OSSA

International Journal of Skeletal Research

VOLUME 3/4 1976-1977

10th ANNIVERSARY ISSUE

Papers in:
Human and Animal Osteology
Forensic Osteology and Applied Techniques
Paleopathology, Prehistoric Environment
Interdisciplinary Studies

Osteological Research Laboratory
University of Stockholm
S-171 71 SOLNA — Sweden

OSSA International Journal of Human and Animal Osteology

SPONSORS
Volume 3/4 1976—1977
The Swedish Natural Science Research Council
The Swedish Council for Research in the Humanistic and Social Sciences
The Sven and Dagmar Salén Foundation

PROGRAM
OSSA is a nonprofit journal directed to all experts and scientists in interrelated fields of human and animal osteology.
OSSA is intended to deal with such material from an interdisciplinary point of view, theoretically, methodologically and practically, in order to use skeletal remains for the exploration of prehistoric and present man, his domestic animals, his environment and its changes, diseases and genetical interrelations, to mention some few aspects.
OSSA is mainly printed in English, but papers in German are also accepted. Each article starts with an English abstract, followed by a resumé in Russian. The summaries should be written in English.
OSSA is *not* delivered on exchange basis.

MANUSCRIPT and BUSINESS ADDRESS
Manuscripts, conforming with the rules on page 3 of this cover as well as communications regarding accepted manuscripts, proofs, orders of reprints, subscriptions, etc. should be addressed to Professor Nils-Gustaf Gejvall, Gnejsvägen 1, S-310 40 HARPLINGE — Sweden.

REPRINTS
Authors will receive 50 reprints free of charge. Further reprints for non-commercial circulation may be ordered by fifties or hundreds according to average prices set by the publisher on a non-profit basis.

SUBSCRIPTION PRICE, including postage
OSSA, volume 1, 1974 (1 issue), Swedish kronor 30: — (US $7: 50) few copies still available
OSSA, volume 2, 1975 (1 issue), Swedish kronor 30: — (US $7: 50)
OSSA, volume 3/4, 1976—1977 (1 issue), Swedish kronor 115: (US $25)
OSSA, volume 3, 1976 supplement 1, Swedish kronor 30: — (US $7: 50)
OSSA, volume 4, 1977 supplement 1, Swedish kronor 30: — (US $7: 50)

OSSA

International Journal of
Skeletal Research

10th ANNIVERSARY ISSUE

To the inauguration of the Osteological Research Laboratory,
University of Stockholm on April 12, 1967

by H. M. King Gustaf VI Adolf

Berlings, Lund 1978

A pathological cannon bone of a giant deer cf. *Praemegaceros verticornis* (Dawkins)

CALVIN WELLS AND PETER LAWRANCE

OSSA

This note describes a pathological metatarsal of *Praemegaceros verticornis* (Dawkins) from West Runton, Norfolk. The bone has a swelling on its antero-medial surface. Its gross and radiographic features are described and the differential diagnoses of the lesion are discussed. The most likely cause of the tumour is ossification of a sub-periosteal haematoma.

В сообщении описывается патологическая плюсневая кость, принадлежащая *Praemegaceros verticornis* (Davkins), найденная в Вест Рунтон, Норфольк. На антеро-медиальной поверхности кости обнаружена опухоль. Дано общее и радиографическое описание её черт, и обсуждается дифференциальный характер повреждения. Наиболее правдоподобной причиной опухоли является окостенение суб-периостальной гематомы.

Calvin Wells and Peter Lawrance, Castle Museum, Norwich, England.

Vol. 3/4, pp 3–9 Lund, ISSN 0345–8865.

The specimen to be described here is in the collections of the Castle Museum, Norwich, England (Acc. No. 80.977). It is a left cannon bone i.e. the fused third and fourth metatarsals of a giant deer. It was found at West Runton, Norfolk, in situ in freshwater detritus muds of early Middle Pleistocene age, about 500,000 B.P. These West Runton sediments are the type sections for the Cromerian stage of the Pleistocene (Zone Cr II) and have long been known as the Upper Freshwater Bed of the Cromer Forest Bed series. This deposit is well known for its fossil mammal remains most of which became washed out onto the beaches of N.E. Norfolk and Suffolk but occasionally, as in this instance, specimens are found within the deposit itself.

The bone, which is heavily mineralized, is exceptionally well preserved and although fractured postmortem is virtually complete, unwarped and uneroded. It is 347 mm. long with diameters, a little below the middle of its shaft, of 38.2 mm. (transverse) and 37.0 mm. (antero-posterior). These dimensions show that it comes from one of the species of large deer common in the Cromerian. At least twelve species of deer are known (Azzaroli, 1953; McWilliams, 1967) five of which are giant. This particular specimen is undoubtedly that of a member of the Megaceros group of which only three species are known for the Cromerian.

Figure 1. Left metatarsal of Praemegaceros verticornis showing swelling on antero-medial surface.

Figure 2. Detail of tumour.

The commonest Megaceros species for the Forest Bed, Praemegaceros verticornis (Dawkins), (McWilliams 1967), is the only one recorded from the Upper Freshwater Bed itself (Stuart 1974, 1975) and on this basis, plus the lack of suitable comparative material, it is suggested here that the specimen also belongs to this species. The maximum transverse and antero-posterior diameters of the head of the specimen are respectively 55.6 mm. and 60.8 mm.; of its distal condyles 64.9 mm. and 40.5 mm. These, together with the measurements given above, prove that it must have come from a large animal. A number of other measurements and indices which can be obtained from it almost certainly show that it was a male.

On the anterior surface of the bone there is an elliptical swelling, the axes of which measure 87 x 31 mm. with the long axis lying proximo-distally (Fig. 1). It is on the medial half on the metatarsal, from where it encroaches on the median sulcus though only enough to make the lateral border of the groove deviate a couple of millimetres from its normal course (Fig. 2). However, the floor of the sulcus is partly filled by this tumour and is shallower alongside it than elsewhere. Almost in the middle of the anterior surface of the mass is a small conical depression, about 4 mm deep, elliptical in outline and measuring 14 x 7 mm. The surface of the tumour is regular in outline but minutely pitted over most of its area. The rest of the bone is normal.

Radiographs of this lesion (Fig. 3) show that there is a clean line of separation between it and the shaft of the bone. The apparent internal thickening of the cortex below the swelling, where it seems to intrude on the medullary cavity, is merely due to the tumour being slightly "wrapped around" the surface of the metatarsal and to the superimposed effect of this as seen in the film. The coarsely granular appearance of the anterior part of the medullary cavity is an artifact due to intrusive particles of grit. The border of the lesion grades smoothly into the periosteal surface of the bone except at its proximal and where there is slight postmortem damage which has led to the most superficial layer of the new bone flaking of the shaft. This flaking of surface plaques is often seen in dried specimens and usually indicates that the detached layer consists of freshly formed bone which has not yet become firmly attached to the underlying cortex. Several layers may be superimposed to give stratification but this does not seem to have happened in the present case. The tumour is much more radiolucent than the normal cortex of the bone and is of almost uniform density except for a small

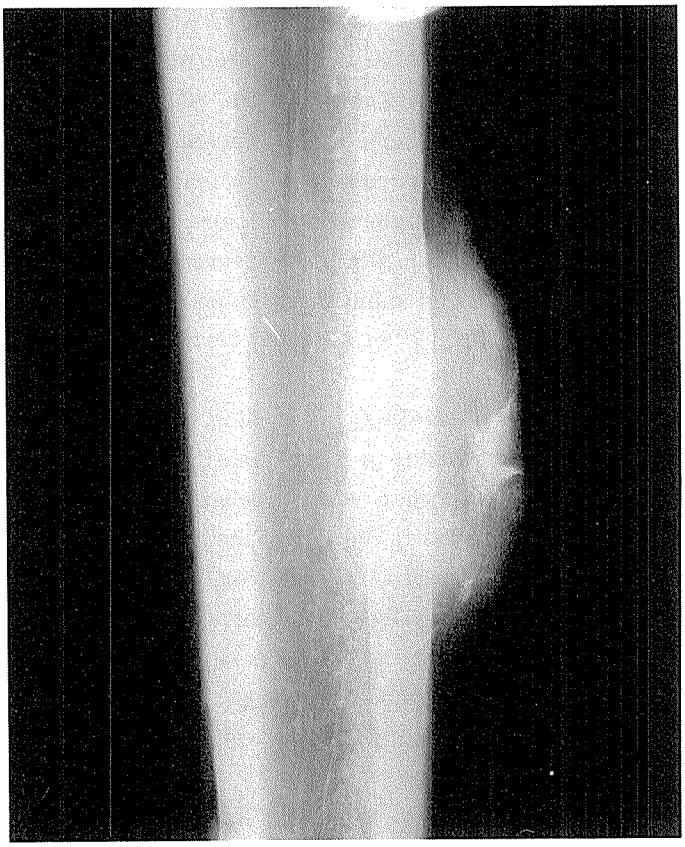


Figure 3. Radiograph of the swelling shown in Figs. 1 and 2. (Exposure 5 ma., 100 KV., 90 Secs. at 275 mm.)

radio-opaque area below the floor of the conical pit which is present in its anterior surface. The internal structure of the mass is neither laminated, chaotic or vacuolated but consists of layers of regularly organized bone almost parallel to the normal anterior surface of the metatarsal.

The diagnosis of this lesion is not immediately obvious. There is no evidence of a fracture anywhere in the bone (except for the postmortem break in its distal

half) so there is no reason to suppose that the tumour is a simple mass of reparative callus. It bears a superficial resemblance to an osteoid osteoma such as that described by Wells (1965) in an Anglo-Saxon femur. But nothing is known about the occurrence of those tumours in deer and the radiographs of this specimen lack the characteristic features which would support this diagnosis.

The possibility of a malignant growth cannot be ignored but the extremely regular shape of the swelling is untypical of many sarcomata i.e. primary growths of bone, and it is even less typical of secondary carcinomatous neoplasms. Moreover, the radiographs again give no support to either of these alternatives. The clean separation of the swelling from the normal shaft and the internal structure of the mass are strongly against a malignant growth. The small pit in the anterior surface of the lesion somewhat resembles the orifice of a fistula through which an abscess might have discharged but there is no evidence of any major infection, such as osteomyelitis, in the medullary cavity. The only trace of an osteitic or periosteitic reaction is the barely detectable roughness or fine pitting on the surface of the swelling which may be due to nothing more than slight chemical or bacterial erosion after the animal's death - an erosion selective for this area on account of the abnormal texture of the bone which formed the lump. It is not clear, radiologically, how deeply the pit originally entered the bone but the area of increased density below it seems to extend about 4-5 mm. beyond the floor of the visible depression and this may give a clue to its original depth.

At a superficial glance this lesion might, perhaps, be attributed to a hydatid cyst of the bone due to invasion by the tapeworm Ecchinococcus granulosus. This is primarily a parasite of the Canidae but deer are among its most common intermediate hosts. Hydatid cysts are often quite regular in outline but the metatarsal subperiosteal region is not a characteristic site for one and, again, the radiographic appearance weighs against it. A more likely diagnosis is that of simple osteoma. These vary much in size and notably in texture, sometimes being loosely cancellous within a thin shell of cortical bone, sometimes being extremely dense throughout the tumour - the so-called "ivory" osteoma. They may occur on any bone of the skeleton.

Osteomata are common in the Bovidae, where they have a predilection for the frontal sinus, but they are also well known in other ruminants, including the Cervidae, though little is known about their frequency or anatomical distribution in early species. The lesion of this Praemegaceros metatarsal could, we think,

be an ordinary osteoma although some of these are pedunculated and many tend to be lobulated rather than of regular profile as this is. Radiographically it does not appear dense enough to be an "ivory" osteoma.

Perhaps the most likely diagnosis is that this is an organized haematoma. The sequence of events which produced it would then probably have been:

(a) a direct blow or other injury on the bone, causing
(b) rupture of a small blood vessel, followed by
(c) extravasation of blood under the periosteum,
(d) clotting of the resultant haematoma and
(e) "organization" of the clot, i.e. its invasion by osteoblasts and subsequent conversion to bone.

If this is what happened the smooth and regular shape of the swelling could then be explained by its initial fluid state, contained within an envelope of periosteum, exerting an even hydrostatic pressure on the surrounding soft tissues. In the median sulcus of the bone, immediately adjacent to the proximal end of the tumour, is a foramen for a distally directed nutrient artery. A small sub-periosteal branch from this would have been vulnerably placed and easily ruptured by trauma of the kind postulated above. If this animal was a male, as seems extremely probable, the lesion may have been the result of a fight for herd leadership or during the rutting season. The slight postmortem flaking noted above, which exposes an almost smooth surface of subjacent cortex, probably indicates that the injury occurred only a short time before the animal's death.

Any suggested aetiology of this swelling ought to explain the small conical pit on the apex of its anterior surface. This cannot be done with certainty but one possibility is that at some time before the haematoma became fully ossified the overstretched periosteum had been weakened and thinned in this area so that, spontaneously or because of another injury, it ruptured. This could have allowed a small part of the clot to dissipate into the surrounding tissues where it was removed by phagocytes instead of being calcified. It is unlikely that a sinus from the clot burst through the overlying skin because, in that event, a substantial infection would probably have supervened, an infection which would have produced more obtrusive changes than the minute pitting or granularity of the bone which has been noted above. However, too much weight should not be placed on this because it is possible that a low grade, relatively non-virulent, infection did

occur and explains not only the surface pitting but also the small radio-opaque area beneath the conical depression.

Acknowledgements

Our thanks are due to the finder of the specimen, Mr. J. Moreton of Norwich, who kindly donated the specimen to the Museum. Also to Mr. Francis Cheetham, Director, Norfolk Museums Service for permission to publish this note, to Miss Mary Kippen for her photographs of the bone and to Mrs. Sylvia Turner for the radiography.

References

Azzaroli, A. 1953: The deer of the Weybourne Crag and Forest Bed of Norfolk. Bull. Brit. Mus. Nat. Hist. (A. Geology) 2, 3-96.
McWilliams, B. 1967: Fossil vertebrates of the Cromer Forest Bed in Norwich. Castle Museum, Norwich. Modern Press 15-18.
Stuart, A.J. 1974: Pleistocene History of the British Vertebrate fauna. Biol. Rev. 49, 225-226.
Stuart, A.J. 1975: The Vertebrate fauna of the type Cromerian. Boreas 4.
Wells, C. 1965: A pathological Angl-Saxon femur. Brit. J. Radiol. 38, 393-394.

Two cases of polytopic osteolytic lesions in the pyramid age Egyptians

EUGEN STROUHAL

OSSA

Two cases of polytopic osteolytic cranial lesions in the 5th–6th Dynasties section of the Naga-ed-Dêr cemetery are described. Larger and older lesions were found side-by-side with minute, beginning lesions, causing the map-like character of the general picture. The process progressed from the external surface of the bone and limits of individual bones were not respected. By single foci also pelvis and thoracic vertebra were affected. Among the possible diagnosis, discussed with respect to the young age of the patients, tuberculosis and Hand-Schüller-Christian disease showed most similar features. An analoguous finding could be detected in older literature.

В работе описаны два случая политопических остеолитических повреждений черепов из сектора V и VI династий некрополя Нага ед-Дер (Египет). Большие, старые повреждения находились рядом с малыми, зарождающимися, в результате чего получился картографический облик процесса. Процесс продвигался с наружной поверхности кости, не соблюдая краёв индивидуальных костей. Единичные очаги находились в тазу и в грудном позвонке. Среди диагностических возможностей, обсуждаемых с точки зрения молодого возраста больных, у туберкулёза и болезни Ханд-Шиллер-Христиана обнаружено большинство сходных черт. Аналогичный случай можно найти в литературе.

Eugen Strouhal, Náprstek – Muzeum of Asian, African and American Cultures, Betlémské Náměstí 1, Prague 1, Czechoslovakia.

Vol. 3/4, pp 11–52, Lund. ISSN 0345–8865.

Introduction

During my study trip to the U. S. A. in 1973, sponsored by the grant No. 2623 of the Wenner-Gren Foundation for Anthropological Research Inc., New York, N. Y. as well as by the grant from the Hrdlička Foundation at the Smithsonian Institution, Washington D. C., I spent two months at the Lowie Museum of Anthropology, University of California, Berkeley, California. In its rich collections I studied the valuable series of human skeletal remains found in cemeteries dating from the Predynastic period until the Coptic time at Naga-ed-Dêr, Upper Egypt. A monography on the whole material, concerning both physical anthropology and paleopathology, is under preparation. The present report deals with two interesting paleopathological cases, discovered among the material from Cemetery 500-900, dated Old Kingdom (5th-6th Dynasties).

Acknowledgements

I would like to express my best thanks to Mrs. Lita Osmundsen, Director of Research at the Wenner-Gren Foundation for Anthropological Research Inc., and to Dr. J. Lawrence Angel, Head of the Subdivision of Physical Anthropology at the Smithsonian Institution, for their basic support of my work. I mostly appreciate the warmest reception and friendly help at the Lowie Museum, thanks to Dr. Frank A. Norick, Principal Museum Anthropologist, to Mr. Dave D. Herod, Senior Curatorial Anthropologist and other colleagues there. For providing the X-ray pictures I am deeply indebted to Dr. Joseph Gregory, Director of the Paleontology Museum, University of California at Berkeley, for some of the photographs to Mr. Eugene Prince from the Lowie Museum, and for the microphotographs to Dr. Alena Němečková, Institute of Histology and Embryology, Medical Faculty, Charles University, at Plzeň, Czechoslovakia. The diagnosis of the published cases was discussed with several colleagues from different Institutes and Clinics of the Medical Faculty, Charles University, Prague, namely Prof. Dr. R. Bláha, DrSc., Doc. Dr. J. Kolář, DrSc., Doc. Dr. V. Pazderka, CSc., Doc. Dr. E. Šilinková-Málková, CSc., Dr. L. Vyhnánek, CSc., and with Dr. E. Vlček, DrSc. from the Anthropological Deparment, National Museum, Prague. Their suggestions have been mostly appreciated.

Archaeological background

The two described pathological specimens were exhumated in the Pyramid age section, labelled "500-900", of the vaste cemetery at Naga-ed-Dêr, Upper Egypt.

This is one of a series of cemeteries covering the period from Predynastic until Coptic times excavated on the eastern bank of the Nile from 1901 till 1903 by the Egyptian Expedition sponsored by Mrs Phoebe A. Hearst and the University of California under the direction of George Reisner. The Pyramid age section was situated on a promontory to the west of the village Naga-ed-Dêr across the 3rd wadi (Reisner 1908, planche 79, Reisner 1932, fig. 1, p. 2). There was shown to be a definite chronological succession in the burials, so that the part nearer to cultivation was dated 2nd-3rd Dynasties, the middle part to 4th or 5th Dynasty and the uppermost part to 5th-6th Dynasties. Thus the cemetery grew generally from southwest to northeast. Alltogether 624 graves were found, covering a period of about five centuries. This points to a small village community.

Both the described pathological specimens were found in the uppermost part of the cemetery, dated 5th-6th Dynasties. Case No. 1 (Lowie Museum Inv. No. 12-4880) comes from tomb No. 761. This was a relatively short rectangular pit (170 x 130 cm, 120 cm deep) with stone slab roof and stone slab lining. The leg-contracted skeleton was lain on left side with head north in a plastered wooden coffin (120 x 54 cm, 40 cm high). The excavator noted that "bone tips were not ossified" and that "very thin bones were eaten by insects". Burial was intact, however, it contained no archaeological objects (Reisner 1932, p. 297).

Case No. 2 (Lowie Museum Inv. No. 12-4891) originates in tomb No. 975. This was a long narrow rectangular pit (160 x 80 cm, 120 x 180 cm deep), opened in a long low end chamber (200 x 100 cm, c. 70 cm high). The disturbed leg-contracted skeleton was lying on left side between traces of the wooden coffin (c. 190 x 50 cm). In debris at head, a red-painted ware, shoulder jar, was found (Reisner 1932, p. 358).

Tombs of Reisner's type VI a-d, dated 5th-6th Dynasties, lie in rows after the manner of family groups (Reisner 1932, p. 189). Both tombs, nos. 761 and 975 situated at a distance of c. 28 m, did not, however, belong to the same "family row", but to two different rows, separated by a third one in between (Reisner 1932, plan, sheet III:D2 and C3).

Previous anthropological work

The anthropological material was entrusted to Grafton Elliot Smith, at that time Professor of Comparative Anatomy at the Khedivial School of Medicine in Cairo, who examined the skeletons in the graves and transported the major part of the bones to his Institute in Cairo, where he continued their study (Reisner 1908). Unfortunately, he never published fully his results except some notes on them (Smith and Jones 1910). The material perished in Cairo after his death and even his meticulous notebooks were destroyed by ignorance (personal communication of Mr. Dows Dunham, Boston). The smaller part of the anthropological material was shipped by Reisner together with the archaeological specimens to the California University, where they were deposited at the Lowie Museum of Anthropology (Anonymous 1904).

The Lowie Museum Egyptian human remains including the material from Naga-ed-Dêr were studied by R. Wood Leigh, who examined all cranial specimens,

including calvarium, facial bones, and teeth, and determined their descriptive characters and measurements (Leigh 1934). His publication was devoted mainly to morphology of the mandible, palate, teeth and some other structures of the facial skeleton as well as to the study of pathological conditions, such as attrition, dental caries, and other diseases of teeth, maxillary chronic sinusitis, osteoarthritis, lesions on parietal bosses and fractures. There is but, curiously enough, any mention of the pathological specimens described in our present communication.

The same author determined the sex and age of the specimens for the Catalogue No. 12 of the Lowie Museum of Anthropology. The individual No. 12-4880 is indicated simply as "a child", the individual No. 12-4891 as a male of about 30 years.

Vertebral columns of the Lowie Museum Egyptian anthropological collection including our specimens were studied recently by Marylynn S. Barker, University of California at Davis, California (personal communication).

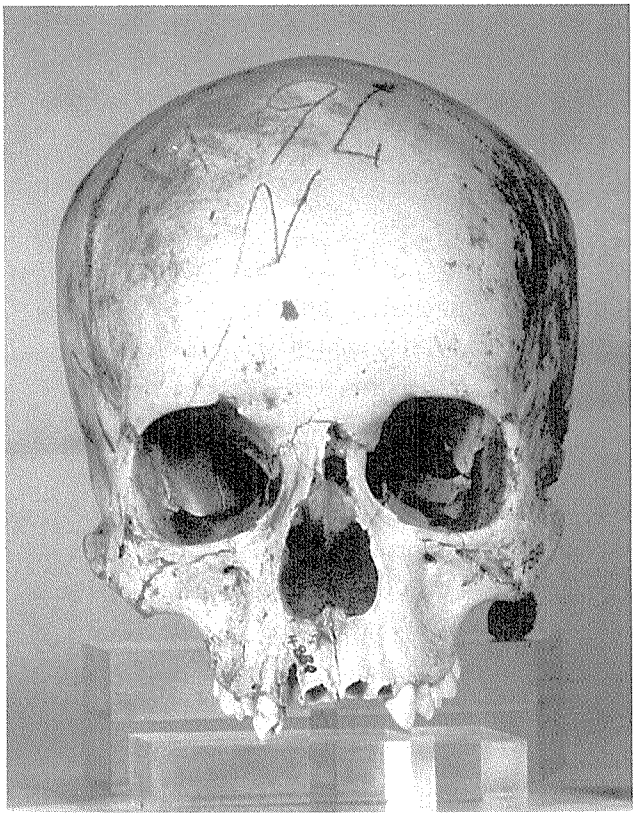


Figure 1. Calvarium of case 1 in norma frontalis.

Case No. 1 (Inv. No. 12-4880)

Basic demographic data

State of preservation is relatively good. The skull (fig. 1-5) is damaged only at the base, to the left of the foramen occipitale magnum, where a part of the occipital bone is missing. All upper incisivi were lost post mortem. No mandible is present. The postcranial skeleton is almost completely preserved.

Individual age. The metric data of the skull (table 1) indicate that the growth was not yet finished. The synchondrosis sphenoccipitalis is largely open (chink of 2 mm), all cranial sutures do not show any signs of obliteration. Both occipitcal condyles still show shallow transverse grooves. In the upper dentition on both sides hypodontia of the third permanent molar was found. The other teeth of the permanent dentition are fully erupted including the second molar. The teeth roots are completely developed (fig. 10). The attrition of the teeth is not yet apparent on the premolars and on the second molars, it concerns the enamel only on the canines and it exposed dots of dentin on the first molars.

The long bones of the postcranial skeleton have not yet united their epiphyses with the respective diaphyses. Their length (table 2) would correspond to an age of 11-12 years according to the growth of older bronze age material (Strouhal 1973). In the humerus, also the epicondylus lateralis, which unites between 10-12 years according to Borovanský and Hněvkovský (1930) or at 14 years according to Schinz et al. (1952), is not yet present. Ilium, ischium and pubis are not yet united; their union occurs at 16 years according to Schinz et al. (1952). The neural arches of the vertebrae are completed but on the lower and upper faces of the vertebral bodies radial grooves are present. The sacral vertebrae are not yet united both between the bodies as well as between the lateral parts; their synostosis occurs between 11-13 years according to Schinz et al. (1952).

We may conclude, that according to the eruption and attrition of the teeth, the age of 13-14 years seems mostly probable. The features of the postcranial skeleton, however, would suggest a lower age of about 11-12 years. This discrepancy would point either to the delayed evolution of the postcranial skeleton, probably connected with the disease (?), or to the accelerated eruption of the teeth, especially second molar, a fact well established also in other osteological series.

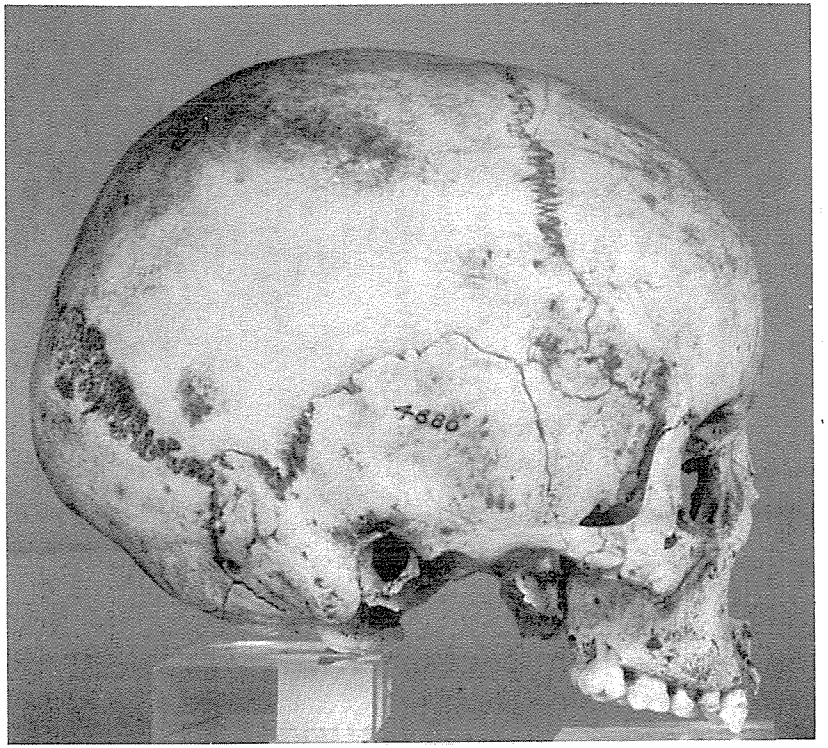


Figure 2. Calvarium of case 1 in norma lateralis dexter.

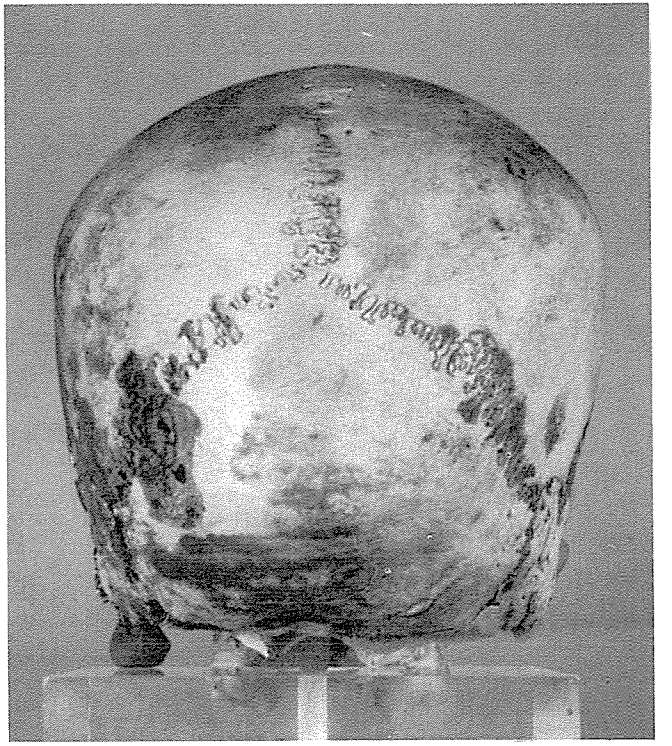


Figure 3. Calvarium of case 1 in norma occipitalis.

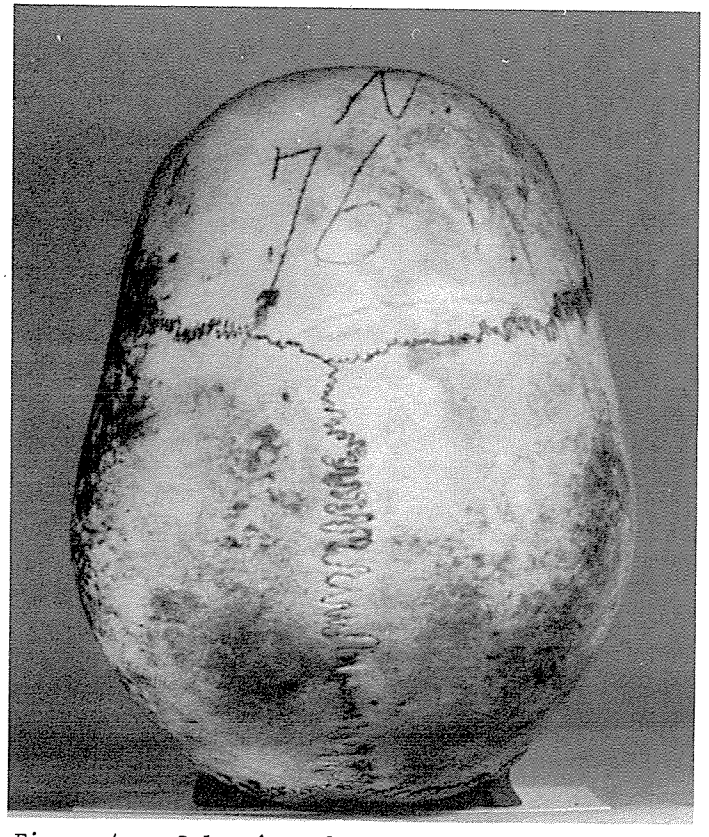


Figure 4. Calvarium of case 1 in norma verticalis

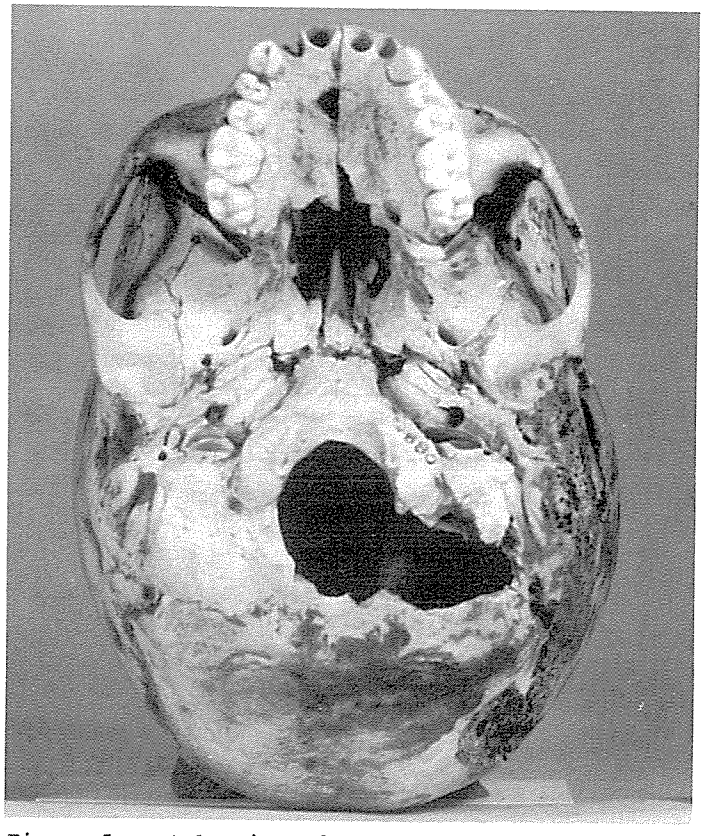


Figure 5. Calvarium of case 1 in norma basalis.

An age determination of 12-13 years for the mentioned individual should be, therefore, taken into account as a compromisive approximation.

Sex determination. The secondary sexual features are mostly not yet fixed at this low age. There is, however, no feature which would suggest a development towards the male sex, so that the female one would seem to be somewhat more probable.

Description of the lesions

Skull: macroscopic picture. The left half of the brain-case is affected by osteolytic lesions (fig. 6). One lesion (fig. 7) is situated around the middle of the left half of the lambdoid suture, affecting mainly the occipital squama in an irregular oval area (33 x 21 mm), but as well reaching across the lambdoid suture on the left parietal bone by a roughly square projection (9 x 10 mm). On the edges of the lesion the outer table is slightly obliquely eroded in a band of 1-2 mm breadth. Towards the center the erosion continuing in the same slightly slanting direction, uncovered the diploë in a band of mostly 6 mm breadth. In the central part of the lesion, the inner table was denuded on two places (13 x 8 and 8 x 8 mm). Its thinning by the erosion resulted in perforation in the center of both places.

The other lesion (fig. 8) uncovered the cellulae mastoideae and the diploic cavity of the left temporal bone from the base of processus mastoideus to the squama temporalis and from the root of processus zygomaticus to about 14 mm in front of the left asterion. In the center of the temporal squama the inner table was denuded. There is a preserved section of it at the anterior and lower edge of a large perforation, which partly resulted from the thinning of the inner table, partly was secondarily enlarged.

A third lesion (fig. 9) can be observed around the lower third of the left half of the coronal suture. It is situated mostly on the left parietal bone with a small projection in its lower anterior angle to the frontal bone. The shape is of an irregular rectangular triangle with one side roughly sagittal (21 mm) and the other transversal (21 mm), the hypotenuse running obliquely (32 mm). There is an additional circular projection in the upper angle of the triangle. The edges of this lesion are sharply cut out in both the outer and the inner table, which is perforated in the whole extent of the lesion. The diploic layer is deeply undermined between the both tables.

Another small lesion is situated on the lateral surface of the left ala magna

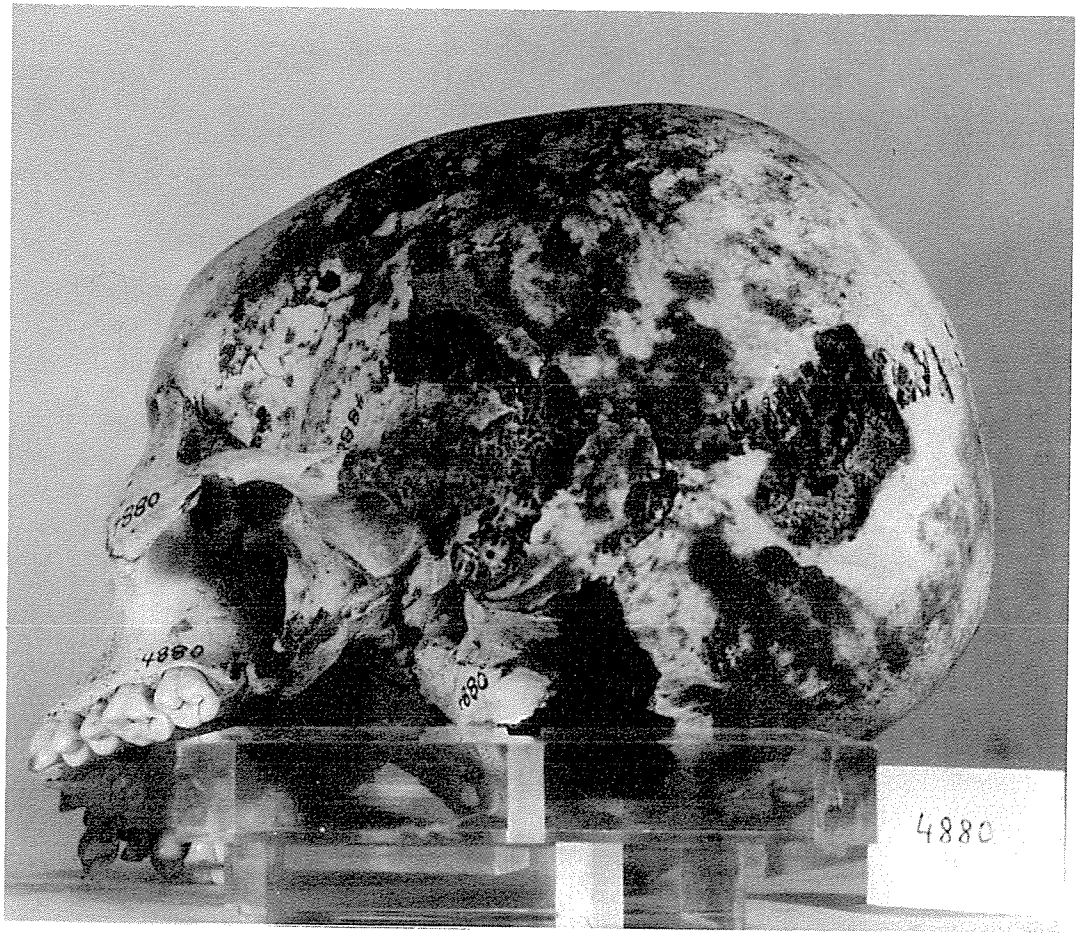


Figure 6. Calvarium of case 1 showing the left lateral side with the lesions.

