 1879 til Universitetsmuseet indkomne bidrag til landets forhistoriske fauna. *Foredragsreferat Kong. dan. Vid. Selsk.*, pp. 132–146.
Strandgaard, H. (1972). The roe deer (*Capreolus capreolus*) population at Kalø and the factors regulating its size. *Danish Review of Game Biology* **7.**
Tasnadi-Kubacska, A. (1962). Paläopathologie. Pathologie der vorzeitlichen Tiere. *Paläopathologie* **1.**
Troels-Smith, J. (1956). Nulevende rensdyrjægere. *Fra Nationalmuseets Arbejdsmark* **1956,** 23–40.
Troels-Smith, J. (1957). Maglemosetidens jægere og fiskere. *Fra Nationalmuseets Arbejdsmark* **1957,** 101–123.
Troels-Smith, J. (1959). En elmetræsbue fra Åmosen og andre træsager fra tidlig neolithisk tid. *Årb. Nord. Oldk. Hist.* **1960,** 91–145.
Troels-Smith, J. (1960). Ivy, misteltoe, and elm climate indicators—fodder plants. *Danmarks geoligiska Undersølgelse* **IV** (4), 4–32.
Troels-Smith, J. (1961). Et pileskaft fra tidlig Maglemose tid. *Årb. Nord. Oldk. Hist.* **1961,** 122–144.
Warren, H. S. (1911). Træspyd. *Quarterly Journal of Geological Society* **67,** xcix.
Warren, H. S. (1950). The Clacton flint industry: A new interpretation. *Proceedings of Geological Association* **62,** 107–135.
Westerby, E. (1927). *Stenalderbopladser ved Klampenborg. Nogle bidrag til Studiet af den Mesolitiske Periode*. Copenhagen.
White, T. E. (1953). A method of calculating the dietary percentage of various food animals utilized by aboriginal peoples. *Antiquity* **18,** 396–398.
Winge, H. (1904). Jordfundne pattedyr. *Videnskabelige meddelelser fra den Naturhistoriske forening i Kobenhavn* **1904,** 193–304.