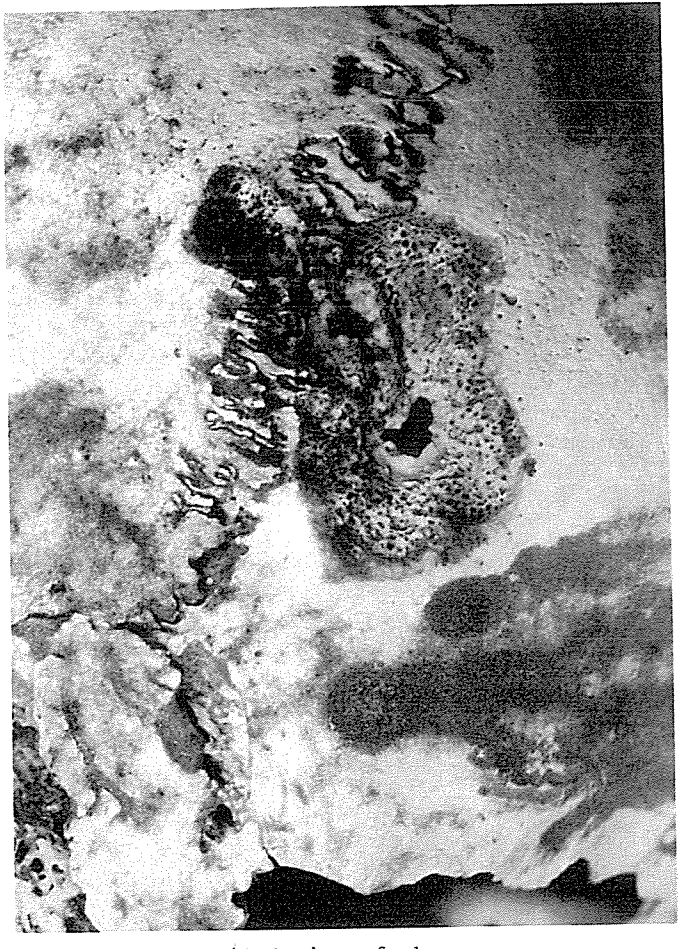


Figure 7. Detailed view of the occipital lesion of case 1.

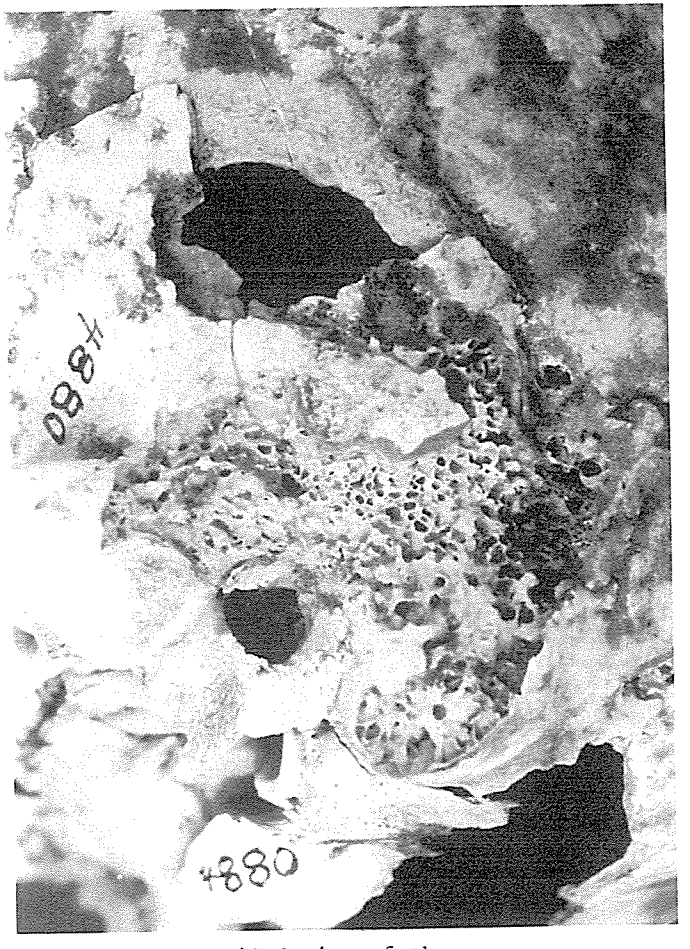


Figure 8. Detailed view of the temporal lesion of case 1.

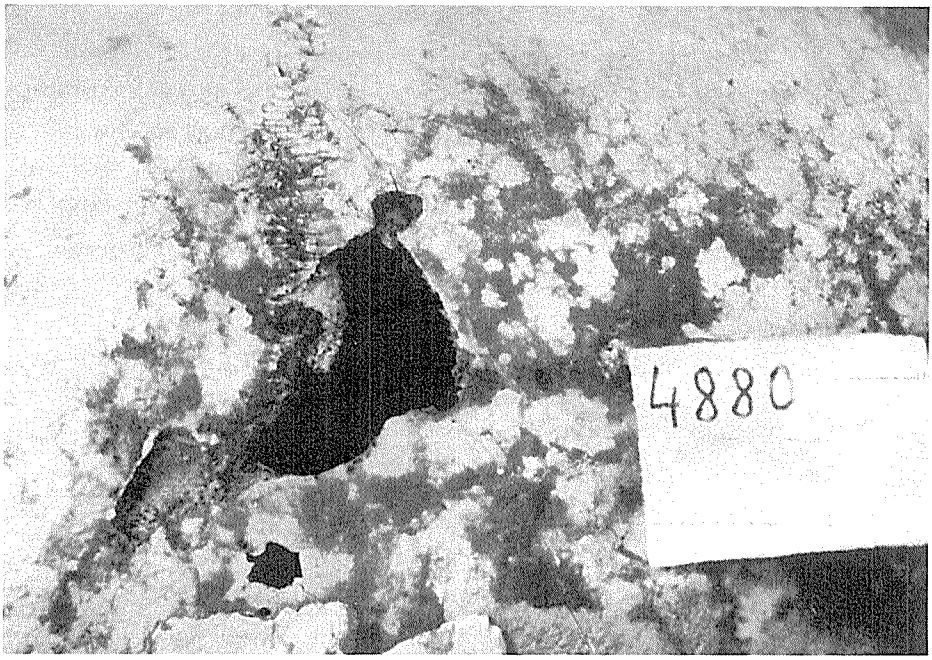


Figure 9. Detailed view of the lesion in the left coronal region of case 1

sphenoidis just above the crista infratemporalis. Its shape is irregular (7 x 14 mm), secondarily enlarged, with typically sharply cut out edges and undermined diploë.

Both orbits show typical cribra orbitalis. In the roof of the left orbit, there is, moreover, the fifth lesion of trefoil outline. One oblong projection is directed medially and anteriorly (14 x 7 mm), another medially and posteriorly (18 x 9 mm) and the third, circular one, laterally and anteriorly (diameter 13 mm). It cannot be excluded, however, that both medially directed projections continued farther medially and destroyed some of the now-a-days wholy missing medial wall of the orbit. Outer table is sharply cut out and the diploic layer is uncovered in the whole extent of the lesion. Some signs of reactive remodelling of the diploic cellules can

be observed.

Skull: X-ray picture. In the side, slightly oblique view (fig. 10) we may observe the three largest lesions, in the lambdoid, temporal and coronal regions. They are characterized by large irregular map-like areas of brightness, corresponding to the perforation as well as to the extreme thinning of the bone. The borders of all lesions are well defined. The structure of the bony tissue in their vicinity is quite normal without any visible osteoplastic reaction or osteoporotic rarefaction.

Figure 10. Lateral radiograph of case 1 showing all lesions.

Postcranial skeleton. The whole postcranial skeleton studied both macroscopically and by X-ray was found in normal condition without any sign of lesion as described on the skull, except the pelvis.

On the interior aspect of the left innominate bone, in the area of the tuberositas iliaca, there opens a roughly oval cavity (10 x 8 mm), penetrating into the bony marrow, but not perforating the external compact zone of the bone (fig. 11). The corresponding right ilium (ischium and pubis missing) is free of pathological changes (fig. 12). On the radiograph, the clearly outlined character of the focus without peripheric zone of condensation or rarefaction is apparent (fig. 13).

Figure 11. Left innominate bone of case 1 with a hole at tuberositas iliaca.

Figure 13. Radiograph of the left innominate bone of case 1 showing the lesion.

Figure 12. Right iliac bone of case 1 without pathological changes.

Case No. 2 (Inv. No. 12-4891)

Basic demographic data

State of preservation. The skull (figs. 14-19) was reconstructed from a number of small fragments. Its facial part is, nevertheless, not complete and besides the pathological destruction some parts (left zygomatic bone, right maxilla with teeth, part of the right zygomatic bone, part of right ala magna sphenoidis, lower margin of left mandibular angle etc. (could have been lost post-mortally. The postcranial skeleton is almost complete, but the majority of bones are broken and some of their parts missing. Right clavicle has not been preserved.

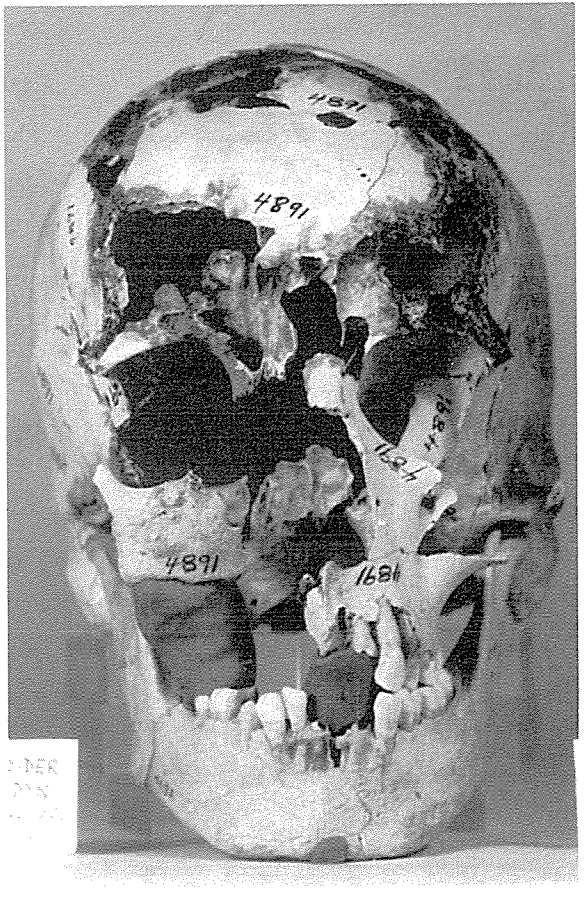
Individual age. A complete permanent dentition was originally present in the jaws, including the third molars (figs. 14-16). The attrition of most teeth is only slight, limited to the enamel. The lower frontal teeth and the first lower molars show beginnings of uncovering dentine (fig. 19), the upper first molar bands of usured dentine. The sutures of the cranial vault are open except the total closure of the sagittal suture (fig. 18), which seems to be premature.

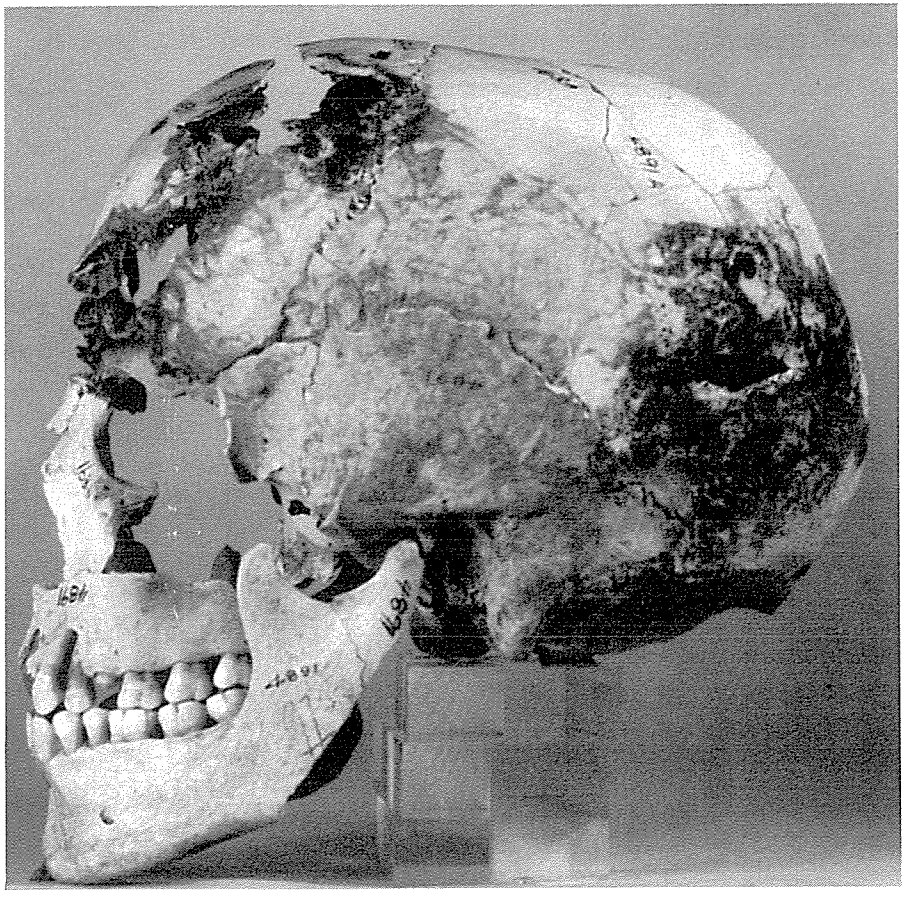
There are no signs of senile changes at the postcranial skeleton except areas of atrophy in the center of both pelvic bones. On the other hand, there are still visible traces of epiphyseal junction at the heads of humeri and femori and at the lower ends of both radii and ulnae, as well as under crista iliaca and tuberositas glutea of both pelvic bones and at the edges of vertebral apophyses.

According to this findings, a young adult age of about 25 years seems to be most probable.

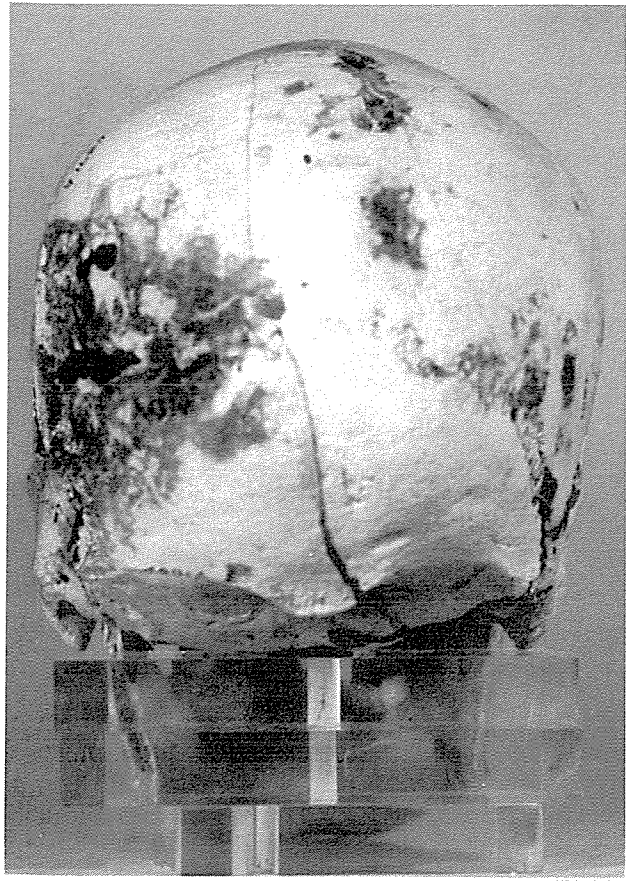
Sex determination. The overall dimensions of the skull (table 3) are large. The robusticity of the skull and postcranial skeleton is medium to well marked. Both glabella and arcus superciliares were destroyed by the disease, the protuberantia occipitalis externa (fig. 17) is very well expressed (Broca 4). The occipital squama is medium bulged and the occipital muscular relief medium marked. The mandible (figs. 14, 16, 18, 19) has medium to well developed muscular relief with everted angle. The lower teeth row is angulated at the canini. The chin has a slightly developed protuberance but very strongly marked tubercula mentalia, which form an outstanding cornice (46 mm large). The secondary sexual features of the pelvis are clearly that of a male.

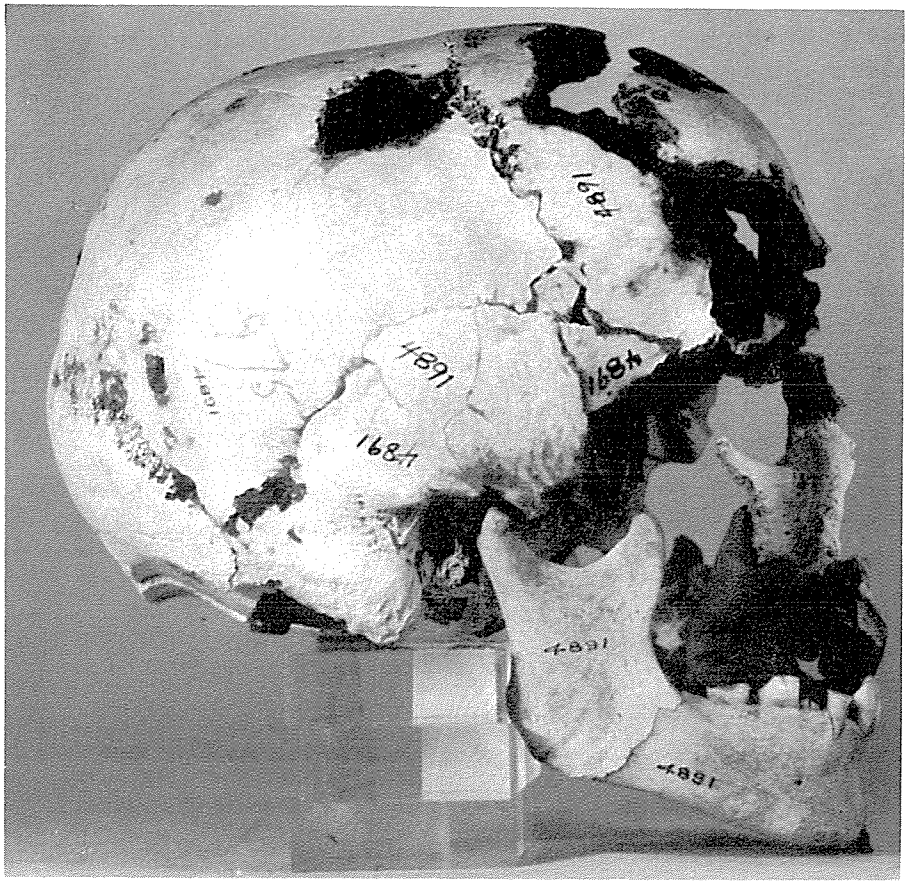
There can be, according to the mentioned features, no doubts that the remains belong to a man.





Figures 14 and 15. Skull of case 2 in norma frontalis and in norma lateralis sin.





Figures 16 and 17. Skull of case 2 in occipital view and in norma lateralis dexter.

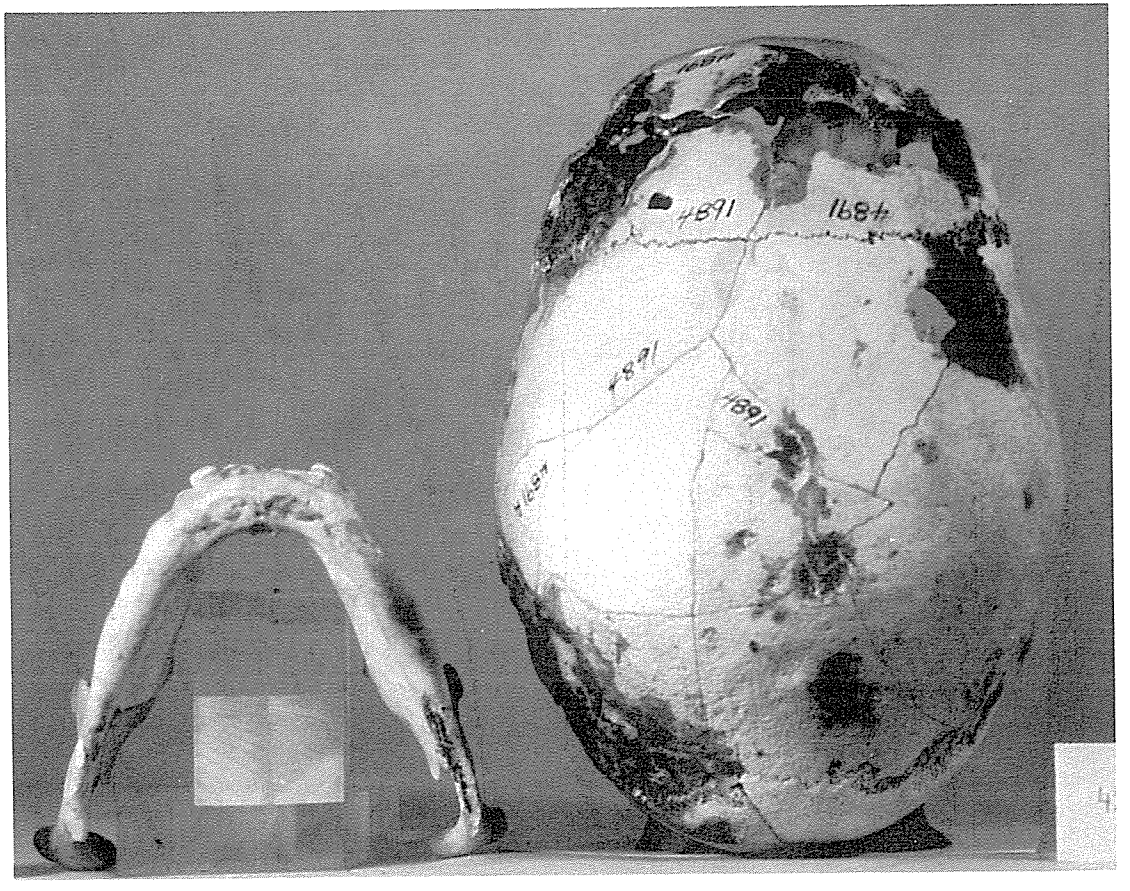


Figure 18. Mandible and skull of case 2 in norma verticalis.

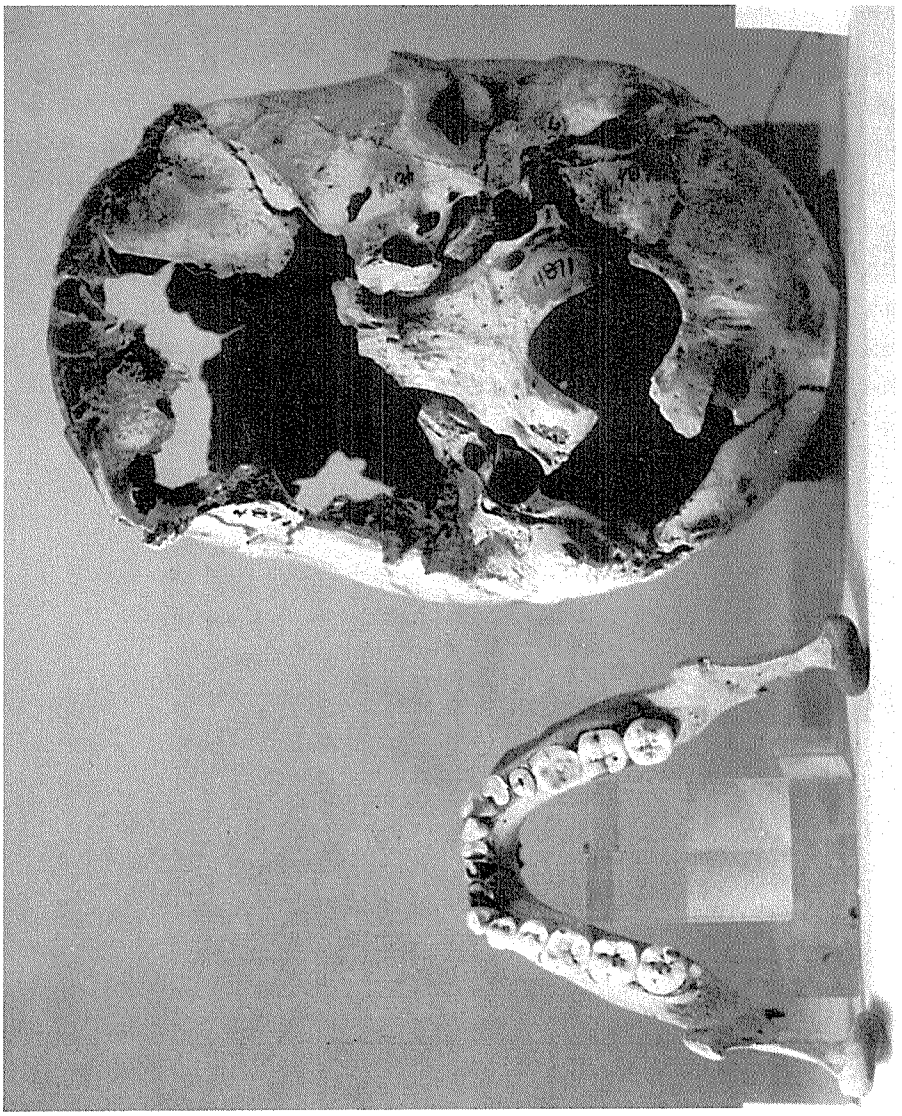


Figure 19. Mandible and skull of case 2 in norma basalis.

Description of the lesions

Skull: macroscopic picture. The extent and intensity of the lesions are, in comparison with the preceding case, much bigger. They are also mainly situated in the calva and show a polytopic map-like pattern.

The frontal squama is the mostly afflicted area (fig. 20). Its right lower quarter is perforated by a large almost triangular hole (49 x 34 mm), stretching from the mediosagittal line to the anterior end of the right linea temporalis and up laterally of the right tuber frontale. The upper and medial edges of the perforation are sharply cut out, both the outer and inner table being undermined sandwichlikely by the growth of the pathological tissue as much as 10 mm inside the diploic layer.

Figure 20. Lower frontal region of case 2 with massive lesions.

On the other hand, the lateral edge was eroded in a slightly sloping direction from outside, resulting in uncovering of a maximally 6 mm large band of diploë. On the lower and medial edges the lesion penetrated the right frontal sinus, as well as the roof of the right orbit, which show together with the left one a slight cribra orbitalis. A projection of the pathological condition penetrated laterally into the right processus zygomaticus of the frontal bone. The whole extent of the lesion, measured at the surface of the outer table, is transversally 56 mm, sagittally 41 mm not including the region of the frontal sinus.

A similarly situated triangular lesion in the left lower quarter of the frontal scale (fig. 20) has a smaller perforation of V-shape (23 x 26 mm). Around it the diploë has been largely uncovered, showing a gentle slope from the edges in the outer table towards the edges of the perforation in the inner table. Medially the lesion penetrated the left frontal sinus, caudally it destroyed the anterior edge of the left orbital roof. A projection of the condition into the left processus zygomaticus of the frontal bone penetrated deep into the diploic layer. The upper projection reached laterally of the left tuber frontale. The extent of the lesion is 41 mm both transversally and sagittally (without the frontal sinus).

In a macrophotographic view of the described lesion (fig. 21) it is possible to see the vital reaction in the diploic layer resulting in sclerosis of same diploic cellules but without any bigger osteoplastic production.

Both described lesions were connected by the lesion of the area of sinus frontalis (fig. 20). Only parts of its posterior wall persisted, but even in it a perforation of its left medial quarter occurred. Its anterior wall was, most probably as result of the pathological condition, completely devoured. We cannot be quite sure how far the pathological condition penetrated caudally and occipitally into the ethmoid area, because some of the missing structures could have been lost secondarily. Owing to the gnawed anterior part of the opened sphenoid sinus (fig. 14) we may assume, however, that the pathological condition reached till there. It cannot be excluded, that also some of the missing parts of the right maxilla were devoured by the pathological condition.

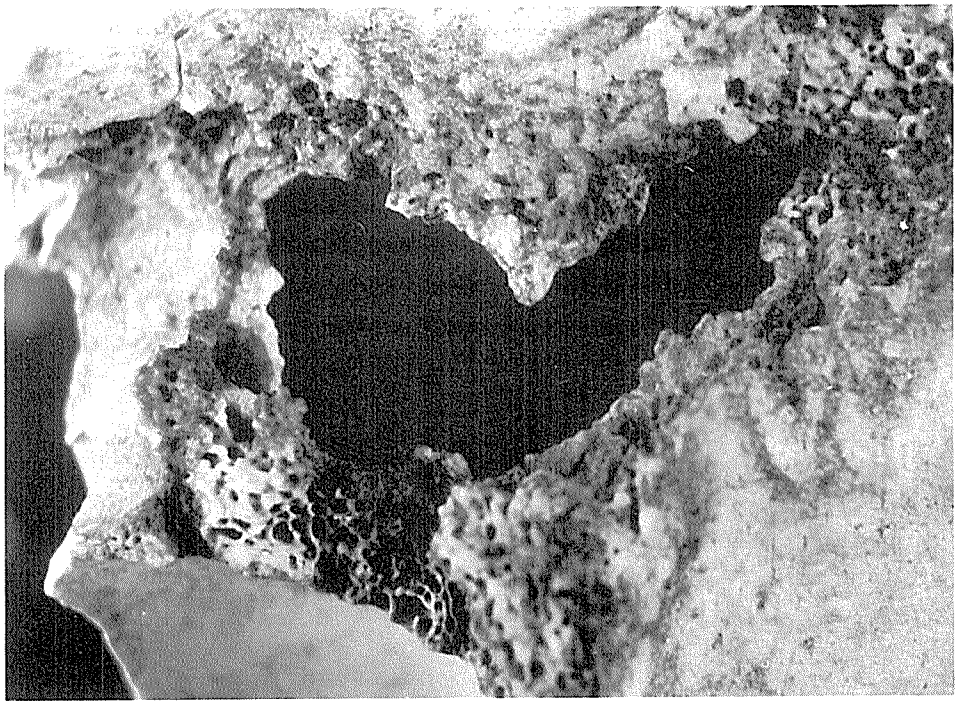


Figure 21. Detailed view of the perforated lesion in the left supraorbital region of case 2 showing sclerotic changes in the diploë.

Another girdle of destruction is situated transversally in the upper half of the frontal scale paralelly to the nearby coronal suture (fig. 22). Its outline is rather irregular with several projections. The maximum extent of the destruction is transversally 107 mm, sagittally 58 mm. Greater part of the destruction shows perforation of the inner table (98 x 50 mm). The edges of the lesion are in its right and medium thirds mostly sharply cut out and deeply undermined by the destruction of the diploic layer (as much as 20 mm deep, fig. 23). On the other hand, in the left third of the lesion and in two other smaller sections, the diploë is uncovered by gently sloping erosion in a very broad band (max. 30 mm). The surface of the diploë is very irregular: on some places there are normal diploic cellules, on other osteoplastic changes reaching till a dense sclerotic layer (fig. 24).

The spreading of the pathological condition occurred probably also through the diploic layer. This can be exemplified by 3 small foci penetrating the outer table

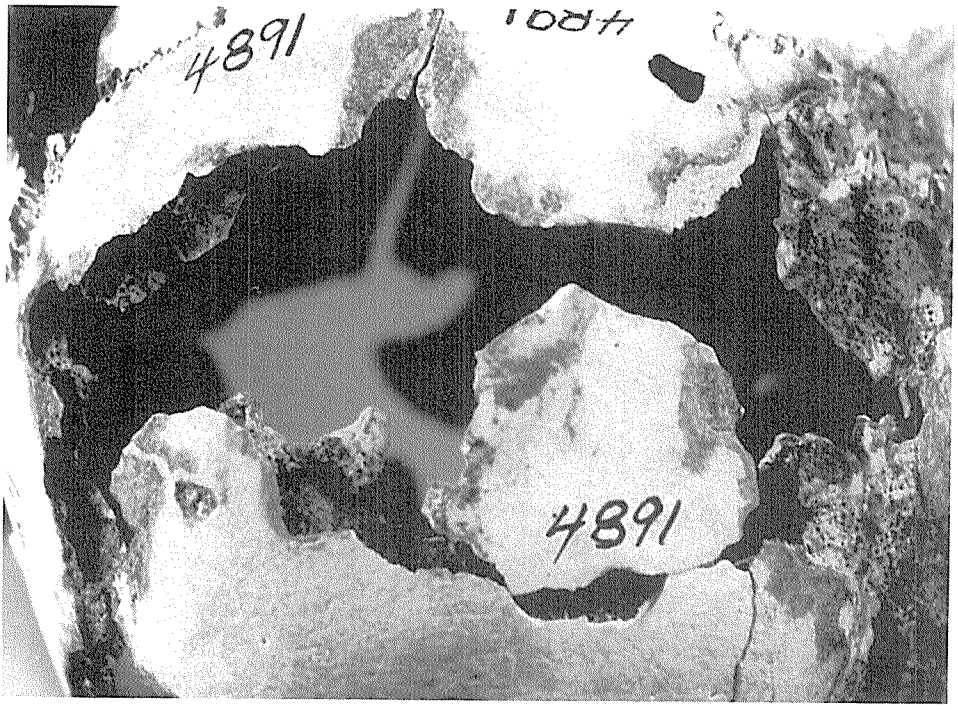


Figure 22. Upper frontal region of case 2 with largely perforated lesions.

which are situated just nearby the described destruction (fig. 22). The first one (6 x 4 mm) lies 8 mm above the destruction, 10 mm anteriorly of the coronal suture and 19 mm left of the mediosagittal line (mid-line). The second one (10 x 6 mm) is situated 8 mm anteriorly of the destruction and 4 mm left of the mid-line and has also the inner table perforated. The third one (4 x 4 mm) can be found 7 mm anteriorly of the destruction just above the right tuber frontale.

Both the described large destructions in the frontal scale were connected laterally of tubera frontalia. The greatest resistence towards the progression of the pathological condition showed, therefore, the central part of the frontal scale between the both tubera.

The right parietal bone is less afflicted by the lesion (fig. 18). A large one, perforating the bone, joins with its anterior edge the coronal suture, starting 43 mm right of bregma. Its outline is irregular with rounded projections (31 x 34 mm), the edges are sharply cut out and both compact tables undermined (max. 10 mm). This lesion is situated only 8 mm posteriorly of the right lateral

Figure 23. Detailed view of lesion in the right upper frontal region of case 2 showing the undermined compact tables.

projection of the rear lesion at the frontal scale.

There is still a number of smaller foci on the right parietal. Some of them show only abraded outer table, other penetrated deeper into the diploë which is either undermined or shows some osteoplastic reaction, and in some of them also small parts of the inner table were perforated. Three foci lie on a line starting 50 mm posteriorly of the coronal suture and 7 mm right of the mid-line and ending 16 mm anteriorly of the lambdoid suture and 18 mm right of the mid-line. The first focus is sagittally oval (13 x 7 mm), the second one circular (diameter 14 mm), both perforating the inner table (fig. 25) and the third one

Figure 24. Detailed view of the lesion in the left upper frontal region of case 2 showing the osteoplastic changes in the diploë.

roughly sagittally oval (20 x 13 mm), shallow, with only slightly touched diploë. Further minute, beginning foci, concerning only the outer table, are situated on the right tuber parietale, and further five near the posterior edge of the right parietal, some of them joining the lambdoid suture. Only the last of them reaches deeper till the diploë.

On the left parietal bone a large lesion is situated in its posterior lateral quarter (fig. 26) reaching from tuber parietale to asterion and from the notch of the squama temporalis almost to lambda (82 x 79 mm). The lambdoid suture is crossed by some small projections to the occipital scale. On the whole surface

of the lesion the diploë is uncovered, showing no normal diploic cellules, but very irregular rough relief with small tubercles, crests and pits of newly formed sclerotic bone. On three places, however, the erosion perforated also the inner table. The edges of the perforations are gently sloping from the outside.

A small superficial focus (14 x 8 mm) can be found 22 mm left of the mid-line and 41 mm anteriorly of the lambdoid suture (fig. 18).

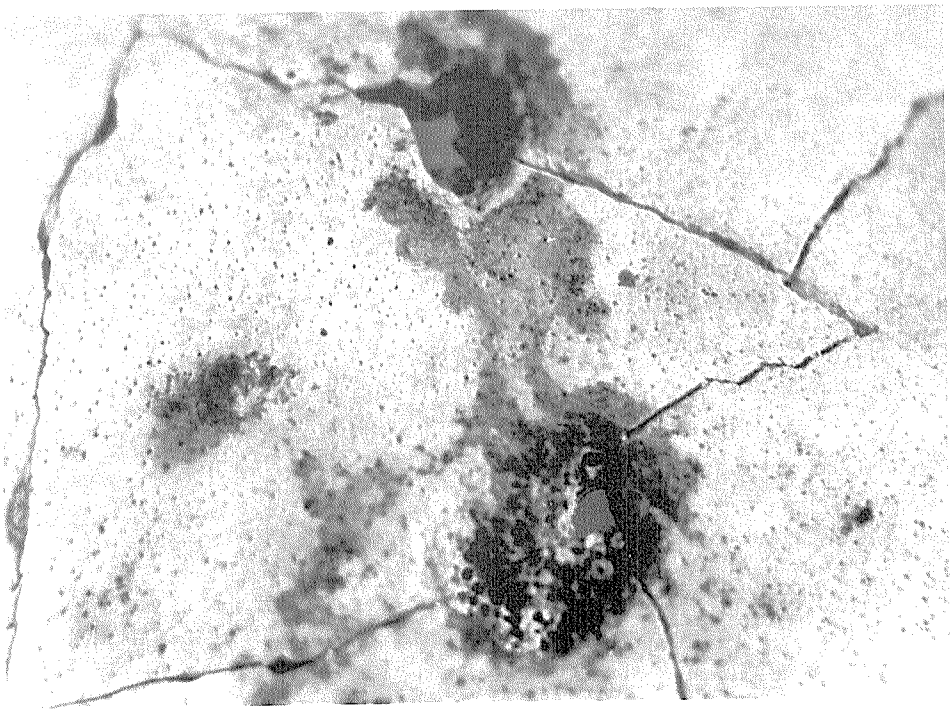


Figure 25. Detailed view of two smaller foci on the right parietal and of a minute focus on the left parietal of case 2. The sagittal suture, which should run in between, is smoothly closed.

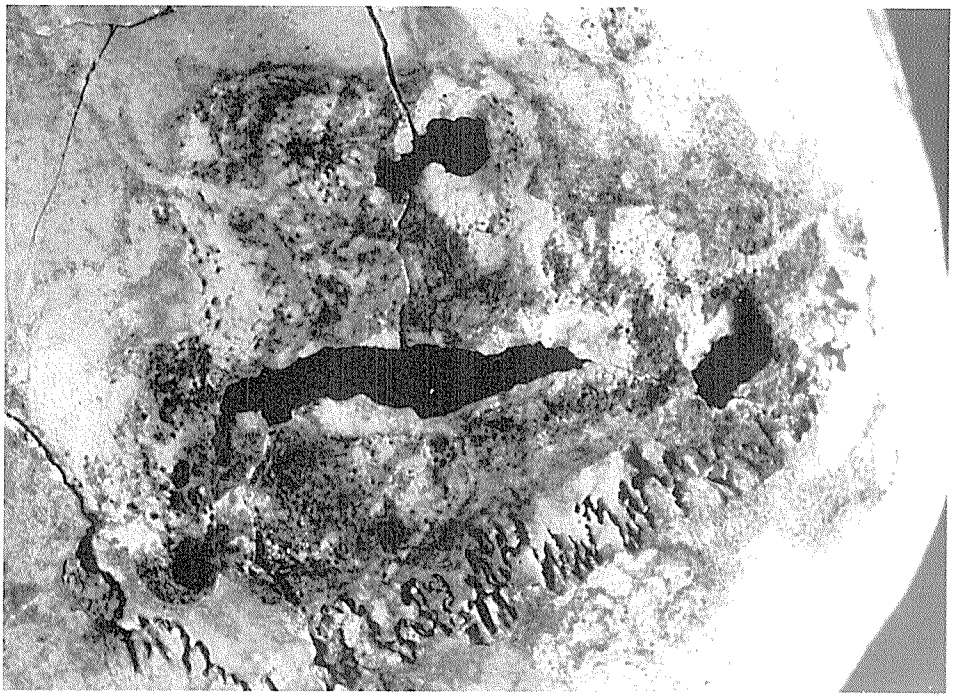


Figure 26. Detailed view of the large lesion in the posterior larger quarter of the left parietal of case 2 showing perforations and osteoplastic reactions.

The occipital scale is almost free of the pathology. There is only a minute focus just left of the mid-line and 16 mm below the lambda.

Furthermore, areas of brownish pigmentation, connected most probably with the pathological processi on the surface of the periost, can be observed in some places on the calva, in the vicinity or on the surface of the described lesions.

Skull: microscopic picture. A small fragment taken at the edge of the lesion posteriorly of the left tuber frontale was decalcified and stained by

safranin and anilin (method of Němec). The section (fig. 27) shows a large portion of compact bone (a) with some Haversian channels and concentric lamellae (b), as well as remnants of the usured spongious bone (diploë) (c) (according to A. Němečková).

Figure 27. Microphotograph of a section of the edge of the lesion of case 2. a = compact bone, b = Haversian channel, c = spongious bone.

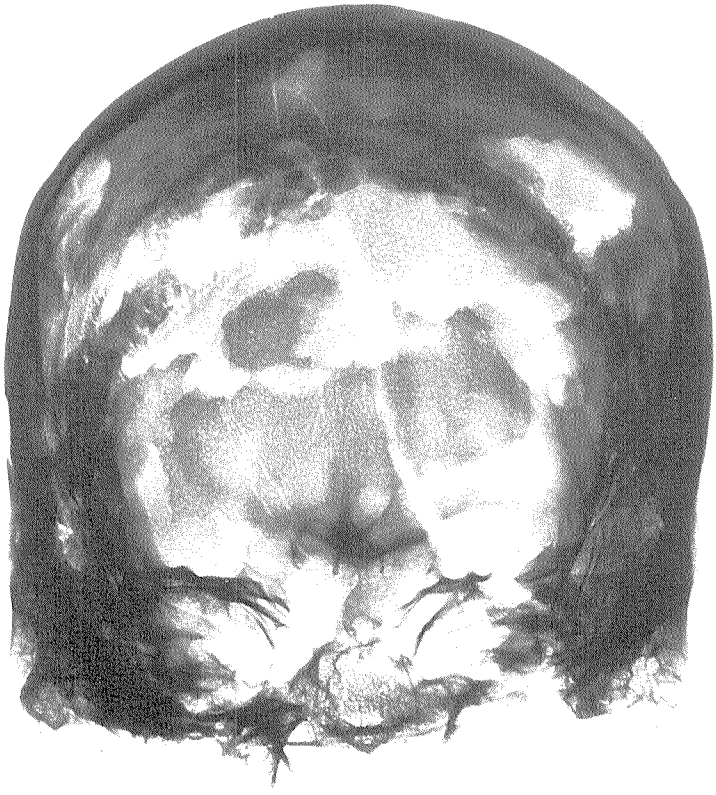


Figure 28. Antero-posterior radiograph of case 2 showing the map-like appearance of the principal lesions.

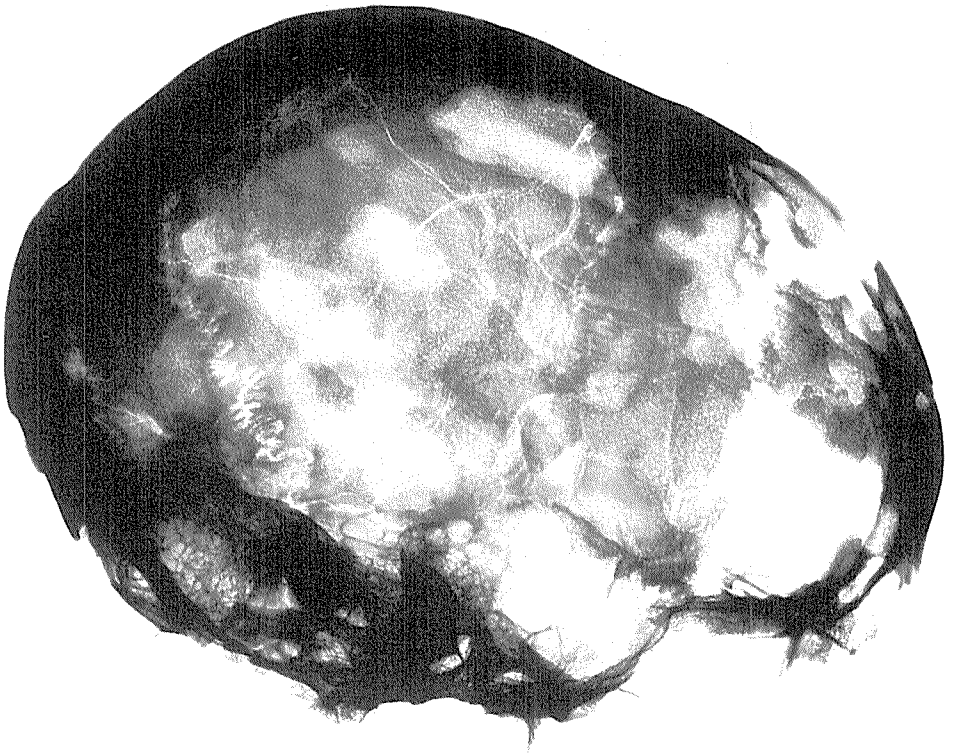


Figure 29. Lateral radiograph of case 2 showing the map-like appearance of the principal lesions.

Skull: X-ray picture. The antero-posterior view (fig. 28) shows clearly the map-like lesions in the lower and upper frontal regions, in the anterior right parietal as well as in the posterior left parietal regions. The destruction of the ethmoid area and the corpus sphenoidis combines with the perforation of the roof of both orbits.

The whole extent of the lesion in the posterior left parietal region together with its perforation and areas of slight rarefaction and condensation can be observed well in the lateral view (fig. 29). In the same view also the relief of the upper frontal lesion is well marked as well as the other major lesions. The coronal and lambdoid sutures are open and no irregularities in the course of the arteria meningica media or enlargement of the diploic veins can be detected.

Postcranial skeleton. The whole postcranial skeleton studied both macroscopically and by the X-rays showed no signs of pathological changes except the 4th-5th thoracic vertebrae.

The 5th thoracic vertebra is wedge-shaped in the sagittal plane and fixed to the 4th thoracic vertebra along the edges of its body as well as in the intervertebral joints (fig. 30). The anterior face of the body is eroded with an uneven rough sclerotic surface (fig. 31). The X-ray, however, shows the body of the 5th vertebra driven into the body of the 4th vertebra with no clear caudal delimitation of the two posterior thirds of the later vertebra (fig. 32). The cranial and the upper anterior delimination of the 5th vertebra can be, however, detected as a line of condensation. This vertebral block is clearly a secondary one. A cavity with pathological contents was, most probably, present in the body of the 4th vertebra. Later on, the caudal wall of the vertebral body was fractured and the contents of the cavity opened along the anterior face of the 5th vertebra, causing sclerotic changes on it. A typical angular kyphosis resulted from these changes.

Diagnostic reflections

In both described cases, as most often in paleopathology, we lack the specific diagnostic mean, the pathological tissue itself, which could be determined by pathohistological and histochemical examination. All we possess is the reactive osseous mould formed on places where the pathological process attacked through its osteolytic quality the osseous tissue. The same osseous changes could have been caused, however, by different diagnostic entities. It is well known that the differential diagnosis of bone newformation is generally easier than that of the osteolytic changes (Mayer 1959). Nevertheless, there are present certain features which could be used in a tentative diagnostic solution.

In both cases we would like to emphasize these features:

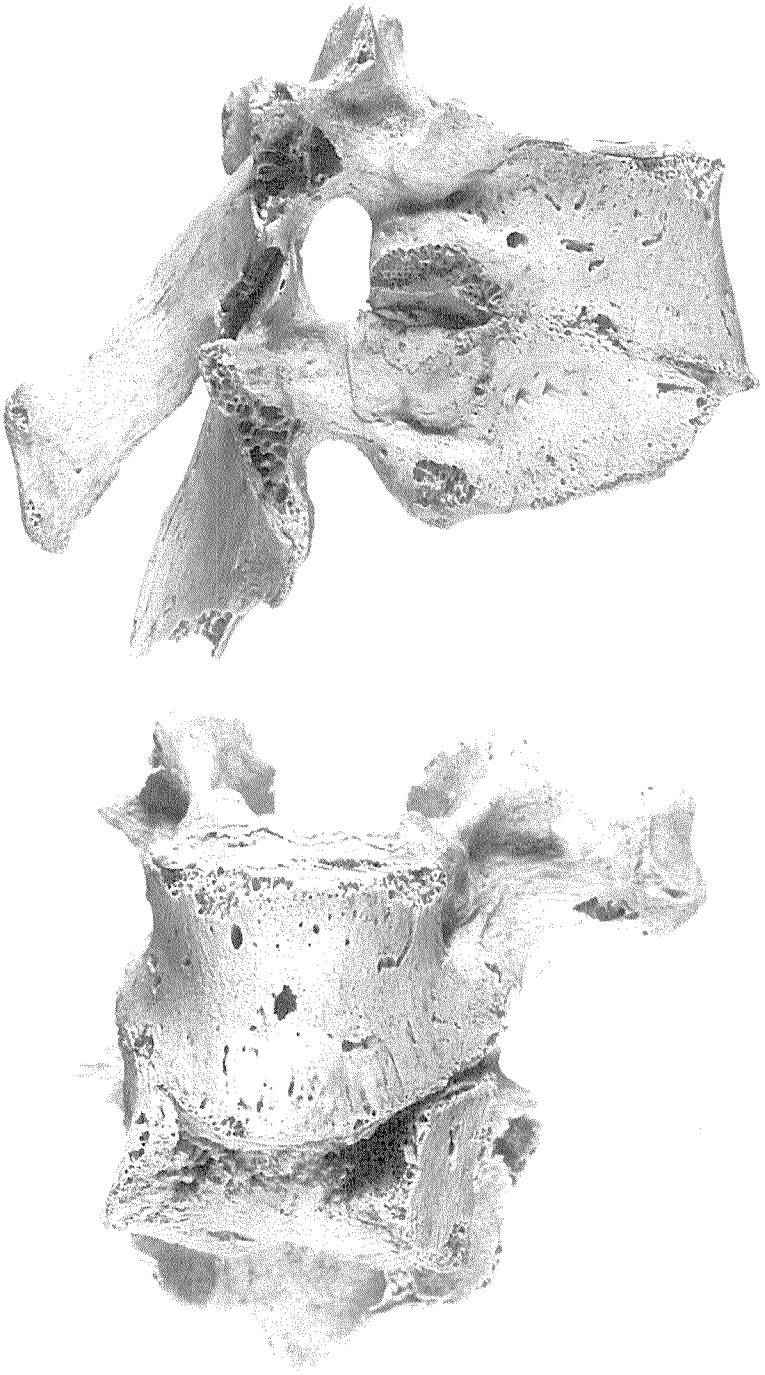
1. The lesions are predominantly osteolytic, with only a slight osteoplastic, mostly only sclerotic reaction.

2. Their edges are well defined, irregular, partly rounded, partly having tips.
3. There are multiple, polytopic foci, some longlasting, large and confluenting, others minute, just beginning, causing the map-like character of the general picture.
4. Their expansion was clearly directed from the external surface of the bone, attacking firstly the outer table, then the diploë, through which further progress was also possible as reflected by the areas of undermined tables, and finally the inner table, where it resulted in perforation.
5. Limits of individual bones (sutures) were not respected by the lesions.
6. A very outstanding feature is the predilection of the lesions to the skull and predominantly to the calva. In case 1 a focus was found also in the pelvis, in case 2 pathological changes were encountered in two thoracic vertebrae.
7. Both the afflicted individuals were young, a 12-13 year old child (girl?) and about 25 year old man. Both differed not in the character, but in the extent of the lesions, which progressed more in the older individual. We would therefore, favour the hypothesis of the same pathological condition in both cases.

If this is true, the frequency of the pathology found twice in 23 preserved skeletons of the Pyramid age cemetery (8,7 per cent) or twice in the 17 skeletons of its 5th-6th Dynasties section (11,8 per cent) is strikingly high. In spite of not belonging to the same "family row", both respective tombs were situated relatively close, at a distance of only 28 m.

According to the above sketched features we may exclude in our diagnostic reflections all primary bone tumours, benigns as well as maligns. With regard to the young age, especially sarcoma, reticulosarcoma or Ewing's sarcoma could be considered, but all are characterised by far more expressed newformation of enostotic bone or spiculae than shown by our cases (Lorenz 1963, Červeňanský 1964).

As regards tumours of extrabone origin, hemangioma would show anomalies of arteria meningica media and enlargement of diploic veins. Its X-ray picture usually consists of a number of small circular bright or cavernous areas resembling cellules which merge in larger areas of osteolysis (Mayer 1959, Süsse 1963). Fine radially arranged spiculae are very typical (Lorenz 1963). Multiple myeloma (plasmocytoma) is firstly an affection of middle and old age, secondly it shows plenty of mostly small, well circumscribed foci of destruction, usually uniform in size. They are not restricted to the skull only, but occur even more frequently



Figures 30 and 31. Lateral and frontal view of the block of the 4th and 5th thoracic vertebra of case 2.

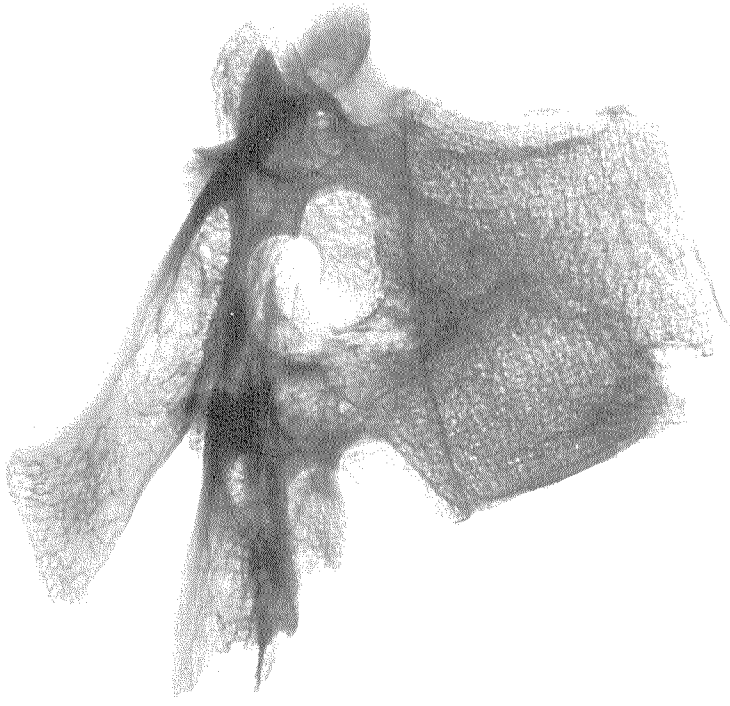


Figure 32. Lateral radiograph of the vertebral block of case 2 showing the body of the 5th vertebra driven into the body of the 4th vertebra.

Figure 33. Skull from Rhoda published by Lortet (1907) showing similar lesions as exhibited by our cases.

in ribs, vertebrae and sternum, as well as in other bones (Burkhardt and Fischer 1970, Murray and Jacobson 1971). With the young age chloroma would be more conform. It prefers flat bones, mostly the diploë of the calva (Lorenz 1963), but also the skull base and orbitae (Burkhardt and Fischer 1970). Its foci, however, are mostly only of a hazelnut size, showing fine spiculae and periostal hem.

In acute leukemia of lymphatic order osteolytic foci can be present, but not sharply edged, and surrounded by reactive osteosclerosis. In chronic myeloic leukemia sclerotic foci indicate the places of small tumourous infiltrates (Lorenz 1963). Small polytopic areas of brightness can be found in calva also in malign lymphoma (lymphosarkoma) or in lymphogranuloma (Hodgkin disease). Any of the described pictures does not suit, however, to the characteristics of our cases.

Among the metastatic tumours, the young age of our individuals does not agree with the most common condition affecting predominantly the skull, the malign struma, as well as with different carcinomas (Červeňanský 1964, Burkhardt and Fischer 1970). Only metastases of neuroblastoma (sympatoblastoma) of sympathic or suprarenal medullar origin would be more conform with the age. One of its forms afflictes mostly calva and orbits, beginning in the diploë and causing perforation, but mostly of the inner table only. Moreover, spiculae, sometimes even of the brush-skull appearance, can be present (Lorenz 1963).

Out of the parasitic diseases which could occur in Ancient Egypt, cysts of Echinococcus granulosus are only rarely localised in the calvarium, being mostly in the pelvis, vertebral bodies, tubular bones and ribs, and they show a different X-ray picture (Sehr 1974, p. 97-99).

Out of the specific inflammations, tertiary lues (gumma) can be easily excluded morphologically, with respect to the young age of our cases and also in the light of the widely accepted New World origin of the disease (Goff 1967, Burkhardt and Fischer 1970).

On the other hand, tuberculosis would agree with the majority of the features of our cases. Ample evidence that tuberculosis was a common condition in Ancient Egypt is based almost exclusively on pictorial representation of hunchback deformities and on paleopathological findings of spinal tuberculosis connected with angular kyphosis (Smith and Ruffer 1910, Derry 1938, Morse, Brothwell and Ucko 1964, Morse 1967). The same diagnosis would suit the finding on the 4th and 5th thoracic vertebrae of our case 2. We should, nevertheless, recall that also other conditions could produce a similar picture, if only dried specimens are available. Morse

(1967, table I) mentioned further 14 possible diagnoses.

As concerns the localisation of tuberculosis on calvar bones, no cases were reported in the paleopathological material until now including the detailed survey by Morse (1967). This form of tuberculosis has not been uncommon in clinical praxis, causing singular or multiple foci with sharp delimitation and involving both tables, each with different intensity. Defects can reach large extent and sutures do not prevent their progression. The frontal bone is usually most frequently afflicted (Bláha 1963). Two features of our cases are not, however, in consent with modern descriptions of this condition. The direction of the pathological process of our two cases from the external surface of the bone does not answer to the progression of tuberculosis from the surface of dura mater causing largest defect in the inner table, smaller in the diploë and smallest in the outer table (Burkhardt and Fischer 1970). Furthermore, the slight osteoplastic, mostly only sclerotic reaction of our cases differs from the described caseotic exudative and productive processes with sequestration and massive osteoplastic newformation at the edges of the foci, called paratuberculotic osteosclerosis (Burkhardt and Fischer 1970).

Out of the lipoid granulomatosis, the Niemann-Pick disease, occurring mostly in very small children and often fatal, show only infrequently skeletal lytic foci, predominantly in postcranial skeleton. The Gaucher's disease can occur in any time before 30 years and its course is chronical. In the skeleton it causes mostly necrosis of femoral or humeral heads and diaphyseal infarcts of the shaft of the lower limb bones (Lorenz 1963, Murray and Jacobson 1971), but also angular kyphosis of the spine is encountered (Bláha 1963).

Out of the group of histiocytic granulomatosis (Červeňanský 1964) or histiocytosis X (Lichtenstein 1953), the eosinophil granuloma is considered by Lichtenstein (1965, 1970) the early form. Young age, preference to the skull and mostly calva, and the morphology of sharply stamped foci with any essential osteoplastic reaction, bone necrosis and greater sequestration would conform to our cases (Burkhardt and Fischer 1970). Eosinophil granuloma is, however, in three quarters of cases solitary and if multiple, 4 or 5 foci are the maximum find (Murray and Jacobson 1972). They are, moreover, mostly relatively small, of pseudocystic circular shape (Červeňanský 1964).

The Abt-Letterer-Siwe disease, considered acute or subacute form of the same disease (Lichtenstein 1965, 1970), can produce in the ends of diaphyses or in the

skull multiple, but usually poorly defined, punctuate lucent defects (Murray and Jacobson 1971). The disease afflicts, however, very small children, mostly of the 2nd year of age, and ends fatally in a few weeks or months (Lorenz 1963, Burkhardt and Fischer 1970).

Only the Hand-Schüller-Christian disease (cholesteringranulomatosis), after Lichtenstein (1965, 1970) the chronic form of histiocytosis X, seems to be in agreement with features of our cases. It starts mostly in the first decennium with a range until the middle age; Lorenz (1963) stresses the period of 3 to 16 years, Bláha (1963) the range of 2-5 years. It shows a preference for the skull, situated mostly in the frontoparietal region or temporal squama, but also the cranial base can be involved. The lesions are multiple, widely disseminated, progressing either from the external surface of the bone, from the diploë or from the internal, dural surface. The foci are from coin to plate size, polycyclically outlined, with sharp edges, sometimes with a slight osteosclerotic rim. They progress slowly, enlarging and confluenting, not respecting the limits of individual bones, but tend to remain relatively low-grade in severity. In the vicinity of big defects it is possible to detect on X-ray pictures small smudged irregularities, which correspond to the beginning foci as shown in our cases. The typical resulting picture was called map-skull or gap-skull (Landkartenschädel, Lückenschädel). If present, foci at the skull base and orbital roof (our case 2) may cause the other two clinically important symptoms, diabetes insipidus and protrusion bulbi. Further foci may be localised in the pelvis (our case 1), femur, vertebrae (our case 2), ribs and humerus (Bláha 1963, Lorenz 1963, Burkhardt and Fischer 1970, Murray and Jacobson 1972). The general prognosis is unfavourable; owing to the chronical character patients may survive for some time (our case 2) or die quicklier (our case 1) if developing a fulminating pattern simulating the Letterer-Siwe disease (Murray and Jacobson 1972). Contrary to lipoid granulomatosis, the Hand-Schüller-Christian disease is not familiar and not confined mostly to Jews (Bláha 1963).

In connection with our cases it might be of interest to note that expressed (case 1) or slight (case 2) degree of cribra orbitalis was present in both of them. No other skull of the same cemetery showed this condition. We should recall that cribra orbitalis was found recently by Hengen (1971) a pathological condition caused by an overactivity of red bone marrow most probably induced by iron deficiency anemias. It could be quite possible that our two cases were complicated by anemia.

Analoguous finding

L. C. Lortet published in 1907 a skull found with body in flexed position in a rectangular tomb at the desert edge at Rhoda, Upper Egypt, not far from Luxor. He considered the finding prehistoric, but objections against this dating were rised by Chantre (1907) who believed that it was not older than of the 4th Dynasty. The skull belonged to a young female aged 20-23 years. The surface of the calva was afflicted by pathological changes (fig. 33) described by Lortet (1907) as follows:

"Le pariétal gauche est profondément attaqué par une ulcération serpigineuse irrégulièrement circonvoluée, ayant fait disparaître entièrement le feuillet externe de l'os, tandis que, dans certains endroits, la lame interne, attaquée à son tour, a permis de véritable perforations, établissant des communications directes entre l'extérieur et la cavité cranienne. Au voisinage de cette lésion ... se voient cinq ou six autres points atteints d'une nécrose semblable ayant donné lieu à des perforations complètes du diploë et de la table interne. Ailleurs, d'autres régions commencent à être atteintes par le processus pathologique, et, au début, présentent des tâches irrégulières, blanchâtres ... Ce dépoli est dû à l'altération commençante de la table externe de l'os."

The author found minor lesions of the same character also in other bones of the cerebral part of the skull, the base and face, however, being free of pathological changes. Lortet (1907) considered his finding an evidence of syphilis, Gangolphe (quoted by Janssens 1970, p. 108), however, disapproved his diagnosis and attributed the lesions to post-mortem action of rodents and beetles. Presently it has been concluded, that there is no evidence whatsoever of syphilis in Ancient Egypt (Sandison 1969).

Comparing this case with our two cases, their basic similarity can be assessed with great probability, even if we could not check the skull described by Lortet (1907). If so, the discussed pathology seems to not quite rare in Egypt during the Pyramid age.

Photographs by the author except:

Fig. 11, 12, 30, 31 by E. Prinz. Courtesy of the Lowie Museum of Anthropology, University of California, Berkeley.
Fig. 10, 13, 28, 29 by J. Gregory. Courtesy of the Paleonotological Museum, University of California, Berkeley.
Fig. 27 by A. Němečková. Courtesy of the Institute of Histology and Embryology, Medical Faculty, Charles University, Plzeň.

References

Anonymous. 1904: University of California Researches in Egypt. American Anthropologist 6, 742-743.

Bláha, R. 1963: Rentgenologie kostí a kloubů, díl 1. a 2. Státní zdravotnické nakladatelství, Praha.

Borovanský, L. & Hněvkovský, O. 1930: Vzrůst tela a postup osifikace u hochů od narození do 19 let (Körperwachstum und Verlauf der Ossifikation bei Knaben von Geburt bis 19 Jahren). Česká akademie věd, Praha.

Burkhardt, L. & Fischer, H. 1970: Pathologische Anatomie des Schädels. In Uehlinger, E. (ed.): Handbuch der speziellen pathologischen Anatomie und Histologie, IX. Band, VII. Teil. Springer Verlag, Berlin, Heidelberg, New York.

Červeňanský, J. 1964: Nádory kostí a im podobné afekcie. Vydavatelstvo Slovenské akademie vied, Bratislava.

Chantre, E. 1907: Discussion. Bulletin de la Société d'Anthropologie de Lyon 26, 225.

Derry, D. E. 1938: Pott's disease in Ancient Egypt. Med. Press 197, 1.

Goff, C. W. 1967: Syphilis. In Brothwell, D. & Sandison, A. T. (eds.): Diseases in Antiquity. Ch. C. Thomas Publ., Springfield, Illinois, 279-294.

Hengen, O. P. 1971: Cribra orbitalis: Pathogenesis and probable etiology. Homo 22, 57-76.

Janssens, P. A. 1970: Paleopathology. Disease and injuries of prehistoric man. J. Backer, London.

Leigh, R. W. 1934: Notes on the Stomatology and Pathology of Ancient Egypt. University of California Press, Berkeley, California.

Lichtenstein, L. 1953: Histiocytosis X. Integration of eosinophilic granuloma of bone, "Letterer-Siwe" disease, and "Schüller-Christian" disease as related manifestations of a single nosologic entity. A. M. A. Arch. Path. 56, 84-102.

Lichtenstein, L. 1965: Bone Tumors, 3rd edition. The C. V. Mosby Company, Saint Louis.

Lichtenstein, L. 1970: Diseases of Bone and Joints. The C. V. Mosby Company, Saint Louis.

Lorenz, R. 1963: Röntgendiagnostik des Schädeldaches. In Olsson, O., Strand, F., Vieten, H. & Zuppinger, A. (eds.): Handbuch der medizinischer Radiologie, VII. Band, 1. Teil. Springer Verlag, Berlin, Göttingen, Heidelberg, 340-429.

Lortet, L. C. 1907: Crâne syphilitique et nécropoles préhistoriques de la Haute Égypte. Bulletin de la Société d'Anthropologie de Lyon 26, 211-225.

Martin, R. & Saller, K. 1959: Lehrbuch der Anthropologie, 3. Auflage, Band II, G. Fischer, Stuttgart.

Mayer, E. G. 1959. Diagnose und Differentialdiagnose in der Schädelröntgenologie. Springer Verlag, Wien.

Morse, D. 1967: Tuberculosis. In Brothwell, D. & Sandison, A. T. (eds.): Diseases in Antiquity. Ch. C. Thomas Publ., Springfield, Illinois, 249-271.

Morse, D., Brothwell, D. & Ucko, P. J. 1960: Tuberculosis in Ancient Egypt. Amer. Rev. Respir. Diseases 90, 524.

Murray, R. O. & Jacobson, H. G. 1972: The Radiology of Skeletal Disorders. Exercises in Diagnosis. Vol. I. Churchill Livingstone, Edinburgh and London.

Reisner, G. A. 1908: The Early Dynastic Cemeteries of Naga-ed-Dêr. Part I. University of California Publications, Egyptian Archaeology, vol. II. J. C. Hinrichs, Leipzig.

Reisner, G.A. 1932: A Provincial Cemetery of the Pyramid Age. Naga-ed-Dêr. Part III. University of California Publications, Egyptian Archaeology, vol. VI, Hearst Egyptian Expedition. University of California Press, Berkeley and Los Angeles.
Sandison, A.T. 1969: Diseases in Ancient Egypt. Rivista di Antropologia 56, 225-228.
Schinz, H.R., Baensch, W.E., Friedel, E. & Uehlinger, E. 1952: Lehrbuch der Röntgendiagnostik. G. Thieme, Stuttgart.
Sehr, A. 1974: The Radiology of Parasitic Diseases. Acta Universitatis Carolinae, Medica, Monographia LXIII, Universita Karlova, Praha.
Smith, G.E. & Ruffer, M.A. 1910: Pott'sche Krankheit an einer ägyptischen Mumie aus der Zeit der 21. Dynastie (um 1000 v. Chr.). In Sudhoff, K. (ed.): Zur historischen Biologie der Krankheitserreger, 3. Heft, Giessen, 9-16.
Smith, G.E. & Jones, R.W. 1910: Report on the Human Remains. The Archaeological Survey of Nubia, Report for 1907-1908. Governmental Printing Office, Cairo.
Strouhal, E. 1973: Über das Wachstum der langen Gliedmassenknochen in der älteren Bronzezeit. Ärztliche Jugendkunde 64, 371-386.
Süsse, H.J. 1963: Die Gefäss-Strukturen der Schädelknochen, ihre Anomalien und ihre Röntgenpathologie. In Ohlsson, O., Strand, F., Vieten, H. & Zuppinger, A. (eds.): Handbuch der medizinischer Radiologie, VII. Band, 1. Teil. Springer Verlag, Berlin, Göttingen, Heidelberg, 153-225.

Table 1. Cranial measurements and indices of individual No. 12-4880.

Maximum length of the skull /1/	172
Maximum breadth of the skull /8/	131
Cranial index /I 1/	76,2
Horizontal circumference of the skull /23/	482
Height of the upper face /48/	63
Bizygomatic breadth /45/	117
Upper facial index /I 39/	53,8
Maxilloalveolar length /60/	48
Maxilloalveolar breadth /61/	59
Maxilloalveolar index /I 54/	122,9

All measurements are in mm. Numbers in brackets point to the technique of Martin and Saller /1959/.

Table 2. Long bones length measurements of individual No. 12-4880.

	right	left
Clavicula	97	99
Humerus	217+	217+
Radius	155	152
Ulna	177	175
Femur	323+	322+
Tibia	264+	262++
Fibula	251++	253++

All measurements are in mm. Figures without brand express diaphysis length, + = diaphysis with both epiphyses attached, ++ = diaphysis with distal epiphysis attached.

Table 3. Cranial measurements and indices of individual No. 12-4891.

Maximum length of the skull /1/	193
Maximum breadth of the skull /8/	133
Cranial index /I 1/	68,9
Horizontal circumference of the skull /23/	531
Height of the upper face /48/	69
Maxilloalveolar length /60/	58
Nasal breadth /54/	26
Nasal height /55/	49
Nasal index /I 48/	53,1

All measurements are in mm. Numbers in brackets point to the technique of Martin and Saller /1959/.

A trepanned skull from the Gillhög passage-grave at Barsebäck in West Scania (Southern Sweden)

OVE PERSSON

OSSA

A unique case of a large trepanation coming from a passage-grave in Gillhög at Barsebäck in W. Scania (S. Sweden) is described. The excision is of oblong elliptic shape, and it is placed symmetrically over the median line of the crown.

Описан уникальный случай большой трепанации, поступившей из неолитического погребения в Гиллхёг около Барсебэк, в западном Сконе (южная Швеция). Эксцизия имеет продолговатую эллиптическую форму и размещается симметрично над медиальной линией темени.

Ove Persson, KULTUREN, S–221 04 Lund, Sweden.

Vol. 3/4, pp 53–61, Lund. ISSN 0345–8865.

During 1931 and 1932 a passage-grave called Gillhög or Gilles hög was excavated at Barsebäck in western Scania. The results of the excavation have been extensively accounted for by Rydbeck (1932, pp 32-44). The grave is estimated to have been built during the transition period between Early Neolithic and Middle Neolithic, but secondary burials have in all probability taken place. It seems that at some occasion a "cleaning" has been undertaken and gravegoods as well as skeletal remains have been thrown out. This material was found in the passage of the grave during the excavation. After the cleaning, supposedly undertaken during Early or Middle Neolithic, the grave was used for new burials (Rydbeck 1932, pp 42-43).

Among the skeletal remains is an incomplete male skull with a large trepanation aperture in the parietal region. Due to the above mentioned disturbances in the grave the dating of the skull cannot be determined more accurately as to the Early or Middle Neolithic, nor is it possible to associate it with any degree of certainty with some of the postcranial skeletal remains found with it.

Material

The extant part of the skull (Figs 1-5) consists only of the incomplete neurocranium (calvaria sensu Martin & Saller 1957, p 432). Not only the facial skeletal structure, but also the entire front part of the basal region, pars temporalis ossis frontalis sin., and trigonum supraorbitale sin. are missing. - The surface is partly damaged by weathering. However, the parietal region with the trepanation excision is well preserved. - The surface is gray to grayish-brown in colour.

General description. The measurements which could be taken are represented in Table 1. Estimated measurements and calculated indices based upon them are underlined in the table as well as in the text.

The skull is not particularly large. The horizontal circumference (Martin & Saller 1957, pp 462-463; measurement 23) is 53 cm. The capacity, measured according to the Lee-Pearson formula (Martin & Saller 1957, p 473; corrected by Gejvall 1960, p 24), is 1371 cc (euencephalic).

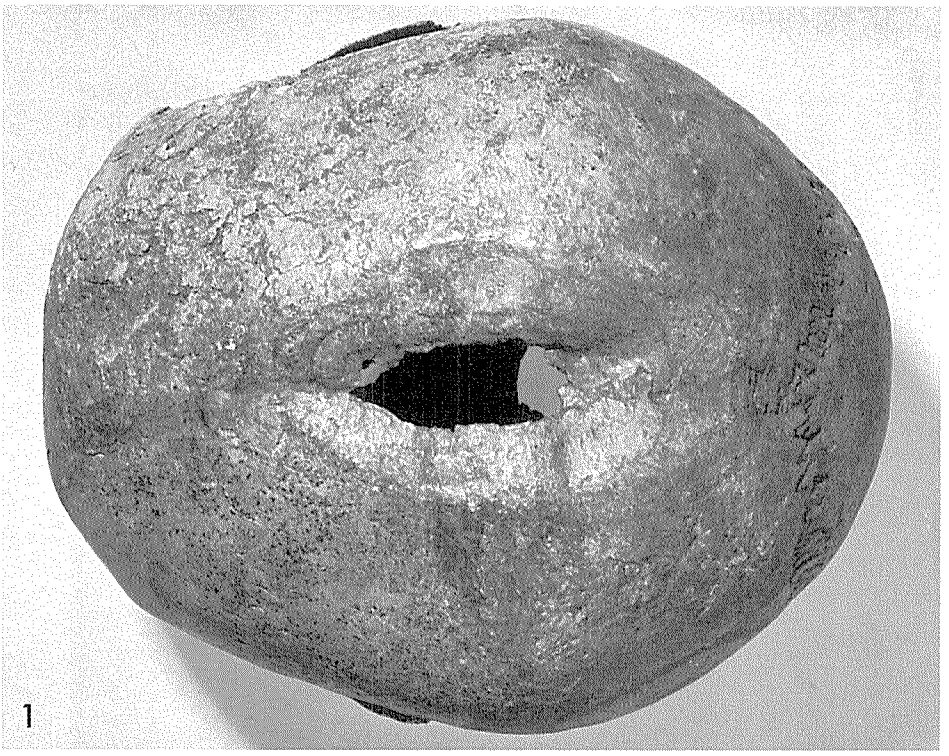
The shapes of the glabella and of the arcus superciliares are of a clearly male type. The size of the skull and the thickness of the bones of the skullcap indicate equally, that it was the skull of a male. - The cristae et facies musculares are moderately well developed. In other words, to judge by the preserved part of the cranium, the man was not particularly heavily built.

Cranial sutures, estimation of age at death, etc: the whole of the sutura coronaria is in a much advanced state of synostosis. Certain parts of the suture are almost completely obliterated. Due to the opening caused by the trepanation, only the utmost back part of the sutura sagittalis can be seen. Here (as far as can be established) the synostosis occurs only in spots, and only on the tabula interna. The same is valid for the sutura lambdoidea. - On the whole, the synostosis stages indicate that the male individual was approximately 40-50 years old at death.

No accessory sutural bones can be traced.

Anthropological characteristics.

Norma verticalis (Fig 1): symmetric, regular. Sphenoid shape. Apart from the trepanation, there are no artificial deformations. The tubera frontalia are faintly indicated, the tubera parietali on the other hand are very markedly bulging. - The length-breadth index is 80.5 (brachycranial).



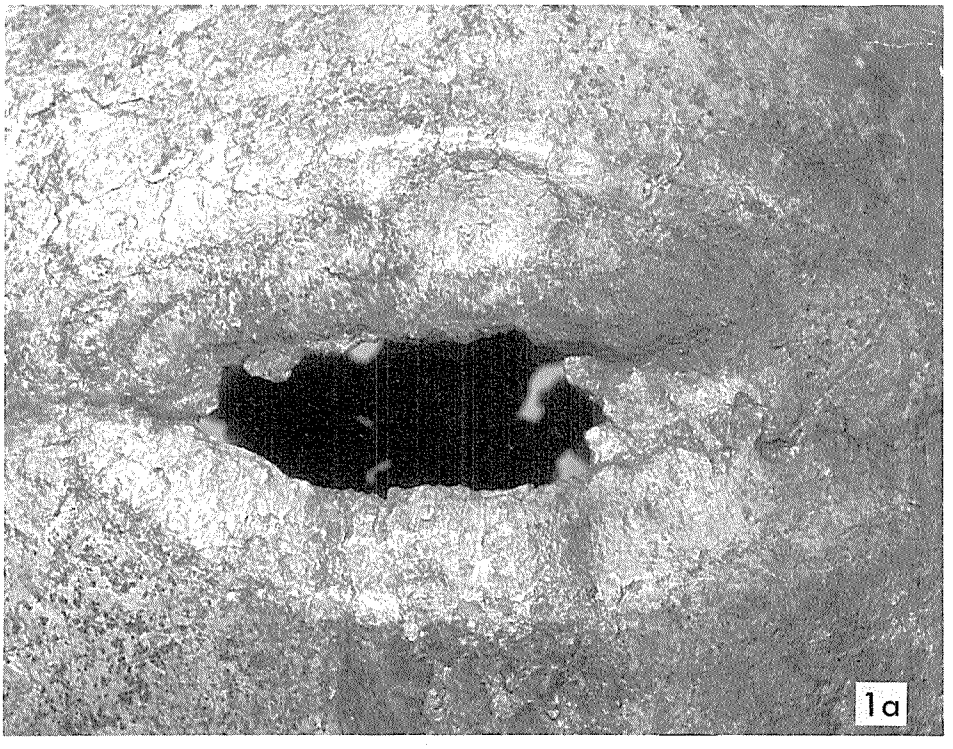
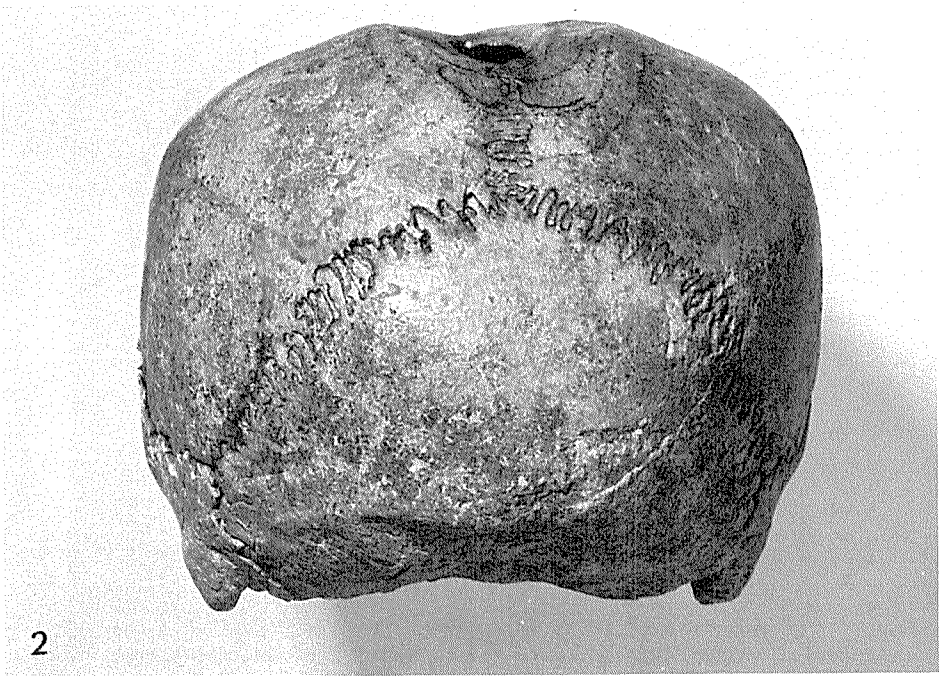


Figure 1. Norma verticalis.

Figure 1a. Partial view of the parietal region.



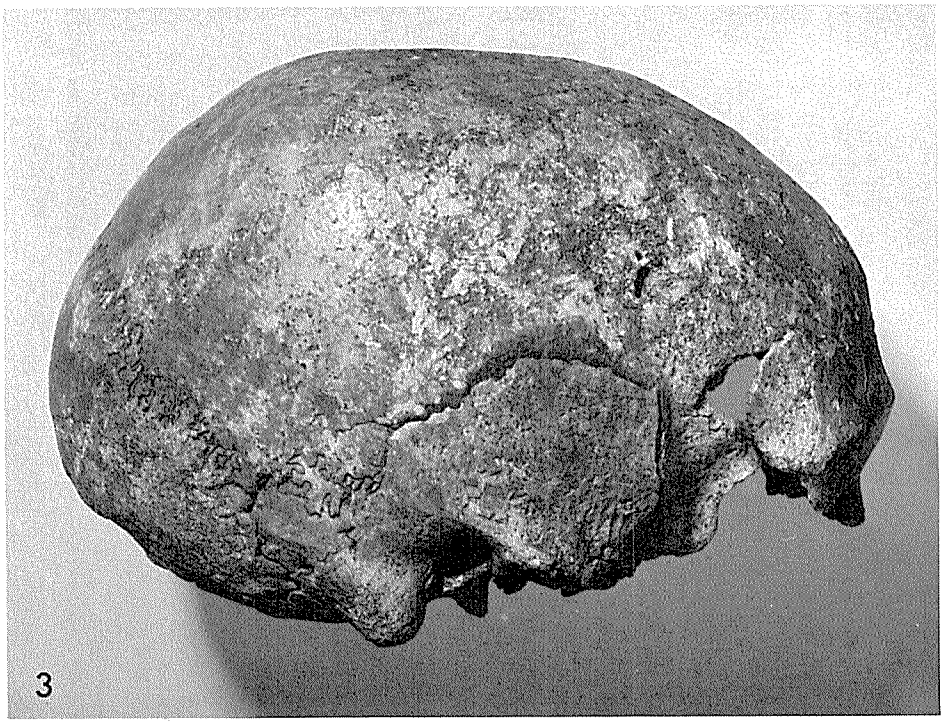


Figure 2. Norma occipitalis.

Figure 3. Norma lateralis

Norma occipitalis (Fig 2): symmetric, regular. The contour of the skull seems to have been rather flat, although the original shape cannot be established with certainty due to the marks after the trepanation. The lateral contours are curved, somewhat converging downward. The tubera parts of both sides are high. The processus mastoidei are moderately large and blunt. The breadth-height index is 79 (tapeinocranial).

Norma lateralis (Fig 3): the curva sagittalis has probably been even and regular preceding the trepanation. Neither clinocephaly nor bathrocephaloid shelf are in evidence. The glabella is moderately protuberant. The forehead is fairly low, somewhat receding. The pori acustici externi ossei are fairly wide and have no exostoses. The length-height index is 63 (chamaecranial).

Norma facialis (Fig 4): the preserved part is symmetrically and regularly shaped. The forehead is moderately wide. The transversal frontal index is 87 (parallelotop); the transversal frontoparietal index is 70 (metriometop). - The arcus superciliares are fairly strong; the tubera frontalia are just faintly distinguishable; the trigonum superciliaris (only the one on the right side is preserved) is small and flat.

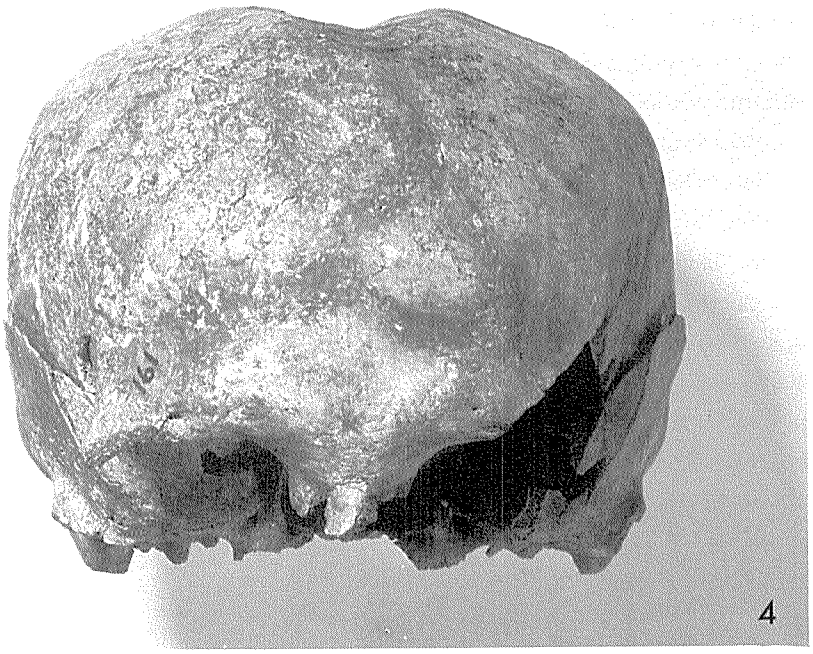
Norma basalis (Fig 5): symmetric, regular.

In conclusion. Sex: male. Age: 40-50 years. - The man had a low, fairly wide head. The lenght-breadth index (80.5) is very close to the threshold of the maximal value of the mesocranial shape (79.9; Martin & Saller 1957, p 488). The size of the latitudinal measurement derives in this case partly from the strong lateral bulges of the ossa parietalia.

The trepanation

In the parietal region of the skull a large area is scraped off (cf Figs 1 and 1a), probably with some chisel-like implement. The treated area is subelliptical, approximately 11 cm long and approximately 5 cm wide. The longitudinal axis of the ellipse coincides more or less with the median line of the parietal region. The anterior margin of the area is on the os frontale, approximately 2 cm from the bregma (this point is difficult to establish, since the sutures of the scraped area are completely obliterated). The posterior limit is located on the ossa parietalia, approximately 2 cm in front of the lambda.

The scraping has obviously been done by starting at the outer periphery of the



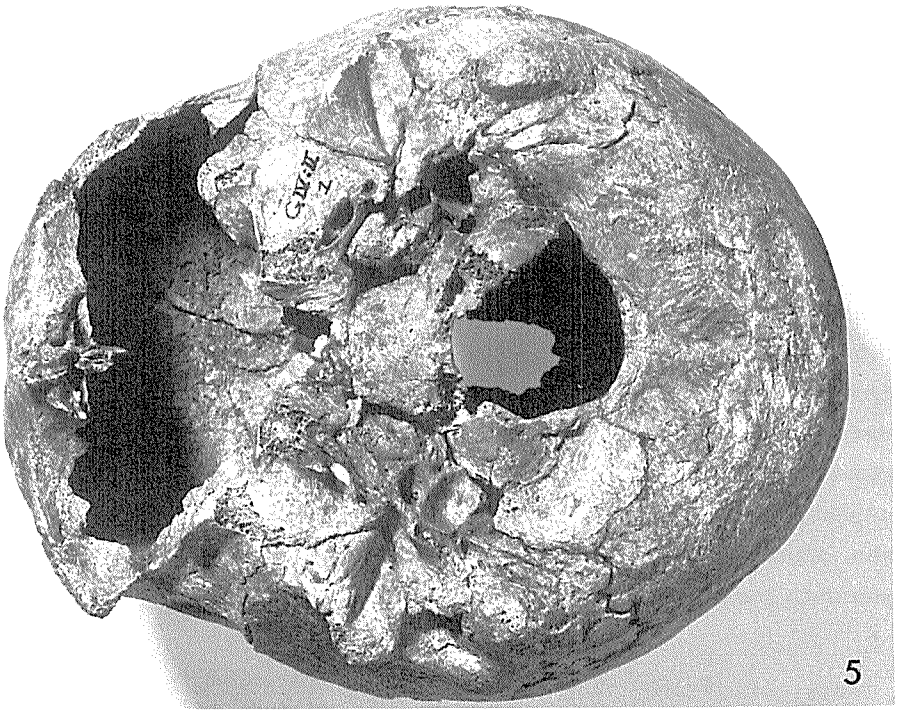


Figure 4. Norma facialis.

Figure 5. Norma basalis.

ellipse and going inward. The skullcap has been gradually tapered off towards the centre, and this procedure resulted in a 44 mm long and 16 mm wide opening in the centre itself. Throughout the entire scraped area a marked vital reaction is observable, and all around the opening a thin border of secondary bone tissue has developed. Thus, the man survived the operation. - According to Anda (1951, pp 251-316), it takes about three months before the osteoplastic reaction at the edge of the bone is far enough advanced and can definitely be traced. Apart from this particular information, the author of the present article was unable to find any dates whatsoever in the pertaining literature about the time necessary for the development of new bone tissue. It follows, that it would be impossible for the author to judge the lifespan of the individual after the operation. For all we know, the operation could have been performed when the man was quite young.

The various theories concerning prehistoric and early historic trepanations in Europe, their origin and geographic extension, the motivs behind them, the methods employed, etc, have been extensively treated by Matthias & Ullrich (1968), Ullrich (1958; 1967) and Ullrich & Weichmann (1963; 1965). The same authors, Matthias & Ullrich (1968, pp 36-37), Ullrich (1964, pp 60-61), Ullrich & Weichmann (1965, pp 264-269; Abb 3-5) also present a survey of the shapes of trepanation apertures and their position on the cranium. In all the cases mentioned in these works, there is not one single instance where the opening is placed symmetrically over the median line of the crown, as in the case of the Gillhög cranium. The skull is equally unique in the oblong elliptic shape of the excision.

Speculations about the reasons for the operation can of course only be guesswork. On the inside of the brain cavity no pathological changes can be observed. Naturally, the cause could have been a kind of brain illness or defect which does not leave any traces in the bone tissue. Or the operation could possibly have been undertaken to extract bone splinters and to even out the edges of the bone after a fracture of the skullcap - although the oblong shape of the hole contradicts to a certain extent this latter supposition. On the other hand, it would be quite possible that a blow from e.g. a stone axe with a broad edge could have caused a longish fracture. Ullrich 1958, pp 395-399; 1964, p 59) and Ullrich and Weichmann (1965, pp 269-270) mention, that in some cases of prehistoric trepanations traumatic or pathological changes of the postcranial skeletal parts can be proven. Hence, trepanations might very well have been performed to alleviate pain in other parts of the body than the head. As mentioned above, in the case of the Gillhög skull

none of the other skeletal remains can be clearly connected with it, and any such possible reason for the operation must therefore be excluded from discussion. There is of course also the further possibility that the trepanation has been performed out of religious-ritualistic motivs.

Ullrich & Weichmann (1963, pp 103-121; 1965, p 270) point out, that central Germany seems to have been an important centre of prehistoric brain surgery. The fact, that the operation methods have obviously reached as far away territories as Scandinavia, opens broad perspectives and offers an opportunity to discuss migration and/or cultural influences in prehistoric times. Such discussions, however, belong rather to the domain of archaeology proper.

Table 1.

Measurements and indices

Estimated measurements and indices derived from them are underlined.
-- The numbers of the left column indicate the measurements taken from Martin and Saller 1957, pp 453-499.

No.			
	1 maximal skull length	183.8	mm
	2 glabella-inion length	175.3	"
	3 glabella-lambda length	172.5	"
	5 nasion-basion length	99	"
	8 maximal skull breadth	148.0	"
	9 minimal forehead breadth	104	"
	10 maximal forehead breadth	119	"
	17 basion-bregma height	117	"
	23 horizontal circumference	53	cm
	38 skull capacity	1371	cc
I	1 length-breadth index	80.5	
I	2 length-height index	63	
I	3 breadth-height index	79	
I	12 transversal frontal index	87	
I	13 transversal frontoparietal index	70	

References

Anda, T. 1951: Recherches archéologiques sur la pratique médicale des Hongrois à l'époque de la conquète du pays. Acta Acad. Scien. Hung. 1. Budapest.

Gejvall, N.-G. 1960: Westerhus. Medieval Population and Church in the Light of Skeletal Remains. Lund.

Martin, R. & Saller, K. 1957: Lehrbuch der Anthropologie in systematischer Darstellung. I. Stuttgart.

Matthias, W. & Ullrich, H. 1968: Ein trepanierter Schädel aus einem schnurkeramischen Grabe von Königsaue, Kr. Aschersleben. Ausgrabungen und Funde, Bd. 13. Berlin.

Rydbeck, O. 1932: Stenkammargravar i Barsebäck. Arkeologiska studier tillägnade H. K. H. Kronprins Gustav Adolf. Stockholm.

Ullrich, H. 1958: Methodische Bemerkungen zur Untersuchung von drei Schädeltrepanationen aus Frühbronzezeit von Grossrembach. Ausgrabungen und Funde Bd. 3. Berlin.

Ullrich, H. 1964: Eine ungewöhnliche Trepanation aus dem Neolithikum Mitteldeutschlands. Varia Archaeologica. Wilhelm Unversagt zum 70. Geburtstag dargebracht. Berlin.

Ullrich, H. 1967: Entstehung und Ausbreitung der Trepanation in der europäischen Vorgeschichte. Anthropos. Akten des anthropologischen Kongresses Brno (Tschechoslowakei) 1965. Brno.

Ullrich, H. & Weichmann, F. 1963: Prähistorische "Neurochirurgie" im mitteldeutschen Raum. Zentralblatt für Neurochirurgie. 24. Jahrgang, Heft 2-3. Leipzig.

Ullrich, H. & Weichmann, F. 1965: Prähistorische Trepanationen und ihre Abgrenzung gegen andere Schädeldefekte. Neue Untersuchungen am mitteldeutschen Fundmaterial. Anthrop. Anz. Jg. 29. Festband Gieseler. Stuttgart.

A Medieval (?) bone with a copper plate support, indicating an open surgical treatment

DAN-AXEL HALLBÄCK

OSSA

About 1928 a human humerus *sin.* of probable Medieval date was found during archaeological excavations at the Cistercian abbey of Varnhem, Sweden. The bone shows many pathologic changes, among others a proliferative bone reaction with two exostoses. These fit well with a copper plate, which has been wrapped around the bone in vivo, and held together with three rivets, sinews or threads etc., which now have disappeared. It seems likely that the patient had been the subject of some surgical treatment during which the copper plate had been applied. Judging from the bone the patient had survived this operation long enough for his lesion to heal.

The bone and the copper plate are described in some detail. The treatment as well as the reason for it are discussed.

Около 1928 года, в течение археологических раскопок в цистерцианском аббатстве в Варнхем (Швеция), была найдена, по всей вероятности, средневековая человеческая правая плечевая кость. На кости обнаружены патологические изменения, среди прочих – пролиферативная костная дєформация, результирующаяся двумя выростами. Это отвечает попытке лечения такого заболевания с помощью медной пластинки, стянутой вокруг кости in vivo и скрепленной тремя заклёпками, сухожилиями или нитями, исчезнувшими к настоящему времени. Кажется вероятным, что пациент явился объектом какого-то хирургического вмешательства, во время которого была применена медная пластинка. Судя по кости, пациент прожил после операции достаточно долгое время, позволившее заживление повреждения. Дано детальное описание кости и медной пластинки. Обсуждаются способ лечения и его причины.

Dan-Axel Hallbäck, Institute of Physiology, University of Göteborg, Fack, S-400 33 Göteborg 33, Sweden

Vol. 3/4, pp 63–82, Lund. ISSN 0345–8865.

Introduction

In connection with the archaeological excavations of the Cistercian abbey at Varnhem, Västergötland, Sweden, 1923 to 1927 under the leadership of the late professor and King's Custodian of Antiquities S. Curman, and the late architect A. Forssén, a remarkable discovery was made in about 1928. In the so called aisle, i.e. not the one in the church, but the one in the cloister, a piece of human humerus sin. was found, which shows traces of advanced surgical treatments, primarily in the form of a copper plate, which had been wrapped around the bone in vivo, probably for stabilization.

This find met with little interest, and in the ATA-archives of the Museum of

History in Stockholm it is not possible to find any record of the number (18393:1090 Vg) on the bone. Upon request, the museum staff say that they take it, that the bone was found when the excavations were concluded and/or that the numbering was carried out indoors and subsequent to the excavation work. However, at this museum there is an investigation supplement, containing the following description: "Humerus from man with a copper plate support, length 23 cm, width 2.7-6.7 cm. Length of the plate 7.55 cm, thickness 0.15 cm. The bone shows well defined pathological changes. The plate that has rounded edges has been held together with three rivets, now disappeared. The north part of the aisle, 1928."

A newspaper article in the Göteborgs-Tidningen of August 12, 1928, mentions this bone, and reports that the bone was examined by the late professor Fürst of Lund, but to my knowledge, professor Fürst unfortunately has not left any written report of the examination.

Since 1928, the bone from Varnhem has been mentioned in at least four papers (W. Holmqvist, S. Bengtsson, S-A. Hallbäck and S. Lindroth). In these articles the bone is mentioned briefly and only as an example of Medieval surgical skill. It thus seems to me that this bone has been paid so little scientific attention that this article is justified.

Determination of age

An exact date would of course be of great interest, but, unfortunately, the C-14 method can only supply an inexact estimation within the actual time interval. Besides, the bone would have to be milled, and thus destroyed (Gejvall 1.). Another technique, the mass-spectrometry technique does not separate the minimal ^{14}C fraction from the ^{12}C and ^{13}C-ones, and so has not been used.

Neither can archaeology give us a reliable fixed time, as appears from the following short historical resumé. The facts in this resumé are mainly from A. Forssén and from F.A. Wingborg.

Varnhem abbey was founded in about 1150 by monks from Alvastra, Östergötland, Sweden. In 1234 a disastrous fire burned down the abbey, but restoration work was initiated immediately and lasted till about 1260. The present church dates from the last third of the 13th century. From the end of the 13th century and to 1527 the abbey flourished and grew in importance, both locally and nationally.

In 1527 king Gustav Vasa introduced the Reformation in Sweden, and the property of the abbey was confiscated by the State. The church and abbey fell into decay until 1566, when they were burned down by the Danes, and became ruins.

In about 1650 these ruins were visited by the wealthy count Magnus Gabriel De la Gardie, who decided to restore the church. The restoration started in 1654 and ended in 1674. As a result, the church got its system of large buttresses, which divided the north aisle into smaller parts. During the restoration of the church, huge masses of soil were transported from the vicinity to the former abbey, and the ruins were covered with a hill, which remained until the excavations 1923.

The Varnhem church, however, was more or less the private church of Magnus Gabriel De la Gardie and the nobility.

In 1695 the church was transformed into a parish church with public cemetery in accordance with a letter from the king dated February 23, 1695 (F. A. Wingborg, p. 27). Before 1695, the parish church was situated at Skarke about 1 km north of the Varnhem church.

Burials have thus taken place at the Varnhem church during three periods:

1. From the end of the 12th century to 1527.
2. From 1674 to 1695 (only the nobility and mainly in the interior of the church).
3. After 1695.

From my point of view, it seems likely that the bone was buried sometime during the period c. 1150-1527, probably after 1260, at or in the neighbourhood of the abbey of Varnhem. It is then quite possible that the bone, hidden in soil, has been moved during the restoration works in the 1650's/1660's.

That the bone was buried in the period 1674 to 1695 is a second possibility, but in view of the circumstances of the finding this seems less probable.

I can find no clues indicating that the bone was buried later than 1695.

Description

The relic consists of approximately 2/3 of the distal part of a left human humerus. The weight and measurements of the bone are shown in table 1. As can be seen in this table, the figures correspond comparatively well with those of the investigation supplement from the Museum of History, Stockholm. However, the figures of the bone length differ by 1.5 cm. The length of the bone can be

seen in fig. 1. Table 1 also contains the length and weight of the copper plate. Also in this case the figures correspond quite well, but the thickness of the plate is a bit too great in the investigation supplement.

The plate has the form of a rectangle with rounded corners. Each of the two short sides shows three holes, which correspond to those of the other side,

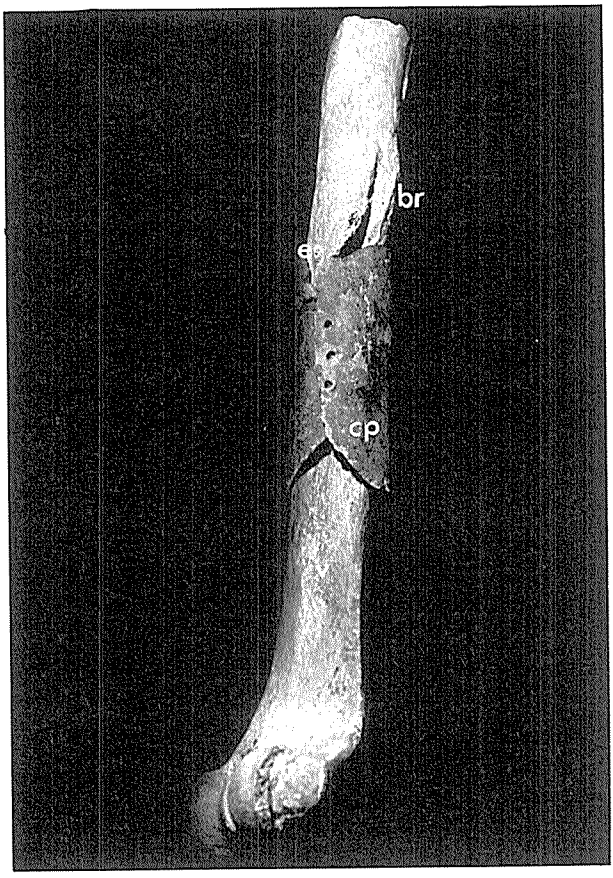
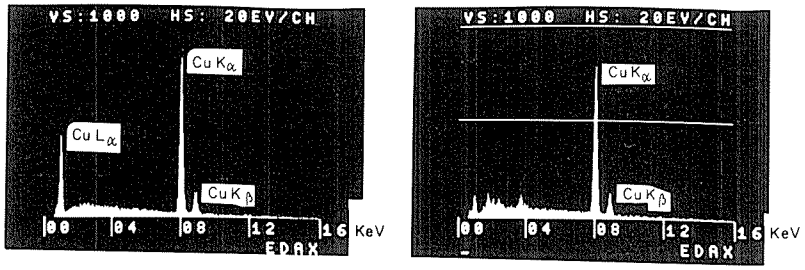


Figure 1. The bone from Varnhem, Sweden, seen from the lateral and ventral side. Note the proliferative bone reaction (br), with its two edges and central score. Note also the two exostoses (e), the copper plate (cp) and the verdigris (v).

PHOTOS OF SCREEN SCANNINGELECTRONMICROSCOPETECHNIQUE.

A. POLISHED PLATE

B. UNPOLISHED PLATE



DETAIL OF PLOT. FLUORECENCETECHNIQUE.

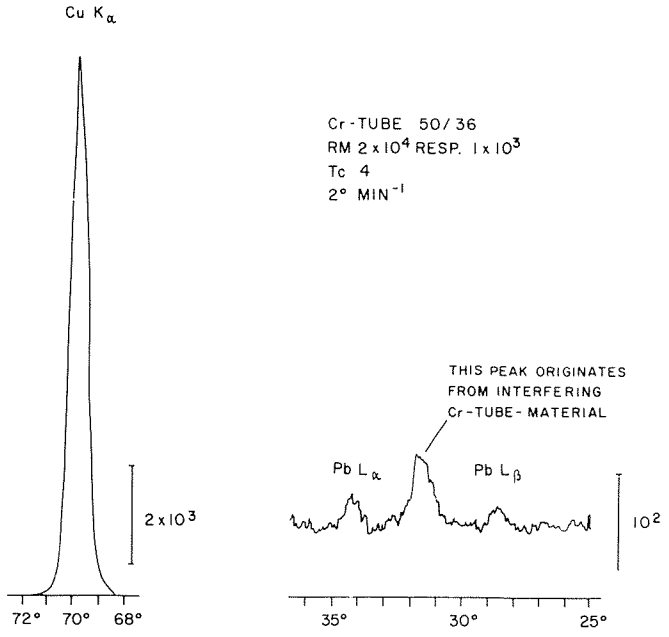


Figure 2. Chemical examinations of the copper plate.

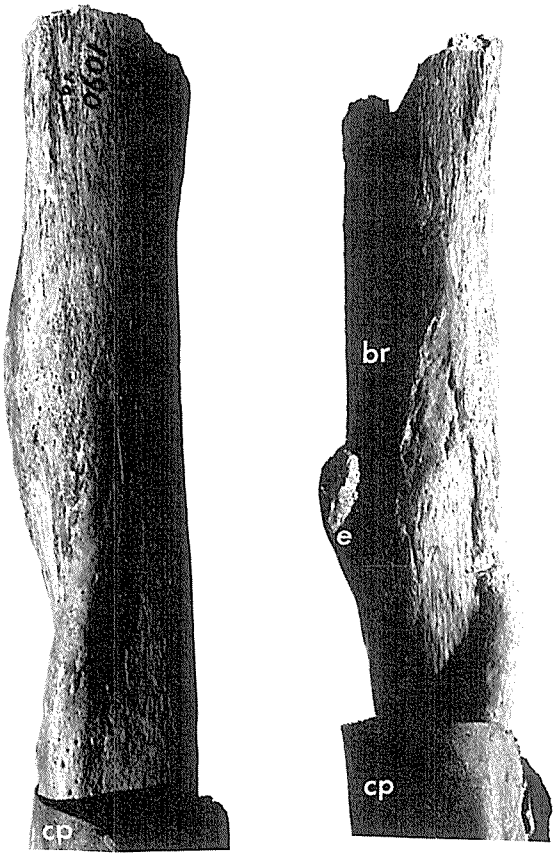


Figure 3. (left). Proximal part of the bone seen from the dorsal and medial side. Note the proliferative bone reaction (br) with its porous surface and the copper plate.

Figure 4. (right). Proximal part of the bone seen from the dorsal and lateral side. Note the larger of the two exostoses (e) and the proliferative bone reaction (br) with its porous surface. cp = copper plate.

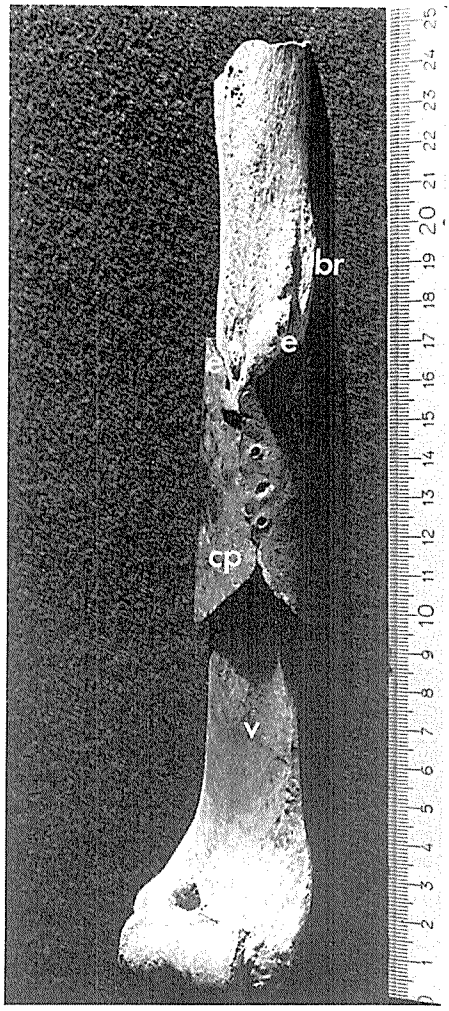


Figure 5. The bone seen from the lateral side. Note the two exostoses (e), the proliferative bone reaction (br) with its central score, the copper plate (cp) and the verdigris (v).

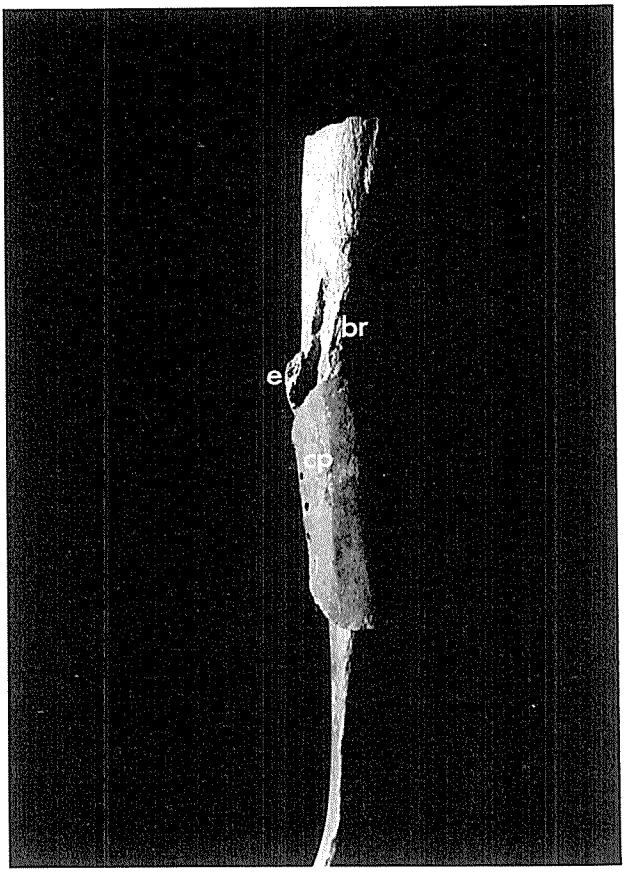


Figure 6. The bone seen from the lateral side. Note the larger of the two exostoses (e), the proliferative bone reaction (br) with its central score, and the copper plate (cp).

and probably have been held together with rivets, sinews or threads, nowadays disappeared. A second possibility is that there were three pins, used to nail the copper plate to the bone. The absence of holes or marks on the bone speaks against this theory. When the six holes are brought together to fit three to three,

the copper plate is held firmly to the bone, so that there is very little space left for soft parts under the plate. It is nevertheless possible to move the plate on the humerus between the distal epiphysis and an exostosis connected with a proliferative bone reaction in the proximal part of the remaining piece of bone. On the plate some smaller flaws are visible.

Analysis of the content of the plate gives evidence of a remarkably pure copper. Assuming that the sample is representative for the whole plate it thus consists of:

Cu	99%
Pb max	0.5%

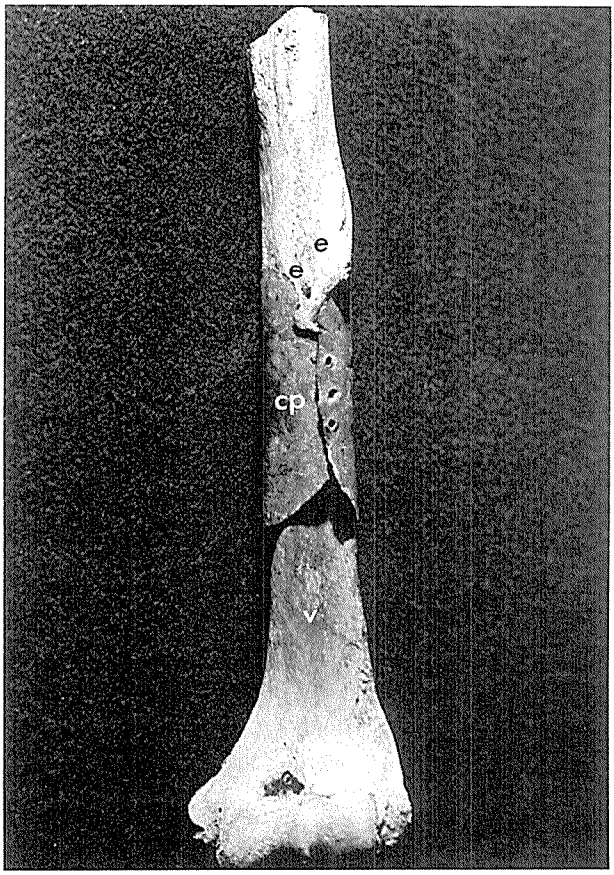


Figure 7. The bone seen from the ventral side. Note the two exostoses (e), the copper plate (cp) and the verdigris (v). Note also the little Foramen in Fossa coronoidea (not mentioned in the text).

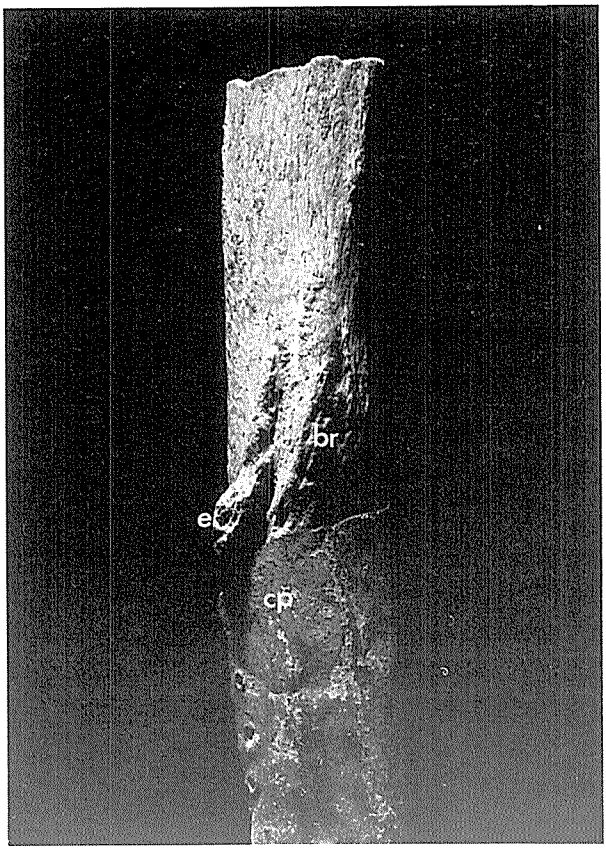


Figure 8. A close up picture of the proliferative bone reaction (br) with its two edges and central score. Note also the larger exostosis (e) and the copper plate (cp).

Proximally on the anterior face, approximately on the place where the distal part of the deltoid muscle is attached to the bone, a proliferative bone reaction can be seen. This bone reaction is approximately 6 cm long and 2 cm wide. It consists of two parallel edges with a score between them. The surface of the bone is porous, a defect which seems to originate from an inflammatory reaction.

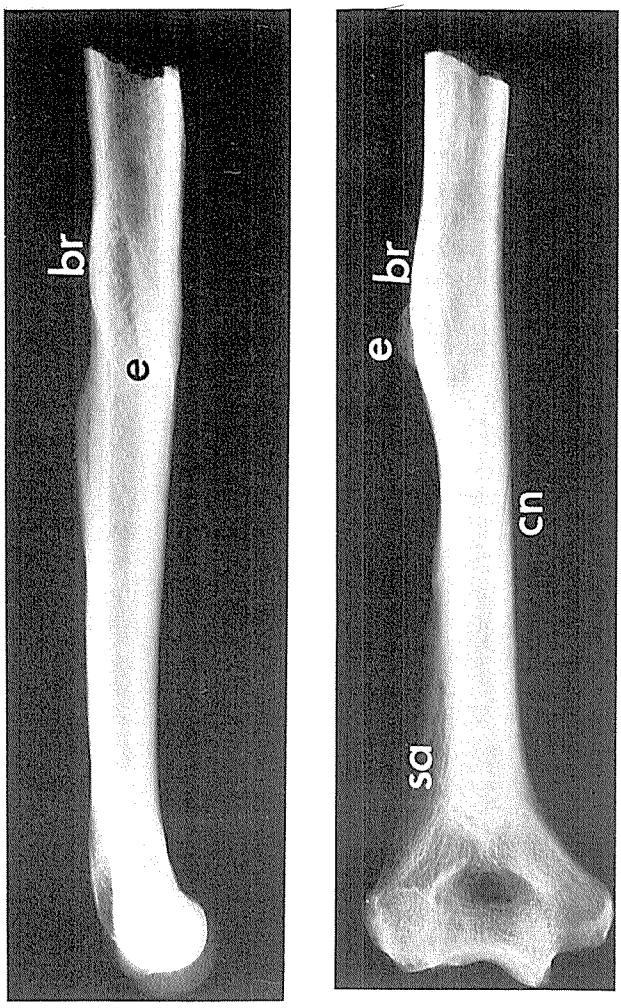


Figure 9. (left). X-ray picture. Side view. Note the proliferative bone reaction (br) and the larger exostosis (e), seen as an opaque ring.

Figure 10. (right). X-ray picture. Front view. Note the proliferative bone reaction (br) and the larger exostosis (e). Note also the spotted area (sa) and the Canalis nutricius (Cn) mentioned in the text.

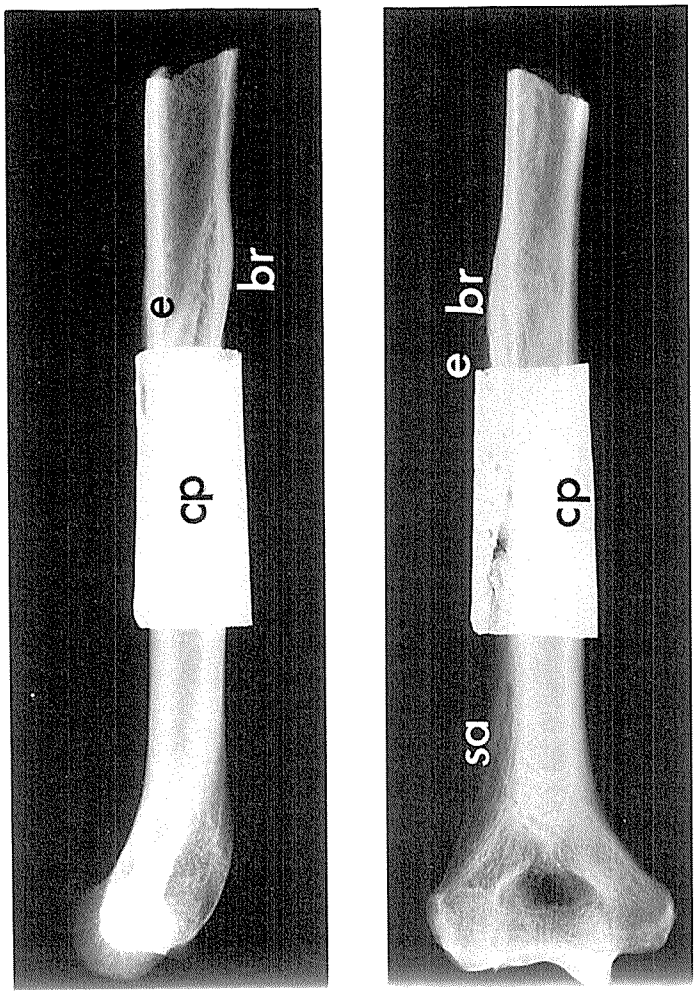


Figure 11. (left). X-ray picture. Side view with applicated copper plate (cp). Note the very distinct appearance of the proliferative bone reaction (br) with its central score. Note also the larger exostosis (e).

Figure 12. (right). X-ray picture. Front view with applicated copper plate (cp). Note the proliferative bone reaction (br), the larger exostosis (e) and the spotted area (sa).

The porous surface of the bone reaction can be seen in fig. 3 and 4. At the distal part of the anterior edge two exostoses can be identified (see fig. 5, 6, 7, and 8). The bigger, more laterally placed exostosis has a height of about 8 mm, a length of 2.5 cm and a width of 9 mm. The smaller and medially placed exostosis has a height of approximately 1.5 mm, a length of 6.5 mm and a width of 3.5 mm. On both exostoses the cortical layer is defective and the cancellous bone is visible. The bigger exostosis fits well in with the copper plate, as can be seen from fig. 1, 5 and 7. About two cm below the bone reaction, and situated on the lateral verge, an intact nutrient foramen with a diameter of 0.8 mm is visible. This foramen is thus to be found under the copper plate.

When compared with a normal humerus, neither rotation nor dislocation occurs. The shape of the bone seems fairly rough however, indicating that it originates from a man. The rough shape may also indicate pathology.

On corpus humeri, presumably on facies anterior lateralis and medialis, a marked verdigris is visible, which can be seen from fig. 1 and 7.

On the distal part of the bone some cortical defects with underlaying cancellous bone can be seen. The surfaces of the joint seem to be unaffected by diseases.

On the side view (fig. 9) an oblique structure is seen in the proximal part. In its ventral part, the structure is more opaque, and this part represents the proliferative bone reaction. Also the bigger exostosis is visible as an opaque ring.

On the dorsal side and distal to the bone reaction, the corticalis layer is much thicker than elsewhere, but this is an effect of the X-ray projection.

On the front view of the X-ray pictures (fig. 10), the proliferative bone reaction is quite distinct, and can be seen on the lateral side. The dense part of the reaction has a width which is twice the width of the corticalis proximal to the reaction. A central clearing in the bone reaction is visible. The bigger of the two exostoses is discernible. The corticalis defect, as well as the cancellous bone in the exostoses, can also be seen.

Distal from the bone reaction and on the medial side a sharp line in the corticalis is visible. This line probably originates from a Canalis nutricius. This assumption is supported by the fact that a Foramen nutricium can be found on the bone surface in agreement with the X-ray picture (see above).

On the distal part of the bone, and on the lateral side, a spotted area can be seen. This area may, in part, be due to the verdigris.

On both sides and in frontview the inner contour of the corticalis layer is smooth

and no fracture notch is discernible.

Discussion

According to the above mentioned newspaper article in Göteborgs-Tidningen of August 12, 1928, the cause of the operation is a fracture. It is also stated that the treatment was successful, but that the patient probably died rather soon. In addition to this newspaper article, the bone from Varnhem is also mentioned in four other works (W. Holmqvist, S. Bengtsson, S-A. Hallbäck and S. Lindroth). In the latter ones, the bone is only briefly mentioned as an example of Medieval surgical skill. W. Holmqvist suggests that the cause of the pathological changes is syphilis, which is reported in some skeletal remains from cloister in Denmark (Kr. Isager and E. Sjövall). An interesting remark of Holmqvist's runs as follows:

"... and the most remarkable is may be that this (= the copper plate[x]) has been, iron hard, fixed with threads, which, evidently, have been wound round the very bone, to leave the soft parts with their blood vessels free."

The question of what caused the pathological changes is indeed a very important one, and when examining the bone we have to consider at least four possibilities, which are listed below:

1. Neoplasm
2. Specific infections, preferably syphilis.
3. Unspecific infections
4. Fracture

There is no evidence of a neoplasm. It also seems unlikely that a tumour, leaving so relatively few marks on the morphology or on the X-ray pictures, should give such severe symtoms, as to justify this advanced method of treatment. When consulted, orthopaedic specialists also believe neoplasm to be a very unlikely alternative. Note, however, the spotted area on the distal part and on the medial side, which is probably due to the verdigris, but which somewhat resembles a pathological phenomenon.

Also a specific infection, such as TBC, syphilis etc., is an alternative of little probability, as there is nothing on the morphology showing bone destruction as in the case of TBC or showing the snail eaten appearance as in the case of syphilis (Robbins, Wells and others). The X-ray pictures cannot supply us with any indications of a specific infection, and consulted orthopaedists and the pathologists

x/ My remark and underlining.

also believe the alternative of a specific infection to be improbable.

Skeletal remains supposed to be syphilitic and with clear marks suggested to have come from bands which have been wound round the bone are presented by Kr. Isager and E. Sjövall, and found at the Øm monastery in Denmark. Their syphilitic character seem however doubtful in the view of the following circumstances (Gejvall 1 and 2):

1. The marks demands extensive syphilitic necrosis leaving the bone exposed. It is hard to believe that such a severe case of syphilis could survive long enough for the bandage to leave such traces of impressions as in this case.
2. The bands must have been passed in between the tibia and the fibula in some cases, which also seems highly unprobable.

Professor Gejvall offers a more probable explanation for these marks in his thesis about skeleton remains from Westerhus (Gejvall 2), where he describes a skeleton from Mjärthögen with similar marks (appendix). Note that in this case, the disease is not syphilis but eventually Mb Paget. According to professor Gejvall: "the channellings must therefore be interpreted as greatly deepened sulcu arteriosi et venosi as a result of the mechanical effects of the progressive increase in size of the bony accretion." In his book professor Gejvall gives clear evidence for this theory.

Since syphilis did not begin to appear frequently in Europe until around 1500 (M. Bergmark), this gives us a very narrow time interval as far as the alternative of syphilis is concerned.

A third alternative is an unspecific infection, an osteomyelitis, a periostitis or an infection in the soft parts. The fixation of the plate so closely to the bone as in this case entails seriously damaged soft parts, and it is a true surgical exploit to carry through this operation so that the patient survived. On the other hand, we cannot exclude the possibility that the copper plate may have been put in to disinfect the wound, in much the same way as copper is now used as an asepticum in the odontological field.

L-I. Jönsson has written about the famous humerus (sin.) fracture of King Erik XIV (1533-1577) of Sweden. This fracture arose from an attempted assassination when the king was kept prisoner. The fracture healed, but within the healed fracture small pieces of iron are to be seen. There are two theories about these iron pieces; either they originate from the weapon (a gun), that caused the frac-

ture, or they have been placed in the wound in order to prevent an infection. This method of putting iron or copper in wounds in order to prevent or stop infections is known since antiquity (A. C. Celsus), and if the second theory is adopted, one may assume that this technique was known and practised during the last part of the Medieval period in Sweden. This royal arm lesion was first described by professor C-H. Hjortsjö.

Note also that the copper plate itself may have caused the bone reaction (chemically and/or mechanically).

The last alternative is that the copper plate was put round the bone to stabilize a fracture. According to the available literature, fractures have been accounted for in most societies and during most periods (among others: J. M. Allison et al., J. L. Angel, D. Brothwell, C. B. Courville, R. R. Crawford, N-G. Gejvall (3), M. S. Goldstein, S. P. F. Hughes, J. L. Price, J. G. Roney, H. E. Sigerist, C. Wells etc.). Most fractures described in this literature have been healed, often with more or less dislocation. The question is whether a well healed fracture with no or little dislocation is an indication of human skill in treatment, and splinting of fractures (Sigerist, Wells and others). Well healed fractures with very little dislocation do, however, occur among animals, for instance among apes (Schultz) and birds (Lepiksaar). On the other hand, treatment of fractures seems to have started at an early date according to G. E. Smith who has examined the art of splinting among old Egyptians of the V:th dynasty and according to Moulin who has written about treatment of facial fractures in Hippocrates' time. Open surgical treatment of fractures does not become more frequent until the 19th century but the techniques are rather well developed in the first part of the 20th century (A. Lambotte). Adopting the fracture alternative one may very well consider that the treatment of the above described bone from Varnhem is one of the oldest of its kind in history.

As pointed out neither dislocation nor rotation in the bone is to be found when compared with a healthy humerus. It has also been mentioned that there are no fracture notches on the X-ray pictures. The explanation may be as follows. If the patient got his injury from, say, an axe or a sword, the result may have been a wound where the bone was bared and visible, more or less damaged. With these presumptions, it would have been natural for the monks who administered the treatment to try to stabilize the bone by placing the copper plate round it, a task that would be possible with the open wound. When the bone was stabilized,

the arm may have been bandaged. The copper in the plate must have had a strong antibacterial effect on the wound, and the infection risk was thus diminished, despite lack of sterile conditions.

An explanation as described above also sounds very plausible to orthopaedic specialists consulted. The lack of fracture notches on the X-ray pictures is a fair possibility in view of the fact that the patient survived for some years after the treatment. Nevertheless, this operation must have been a very difficult task, considering the lack of adequate narcosis and the very difficult surgical area of the fracture. It is surprising that a type of wound which probably was not unusual during the patient's lifetime just as it is fairly common today, was treated with the above described, unique surgical technique, but the circumstances may justify the assumption that the patient was quite an important person.

Another possibility is that the copper plate had been wrapped round the outside of the intact arm, and then gradually strangulated the arm. A fact that speaks against this theory is that the distal parts of the bone are not degenerated or in other ways affected, which could be expected. Furthermore, an intact Foramen nutricium can be seen under the copper plate as has been mentioned above.

Note also that after the death and burial of the patient, the copper plate has slid down to the distal epiphysis, where, for centuries, it has verdigrised the bone (fig. 1 and 7).

Conclusions

1. Sex

The weight and measures indicate that the bone originates from a male.

2. Age

This man probably lived and was treated for his injury within the period 1260-1527.

3. Pathological cause

The most probable cause for the treatment is a fracture caused by violence in some form. The alternative of an unspecific infection cannot be excluded. A neoplasm or a specific infection are alternatives of less probability.

4. Technique

My assumption is that the injury was caused by a cut from, for instance an axe or a sword, which led to an open wound, with the bared bone visible. The bone was probably not cut in two pieces. The plate was placed round the bone to bring about stabilization. At the same time, the pure copper had an antibacterial effect on the wound. Whether this effect was deliberate or not is impossible to say.

5. Survival

Judging from the bone, and considering the well developed exostoses and the proliferative bone reaction, as well as the lack of fracture notches on the X-ray pictures, the patient must have survived for years, may be decades. Note that nothing can be said about the function of the arm after the operation.

Acknowledgements

I want to express my gratitude to docent Jan Sandegård for supporting me with literature, constructive criticism, stimulating discussions and a never failing interest. I am much grateful to my father, Provincial Custodian of Antiquities S-A. Hallbäck, who showed the bone to me, and who has been of invaluable help to me, as far as archaeological and historical datas are concerned. I am also grateful to docent Bo Nilsson for much advice in matters concerning technical determination of age. To all others to whom I showed the bone, and with whom I discussed it, I also want to express sincere thanks for support, advice and constructive criticism.

For helping me with analyses of the copper plate I thank engineer Lars Eklund and engineer Åke Åkerström at the Swedish Silicate Research Institute, Chalmers Institute of Technology, Gothenburg. For helping me with taking the X-ray pictures I thank professor Sven Scheller and photografer Ole Roos. For helping me with drawing table 1 and picture 2 I thank Miss Pia Larsson and photographer Thomas Palm. For scrutinizing the English I thank Mrs Sara Arvidsson. For typing the final manuscript I thank Miss Elvy Wigholm.

Table 1.

The bone		
max. length	24,3	cm.
diameter of corpus Humeri	2,5 - 3,0	cm.
max. width of the distal epiphys of Humerus	6,9	cm.
weight	95,12	g.
The copper plate		
max. length	7,3	cm.
max. width	10,0	cm.
thickness	0,6 - 0,8	mm.
weight	17,26	g.

References

Allison, J.M., Mendoza, D. & Pezzia, A. 1974: A radiographic approach to childhood illness in precolumbian inhabitants of southern Peru. Am. J. Phys. Anthropol. 40, 409-416.

Angel, J. L. 1946: Skeletal change in ancient Greece. Am. J. Phys. Anthropol. 4, 69-97.

Bengtsson, S. 1975: I Västgötabygd. Skövde. (In Swedish).

Bergmark, M. 1965: Från pest till polio. Natur och Kultur, Stockholm. (In Swedish).

Brothwell, D. 1961: The palaeopathology of early British man. J. Roy. Anth. Inst. 91, 2, 318-343.

Celsus, A. C. 1906: Åtta böcker om läkekonsten. (Eight books of art of medicine.) Translated and annotated by M. V. Odenius. Gleerups, Lund. (In Swedish).

Courville, C.B. 1950: Cranial injuries in prehistoric man. Bull. Los Angeles Neurol. Soc. 15, 1-21.

Crawford, R.R. 1973: A history of the treatment of non-union of fractures in the 19th century, in the United States. J. Bone Joint. surg. am. 55, 1685-97.

Forssén, A. 1969: Varnhem. Kungliga Vitterhets- historie- och antikvitetsakademin. Svenska fornminnesplatser nr 8, 2nd ed. (In Swedish with English summary).

Gejvall, N.-G. (1): Osteological Research laboratory, University of Stockholm, Sweden. Personal communications.

Gejvall, N.-G. (2) 1960: Westerhus. Medieval population and church in the light of skeletal remains. Kungliga Vitterhets- historie- och antikvitetsakademin. Lund.

Gejvall, N.-G. (3) 1968: Patologiska fynd i ett medeltida material. Ronden 20, 231-234. (In Swedish).

Goldstein, M. S. 1969: The palaeopathology of human skeletal remains. In Brothwell, D., Higgs, E. & Clark, G. (eds.): Science in archaeology and research. Thames & Hudson. 2nd ed.
Göteborgs-Tidningen, August 12, 1928: Varnhems kloster utgrävt. (In Swedish).
Hallbäck, S.-A.: Museum of Västergötland. Skara. Personal communications.
Hallbäck, S.-A. & Ahlgren, J. 1976: I platåbergens landskap - en bok om Västergötland. Forum, Borås. (In Swedish).
Hjortsjö, C.-H. 1962: Erik XIV. En historisk, kulturhistorisk och medicinsk-antropologisk undersökning i samband med gravöppningen 1958 i Västerås domkyrka. C.-H. Hjortsjö (ed.), Norstedt, Stockholm. (In Swedish).
Holmqvist, W. 1947: Den stora döden. Svenska Turistföreningens årsskrift 1947, p. 106-121. (In Swedish).
Hughes, S. P. F. 1975: An historical review of fractures involving the ankle joint. Mayo. Clin. Proc. 50, 611-614.
Isager, Kr. & Sjövall, E. 1936: Skeletfundene ved Øm kloster. Levin & Munksgaard, Køpenhavn. (In Danish and Swedish).
Jönsson, L.-I. 1976: Mynten med Älvsborg. Erik XIV:s 3- och 1,5-mark 1562. Numismatiska litteratursällskapet i Göteborg, Göteborg. (In Swedish).
Lambotte, A. 1924: Chirurgie opératoire des Fractures. Bruxelles. (In French).
Lepiksaar, J.: Museum of Nature, Gothenburg, Sweden. Personal communications.
Lindroth, S. 1975: Svensk lärdomshistoria. Medeltiden - Reformationstiden. Norstedt, Stockholm. (In Swedish).
Moulin, D. de 1974: Treatment of facial fractures in Hippocrates time. Arch. chir. neerl. 26, 283-288.
Nilsson, B.: Department of medical chemistry. Univ. of Gothenburg, Sweden. Personal communications.
Nomina Anatomica 1966: Excerpta medica fondation. 3:d ed.
Price, J. L. 1975: The radiology of excavated saxon and Medieval human remains from Winchester. Clin. Radiol. 26, 363-370.
Robbins, S. L. 1967: Pathology. 3:d ed. Saunders.
Roney, J. G. 1959: Palaeopathology of a california archaeological site. Bull. Hist. Med. 33, 97-109.
Sandegård, J.: Department of orthopaedic surgery II, Sahlgren Hospital, Univ. of Gothenburg, Sweden. Personal communications.
Schultz, A. H. 1939: Notes on diseases and healed fractures of wild apes. Bull. Hist. Med. 7, 571-582.
Sigerist, H. E. 1951: A history of medicine. Vol. 1. Primitive and Archaic Medicine. New York.
Smith, G. E. 1908: The most ancient splints. Brit. Med. J. p. 732-734.
Sourander, P.: Department of clinical pathology, Sahlgren Hospital, Univ. of Gothenburg, Sweden. Personal communications.
Wells, C. 1964: Bones bodies and disease. Thames and Hudson, London.
Wingborg, F. A. 1927: Från Valle härad med Varnhems kyrka och kloster, Höjentorp, Axvalla slott och andra märkliga platser inom bygden. Stockholm. (In Swedish).

Dental disease in Eskimo skulls in British museums

M. E. J. CURZON

OSSA

One hundred and sixty Eskimo skulls were located and studied in museums in Great Britain. Details are provided as to location of skulls, collection sites, age, sex and present dental condition. Dental caries was found in six skulls, all from Greenland, and a mean decayed missing index (DMT) of 1.47 was determined for all skulls. Periodontal disease as assessed by the T.C.H. index, was noted in 83% of the skulls. Antemortem loss of teeth was present in 28% of skull material reflecting the high level of periodontal disease prevalent. It would appear that although there has been a marked increase in dental caries in the Eskimo, periodontal disease has always been high.

Сто шестьдесят эскимосских черепов было отобрано и изучено в музеях Англии. Приводятся данные, касающиеся размещения черепов, местонахождений коллекции, возраста, пола и настоящего состояния зубов. Кариоз зубов был обнаружен у шести черепов, причем все они происходили из Гренландии, и средний индекс недостающих зубов (decayed missing index, DMT) величиной 1,47 был определен для всех черепов. Периодонтальная болезнь, как свидетельствует индекс ТЦГ (TCH), отмечена у 83% черепов. Предсмертная потеря зубов имела место у 28% черепов, что отражает преобладающий высокий уровень периодонтальных болезней. Очевидно, что хотя наблюдалось заметное возрастание кариоза зубов у эскимосов, периодонтальная болезнь всегда была широко распространена.

M. E. J. Curzon, Eastman Dental Center, 800 Main Street East, Rochester, New York 14605 U.S.A.

Vol. 3/4 pp 83–95, Lund. ISSN 0345–8865.

Many of the English and Scottish Artic explorers collected skeletal material, including Eskimo skulls, during their travels, and, upon returning to Great Britain, donated the skulls to various museums. It is the objective of this paper to identify these skulls for future study, and report on the dental disease to be found in this material.

The skull collections were identified by correspondence with departments of anatomy, dental anatomy and physical anthropology in the universities of the British Isles. In addition, enquiries were also made at the Royal Colleges of Surgeons of London and Edinburgh, as well as the British Museum of Natural History.

Materials and Methods

A total of 160 skulls were identified, of which 85 were in the British Museum of Natural History. This collection comprised three previous collections from the Natural History Museum, Lodon; the Department of Anatomy, University of Oxford; and the Royal College of Surgeons of England, in London. Smaller groups of skulls were located in Cambridge, Liverpool and Edinburgh. Oxford retained three skulls of its original collection and single specimens were located in Bristol, Cardiff, Glasgow, Royal College of Surgeons of England and at University College, London.

The origin of the Eskimo skulls was related to the routes travelled by early explorers, so that the largest numbers of skulls came from the west coast of Greenland. A few skulls were from old settlements around Lancaster Sound and Hudson Strait, the two main waterways leading west, and thought likely to be part of the Northwest passage. The dates of collection varied from as early as 1818, to the period of the 1914-18 war. Many skulls were presented to the museums by private collections in the 1930's; and only the date of acquisition is given. Some of the skulls in the British Museum date from the early expeditions of Franklin and Parry, and collection information is written on the skulls themselves.

A small number of skulls were from Port Clarence, Cape Lisburne, Kotzebue and Nunivak Islands in Alaska, and it is of note that in none of the museums were there skulls from McKenzie Delta, central Arctic (Inuvik to Pelly Bay), and the west coast of Hudson's Bay. Finally, in one collection, that of the Duckworth Museum in Cambridge, were 3 skulls from Angmassilik, on the east coast of Greenland. Details of the various collection sites identified, approximate dates of collection, and the survey code letters assigned to each area, are given in Table 1.

The records of the individual museums give no information regarding the dating of the skull material. It appears that no attempts have been made to date the skulls. In some instance there are notes on individual skulls, to the effect that a skull is "probably 200 years old". The only evidence for such statements is the actual date of collection. Thus, these skulls collected in 1823 by the expedition led by Sir Edward Parry, were probably of Eskimos who died sometime at the end of the 18th century. However, since bones decay in the Artic at a very slow rate, it is quite possible that some of the skulls would be even older. A proper dating of material described in this paper, is required.

Skulls identification

Each museum had its own cataloguing system and method of notation for their Eskimo skulls. None of these systems was the same, and in the case of the British Museum, several annotations were in use for the same collection. Typical catalogue numbers would be: AMIO 856, BD 1192 or F. C. 832, depending upon whether the skull originated from Oxford, the Natural History Museum, or the Royal College of Surgeons of England, respectively. The Duckworth Museum, Cambridge, numbered its skulls variously as 1869, AM 1. 0. 7, 76. 9, VIII 29IV, or 5-13 which was confusing.

Accordingly, in this study, the skulls have been grouped by museum, and then by original collection site within each museum collection. The skulls were sequentially numbered together with a code letter indicating the museum of ownership. Thus, 126-0 being the one hundred and twenty-sixth skull examined from the Department of Anatomy in Oxford. Details as to the museums, number of skulls, identification letters and sites of origin, are given in Table II.

Of the total of 160 specimens, 42 were complete with all facial bones and mandible, together with some teeth, and 131 mandibles and/or maxillas were suitable for some form of data collection. There were six specimens comprising mandibles only, and five calvaria with no facial bones. For the purpose of future dental studies, only a quarter of the total material can be considered suitable.

Confusion exists in some of the collections as to original identification of the skull, particularly where previous reports exist. Thus, the Liverpool collection, marked Aa1 to Aa17, is not related to the original cataloguing by Brierly and Parsons (1903). It appears that this collection, which was individually labelled, was transferred out of Liverpool for safe keeping during the 1939-45 war. In 1946, when the skeletal material was returned, each skull was numbered as per Brierly's classification, but this new numbering was in error, and does not bear any relation to the description of each skull in Brierly's original text.

Several of the British Museum's skulls are listed in that museum's catalogue as originating from the Royal College of Surgeons of England, but no longer appear to exist. In some cases, skulls are listed as having been returned to the Royal College, but they are not there. It is known that some skeletal material was damaged by a bomb, which exploded in the Royal College in the 1939-45 war, and this might explain the fate of the missing skulls. In some instances, maxillas and mandibles are stored and catalogued as being of one individual, when close exami-

nation of the occlusion and the fitting of the mandibular condyles into the glenoid fossae showed them to be from different Eskimos. For the purpose of this survey, they have been listed as two separate individuals.

Many specimens had lost teeth post-mortem, particularly incisors, as would be expected from their root configuration. In some instances, teeth were loose in the skull's box, and in others, teeth had been glued into place, sometimes wrongly. When the present examinations were compared to previous reports, such as Brierly and Parsons (1903), it appeared that many teeth had been lost whilst the skulls were in the possession of the various museums.

Age and Sex

The age and sex of each skull was determined by reference to such previous records as existed and by examination. The age of each skull at death was determined by tooth eruption patterns (Schour and Massler, 1940) for ages under twenty years, and by the extent of occlusal wear on the molar teeth (Miles, 1963) for all others. Ages were specified as being within ten year groups.

Sex was determined by examination of bone structure and points of muscle attachment. In both cases of age and sex, there were a number of instances where personal examination did not agree with previous records, or catalogues. In these cases, a re-examination was carried out and a final decision made. The sexing of human skulls is very difficult (Brooks, 1955), particularly when material is damaged, however, a probable sex was assigned to each skull. In some cases the skull examined was of a young child, and then no sex was recorded. The distribution of skulls by age groups and sex for each museum collection is reported in Table III.

Dental Examinations

All skulls were examined and scored for dental caries and periodontal disease. Dental decay was determined with standardized probes and mouth mirrors, using artificial light, in the same manner as in clinical studies on modern eskimos (Curzon and Curzon, 1970) and other epidemiologic caries studies (Curzon, Kubota and Bibby, 1971, Curzon, Adkins, Bibby and Losee, 1970). The criteria for diagnosis of a cavity was when the probe penetrated 2 mm beyond the surface of the enamel into the dentine, thus, catches, sticky pits and fissures were not diagnosed as decay. No bite wing radiographs were taken, since suitable radio-

graphic equipment was not available.

During the examinations, it was evident that most carious cavities were secondary caries. In this situation caries starts only after severe wear has exposed the dentine. Therefore, in recording carious cavities, distinction was made between primary and secondary caries.

Periodontal disease was assessed by measuring the degree of bone loss around each tooth using the method of Davies, Picton and Alexander (1969). Two measurements were made for each tooth from the alveolar crest to the amelo-cemental junction and from the average of these for the whole mouth an estimate was calculated, known as the Tooth Cervical Height-index (T. C. H.) for each skull. These measurements, when summed and divided by twice the number of teeth present, gave an index of periodontal disease. In the manner used in this survey, the data was then recalculated so that a T. C. H. of 1.0 represented a skull where the mean depth of pockets would have been 2.0 mm. Any index greater than 1.0 would, therefore, indicate an increase in pocket depth which must be related to periodontal disease.

Results

Since the condition of some of the skulls was not good, and in many cases either maxilla and/or mandible were missing, the dental caries results were based on examination of only 42 complete skulls with mandibles. A decayed-missing (ante-mortem) index (DM) was calculated for each skull, and the mean index was 1.47 (S. E. $\pm$ 0.39), reflecting a very low tooth morbidity and mortality. However, in the 42 skulls there were only 7 cavities, which occurred in only 4 skulls. Of the 7 cavities identified, only 1 was primary dental decay in enamel, whilst the remainder were secondary caries of dentine arising after exposure due to severe attrition. In considering the 131 skulls, with one or more teeth present, six, and all from Greenland, had decay in at least one tooth. The percentage of caries free individuals of all ages was therefore, 95.4.

In assessing the T. C. H. index, only skulls aged between 10 and 60, at time of death were used. Below the age of 10, problems of the mixed dentition arose and there were only 3 skulls felt to be over the age of 60, that still had any teeth left. The results of the T. C. H. measurements are given in Table IV. There was some evidence of periodontal disease even in the youngest skulls measured. Eighty-eight skulls, or 83% of the total examined and scored, recorded a T. C. H. of

greater than 1.0. In some instances bone loss was marked with bifurcation and trifurcation involvement (Figure A). Some skulls still had large deposits of calculus present on the teeth even though they had been collected as early as 1823. Heavy attrition was present on many teeth as shown in Figure A.

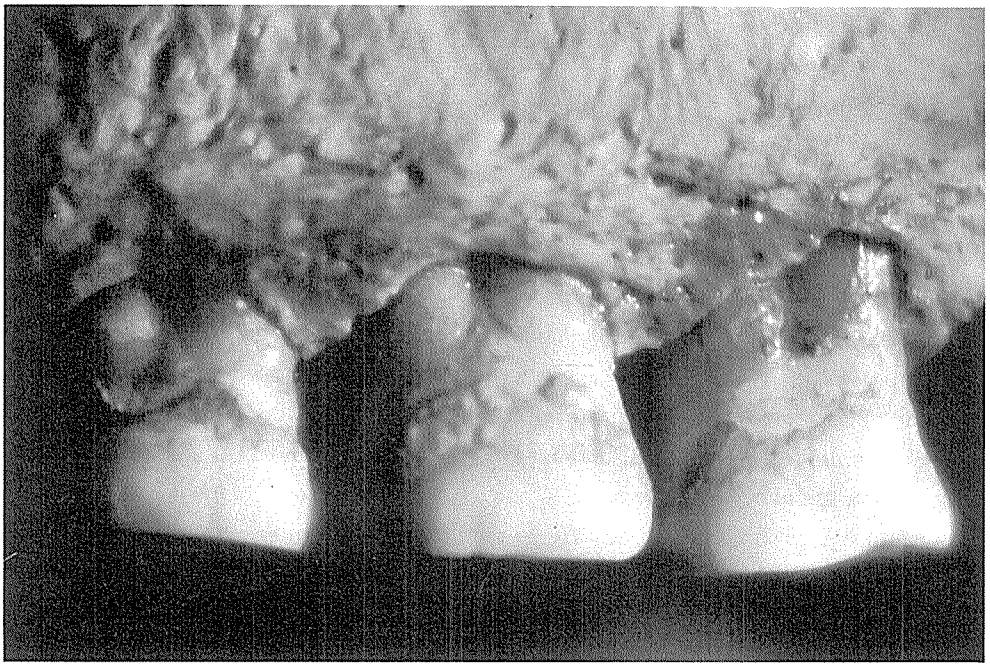
Antemortem loss of teeth was noted in 35 maxillas and 19 mandibles, and mostly involved molars and incisors. The distribution of teeth lost before death, and presumably from periodontal disease, is shown in Figure B. As can be clearly seen, incisors and molars were predominently lost antemortem. It could be that some of the incisors may have been lost due to trauma, however, in the authors experience of providing dental treatment to the modern Eskimo, trauma to the incisors is very rare indeed. Antemortem loss of teeth in ancient Eskimos was probably solely due to periodontal disease.

A few dental anomalies were noted in examining the skulls. The most frequent was the presence of a third root on the first permanent mandibular molar. A frequency of 12.7% was found which has been reported more fully elsewhere (Curzon, 1974). In sixteen skulls at least one third permanent molar was missing. Two cases of congenitally missing second premolars were seen, and one case each of missing maxillary lateral incisors, and of mandibular central incisors. Although, in two skulls, examples of evaginated odontomes were seen the heavy wear on the occlusal surfaces of so many teeth made a proper analysis of this anomaly impossible. No examples were noted of germinations or fusions.

Discussion

Although not large in number, in comparison to other Eskimo skull collections, such as in Copenhagen (Fürst and Hanson 1915) and diversified in ten different institutions, the Eskimo skulls of the British Isles form an ideal basis for research in dental anthropology and morphology. Within the collections are represented skulls of 5 groups of Eskimo settlements originating before the advent of European gene mixture and culture.

Some of the Eskimo skull material herein described has been used for dental research by several authors in the past (Davies and Picton, 1969, Lavelle, 1970), however, the material used previously was that of the British Museum in London, and did not include some of the excellent skull material residing elsewhere, such as the three Oxford skulls. The use of this other material would increase the



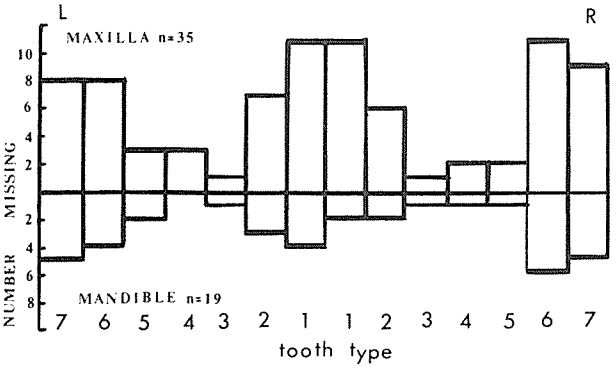


Figure A. Severe periodontal disease in an Eskimo skull showing calculus, pocketing and trifurcation involvement.

Figure B. Distribution of antemortem tooth loss in Eskimo skulls.

sample size for study and hence the validity of results.

The very low level of dental decay in the Eskimo, prior to the advent of western civilization, has been commented upon before (Pederson, 1969). The results of the present study show the prevalence of decay in the Eskimo to have been extremely low. It is of note that the six skulls with decay, were all from Greenland where European civilisation and culture first had an impact.

The comparison of the dental status of the modern Eskimo as reported by several recent studies on Eskimo communities of Alaska (Mayhall et al., 1970), Keewatin (Curzon and Curzon, 1970, McPhail et al., 1972), and Greenland (Möller, Poulsen and Nielsen, 1972), all show the terrible destruction of the dentitions that has occurred in the past three decades.

The assessment of periodontal disease shows the condition to have been as widespread in the early Eskimo as it is now (McPhail, et al., 1972). Even the youngest age group considered, 10-20 years, showed a mean increase of T. C. H. index, and hence, of pocket depth. The number of teeth per individual skull, was rather low, 7.5, which may have biased the analysis. However, comparison with the data of Davies and Picton (1969) shows very similar results to their coastal and inland Eskimo where 14.0 and 11.6 were the mean number of teeth. Since these authors used skull material from one of the collections (British Museum, London), the material must be identical in part. Davies and Picton describe "inlanders" as living fifty miles inland, however, as Tables I and II show, all the skulls at the British Museum were collected from sites by the sea. The data of Davies and Picton should, therefore, be considered as for Eskimos in general. Nevertheless, the T. C. H. indicies for the two studies are very similar and demonstrate the extent of periodontal disease in the early Eskimo.

This collection of material is unique in Great Britain, and is irreplaceable. The modern Eskimo has changed considerably from his ancestor of only 100 years ago, both by miscegenation and aculturation. Already there is evidence of change in dental morphology, although it is a yet slight (Curzon, 1974b). Recently Eskimo leaders have been pressing for the cessation of anthropological acquisition of skeletal remains on moral and religious grounds. This makes the present material even more valuable for dental and anthropological study.

References

Brooks, S.T. 1965: Skeletal Age at Death. Reliability of Cranial and Pelvic Age Indicators. Am. J. Phys. Anthro. N.S. 13, 567.

Brierly, J. & Parsons, F.G. 1903: Notes on a Collection of Eskimo Skulls. 13, 103-120.

Curzon, M.E.J. & Curzon, J.A. 1970: Dental Caries in Eskimo Children of the Keenatin District in the Northwest Territories. J. Canadian Dent. Assn. 36, 342-345.

Curzon, M.E.J., Adkins, B.J., Bibby, B.G. & Losee, F.L. 1970: Combined Effect of Trace Elements and Fluorine on Dental Caries. J. Dent. Res. 49, 526-528.

Curzon, M.E.J., Kubota, J. & Bibby, B.G. 1971: Environmental Effects of Molybdenum on Dental Caries. J. Dent. Res. 50, 74-77.

Curzon, M.E.J. 1974: Three-rooted Mandibular First Permanent Molars in Greenland Eskimo Skulls. Arctic 27, 150-153.

Curzon, M.E.J. 1974: Miscegenation and the Prevalence of Three-rooted Mandibular First Molars in the Baffin Eskimo. Community Dent. Oral Epidemiol. 2, 130-131.

Davies, D.M., Picton, D.C.A. & Alexander, A.G. 1969: An Objective Method of Assessing the Periodontal Condition in Human Skulls. J. Periodont. Res. 4, 74-77.

Davies, D.M. & Picton, D.C.A. 1969: A study of the Periodontal State in Two Hundred and Two Skulls of Primitive Peoples. J. Periodont. Res. 4, 230-234.

Fürst, C.M. & Hansen, C.C. 1949: Crania Groenlandica. Andr. Fred. Host., Köbenhavn.

Lavelle, C.L.B. 1970: Analysis of Attrition in Adult Human Molars. J. Dent. Res. 49, 822-828.

Mayhall, J.T., Dahlberg, A.A. & Owen, D.G. 1970: Dental Caries In the Eskimo of Wainwright, Alaska. J. Dent. Res. 49, 886.

McPhail, C.W.B., Curry, T.M., Hazelton, R.D., Paynter, K.J. & Williamson, R.G. 1972: Geographic Pathology of Dental Disease in Canadian Central Arctic Populations. J. Canadian Dent. Assn. 38, 288-296.

Miles, A.E.W. 1963: Dentition In the Assessment of Individual Age In Skeletal Material. In Brothwell, D. (ed.): Dental Anthropology. Pergamon Press, London.

Möller, I.J., Poulsen, S. & Nielsen, V.D. 1972: The Prevalence of Dental Caries in Godhavn and Scoresbysund Districts, Greenland. Scand. J. Dent. Res. 80, 169-180.

Pederson, P.O. 1949: The East Greenland Eskimo Dentition. C.A. Reitzels Forlag, Köbenhavn.

Schour, I. & Massler, M. 1940: Studies In Tooth Development: The Growth Pattern of Human Teeth Part II. J. Am. Dent. Assn. 27, 1918-1931.

Table I

COLLECTION SITES OF ESKIMO SKULLS OF BRITISH MUSEUMS

COLLECTION AREA +	AREA IDENTIFICATION LETTER	IDENTIFIED SETTLEMENTS AND AREAS
Alaska	A	Port Clarence, Cape Lisburne, Kotzebue, Nunivak Island
Labrador	L	Hopedale, Nain
Baffin	B	Lancaster Sound, Pond Inlet, Melville Peninsular Baden Bay, Cape Warrender, Igloolik, "Baffia"
West Greenland	W.G.*	Upernavik, Holstenborg, Wolstenholm Sound, Narsak, Issungvak, Christianshaab, Godhavn, Rhode Bay, Semermint, Ikersaak, Egedesminde, hunde islands, Cape Simpson
East Greenland	E.G.	Angmassilik
Not Known	N.K.	

*Also includes a few skulls listed as "Greenland", and therefore, probably collected on the west coast.

+No skulls identified from McKenzie Delta, Coppermine, Interior Keewatin or coast of Hudson Bay areas.

Table II

DISTRIBUTION OF ESKIMO SKULLS BY MUSEUM

MUSEUM (IDENTIFICATION LETTER)	TOTAL SKULLS	SURVEY NUMBERS	COLLECTION DATES	COLLECTION* SITES
British Museum, Natural History (N)	85	1-85	1821-1911	A, L, B, W.G., N.K.
Duckworth Museum, Cambridge (D)	24	86-109	1864-1902	L, W.G., E G, N.K.
Dept. Anatomy, Liverpool (L)	16	110-125	1900	W.G.
Dept. Anatomy, Oxford (O)	3	126-128	1869	W.G.
Dept. Anatomy, Cardiff (C)	1	129	1890	B
Dept. Anatomy, Glasgow (G)	1	130	N.K.	W.G.
Royal College Surgeons, London (R)	1	131	1818	W.G.
Dept. Physical Anthropology, Univ. College, London (U)	1	132	N.K.	N.K.
Dept. Anatomy, Bristol (B)	1	133	N.K.	N.K.
Dept. Anatomy, Edinburgh (E)	27	134-160	1800's	A, L, B, W.G., E.G., N.K.

*See Table I for code letters.

N.K. - Not Known

Table III

AGE AND SEX DISTRIBUTION OF ESKIMO SKULLS

	SEX			AGE						
MUSEUM	F	M	CHILD	0-10	10-20	20-30	30-40	40-50	50-60	60+
N	37	41	5	3	10	22	17	15	11	5
D	6	15	3	2	3	6	4	2	5	2
L	3	12	1		1	7	4		2	2
O	1	2				1	1			1
C			1	1						
G	1						1			
R	1					1				
U		1					1			
B*										

*Too weathered for proper identification.

Table IV

T.C.H. INDICIES OF PERIODONTAL

DISEASE IN ESKIMO SKULLS

AGE GROUP	Mean Index (± S.E.) in Skulls* MALE	FEMALE	TOTAL
10-20	1.06 ± 0.05	1.01 ± 0.05	1.02 ± 0.04
20-30	1.46 ± 0.10	1.25 ± 0.07	1.36 ± 0.06
30-40	1.56 ± 0.08	1.58 ± 0.15	1.57 ± 0.07
40-50	2.09 ± 0.23	2.17 ± 0.31	2.12 ± 0.18
50-60	2.09 ± 0.17	2.05 ± 0.17	2.06 ± 0.11

* = 56 Male and 50 Female

A method for familial studies based on minor skeletal variants

TORSTEIN SJØVOLD

OSSA

The author describes a model for the occurrence of minor non-metrical skeletal variants (discrete traits). Based on the assumption underlying this model the distribution of the variants in a closed population is derived, from which the probability for a randomly chosen individual to possess each particular variant or combination of variants may be obtained. Family relationships may be revealed regarding individuals having approximately the same probability of possessing their particular patterns of a number of selected rare variants.

Автор описывает модель частоты малых неметрических скелетных вариантов (дискретных черт). На основании предположений, обосновывающих эту модель, выводится распределение вариантов в замкнутой популяции, из которого может быть получена вероятность, что произвольно выбранный индивидуум будет обладать каждым отдельным вариантом или комбинацией вариантов. Может быть обнаружено семейное родство, касающееся индивидуумов, имеющих приблизительно одинаковую вероятность обладания определенным набором числа выбранных редких вариантов.

Torstein Sjovold, Osteological Research Laboratory, University of Stockholm, S-171 71 Solna, Sweden

Vol. 3/4, pp 97–107, Lund. ISSN 0345–8865.

Introduction

In the study of skeletal remains from prehistoric cemeteries, there is often reason to assume that a number of buried individuals are related to one another. In some instances the presence of related individuals is obvious, as for instance if the cemetery has belonged to a small village or to some few neighbouring villages. The larger the community using the cemetery, the more difficult it may be later to trace related individuals by means of exhumed skeletal remains.

At present many skeletal traits which were previously assumed to be anomalies or random skeletal variations have been shown to be inherited characters. Examples of such traits are the persistance of the metopic suture into adulthood (Montagu 1937, Torgersen 1951, 1952), occurrence of *torus palatinus* or *torus mandibularis* (Suzuki & Sakai 1960, Johnson, Gorlin & Anderson 1965), interparietal and *Inca* bones (Torgersen 1952, 1963), vertebral variations (Kühne 1931, Kühne & Tschetschin 1959), supernumerary and congenitally

missing teeth (Grahnén 1962) and certain tooth variations (Grahnén 1956). The occurrence of such variants, which share the property that they are either present or absent in an individual, will constitute the basis of the model for familial studies. If these can be detected by means of X-rays or directly observed (e.g. tooth variations and tooth anomalies), or palpated under the skin, they may even be useful for forensic or paternal purposes.

Many of the investigations referred to above have been carried out by means of X-ray photos because of the lack of suitable large human skeletal series of related individuals. Because of man's relatively slow reproduction rate, the most comprehensive studies of hereditary skeletal variants, similar to those in man, have been carried out on skeletons of genetically homogenous strains of laboratory mammals. In such homogenous populations the incidences of the different variants seem to be fairly stable from generation to generation. Generally it is assumed that the variants occur at the extremes of continuous distributions generated by the joint effects of a number of interacting alleles at different loci. If the accumulated effect of these alleles is sufficient, a variant may appear. The phenotype is therefore a result of very complex genetic interactions (Grüneberg 1963, Berry 1968). As a somewhat curious result, most variants in laboratory mammals seem to occur virtually independently of one another. That is to say, the number of significant correlations observed between pairs of variants when large numbers of variants are examined simultaneously is of the same magnitude as would be expected by chance alone (see Grüneberg 1963 Ch. 12 & 13, Berry & Searle 1963, Howe & Parsons 1967). The validity of this property has even been demonstrated for man (Berry & Berry 1967, Kellock & Parsons 1970, Benfer 1970, Lane & Sublett 1972), although Corruccini (1974) concluded that "It appears that association, although greater than expected on the average, does not reach a detectable level in individual pairs of binary traits".

Sexual dimorphism in the frequency of certain variants has been claimed by certain authors (Janz 1970, Finnegan 1972, Corruccini 1974), generally comprising a smaller group of the variants investigated. Others have stated that sexually distinct variants are lacking in their material (Birkby 1973) or restricts such variants to special kinds of variants (Sublett & Lane 1970).
It thus seems that it is permissible to treat most, or at least a large number of variants as if they were independent with regard to one another and with

regard to sex. However, in any particular family there may be an accumulation of certain alleles, so that some variants will crop up regularly and appear to be inherited in a regular fashion (Berry 1968). Such variants that "run in families" may be useful for familial studies, especially if they are relatively rare.

Methods

This possibility has already been perceived by physical anthropologists. A declaration of the principles of such investigations was given by Acsádi & Nemeskéri (1957) and subsequently by Nemeskéri (1962). Simultaneously, and independently of these authors, Ullrich (1962) proceeded from a similar point of view. Other evidence of familial relations between individuals were later also included, such as skull measurements and indices.

Ullrich (1969) utilized a number of different approaches to relationship, among which minor skeletal variants constituted one. He weighted the importance of the variants as to whether they were rare, relatively common or common. An individual score was obtained by adding the weights of the variants observed, and adding the negative of the weight for each variant sought but not observed in this individual. The argument underlying this method was that related individuals (i.e. family members) would most likely turn out to be more alike in the pattern of variants possessed when compared to one another than when compared to non-related individuals. The scores obtained for family members would therefore also tend to be more alike than scores obtained by non-family members, provided that the variants used could be regarded as inherited characters.

However, by using a fixed number of weights as well as fixed weighting for the different variants, the method remains relatively crude. Even if two variants are rare, the incidence of one is generally different from the other, although which is the rarest may be hard to determine. In some populations the one may be the rarer, while in other populations the reverse will be true. This is especially so if the variants are hereditary characters and thus genetically determined. Instead of fixed weights, the variants should therefore be given differentiated weights according to whether they are more or less common, or more or less rare.

In the literature on minor variants in the human skull, most of which are now regarded as possibly hereditary effects, a number of relatively rare variants

have been described (see e.g. Le Double 1903, 1906, Augier 1931). However, there are problems with this, and generalization of the rate of occurrence by means of information from the literature is a hazardous task if the details underlying a particular result is not clear. If, for example, a new variant is reported with an incidence of one per thousand, two completely different situations may have occurred. Firstly, the new variant may have been observed when one thousand or nearly one thousand individuals were being investigated for some other purpose. In this case less obvious manifestations - those which prior to the first observed case were not properly recognized - might well have been present in some of the other individuals. On the other hand the new variant may have been recorded first, and the thousand individuals then investigated to determine its frequency.

From these considerations the great uncertainty of deciding from the literature which variants are common and which are uncommon must be stressed. Instead, use of a r e f e r e n c e p o p u l a t i o n will be recommended.

However, although Ullrich (1969) utilized information from the literature to classify the variants into his three groups, the idea of detecting family likeness between individuals presented in this paper is mainly the same, though the present approach differs from his in several respects. Provided that the variants can be regarded as hereditary characters, patterns of occurrence in closely related individuals will tend to be more similar than those observed if non-related individuals are compared. However, instead of weighting all the different variants, those may be sorted out and used which turn out to be most useful for deciding whether two (or more) individuals may be related to one another.

In this respect the group of variants which are relatively common is of little importance. Instead, the most valuable variants will be those which are either most rare or most common. In the latter case the a b s e n c e of the variant would consequently be rare. Which variants may be regarded as rare, relatively common or common is, however, decided by means of the reference population.

The question of familial relationship may arise in two different situations. In the first place, which is probably the most common situation, a small number of skeletons may be exhumed, say, within the same grave mound. In the second place, some skeletons from a gravefield, a cemetery or a mass grave may be suspected of belonging to individuals from the same family.

The second situation is in many respects the simplest. In this case the reference

population is obvious, because it is most reasonable to compare the supposed related individuals with the other individuals from the cemetery. In the first situation a reference population which may differ in time and space will have to be selected. This may of course also be done in the second situation if the number of exhumed or available skeletons from the cemetery is small. The argument for selecting a reference population which may differ in time and space from the individuals to be investigated is that when only rare variants are concerned, including absence of very common variants, it may be assumed that the accumulated genetic effects producing such variants will very rarely be found in any population except for groups of closely related individuals.

When a reference population is selected, the skeletons of individuals thought to be related should be investigated for rare variants. The rare variants which may be selected are those which occur in at least one of these skeletons. When all variants judged as sufficiently rare are selected, the skeletons of the reference population are investigated for the presence or absence of the same variants. Finally the number of observed variant frequencies in the reference population as well as in the related individuals are pooled, to obtain total (pooled) frequencies of the variants. If the reference population is made up of the other available skeletons from the cemetery, the pooled population will thus consist of all available skeletons from the cemetery. The rarest variants which will occur in this connection are thus those which occur in only one of the skeletons suspected of belonging to related individuals.

If a single individual is considered to be drawn at random from the pooled population, it is easy to calculate the probability that this individual will possess a certain variant. If it possesses a unilateral variant, the probability sought is simply the ratio of the number of times the variant was observed in the pooled population, to the number of times the variant was judged as present or absent in the same population. If it does not possess the trait, the probability sought is simply one minus the probability for possessing it. When a bilateral variant is concerned, and the manifestation of the variant on the two sides may be regarded as independent, the problem is somewhat more complex. If the manifestations according to sides are significantly correlated, however, the variant may be regarded as unilateral. The presence of the variant is then noted when it is present in at least one side of the individual.

A comment concerning the scoring of the variants should be made. Because

of damage, age or other reasons, it may be impossible to score a particular variant at all. For instance, completely obliterated skull sutures makes it impossible to search for sutural ossicles. If parts of the skeleton are missing or covered by dried soft tissue, it is impossible to search for variants which may have existed in these parts. Therefore the relative incidence of each variant is always equal to the number of times the variant is observed divided by the number of times observations of presence or absence actually can be made. In the unilateral case, as well as in the case when bilateral variants are "transformed" to unilateral ones, the maximum possible number of observations equals the number of individuals in the pooled sample, and twice that number when the manifestation by side may be regarded as independent in the bilateral case. In determining the number of observations when bilateral variants are "transformed" to unilateral ones, the individuals from the reference population in which only one side is observable showing the negative of the variant sought have to be delected, because the variant may have been present in the other side. If such variants are observable in only one side of some of the possible family members, the variants have to be judged as present or absent according to what is actually observed in the observable side. Because of obvious reasons, one can not delete any of these individuals, whose closer genetical relationship one is to investigate.

The situation when seeking the probability that an individual chosen at random from a larger group possesses a certain skeletal variant is in fact a special case of the general situation described by Sjøvold (1975). In that paper, the probability that a small group of individuals was a random sample from a larger group was sought, based on the small group's incidence of non-metrical variants. In this case the probability that one individual at the time is chosen at random from the larger population is sought. Each individual investigated thus is replaced in the larger group before the next one is chosen. Therefore one may consider each individual as the smallest group possible in the notation of the previous paper, so the mathematical theory given in that paper can be directly applied for the purpose of investigating family relationship. If two individuals possess (or lack) the same variant they have of course the same probability of being chosen at random. In this way it is possible to express similarity between individuals.

Concerning the bilateral variants for which the manifestation according to

sides can be regarded as independent, however, the present case resembles more the general situation, because the variant may be present in both, one or none of the sides. For each of the three alternatives, the probability sought is the probability of selecting two out of the total number of observable sides for which a given number possesses the variant. Sjøvold (1975) showed that this probability may be calculated by means of the hypergeometric distribution, or it may be obtained directly by utilizing tables of this distribution, e.g. Lieberman & Owen (1961). This distribution even yields the probability of possessing or lacking a unilateral variant. If a bilateral variant, for which the manifestation may be regarded as independent according to sides, can be judged only as present or absent in one of the sides of the individual selected, the probability sought is of course that for the one side possessing (or lacking) the variant, given the total number of observable sides.

To determine the joint probability of possessing a given number of variants simultaneously, or to determine the probability of possessing a given pattern of traits, the previously mentioned assumption that the variants can be treated as if they were independent is used. The argument that related individuals should be more alike in pattern than non-related ones does, however, mean that related individuals are assumed to possess each particular variant with greater probability than non-related individuals and, furthermore, that they are more likely to possess certain combinations of these variants. Within a family group the occurrence of the variants therefore may tend to be significantly correlated. However, because these correlations are caused by local genetical conditions within a particular family and as such not significant in man in general (especially when the pooled group is concerned) they may therefore be neglected. Rather than disturbing the assumptions underlying this model, these "familial correlations" between the variants are in fact utilized to determine the groups of related individuals. Because the variants may still be regarded as independent within the pooled group, the joint probability of possessing a given pattern of variants is simply given by the product of the probabilities obtained for each unilateral variant and each pattern of bilateral variants. If two individuals possess an identical pattern of variants, the corresponding joint probabilities will also be identical. If two individuals are genetically related, their joint probabilities of possessing particular patterns of hereditary variants will tend to be closer than will those for any non-related individuals, provided

that the variants are carefully selected. As the joint probabilities rapidly approach zero, as the number of variants increases, the mean probability of, say k variants should be given. Because the joint probabilities are a p r o d u c t of probabilities, however, the corresponding mean is given by the g e o m e t r i c m e a n, defined as the k-th root of the product. This corresponds to taking the arithmetic mean of the sum of logarithms of the single probabilities. The geometric mean probabilities for a group of related individuals, as well as the corresponding joint probabilities will thus, according to this model, tend to cluster compared with non-related individuals. That is to say, the probabilities (whether it be the joint or the geometric mean probability) of related individuals will tend to fairly similar, and much smaller than the probabilities obtained from non-related individuals, when rare, hereditary variants are used. Individuals initially thought to belong to a family group may be excluded from that group if the mean probabilities obtained from them exceed a certain value.

The argument presented above has mainly concerned the case when some individuals a p r i o r i may be suspected to be related to one another. On the other hand, if the pooled sample consists of skeletons all exhumed from the same cemetery, this method may even be used to trace other possible family members. These may be detected if the mean probabilities for all individuals in the pooled sample to possess their particular patterns of variants are calculated. Other individuals possessing mean probabilities similar to those from the individuals found to be related may be observed, and may thus be taken to belong to the same family group. Otherwise, the more variants and the rarer the variants used, the less the possibility that some individuals will be incorrectly related to a family group.

If the mean probabilities for all individuals in the pooled sample are calculated, another result that may possible occur is that new groups of individuals possessing fairly similar mean probabilities are traced. If the reference sample derives from a single cemetery, other possible family groups may be detected in this way, independent of if it is the same cemetery from which the individuals initially investigated are belonging or not. To study this possibility, the members of such new groups should be searched for additional rare skeletal variants, and investigated in the same way as done with the first group. Especially if it concerns individuals from the same cemetery as those initially studied, one may possibly be able to detect most family groups buried on this cemetery.

Conclusions

By means of the model described in this paper it may not be possible to detect the internal structure within a particular family group. Although it may be clear which individuals are related, it is more difficult by these means to detect in which way the different family members are related. Some aspects of the method developed also are not completely solved, such as the number of variants that must be used before a definite conclusion can be drawn. Intuitively, a conclusion based on, say, twenty rare variants appears to be more valid than one based on a single variant. On the other hand, this may actually not be the case if the single variant is extremely rare and known to be strongly genetically determined, whereas the other twenty are not that rare and are of uncertain genetic origin. The main difficulty may therefore be said to lie in insufficient knowledge of the genetical basis for these variants in man.

At present, however, the recognition of family groups, whether found isolated within a grave mound or within a larger cemetery, depends greatly on the detection of rare characteristics for "family likeness". If such varians are not detected, the possibility of making a conclusion concerning the size and numbers of family groups decreases. When such groups are detected, however, one may procede by other means, for instance if blood group determinations are possible to carry through with a certain likelihood, to reveal probabilities for different patterns of internal structure within each particular family.

Acknowledgements

The author wishes to express his thanks to Dr. G. P. Rightmire for reading the manuscript. This study was supported by the Swedish Natural Science Research Council, grant no. B2664-010.

References

Acsádi, G. & Nemeskéri, J. 1957: Paleodemographische Probleme am Beispiel des frühmittelalterlichen Gräberfeldes von Halimba-Cseres Kom. Veszprém/Ungarn. HOMO 8, 133-148.

Augier, M.A. 1931: Squelette cephalique. In Poirier, P. & Charpy, A. (eds.): Traite d'anatomie humaine, Tom. I, Fasc. I, 1. div., Paris.

Benfer, R.A. 1970: Association among cranial traits. Am. J. Phys. Anthrop. 32, 463-464.

Berry, A.C. & Berry, R.J. 1967: Epigenetic variation in the human cranium. J. Anat. 101, 361-379.

Berry, R.J. 1968: The biology of non-metrical variation in mice and men. In Brothwell, D.R. (ed.): The Skeletal Biology of Earlier Human Populations. Pergamon Press, London.

Berry, R.J. & Searle, A.G. 1963: Epigenetic polymorphism in the rodent skeleton. Proc. Zool. Soc. London 140, 557-615.

Birkby, W.H. 1973: Discontinuous morphological traits of the skull as population markers in the prehistoric Southwest. Ph.D. dissertation, University of Arizona.

Corruccini, R.S. 1974: An examination of the meaning of cranial discrete traits for human skeletal biological studies. Am. J. Phys. Anthrop. 40, 425-446.

Finnegan, M.J. 1972: Population definition on the Northwest coast by analysis of discrete character variation. Ph.D. dissertation, University of Colorado.

Grahnén, H. 1956: Hypodontia in the permanent dentinition. A clinical and genetical investigation. Odont. Revy 7, suppl. 3.

Grahnén, H. 1956: Hereditary factors in relation to dental caries and congenitally missing teeth. In Witkop, C.J. (ed.): Genetics and Dental Health. McGraw-Hill, New York.

Grüneberg, H. 1963: The Pathology of Development, Blackwell, Oxford.

Howe, W.L. & Parsons, P.A. 1967: Genotype and environment in the determination of minor skeletal variants and body weight in mice. J. Embryol. exp. Morph. 17, 283-292.

Janz, R.L. 1970: Change and variation in skeletal populations of Arikara Indians. Ph.D. dissertation, University of Kansas, Lawrence.

Johnson, C.C., Gorlin, R.J. & Anderson, V.E. 1965: Torus mandibularis: a genetic study. Am. J. Hum. Genet. 17, 433-442.

Kellock, W.L. & Parsons, P.A. 1970: Variation of minor non-metrical cranial variants in Australian aborigines. Am. J. Phys. Anthrop. 32, 409-421.

Kühne, K. 1931: Die Vererbung der Variationen der menschlichen Wirbelsäule. Z. Morph. Anthrop. 30, 1-221.

Kühne, K. & Tschetschin, M. 1959: Beiträge zur Frage der Vererbung normaler segmentaler Variationen der Wirbelsäule. Z. Morph. Anthrop. 49, 265-305.

Lane, R.A. & Sublett, A.J. 1972: Osteology of social organization: Residence pattern. Am. Antiquity 37, 186-202.

Le Double, A.F. 1903: Traite des variations des os du crane de l'homme et leur signification au point de vue de l'anthropologie zoologique. Vigot, Paris.

Le Double, A.F. 1906: Traite des variations des os de la face de l'homme et leur signification au point de vue de l'anthropologie zoologique. Vigot, Paris.

Lieberman, G.J. & Owen, D.B. 1961: Tables of the Hypergeometric Probability Distribution. Stanford University Press, California.

Montagu, M. F. A. 1937: The medio-frontal suture and the problem of metopism in the primates. J. Roy. Anthrop. Inst. 67, 157-201.
Nemeskéri, J. 1960: Problèmes de la reconstruction biologique en anthropologie historique. Actes VI[e] Congr. Intern. Sci. Anthrop. Ethnol. Paris 1960, 1, 669-675. Paris 1962.
Sjøvold, T. 1975: Allocation of single or some few individuals to one of two or more groups by means of discrete traits in the skeleton. OSSA 2, pp 41-46.
Sublett, A. J. & Lane, R. A. 1970: Comparison and discussion of cranial traits of the Allegany populations. Dept. of Anthrop., Florida Atlantic University. Xeroxed. (Quoted from Lane & Sublett 1972.)
Suzuki, M. & Sakai, T. 1960: A familial study of torus palatinus and torus mandibularis. Am. J. Phys. Anthrop. 18, 263-272.
Torgersen, J. 1951: The developmental genetics and evolutionary meaning of the metopic suture. Am. J. Phys. Anthrop. 9, 193-210.
Torgersen, J. 1952: Genetic dynamics of human evolution. Trans. 4th int. Congr. Anthrop. Ethnol., 98-102, Vienna.
Torgersen, J. 1963: Uber Erbfaktoren für die Ausbildung von Schädelnähten und deren Aussagewert über den Hominisationsverlauf. HOMO 14, 16-29.
Ullrich, H. 1962: Anthropologische Untersuchungen am Skelettmaterial eines Aunjetitzer Gräberfeldes von Grossbrembach, besonders im Hinblick auf die Frage nach der Herkunft der mitteldeutschen Aunjetitzer. Math.-nat. Diss., Berlin (Quoted from Ullrich 1969.)
Ullrich, H. 1969: Interpretation morphologisch-metrischer Ähnlichkeiten an ur- und frühgeschichtlichen Skeletten in verwandschaftlicher Hinsicht. Z. Archäol. 3, 48-88.

Vertebrae of the larger mammals of Western Europe

H. H. CARTER

OSSA

The basic anatomy of mammalian vertebrae is described, and characters given which enable a vertebra to be assigned to its correct place in the vertebral column and the sex of a sacrum to be determined.

Further characters are given for the identification of the following families and species of large mammals likely to be found on archaeological sites in Western Europe:

Equidae: Horse *Equus caballus* L.
Suidae: Pig *Sus scrofa* L.
Cervidae: Elk *Alces alces* (L.)
Irish Elk *Megaloceros giganteus* Blumenbach
Red Deer *Cervus elaphus* L.
Reindeer *Rangifer tarandus* L.
Fallow Deer *Dama dama* (L.)
Roe Deer *Capreolus capreolus* (L.)
Bovidae: Cattle *Bos primigenius* Bojanus (including domesticated forms)
Sheep *Ovis aries* L.
Goat *Capra hircus* L.

В статье описана основная анатомия позвонков млекопитающих и дана их характеристика, позволяющая определить правильное положение позвонков в позвоночнике и установить пол копытных четвероногих животных по их крестцу.

Нижеприведенные характеристики даны для идентификации следующих семейств и видов крупных млекопитающих, которые могут встречаться в местах археологических раскопок в Западной Европе:

Equidae: Лошадь – *Equus caballus* L.
Осел – *E. asinus* L.
Suidae: Свинья – *Sus scrofa* L.
Cervidae: Олень – *Alces alces* L. или *Megaloceros giganteus* Blumenbach.
Марал – *Cervus elaphus* L.
Северный олень – *Rangifer tarandus* L.
Лань – *Dama dama* L.
Косуля – *Capreolus capreolus* L.
Bovidae: Крупный рогатый скот – *Bos primigenius* Bojanus (включая одомашненные формы).
Овца – *Ovis aries* L.
Коза – *Capra hircus* L.
Ursidae: Медведь – *Ursus arctos* L.
Canidae: Волк – *Canis lupus* L. (включая одомашненные формы).

H. H. Carter, County Borough of Reading, Museum & Art Gallery, Blagrave Street, Reading RG1 1QL, England.

Vol. 3/4, pp 109–127. Lund. ISSN 0345–8865.

Introduction

The object of the present paper is to present criteria for the determination of vertebrae of the larger mammals likely to be encountered among food remains on archaeological sites in Western Europe. Several species characteristic of the high Alps or the tundra have therefore been omitted. It is assumed that the appearance of human vertebrae will already be familiar to the reader. This leaves for our consideration the members of the two ungulate orders, comprising the families Equidae (Horses), Suidae (Pigs), Cervidae (Deer) and Bovidae (Cattle, Sheep and Goats), together with two families of carnivores, the Ursidae (Bears) and Canidae (Wolves) whose members are large enough to merit inclusion, the vertebrae of Bear being comparable in size with those of the larger Deer and those of Wolf with the smallest, i.e. Roe.

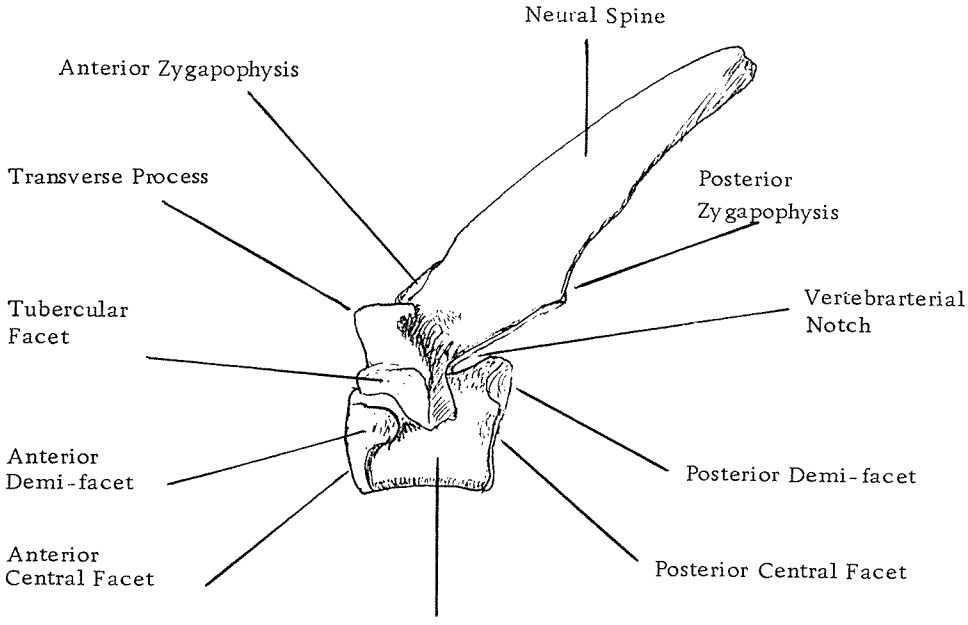
These family relationships are rather faithfully reflected in the form of the vertebrae, and identification to family level is thus a convenient step on the way to the determination of species.

Each vertebra consists of a solid cylindrical body, the centrum, surmounted by a thin-walled arch of bone, the neural arch. Arising from the summit of the neural arch in the longitudinal vertical plane there is usually a single neural spine, and from the side of the arch where it is attached to the centrum there project horizontally a pair of transverse processes. At the front and back of the vertebra, approximately on a level with the top of the neural arch, are the two pairs of processes named the anterior and posterior zygapophyses, the essential feature of which is a set of articular facets by which each vertebra makes contact with its neighbours, in addition to the large central facets occupying the whole of each end of the centrum. Beneath the posterior zygapophysis of each side there is a notch in the hind edge of the neural arch, the vertebrarterial notch, and this is sometimes closed behind by the meeting of its upper and lower borders, converting it into a hole in the side of the neural arch.

The thoracic vertebrae also bear facets for the attachment of the ribs, two pairs of demi-facets on the upper corners of the centrum for the head of each rib, which fits in between two successive vertebrae, and a single pair of tubercular facets on the transverse processes for the tuberculum of the rib. Ribs also occur on the cervical vertebrae, where they take the form of bony rods or plates which are fused along much of their length to the centrum and transverse process.

The space thus enclosed normally persists as a tunnel, the vertebrarterial canal, which runs parallel to the side of the centrum and opens behind near the vertebrarterial notch.

Anatomy of a vertebra



THORACIC VERTEBRA of SHEEP (Ovis aries L.)

The vertebral column

The vertebrae from different regions of the column differ so markedly in structure that it is impossible to define specific characters which will apply to all vertebrae of a given species, or even family, and to no other vertebrae.

It is essential to be able to assign any vertebra, even though fragmentary, to its correct place in the column before it can be identified, as comparison with vertebrae from a different place will give no useful information. Characters underlined distinguish the family in which they occur from all other families.

Atlas. The first cervical or atlas vertebra lacks a centrum (but the neural arch is closed beneath), the neural spine is reduced to a mere tubercle, and the transverse processes and cervical ribs are so much modified that the correct orientation, particularly of a fragment, is not always obvious at first glance. The general outline is butterfly-like, with the expanded transverse processes extending like wings in front of and behind the neural arch. At the front end is a pair of deeply concave facets, often divided into separate upper and lower parts, for the occipital condyles of the skull. Immediately behind them the paired foramen transversarium leads from inside the neural arch to the dorsal surface and then typically passes downwards through the transverse process to open into a large depression beneath it. The vertebrarterial canal is obliterated in the Artiodactyla (Suidae, Cervidae, Bovidae) though it can be traced in young Pigs. Behind the foramen transversarium there is generally a small middle foramen running directly from the inside of the neural arch to open into the depression beneath the transverse process.

In Equidae the occipital facets are almost completely separated into upper and lower portions, and the ventral notch between them extends over more than 1/4 of the ventral length of the vertebra. The dorsal opening of the foramen transversarium is wide and shallow. The middle foramen is separate both from the foramen transversarium and from the vertebrarterial canal, which is very short and wide.

In Suidae the atlas, like the other cervicals, is very short, the length of the neural arch in the mid-line about 1/4 of the width of the vertebra. The occipital facets are undivided laterally, and separated ventrally by a distinct groove. The dorsal openings of the foramen transversarium are sunk into a deep circular fossa. There is no middle foramen but a narrow vertebrarterial canal can be traced in young animals.

In Cervidae the width of the atlas is about 3 1/2 times the length of the neural arch. The occipital facets are as in Suidae. The course of the foramen transversarium is oblique, so that the dorsal fossa is longer than wide, and its outer opening is shared with the middle foramen. The vertebrarterial canal

is absent.

In Bovidae the width of the atlas is less than 3 times the length of the neural arch. The occipital facets are at least partly divided into upper and lower parts, separated below by a roughened area or raised ridge, not a groove (Hildebrand 1955). The dorsal fossa is wider than long, and the foramen transversarium and middle foramen share an external opening as in Cervidae, and the vertebrarterial canal is absent.

In Ursidae and Canidae the outline of the atlas is characteristic. The transverse processes in Ursidae are much wider posteriorly, and the two dorsal openings of the foramen transversarium are not sunk into a fossa. In Canidae the transverse processes are also somewhat widened behind, and the foramen transversarium has only one dorsal opening, the outer one leading to the ventral side of the transverse process being replaced by a deep notch in the anterior border of the process. In both families the vertebrarterial canal is present and shares an opening with the middle foramen.

Axis. The second cervical vertebra (also called epistropheus) shows a less extreme degree of modification. A centrum is present, the neural spine takes the form of a long high crest which overhangs the centrum at each end, the anterior zygapophyses are set on very low and merged with the cervical ribs, and between them is a peg-like or spout-like odontoid process. The foramen transversarium, is usually present as a simple circular foramen in the side of the neural arch near its anterior border, with the entrance to the vertebrarterial canal immediately behind and below it, and its exit at the vertebrarterial notch. The centrum is keeled beneath, the keel being deepest posteriorly, and the posterior central facet is concave (opisthocoelous).

In Equidae the odontoid process is spout-shaped but flattened dorsally. The neural spine forms a double ridge. The foramen transversarium is only about 5 mm from the anterior border of the neural arch. The vertebrarterial canal is always present. The whole vertebra is strongly elongate.

In Suidae the odontoid process is peg-shaped and completely separates the two facets of the anterior zygapophyses. The neural spine is high and directed posteriorly. The foramen transversarium is oval, directed posteriorly and aligned with the vertebrarterial canal which is very short, its outer wall being only a narrow strip of bone which is often incomplete. The length of the centrum, excluding the odontoid process, is less than its width.

In Cervidae the odontoid process is of the usual artiodactyl form, spout-shaped with raised sides. The neural spine is long and high, not greatly overhanging the centrum at either end. The foramen transversarium is directed postero-laterally, and its external opening is sunk into a fossa which it shares with the anterior opening of the vertebrarterial canal. This fossa is bridged by a strip of bone running from the transverse process to the anterior zygapophysis. The centrum is long.

In Bovidae the general form of the axis is much as in Cervidae, but the neural spine projects forwards beyond the edge of the neural arch. The development of the vertebrarterial canal is variable, and it may even be present on one side and absent from the other of a single vertebra.

In Ursidae the form of the axis is somewhat similar to that of Suidae, with peg-like odontoid process and short centrum. The foramen transversarium is replaced by a notch in the anterior edge of the neural arch. The centrum has no ventral keel.

In Canidae the odontoid process and foramen transversarium are as in Ursidae. The neural spine is strongly produced anteriorly, extending as far forward as the tip of the odontoid process. The vertebrarterial canal is wide but short, the centrum moderately long.

Cervicals. The remaining cervical vertebrae are transitional in form between the axis and the thoracic series. The neural spine is directed forwards, feebly developed on the anterior cervicals but becoming longer towards the end of the series. The foramen transversarium is usually absent. The vertebrarterial canal is long on cervical 2 and becomes progressively shorter posteriorly. The transverse processes are directed downwards and backwards at first, their direction becoming more lateral with upturned ends posteriorly. The cervical ribs are directed downwards and forwards. On the posterior cervicals they become more distinct from the transverse processes, more ventral in position and elongated posteriorly. On cervical 7 they are absent and there is therefore no vertebrarterial canal (occasionally this is traceable in young pigs). The zygapophyses are large, flattened and continuous with the roof of the neural arch, with broad ovalfacets lying in the dorso-lateral plane. The centrum is stout and weakly or strongly opisthocoelous, with a ventral keel on cervicals 3-5 which is deepest at its posterior end. The length of the centrum diminishes from front to back of the series.

In Equidae the neural spine is vestigial throughout the series. Cervicals 3 and 4 have the vertebrarterial canal short, only 1/3 of the length of the centrum. Cervicals 5 and 6 have the cervical rib rod-like, not expanded and plate-like. The centrum in each case is longer than in the corresponding vertebra of other families, and deeply opisthocoelous. The roughened tip of the transverse process is raised above the level of the rest of the process.

In Suidae the neural spine is rather well-developed throughout the series, smallest on Cervical 3, spout-shaped on 4 and 5, strongly elongate on 6 and 7. A foramen transversarium is present below the anterior zygapophysis. The centrum is wide and very short, its length much less than its width.

In Cervidae the neural spine is almost obsolete, especially in females. The cervical ribs are directed strongly downwards, and the transverse processes are expanded at the tips, not noticeably turned up behind. The anterior border of the transverse process is defined by a distinct ridge running from the anterior zygapophysis to the tip of the process. Vertebrarterial canal at most 1/2 as long as the centrum, its posterior opening sunk into a fossa in the side of the neural arch. The facets of the zygapophyses are distinctly curved, and in some cases the curve is complex as on the lumbar vertebrae. The centrum is deep and narrow, excavate beneath, oblong in cross section, rather deeply opisthocoelous especially on the posterior cervicals, a little longer than the corresponding centrum of Bovidae.

In Bovidae the neural spine is quite strongly developed. The cervical ribs are set higher and directed more laterally than in other families. The transverse processes are similar to those of Cervidae but bulkier and less sharply defined. The vertebrarterial canal is more than 1/2 as long as the centrum on the anterior cervicals. The centrum is bulky and rather short, square or pentagonal in cross section and deeply opisthocoelous especially in the larger species.

In Ursidae the neural spine is moderately developed. The transverse processes are set on low, and hardly distinct from the cervical ribs which are directed posteriorly and nowhere flattened or plate-like. The vertebrarterial canal is short. The centrum is short, its length hardly more than its width, and only slightly opisthocoelous.

In Canidae the neural spine is moderately developed. The transverse processes are very distinct from the cervical ribs, directed strongly backwards, and on cervicals 5-7 turned strongly upwards at the tip. The form of the cervical

ribs is as in Bovidae. The vertebrarterial canal is short and wide. The centrum is small, short, slightly opisthocoelous and with only a low, blunt keel beneath.

Thoracics. The anterior thoracic vertebrae are very distinctive, the posterior ones are transitional to the lumbar series. The possession of demi-facets for ribs characterises all of them, but these may be very small or lacking on the last thoracic, and the 7th cervical also bears a posterior demi-facet for the first rib. The neural spines are elongate and often flattened. On the anterior thoracics they slope backwards, and the slope increases from the 1st to the 8th and decreases to the 11th (the anticlinical vertebra) which has the spine vertical. Beyond this the spines slope forwards and resemble those of the lumbar vertebrae in shape. The transverse processes are thick, short and lumpy. That of the 1st thoracic is very large and low, level with the base of the neural arch. The position of the processes becomes rapidly higher on thoracics 2-4 and gradually falls from there to the end of the series. The size of the rib articulations, both demifacets and tubercular facets, diminishes posteriorly throughout the series.

On the 1st thoracic vertebra the anterior zygapophyses are of cervical form, but from the 2nd to the anticlinal vertebra the zygapophyses take the form of small oval pads very close together on the roof of the neural arch. From the anticlinal vertebra onwards they are of lumbar form.

In Equidae the articulation between the 1st and 2nd thoracics is of cervical form. The zygapophyses of the anterior thoracics bear elongate oval facets which distinctly project beyond the borders of the neural arch. The transverse processes are thin, with a distinct antero-dorsal projection and a deep fossa behind which is continuous with the vertebrarterial notch. The centrum is of cervical form on thoracics 1 and 2, cylindrical and slightly waisted on the remainder, often with a conspicuous lateral nutrient foramen, distinctly opisthocoelous.

In Suidae the neural spine is strongly elongated. The zygapophyses project slightly from the borders of the neural arch. The transverse processes are stout, without an upward projection. The vertebrarterial notch is closed on all except the last few thoracics, and crossed by a bridge of bone joining the transverse process to the posterior demi-facet. The centrum is wide and short, hardly opisthocoelous.

In Cervidae the neural spine is moderately developed. The anterior zygapophyses of the anterior thoracics are united in the mid-line in front of the neural spine, or else they extend up onto the anterior border of the spine. The

transverse processes resemble those of Equidae but are more distinctly pointed in front, and lack the fossa behind. The vertebrarterial notch is open except sometimes on some of the posterior thoracics. The centrum is deep and narrow, slightly opisthocoelous.

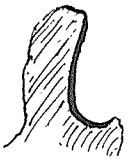
In Bovidae the neural spine is very strongly elongate on the first few thoracics of the larger species. The zygapophyses of the anterior thoracics project only slightly if at all beyond the borders of the neural arch. There is considerable individual variation in the condition of the vertebrarterial notch. The transverse processes resemble those of Suidae but are even more stout and rugged. The centrum is large, cylindrical or waisted, with enlarged demi-facets, slightly opisthocoelous.

In Ursidae the neural spine is short and low, not compressed laterally. The transverse processes are set on low, not raised anteriorly, not joined by a ridge to the posterior demi-facet. The zygapophyses are separated by a distance equal to the width of the centrum. The transverse processes of thoracics 9-14 bear a rod-like projection at the base, directed posteriorly. The vertebrarterial notch is open. The posterior thoracics have the neural spine slightly more compressed, and the demi-facets deeply concave but small. The centrum is short, about 25 mm in length, and not opisthocoelous.

In Canidae the neural spine is moderately high, curved forwards narrow and not much compressed, but thickened and expanded at the tip. The transverse processes and vertebrarterial notch are as in Ursidae. The centrum is cylindrical and rather short.

Lumbars. The neural spine is long and low, often plate-like,vertical or directed somewhat forwards. The zygapophyses are prominent, with facets which are vertical or curved, sometimes displaying complex curvature about a longitudinal axis. The transverse processes are spreading, directed generally somewhat forwards and downwards. The centra are cylindrical on the anterior lumbars, becoming flattened and reniform in cross section on the posterior lumbars.

In Equidae the neural spines are inclined forwards and overlap. The transverse processes are long and broad, inclined forwards only on the last three lumbars, tending to fuse together, especially in domestic animals which have been put to work while still immature. The facets of the zygapophyses are simply curved, the axis of curvature plunging forwards and downwards at 10^{o} to 15^{o} from the horizontal. The vertebrarterial notch is small and narrow. The centrum is deep, somewhat triangular in cross-section and keeled beneath.



Horse
(Simple Curvature)

Pig

Sheep
(Complex curvature)

Transverse Section of Anterior Zygapophysis

In Suidae the neural spine is slightly inclined forwards. The transverse processes are inclined slightly backwards on lumbar 1 and slightly forwards on lumbar 6, and are all curved forwards at the tip. Often they are notched behind at the base, or the notch may be closed to form a foramen. The facets of the zygapophyses are almost flat, with a slight double curvature, inclined outwards and with the axes of curvature slightly converging posteriorly. The centrum is wide and reniform in cross section on all the lumbars.

In Cervidae the neural spine is inclined forwards but does not often overlap the adjacent vertebrae. In most species there is a characteristic oblique line of thickening which runs from the antero-dorsal angle of the spine to the posterior zygapophysis. The zygapophyses are high and laterally compressed, with the curvature of the facets complex but shallow and the axes of curvature horizontal and parallel. The transverse processes are elongate, narrow, all inclined forward and a little downward, often expanded at the tip. The centrum is waisted and keeled beneath.

In Bovidae the neural spine is long and low, not or slightly inclined, not overlapping, sometimes thickened at the top but without a sloping line of thickening. The zygapophyses are stout, with facets strongly curved, varying from simple to complex double or even triple curvature, the axis as in Cervidae. The transverse processes are long and broad, slightly inclined forward and expanded at the tip, the anterior border concave particularly on lumbars 1 and 6. Often there is a trace of a notch in the posterior border near

the base on the anterior lumbars. The vertebrarterial notch may be open or closed. The form of the centrum is as in Cervidae.

In Ursidae the neural spine is low and short, not overlapping. The zygapophyses have simple flat vertical facets separated by a distance equal to the least width of the centrum. The transverse processes are short and waisted, their length hardly exceeding the width of the centrum. The processes of lumbars 1-2 have a posterior projection as on the posterior thoracics. The vertebrarterial notch is open. The centrum is rather wide and shallow with little or no keel.

In Canidae the neural spine is as in Ursidae. The zygapophyses are of similar form but closer together. The transverse processes are elongate and narrow, all inclined strongly forwards, with a triangular forward projection at the tip, and on lumbars 1-4 with a posterior projection as on the posterior thoracics. The vertebrarterial notch and centrum are as in Ursidae.

Sacrum. The sacrum is a group of fused vertebrae (5 in Equidae, 4 in artiodactyls, 3 in carnivores). The joint between the first and second sacrals is the last to fuse. The neural spines may be completely or partly fused together. The fused anterior zygapophyses may form a continuous bony ridge each side of the neural spines. The outer ends of the transverse processes are completely united, and those of the first sacral are very stout and expanded laterally to form the articulation with the ilium. Basally the fusion of the transverse processes is less complete, leaving a series of small dorsal foramina which may be more or less obstructed, and a ventral series of large foramina which correspond to the vertebrarterial notches of other vertebrae and are never closed. In ungulates the sex can be readily determined from the sacrum: in males the centra are shallowly triangular in cross section and bear a blunt but distinct keel ventrally; in females the centra are thinner and flattened dorso-ventrally, without a keel.

In Equidae there are 5 sacral vertebrae. The 1st transverse processes are inclined forward, giving a Y shape to the sacrum, and bear an anterior facet articulating with the last lumbar and a long narrow postero-dorsal facet for the ilium. Between the transverse process and the anterior central facet there is a deep notch. The zygapophyseal ridge is weakly developed and the dorsal foramina are unobstructed.

In Suidae the sacrum is more human in appearance than in other ungulates. It is strongly curved about a horizontal axis and depressed, with vestigial neural spines. The articular surfaces are almost vertical. The zygapophyses are far apart, the greatest width of the sacrum being less than 2 1/2 times the distance

between the anterior zygapophyses. The anterior border of the anterior zygapophyseal facet is emarginate above, projecting below.

In Cervidae and Bovidae the sacrum is very similar. The neural spines are well developed and often completely fused. The degree of separation of the anterior zygapophyses may be as great as in Suidae or much less. The zygapophyseal ridge is strongly developed and overlies the line of dorsal foramina, which in Cervidae especially are more or less obstructed. Both dorsal and ventral foramina are smaller in proportion in Cervidae. The 1st neural arch is more deeply emarginate in Bovidae, allowing the pair of nutrient foramina in the dorsal surface of the 1st centrum to be clearly seen in strictly dorsal view.

In Ursidae and Canidae the sacrum is again similar, though of course much larger in Bear than in any canid. There are only three vertebrae, and the first of these is much less than twice as wide as the second. The neural spines and zygapophyseal ridge are weakly developed.

Specific characters

Equidae. In this family the Horse - Equus caballus L. - is by far the commonest species and the only one native to Western Europe. It exhibits considerable plasticity in size and to a lesser extent in the conformation of the bones. The Donkey - E. asinus L. - has also been recorded, and its vertebrae closely resemble those of some smaller breeds of Horse such as the Shetland Pony. The Mule, a hybrid between these two species, commonly resembles the Horse more closely and cannot be identified from the vertebrae.

The atlas of Horse has the anterior border projecting strongly forward on either side, with the notch between the projections at least as wide as the corresponding ventral notch. The transverse processes are a little wider behind than in front. There is a strong cylindrical tubercle on the ventral surface of the vertebra just in front of the posterior border in the mid-line.

The axis of Donkey has the anterior border hardly projecting forward of the line of the transverse processes, which are parallel-sided or widest at the front. The anterior dorsal notch is narrower than the ventral one. The tubercle beneath is weakly developed.

The axis of Horse has the odontoid process semicircular in outline with a smooth upper surface. That of Donkey has the process parallel-sided with a

bluntly triangular tip and the upper surface hollowed out behind and at either side. However there is some tendency for small ponies to assume the condition found in Donkey. The ventral keel of the axis is over 10 mm wide and flattened anteriorly in Horse. In Donkey it is narrower than 10 mm and raised anteriorly into a tubercle.

The remaining cervicals are shorter and squatter in Donkey than in Horse, but in this respect too, Ponies resemble the Donkey. Cervicals 2-5 however can be separated by the form of the ventral keel, which in Horses of all sizes is blunt and no longer than the centrum, whereas in Donkeys it is sharp-edged and projects posteriorly beyond the central facet.

The thoracic vertebrae show no definite distinguishing features, but in Donkey the rib facets tend to be smaller than in Horse of similar size, and the neural spine is narrowed below the tip, which is laterally compressed. The vertebrarterial notches are more often closed behind in Donkey than in Horse. The lumbar vertebrae usually number 6 in Horse, but only 5 in Donkey, where the transverse process is shorter than in Horse, and either parallel-sided or increasing in width up to 2/3 of their length from the base and then tapering. In Horse they taper from base to tip, where they may be somewhat expanded.

Suidae. Only Pig - Sus scrofa L. - occurs in Europe. I have been unable to distinguish the vertebrae of wild and domesticated Pigs.

Cervidae. The largest members of the family are Elk - Alces alces (L.) - and Irish Elk - Megaloceros giganteus Blumenbach - which both have vertebrae of rather Horse-like aspect compared with other deer, similar in size to those of small domestic Cattle, the length of a middle thoracic centrum being about 50 mm. Megaloceros became extinct in Western Europe at the end of the Pleistocene whereas Alces still exists. The present and Pleistocene distributions are given by Kurtén (1968). I have not seen sufficient material of these two species to be able to distinguish their vertebrae.

Red Deer - cervus elaphus L. - are the commonest deer on archaeological sites and show great variation in size according to sex and habitat. Average specimens have middle thoracic centra about 40 mm. long, but a stag from a forest habitat may equal a small female of one of the preceding species. The cervicals are robust, the centra of males being almost as stout in proportion as those of domestic Cattle. The neural arch has sharply keeled dorsolateral borders, and males have well-developed neural spines, which on

cervicals 4 and 5 are bifid at the tip. On all the cervicals the vertebrarterial canal is short and wide. On cervical 6 the rib is longer than the centrum and very deep. The thoracic vertebrae have rather stout, high, simple neural spines which are set far back along the neural arch. On the middle thoracics, the anterior root of the spine may be almost as far back as the posterior central facet. On thoracics 1-3 the facets of the anterior zygapophyses are separate, concave and extend upwards onto the base of the neural spine. On thoracics 4-10 they meet and fuse in the mid-line in front of the spine, and the zygapophyses themselves become hook-like, curving inwards and upwards like those of the posterior thoracics and lumbars, which are also high and laterally compressed. The vertebrarterial notches are open except sometimes on the last few thoracics. These and the lumbars have low neural arches with high erect neural spines which do not overlap each other, but show the characteristic oblique thickening typical of the family.

Reindeer - rangifer tarandus L. - occurred generally throughout Europe until the Mesolithic, when the species retreated northwards (Kurtén 1968). In Britain they disappear from the south at the end of the Pleistocene but remained in Scotland till historic times and have been re-introduced there. In size this species averages smaller than Red Deer but overlaps with it. The middle thoracic centra are about 35 mm. long. The cervicals have the vertebrarterial canal almost as long as the centrum, and short blunt cervical ribs. The thoracics are narrow and deep, with high neural spines necked towards the tip, short transverse processes and laterally projecting posterior zygapophyses. The lumbars have long, low neural spines, and the overhanging upper part of the anterior zygapophysis is wide, short from front to back, but not emarginate in front.

The vertebrae of Fallow Deer - Dama dama (L.) - are slightly smaller than those of Reindeer but larger than most Sheep or Goat, with the middle thoracic centra about 30 mm. long. The species has long been common in mainland Europe, and is native to Britain but rare on archaeological sites. It is widely believed to have become extinct at an early period and to have been reintroduced as a park animal, not available as food to the average Britain. During the present century many escapes have taken place and Fallow Deer again breed as wild animals in Britain.

The vertebrae display the characters of the family particularly well. The cervicals are bulky but the centrum is small in proportion, with a distinct

roughened tubercle immediately in front of the posterior zygapophyses of males. The zygapophyseal facets have a complex curvature like that of a lumbar vertebra, and there is a raised ridge running from the anterior zygapophysis to the tip of the transverse process. The foramen transversarium of the axis vertebra faces sideways and upwards, and the posterior fossa into which the vertebrarterial canal of the other cervicals opens may be bridged. The length of the middle cervicals is greater than their width.

The thoracics have the neural spine distinctly concave in front, except for the 1st, and on the 4th and succeeding thoracics the portion of the transverse process bearing the rib facet is separated by a shallow groove from the raised anterior part of the process. The demi-facets all project strongly upwards.

The lumbar vertebrae have moderately high neural spines showing the characteristic oblique thickening of the family. The zygapophyseal facets are of S section.

The neural spines of the sacral vertebrae are well separated except at the tip. The Roe - Capreolus capreolus (L.) - is the smallest of the native British deer, with vertebrae comparable in size with those of small Sheep or Goat, the centrum of a middle thoracic being about 20 mm long. The cervical vertebrae are of slender build, not being called upon to support the massive antlers and concomitant neck musculature of the larger deer, and the elongation in this region is therefore conspicuous. The transverse processes project strongly backwards, and tend to be bifid at the tip on the 5th to 7th cervicals. The thoracic vertebrae have long low centra, and neural spines which are emarginate at the base behind. The transverse processes are slender on thoracics 1-10 and vestigial on the remaining thoracics, and the tubercular facets are not so clearly separated from the anterior part of the process as in other species. The lumbar vertebrae have high neural spines which are emarginate in front and overlap behind, with the cervid diagonal thickening very slightly developed. The posterior zygapophyses are separated by a deep semicircular notch as long as it is wide, and their facets have a simple C-shaped curvature. The sacrum is strongly narrowed behind the first vertebra, the posterior diameter of the second being less than 1/3 of the greatest diameter of the 1st. The facets of the zygapophyses are emarginate antero-dorsally. The 1st neural spine is convex anteriorly.

Bovidae. On the great majority cf sites any bovid vertebra with a centrum over 50 mm long can be confidently assigned to Cattle, either the wild race Bos primigenius Bojanus or one of its domesticated forms, formerly

referred to Bos taurus L. On sites of Pleistocene date the possibility of Bison - Bison priscus Bojanus - must be reckoned with. Criteria for the separation of Bison and Bos have been published by Boessneck (1963) and Olsen (1960). Olsen's data relate to B. bison L. of North America, but B. priscus is morphologically very close to this species. It is possible that the form of the dorsal fossa of the atlas in Bos may prove distinctive in being elongate, whereas it is circular in other large bovids. In about 75% of Bos there is a cross-connection between the foramen transversarium and the middle foramen of the atlas which I have not found hitherto in other genera. The neural spine is represented by a low ridge, and the neural arch is only shallowly emarginate behind. The occipital facets are separated ventrally by a roughened area which may be slightly depressed, never by a clearly defined groove.

The axis has the anterior facets wide, the diameter of the vertebra at this point being about equal to the length of the upper surface of the centrum, and slightly convex, inclined backwards on the upper part but almost vertical below. The foramen transversarium is large, about a sixth of the diameter of the anterior facets but with a wide range of variation, circular and directed laterally. The vertebrarterial canal is often obliterated, and when present it is very narrow. Its anterior opening is often very close to the foramen transversarium. The centrum has a strong keel which projects beyond the posterior central facet.

The remaining cervicals are massive, with large central, their posterior facets more or less pentagonal in outline and deeply opisthocoelous, and large spreading zygapophyses with broad flat facets equal in area to the middle cross section of the centrum.

The thoracic vertebrae have very long stout neural spines, although those of the anterior thoracics are not so exaggerated as in Bison, of equal width and thickness throughout. They are commonly broken off in excavated material. The zygapophyses are small, those of the anterior thoracics hardly projecting beyond the borders of the neural arch, usually well separated in the mid-line. The transverse processes are short, very stout and rugged, with large tubercular facets which in old males may be connected across the vertebrarterial notch to the posterior demi-facets. The demi-facets are also strongly developed. The centra are bulky, but may be deeply waisted or even excavate at the sides, appearing as though pinched between finger and thumb. This is probably indicative of malnutrition when it occurs. The vertebrarterial notch is generally

closed behind in adults, narrow and almost occluded by the enlarged demi-facets on the anterior thoracics, larger and more circular on the middle and posterior thoracics.

The lumbars have low, short neural spines, erect and not overlapping. The neural arches are deeply emarginate anteriorly. The transverse processes are set on high up, about half way up the side of the neural arch, long and wide and all curved forwards. The zygapophyses are also high. On lumbars 1-3 the centra are heart-shaped in cross section and rather deeply keeled, and on 1 and 2 at least the vertebrarterial notch is closed behind in adults. Lumbars 4-6 have centra of reniform cross section with a triangular downward projection anteriorly and open semicircular vertebrarterial notches.

The sacrum is broad and rugged with the zygapophyses and foramina large in proportion, and the neural spines normally fused together over their whole length. The transverse processes of the 1st sacral are extended ventrally as in deer.

The atlas and axis of Sheep - Ovis aries L. - and Goat - Capra hircus L. - have been fully characterised by Boessneck (1966). His principal characters may be summarised here for convenience. In Sheep the transverse processes of the atlas project about equally anteriorly and posteriorly, in Goat the posterior projection is greater. The neural spine in Sheep is represented by a rounded tubercle, in Goat by a sharper more elongate ridge. In both species the occipital facets are separated ventrally by a raised ridge.

In the axis, the neural spine tends to be shorter and higher in Sheep, not reaching forward beyond the vertical part of the anterior facets nor backward behind the border of the vertebrarterial notch, whereas in Goat it is longer and often lower. In Sheep the development of the vertebrarterial canal is particularly variable.

The remaining cervicals can often be distinguished by the form of the transverse processes. In Sheep these are short, thick and blunt, often bearing a longitudinal groove, and are inclined strongly backwards. In Goat they are longer and slenderer, spreading laterally so that in dorsal view they stand clear of the posterior zygapophyses, which in Sheep tend to conceal the posterior roots of the transverse processes from above. The 7th cervical of Sheep has the neural spine inclined anteriorly, in Goat it slopes the other way. In Sheep especially, the anterior end of the centrum is very short so that the anterior roots of the cervical ribs on cervicals 3-5 arise from the edges of the central facet.

On the anterior thoracics, the neural spines are more elongate and less erect in Sheep. In Goat they are emarginate behind, so that the posterior zygapophyses project more distinctly from the border of the neural arch.

The neural spines of the lumbars are also higher and shorter in Sheep, their height, viewed from in front, being about equal to the combined height of the centrum and neural arch. In Goat they are about equal in height to the centrum alone. In both species the transverse processes and zygapophyses are set on low. In Sheep the transverse processes spring from the base of the neural arch, not so low as in deer where they are level with the top of the centrum. The vertebrarterial notch is very narrow, especially in Sheep, and usually closed behind in adults.

The zygapophyses of the 1st sacral are well separated, more so in Sheep, in which the full width of the second sacral can be seen from in front through the gap between the zygapophyses. If the least width of sacral 2 is less than 90% of the greatest distance between the facets of the zygapophyses in a male, or less than 75% in a female, the sacrum is probably that of a Sheep; if greater than this, it is probably that of a Goat. The transverse processes of sacral 1 in both species are less extended ventrally than in deer or Cattle.

For the method of sexing the sacrum, see above, page

Ursidae. During the late Pleistocene both Cave Bear - Ursus spelaeus Ros. & Heinr. - and Brown Bear - Ursus arctos L. - occurred in Europe (Kurtén 1968). The two species overlap in size and are closely related, so that the vertebrae are indistinguishable. On the mainland of Europe they can generally be separated by their habitat preferences (spelaeus in caves, arctos elsewhere) but in Britain this is not so. In Holocene deposits only U. arctos is found.

Canidae. Only Wolf - Canis lupus L. - is large enough to be considered here. The various breeds of Dog are now all regarded as domesticated races of Wolf. Most of them can be distinguished from Wolf by size, but there must always be some doubt about the largest canid vertebrae. At the other end of the range, the smaller breeds of Dog are similar in size to Fox. The vertebrae of Fox differ from those of small Dog in the same sort of way as those of deer do from Cattle. They are more gracile, with sharper outlines, smaller central and slenderer, more flattened processes. Also the 3rd sacral of Fox has a pair of spreading free transverse processes not seen in Dog.

References

Boessneck, J. & al. 1963: Seeberg, Burgäschisee-Süd. Teil III Die Tierreste. Acta Bernensia II, Bern.

Boessneck, J. & Meyer-Lempenau 1966: Säugetierkundliche Mitteilungen. Heft I pp 28-36. (For an abridged version of the above in English see Boessneck In Brothwell & Higgs: Science in Archaeology. Thames and Hudson, London, later editions only.)

Hildebrand, M. 1955: California Fish and Game 41 pp 326-346.

Kurtén, B. 1968: Pleistocene Mammals of Europe. Widenfeld & Nicolson, London.

A comparison of methods for back-calculation of fish size from the size of scales found in archaeological sites

RICHARD W. CASTEEL

OSSA

This paper has discussed the two major methods presently in use in archaeology for estimating the size of fish from the size of their scales. These two methods are the proportional method and the single regression method. The former is characterized by marked over- or under-estimation of fish size depending upon the size of the comparative specimen used. The latter is not subject to these variations and the confidence limits of the estimates may be calculated using standard statistical techniques. The single regression method is suggested for reconstruction of fish sizes where appropriate data are available. Where such data are unavailable the proportional method can be used, but it is suggested that the size of the comparative specimen be cited along with the resulting estimates.

В этой статье обсуждаются два основных метода, используемых в настоящее время в археологии для определения размера рыбы по размеру ее чешуи: пропорциональный метод и метод простой регрессии. Первый метод характеризуется выраженной переоценкой или недооценкой размера рыбы в зависимости от размера сравниваемых образцов. Второй метод не страдает от этих вариаций, и доверительные пределы оценок могут быть вычислены при помощи стандартной статистической техники. Метод простой регрессии предлагается для реконструкции размеров рыбы в том случае, когда доступны надлежащие данные. Если же такие данные недоступны, то может быть использован пропорциональный метод, но предполагается, что размеры сравниваемых образцов будут приводиться наряду с заключительными оценками.

R. Casteel, Simon Frazer University, British Columbia V5A 1S6.

Vol. 3/4, pp 129–139, Lund. ISSN 0345–8865.

Introduction

It is often felt necessary to reconstruct the sizes of animals from the remains occurring in archaeological sites. The reasons for doing so may include a more accurate assessment of the minimum number of individuals represented in the assemblage (Иностранцев 1882, Световидов 1948, Casteel 1974), attempts at reconstructing dietary patterns and available energy (Daly 1969, White 1953 a, b, Shawcross 1967a), population estimates (Ascher 1959, Clark 1954, Gilbert 1969, Shawcross 1967b, 1970, 1972), etc. When such reconstructions involve the use of fish scale remains from archaeological sites it appears necessary to exercise some degree of caution in applying certain estimation methods. The purpose of this work is to describe the two major methods which may be applied and to assess their accuracy and other characteristics

of the predictions obtained from each.

The proportional method

The first of the methods to be presented is the proportional method. This method has been in use for some time. One of the clearest descriptions of this method, as applied to the problem of estimation of fish size from archaeological fish scales, appears to be that of Бурдак and Щеглов (1966). They undertook a study of the size of mullet (Mugil auratus Risso) from the settlement of Tarpanchi, located on the Tarkhankut Peninsula, dating from the fourth century B. C. to the third century A. D. Their criterion of scale size was taken to be the longitudinal diameter and the criterion of fish size to be length. Their method was as follows:

> „Средняя длина (L_f) ископаемой кефали каждой возрастной группы была определена по формуле:
>
> $$L_f = \frac{L_n \mathbf{D}_f}{D_n}$$
>
> где D_n – средний продольный диаметр чешуи современной кефали данной возрастной группы (cm), L_n – средняя длина современной кефали той же возрастной группы (cm), D_f – средний продольный диаметр чешуи ископаемой кефали той же возрастной группы (cm).

(The average length (L_f) of excavated mullet of each age group was determined by the formula:

$$L_f = \frac{L_n D_f}{D_n}$$

where D_n -- average longitudinal diameter of scale of contemporary mullet of a given age group (cm), L_n -- average length of contemporary mullet of the same age group (cm), D_f -- average longitudinal diameter of scales of excavated mullet of the same age group (cm)).''

The principal assumption involved in this method is that between the two variables there exists a linear proportional relationship (Лебедев 1960, Лебедев et al. 1961, Житенева 1969). To the extent that this assumption holds, so may estimates derived by means of the proportional method be relied upon.

To test this assumption of linear proportionality a sample of 152 scales of

the Sacramento sucker (*Castostomus occidentalis* Ayres) was analyzed. The longitudinal diameters of the scales were measured and the ratio of fish size to longitudinal diameter of scales was determined for each specimen. This ratio was then plotted against standard length (SL) in order to see if a linear relationship did exist. The results are presented in Figure 1. It is clear that a negative, curvilinear relationship obtains between the ratio L_n/D_n and standard length in this sample. This indicates that, in general, the ratio L_n/D_n is not uniform at all sizes, but instead tends to become smaller at increasingly greater standard length. A similar test was conducted utilizing live weight (in grams), rather than standard length, as the criterion of fish size (Figure 2). Here again, the relationship is not linear. Instead, as fish weight increases the ratio of fish weight to longitudinal scale diameter steadily increases in an asymptotic fashion. Thus, in neither case is the assumption of direct linear relationship born out.

To examine the significance of this for the estimation of fish size three cases will be considered (Table 1). In each case the scales derive from comparative specimens whose weights and lengths were known. The scales were sampled from six areas on the fish's body (Casteel 1972a:77, table 2) and the mean longitudinal diameter was used for each fish. In the first case the length of a fish was determined from a smaller comparative specimen. This resulted in an over-estimation of the size of the specimen. In the second case the length of the same fish was determined from a much larger comparative specimen. The result was an under-estimation of the size of the specimen. Finally, the length of this fish was determined from a fish of exactly the same size. The result was a perfect prediction of fish length. It has been shown elsewhere that under these conditions the proportional method will only predict an accurate size when the size of the archaeological specimen and the comparative specimen are identical (Casteel, in press). This, of course, involves a circular argument, since it is the size of the fish which one wishes to estimate, yet it is this value which one must guess in order to select a comparative specimen of the same size in order to make the most accurate estimate by means of the proportional method. Use of comparative specimens as near to the size of the excavated specimen as possible has also been suggested by Лебедев (1952).

Thus, the use of smaller comparative specimens results in systematic over-estimation of fish lengths, whereas larger specimens yield low estimates of

fish length.

The same test was conducted with the same specimens, but estimating fish weight instead of standard length. These data are presented in Table 2. This time the results are reversed. Smaller comparative specimens produce low estimates of fish weight and larger specimens yield higher estimates. A perfect prediction was obtained using a fish of exactly the same size. Thus, it seems that serious distortions may arise in estimates of fish size, in terms of either weight or length, made by means of the proportional method.

Problems of this sort have long been recognized in the fisheries literature. Schuck (1949:301) has stated that:

> "*In these cases, the line of best fit may be a curvilinear one, or it may be composed of a series of two or more straight lines along successive sections of the total range. In either of these cases, the proportional method of estimating* l_i $[L_f]$ *from* s_i $[D_f]$, S $[D_n]$, *and* L $[L_n]$, *with or without adjustment for the intercept value, will not yield accurate results ...*".

Чугунова (1959) refers to this as the "Rosa Lee phenomenon" and states specifically that under conditions such as those described above the direct proportionality formula will often give inaccurate results.

Finally, while the examples presented above utilized average longitudinal scale diameters, any reconstructions utilizing archaeological material will deal with isolated individual scales from various, probably unknown, body areas. This adds a further problem since it has been demonstrated by a number of investigators that back-calculation of fish sizes by means of the proportional method produces markedly different results with scales from different areas of the body of any single fish (Кагановская 1937, Menon 1953, Phillips 1948).

The single regression method

The second method is that known as the single regression method. Here the size of the fish is predicted directly from the size of the scale. It has been found most practical to take live weight as the criterion of fish size, although other criteria of fish size may be utilized. The criterion of scale size has been taken to be the number of circuli in the anterior field. This allows rapid scale measurement and utilizes circuli from an area of the scale which is least subject to erosion (Casteel 1972b).

Plotting the live weight of the fish as the dependent variable (Y) against the

number of scale circuli as the independent variable (X) on arithmetic coordinates, a positive, curvilinear relationship results. This relationship may be described by an exponential equation of the form:

$$Y = \alpha X^{\beta} \qquad (1)$$

where Y = the weight of the fish in grams; and

X = the number of circuli in the anterior field.

Figure 3 presents a graph of the weight of *C. occidentalis* plotted on the number of circuli in the anterior field of its scales. In this example the relationship is

$$Y = 0.005\ X^{2.5987} \qquad (2)$$

This relationship may be transformed to a linear relationship by transforming the two variables to their logarithms. Doing so, the example becomes

$$\log Y = \log \alpha + \beta (\log X) \qquad (3)$$

or

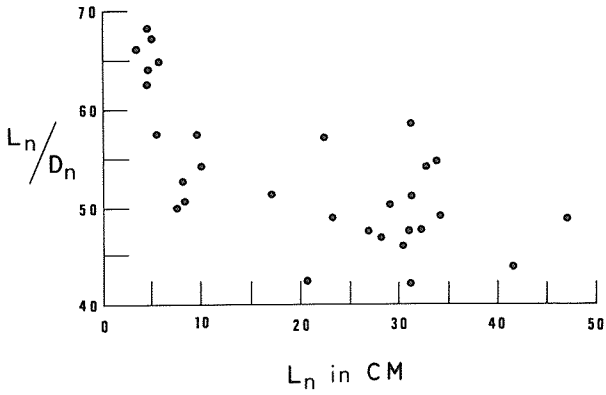
$$\log Y = -2.2914 + 2.5987\ (\log X) \qquad (4)$$

This is a least-squares fit to the data presented in Figure 3 and the two variables are very highly correlated ($r = 0.97$, $N = 152$).

As a comparison, formula (4) was applied to the weight prediction problem examined with regard to the proportional method. Also, the weights of the other comparative specimens used in that example were calculated. The results are presented in Table 3 and may be compared with predictions made by the proportional method. The error involved by use of the single regression method is less than that involved using the proportional method, except in the rare case where sample size is equal to the size of the comparative specimen.

The error involved in weight predictions is 32 grams or about 11% of the known live weight of the specimen in question using the single regression method. In contrast, the weight estimates arrived at by means of the proportional method are in error by some 90 to 95%.

That the same type of error will occur with regard to predictions of length is indicated by the results shown in Table 1 and Figure 1. Here the reverse pattern of over- and under-estimation occurs. This same situation has been shown to hold for size predictions based upon other skeletal elements (Casteel, in press).



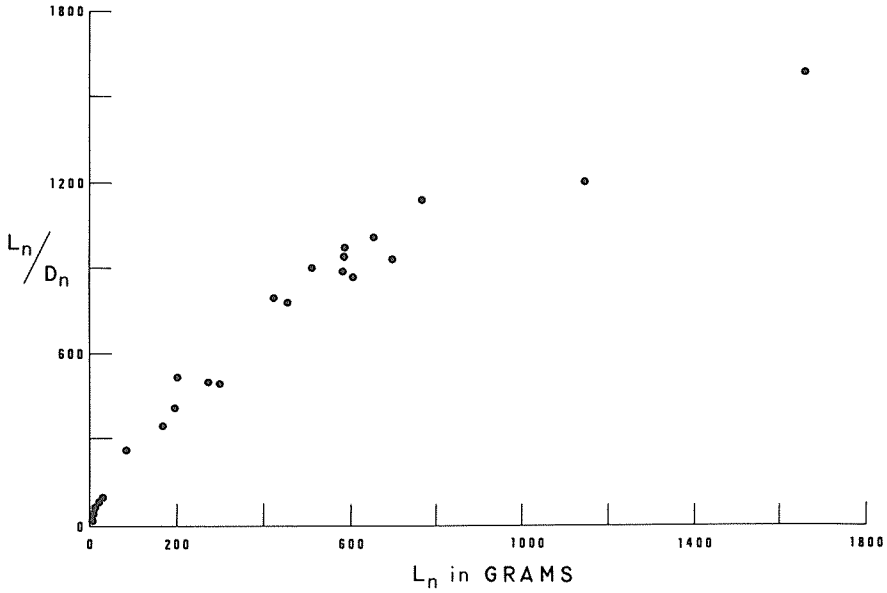


Figure 1. Relationship between the ratio of standard length to longitudinal scale diameter (L_n/D_n) and standard length (L_n) for a sample of 40 specimens of Sacramento sucker (*Catostomus occidentalis* Ayres).

Figure 2. Relationship between the ratio of live weight to longitudinal scale diameter (L_n/D_n) and live weight (L_n) for a sample of 40 specimens of Sacramento sucker (*Catostomus occidentalis* Ayres).

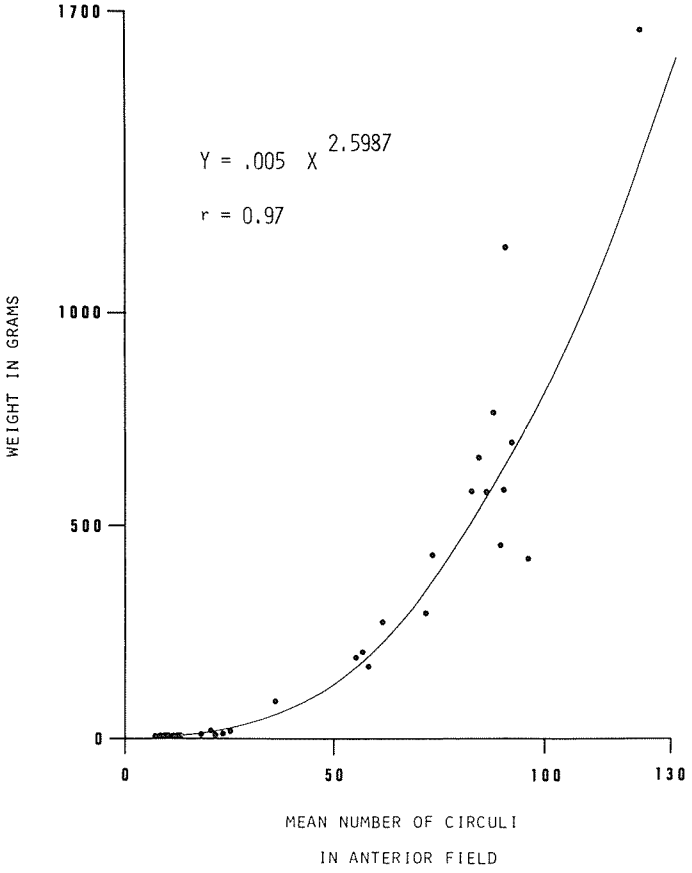


Figure 3. Relationship between number of circuli in the anterior field of scales of Sacramento sucker (*Catostomus occidentalis* Ayres) and live weight of specimens. Line of regression based upon sample size of 152. Data points represent mean circuli counts for each specimen.

Table 1.

Reconstructed standard lengths utilizing the proportional method for Sacramento sucker (*Catostomus occidentalis* Ayres) in mm.

	Known length (mm)	Predicted length (mm)	Error (mm)
Known length of test specimen	282	-	-
Predicted length from smaller specimen (SL = 45 mm)	282	386	104
Predicted length from larger specimen (SL = 312 mm)	282	253	29
Predicted length from specimen of same size (SL = 282 mm)	282	282	0

Table 2.

Reconstructed weights utilizing the proportional method for Sacramento sucker (*Catostomus occidentalis* Ayres) in grams.

	Known weight (g)	Predicted weight (g)	Error (g)
Known weight of test specimen	298	-	-
Predicted weight from smaller specimen (Wt = 1.75 g)	298	15	283
Predicted weight from larger specimen (Wt = 697 g)	298	565	267
Predicted weight from specimen of same size (Wt = 298 g)	298	298	0

Table 3.

Predicted weights of Sacramento sucker (*Catostomus occidentalis* Ayres) utilizing single regression formula: $\log Y = -2.2914 + 2.5987 (\log X)$.

Known weight of specimen	Mean number of circuli	Predicted weight (g)	Error (g)
697	92	649	48
298	71	330	32
1.75	9.8	1.93	0.18

References

Ascher, R. 1959: A prehistoric population estimate using midden analysis and two population models. Southwestern Journal of Anthropology 15, 168-178.

Бурдак, В. Д. and А. Н. Щеглов. 1966. О темпе роста, возрастном составе стад и миграциях некоторых черноморских рыб в античную епоху. In Екологоморфологические исследования некоторыч животнуч: 117–120. Киев.

Casteel, R. W. 1972a: A key, based on scales, to the families of native California freshwater fishes. Proceedings of the California Academy of Sciences 39(7), 75-86.

Casteel, R. W. 1972b: The use of fish remains in archaeology with special reference to the native freshwater and anadromous fishes of California. Ph. D. dissertation. University of California, Davis.

Casteel, R. W. 1974: On the number and sizes of animals in archaeological faunal assemblages. Archaeometry 16(2), 238-243.

Casteel, R. W. 197 : Fish remains in archaeology. Academic Press. London (in press).

Чугунова, Н. И. 1959. Руководство по изучению возраста и роста рыб. Академия наук. Москва.

Clark, J. G. D. 1954: Excavations at Star Carr. Cambridge University Press. Cambridge.

Daly, P. 1969: Approaches to faunal analysis in archaeology. American Antiquity 34(2), 146-153.

Gilbert, B. M. 1969: Some aspects of diet and butchering techniques among prehistoric Indians in South Dakota. Plains Anthropologist 14, 277-294.

Иностранцев, А. А. 1882. Доисторический человек каменнаго века побережья Ладожского озера. Стасюлевич. С.-Петербургъ.

Кагановская, С. М. 1937. О достоверности вычислений длинны и темпа роста по чешуе с разных частеи тела сардиныиваси (Sardinops melanosticia). Известия тихоокеанский научныи институт рыбного хозяиства, 12: 115–124.

Лебедев, В. Д. 1952. Материялы по промысловой ихтиофауне городищ рек Десны и Сейма. Ученые записки московского государственного университета, 158: 253–273

Лебедев, В. Д. 1960. Пресноводная четвертичная ихтиофауна европейской части СССР. Издательство московского университета. Москва.

Лебедев, В. Д., К. П. Марков, Т. Л. Бахметьева, and М. Паскуль. 1961. Рыбы и рыболовство обитателеи асоцкого городища (XI–XIII вв. н.э.) на даугаве. Материялы и исследования по археологий латвийской ССР, 2: 226–233.

Menon, M. D. 1953: The determination of age and growth of fishes of tropical and sub-tropical waters. Journal of the Bombay Natural History Society 51, 623-635.

Phillips, J. B. 1948: Comparison of calculated fish lengths based on scales from different body areas of the sardine . Copeia 1948(2), 99-106.

Schuck, H. A. 1949: Problems in calculating size of fish at various ages from proportional measurements of fish and scale sizes. Journal of Wildlife Management 13(3), 298-303.

Shawcross, W. 1967a: An evaluation of the theoretical capacity of a New Zealand harbour to carry a human population. Tane 13, 3-11.
Shawcross, W. 1967b: An investigation of prehistoric diet and economy on a coastal site at Galatea Bay, New Zealand. Proceedings of the Prehistoric Society, n.s., 33, 107-131.
Shawcross, W. 1970: Ethnographic economics and the study of population in prehistoric New Zealand: viewed through archaeology. Mankind 7, 279-291.
Shawcross, W. 1972: Energy and ecology: thermodynamic models in archaeology. In Clarke, D. L. (ed.): Models in archaeology 577-622. Methuen. London.
Свертовидов, А. Н. 1948. К историй ихтиофауны р. Дона. Материялы и исследования по археологий СССР, 8: 124–127.
White, T. E. 1953a: A method of calculating the dietary percentage of various food animals utilized by aboriginal peoples. American Antiquity 18(4), 396-398.
White, T. E. 1953b: Observation on the butchering technique of some aboriginal peoples No. 2. American Antiquity 19(2), 160-164.
Житенева, Л. Д. 1969. Рыбы поседения Маяки (конец III тысячелетия до н.э.). Зоологический журнал, 48(1): 93–98.

A consideration of the behaviour of the minimum number of individuals index: A problem in faunal characterization

RICHARD W. CASTEEL

OSSA

There has been concern for several decades regarding the manner in which the minimum number of individuals index behaves at varying sample sizes, as well as concern over its behaviour with regard to aggregation of sampling units and the effects of varying operational definitions of the measure among different investigators. Regularities in the behaviour of this index at varying sample sizes are examined and a general model of this behaviour is proposed on the basis of a sample of North American, Central American, and Eurasian faunal assemblages. It is argued that the minimum number of individuals is a direct function of the number of identified specimens per taxon or for the assemblage as a whole. This has serious implications regarding the adequacy of most field techniques for recovery of faunal materials, as well as for the comparability of faunal assemblages derived using varying recovery techniques.

В течение нескольких десятилетий проявлялся интерес по отношению к тому, каким образом определяемое минимальное число индивидуумов изменяется в различных единицах образца и в зависимости от размера образца, и как отдельные исследователи определяли этот размер, базируясь на неодинаковых принципах. В работе изучаются закономерности в поведении индекса минимального числа индивидуумов при изменении величины образца и предлагается общая модель этого поведения, полученная на основании образцов из Северной Америки, Центральной Америки и евро-азиатских систем фауны. Отмечается, что минимальное число индивидуумов является прямой функцией числа идентифицированных особей в таксоне или в системе как в целом. Это имеет серьезные последствия, касающиеся адекватности большинства полевых техник восстановления материалов фауны, так же как для сравнимости систем фауны, полученных при помощи различных техник восстановления.

R. Casteel, Simon Frazer University, British Columbia V5A 1S6.

Vol. 3/4, pp 141–151, Lund. ISSN 0345–8865.

Introduction

The minimum number of individuals has been used within both archaeology and paleontology as an index for estimating the relative significance of various taxa constituting faunal assemblages. In use since at least the late nineteenth century (Иностранцев 1882), this index has been used increasingly as a common base for presenting the results of faunal analyses (Chaplin 1971, Grayson 1973, Паавер 1958).

In spite of the growing popularity of this index in faunal studies, there seems to be an increasing body of data which indicates serious and occasionally systematic problems with the measure.

The present study involves a brief discussion of the major criticisms levelled thus far against the minimum number of individuals index, an examination of studies dealing with the relationship between the minimum number of individuals and the number of identified elements per taxon, and a generalized model of the behaviour of the minimum number of individuals index at increasingly larger sample sizes.

Earlier studies

Паавер (1958)demonstrated that the minimum number of indivudals index was subject to numerous factors which effected its size. Specifically, Паавер showed that the minimum number of individuals for any species would also vary as a function of the degree of aggregation of the sampling units. To illustrate this he calculated the minimum numbers of individuals for twelve species of mammals recovered from the excavations at the thirteenth century city of Лыхавере. The 2030 bones and bone fragments were first used to calculate the minimum number of individuals for the site as a whole, treating all the bone remains as a single unit. The result was a total minimum number of individuals of 29 representing all species combined. Then Паавер recalculated his minimum number of individuals figures for each species, but based upon individual quadrats within the site. This produced a total minimum number of individuals for all species of 129 -- some 4.5 times larger than the figure earlier obtained.

Grayson (1973) found the same response of the minimum number of individuals index with regard to aggregation of sampling units. Utilizing minimum number of individuals estimates made on the basis of his maximum distinction (M_x) and minimum distinction (M_i) methods at the site of Cerro Brujo, he found the total minimum numbers of individuals for all species to be 466 and 75, respectively. Grayson (1973: 438) noted that only the ordinal abundance of the taxa was unaffected by the aggregation of sampling units. Similar results were also found by Grayson (1974b).

By the late 1930's investigators were beginning to observe certain regularities in the behaviour of the minimum number of individuals index. Kuhn (1938: 258) noted that the minimum number of individuals index varied as a function of the amount of bone remains recovered for a taxon. Ten years later Громова (1948: 113) also commented on this phenomenon:

> "*It should be noted that the percentage relationship calculated by us for various animals is only approximate. It suffers from certain major defects. For those animals, the remains of which are numerous (at a very rough approximation greater than 100–150), the figure expressing the number of individuals is obviously really smaller; for those, the remains of which are less numerous (likewise, approximately less than 30–50), this figure more closely conforms with the real number of individuals.*"

Thus, the minimum number of individuals index was seen as being approximately correct where the number of bone remains for a taxon was in the range of 30 to 50; however, where more than about 100 to 150 bones were involved for a taxon, this measure was interpreted as under-estimating the "real" number of individuals. This same interpretation has been supported by Цалкин (1956: 122). The pattern of variation in the index as a function of the number of bone remains for a taxon was so well established that by the late 1950's Паавер (1958: 286) urged that the index be renamed the "условным числом особей" (conditional number of individuals), thus stressing the fact that the behaviour of this measure was conditioned by the number of elements being dealt with.

Shotwell (1958) discussed the manner in which the number of identified specimens per individual varied in relation to the minimum number of individuals. Perkins (1973) has also referred to the "... *serious distortion* ..." which may occur in the minimum number of individuals index when sample sizes of 1000 or fewer bones or bone fragments are used (see also von den Driesch 1972: 19, Munson 1974).

In 1969 Gejvall presented a graphical representation of the relationship between the percent of the ratio of the minimum number of individuals to the number of identified fragments (abbreviated here as MNI/E following Grayson's (1947a) notation and the number of identified fragments (E). He showed that in the materials from the pre-classic site of Lerna the ratio MNI/E varied in a negative curvilinear manner relative to E for remains of pig, cattle, and sheep/goat. Based upon his data from Lerna, Gejvall (1969: 4) concluded that

> "... *we must count on at least 300 fragments, and we are not sure that when we are dealing with less than that number of fragments of domestic cattle, pig, sheep, and goat that our estimate of MIND* [minimum number of individuals] *will be at all realistic* ...".

In 1974 Grayson (1974a) presented a study which built upon Gejvall's (1969) work. Grayson used the ratio MNI/E as a measure of the proportionate contribution of the specimens of the bone sample for that taxon to the minimum number

of individuals determined from that sample. Grayson examined the faunal remains from three paleontological assemblages of mid-Pliocene age and three archaeological faunal assemblages. When the relationships between the MNI/E ratios and E for all assemblages were examined, they were all found to be negative hyperbolic functions of the general form:

$$Y = \alpha X^{\beta} \qquad (1)$$

In his six sample assemblages Grayson found the values for α to vary between 0.448 and 0.97 and the values for β to vary from -0.46 to -0.71. On the basis of his findings Grayson stated that the minimum number of individuals index was greatly exaggerated when sample sizes (E) were quite small. Grayson argued that this exaggeration in the minimum number of individuals index could be controlled by using sample sizes (E) larger than 30 to 50 elements per taxon.

Though the phenomenon observed was the same, the interpretations of Громова (1948), Паавер (1958), and Цалкин (1956) are directly opposite those of Gejvall (1969) and Grayson (1974a). The former maintain that the minimum number of individuals index is only accurate at or below E values of 30 to 50, whereas the latter argue that this measure is relatively controllable only at sample sizes (E) greater than 30 to 50. Whichever of the preceeding interpretations one may choose to accept, it is clear that the ratio MNI/E varies as a negative hyperbolic function of E.

In addition to the problems involved in estimates of the minimum number of individuals at varying sample sizes of identified bones per taxon (E) and with regard to aggregation of sampling units, which have been outlined above, there has been a growing awareness that different investigators may utilize various methods for assessing the minimum number of individuals (compare, for example White 1953, Bökönyi 1970, Бекени 1969, Krantz 1968). The disturbing fact here is that these diverse methods of assessing the minimum number of individuals yield differing results when applied to the same body of data (Boessneck 1960, Boessneck et al. 1968: 7, Boessneck et al. 1971, Casteel in press, Clason 1972, Flannery 1967, Payne 1972).

Indeed, the problems associated with the minimum number of individuals index are of such magnitude that many investigators have seriously questioned the value of this index (Ambros 1969, von den Driesch 1972). Kubasiewicz (1973: 374) has presented a cogent argument against the use of this index when

dealing with faunal remains from Medieval cities and it is an argument that can easily be extended to other archaeological contexts as well:

is unfit for large Medieval sites. I have spoken quite often about these problems in my works. My opinion is that it is nonsense to determine the number of individuals from Medieval cities, just as it would be nonsensical to determine how high meat consumption in a present day city is if one calculated the number of individuals represented by the bones which had been found in a refuse heap. If someone buys four cow's feet from the butcher in order to make gelatin and throws four metapodials, each from a different animal, on the garbage pile, this case is not evidence that he and his family have consumed four cows. There were also butcher shops in the Medieval cities and one bought meat there by the kilogram or by the pound."

Relationship between the ratio MNI/E and E

In order to examine in more detail the pattern illustrated in Grayson's (1974a) and Gejvall's (1969) studies, a large sample was sought which could illustrate the behaviour of the ratio MNI/E at varying sizes of E. To accomplish this a sample of minimum numbers of individuals and their corresponding E values was obtained. This sample is not random, but nonetheless may permit valid generalization of the behaviour of the minimum number of individuals index. Because of the effects of sample aggregation, schemes, differing operational definitions of the MNI index, and widely divergent sample sizes (E). The data derive from studies of both archaeological and paleontological assemblages undertaken by a variety of investigators in North America, Central America, and Eurasia. Thus, the sample may be seen as reflecting a wide spectrum of the results obtainable from faunal analyses. The sample itself was limited to materials which were readily available for analysis and includes data for mammals, birds, reptiles, fish, and bivalves. The final sample consisted of 610 pairs of data.

On the basis of all the above, as well as the known effects of differing methods for assessing the minimum number of individuals, it is reasonable to assume that the relationship between MNI and E will reflect considerable variance.

Analysis of the data in this sample indicates a significant negative correlation ($r = -0.88$) between the ratio MNI/E and E. Furthermore, the form of

this relationship is the same as that obtained earlier by Gejvall (1969) and Grayson (1974a) and may be described as follows:

$$MNI/E = 0.77\ (E)^{-0.48} \qquad (2)$$

These results are presented in Figure 1.

The values for α and β are within the range earlier presented by Grayson (1974a) and the relationship is, again, a negative hyperbolic one.

Relationship between MNI and E

It may be argued that what is really sought is not the relationship between the ratio MNI/E and E, but the relationship between MNI and E. Thus, it would be possible, based upon the significant correlation illustrated in Figure 1 between the ratio MNI/E and E, to predict with a reasonable degree of accuracy the minimum number of individuals for any taxon or for all taxa based solely upon a knowledge of E for that taxon or for the assemblage as a whole.

In order to accomplish this the same sample of 610 data pairs was utilized. The relationship between MNI and E was examined from two points of view: first, with regard to small faunal collections ($E \leq 1000$); and second, with regard to large faunal collections ($E > 1000$). For small samples ($E \leq 1000$) it was found that the following power function could accurately describe the relationship:

$$MNI = 0.77\ (E)^{0.52} \qquad (3)$$

This accounts for approximately 80 percent of the variance in the original data. The correlation between these two variables is 0.89 and is highly significant. The form of this relationship is illustrated in Figure 2(A) for values of E between 0 and 1000. For large samples of bone remains ($E > 1000$) it was found that the following linear regression best described the relationship:

$$MNI = 5.56 + 0.0225\ (E) \qquad (4)$$

Again, there is a significant correlation between the two variables ($r = 0.98$). Approximately 96 percent of the variance in the sample data is accounted for by this least squares regression. This relationship is illustrated in Figure 2(B) for values of E between 1000 and 100,000.

It is suggested that whenever either formula (3) or (4) is used, the resultant

MNI be rounded to an integer value.

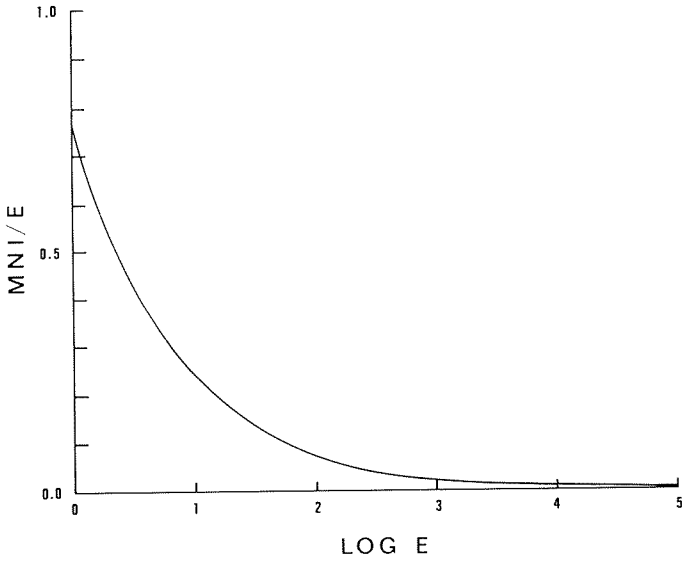
Conclusions

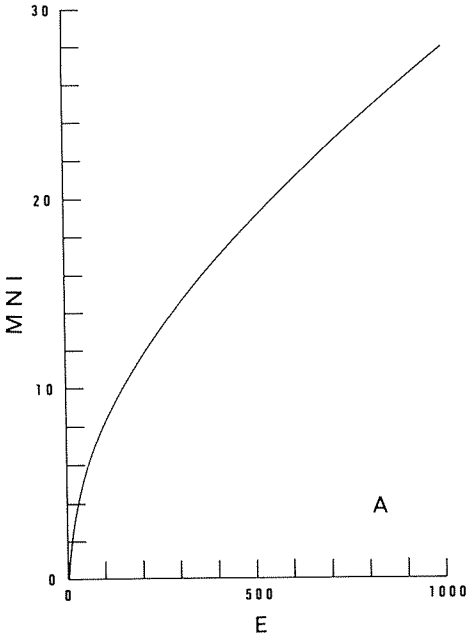
The fact that the minimum number of individuals can be clearly demonstrated to be a function of the number of identified specimens for a taxon or assemblage has serious implications for the field techniques utilized in recovery of faunal remains. A number of studies have shown that significant biases exist in the faunal collection techniques currently employed in field archaeology (Casteel 1972, Payne 1972, 1975, Sparks 1961, Fitch 1969). Numerous investigators have proposed corrective measures for poor field recovery of faunal materials (Thomas 1969, Watson 1972, Ziegler 1965, 1973); however, their effectiveness remains a matter of some concern. What is apparent is that these recovery biases operate against faunal materials of smaller size and of certain colours. Payne's (1972, 1975) studies demonstrate that even the remains of large-sized taxa may be negatively effected. Thus, given that the minimum number of individuals is a function of E, even the minimum numbers of individuals for large-sized taxa may be subject to marked deviation. This is especially so in small collections.

The conclusion is inescapable that considerably more attention must be given to the adequate recovery of faunal remains. Where this is lacking and cannot be confidently corrected, it may result in error in MNI values of major but unknown magnitude. This error extends also to comparisons between the faunal assemblages of different sites, based upon MNI estimates where differing recovery techniques have been applied.

Acknowledgements

Sincere thanks to Dr. D. K. Grayson, Department of Anthropology, University of Washington, Seattle, Dr. K. Paaver, Institute of Zoology and Botany, Academy of Sciences of the Estonian SSR, Tartu, and Dr. J. Boessneck, Institut für Palaeoanatomie, Domestikationsforschung und Geschichte der Tiermedizin, University of München for their assistance in this study and their patience in discussion. This study was partially supported by a President's Research Grant, Simon Fraser University.





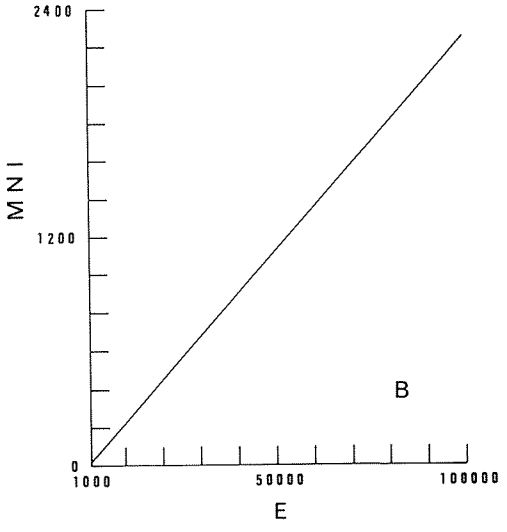


Figure 1. Relationship between the ratio MNI/E and E. Based upon data from Алексашина (1950); Бибикова (1950); Boessneck (1960); Flannery (1967); Grayson (1973, 1974a, b); Громова (1948); Higham (1968); Munson (1974); Noyes and Hill (1974); Shotwell (1955, 1958); Simones (1973); Turnbull and Reed (1974); Верешагин and Колбутов (1957). $MNI = 0.77\ (E)^{-0.48}$. Data plotted on semi-logarithmic scale for ease of illustration.

Figure 2. Relationship between MNI and E. A, MNI as function of E for small samples ($E \not> 1000$): $MNI = 0.78\ (E)^{0.52}$. B, MNI as function of E for large samples ($E \geq 1000$): $MNI = 5.56 + 0.0225\ (E)$.

References

Алексашина, К. С. 1950. Остатки фауны из некоторых городищ Верхнего Поволжья. Материалы и исследования по археологии СССР, № 13: 148–151.

Ambros, C. 1969: Bemerkungen zur Auswertung der Tierknochen aus Siedlungsgrabungen. Deutsche Forschungsgemeinschaft, Forschungsberichte (Wiesbaden) 15, 76-87.

Бибикова, В. И. 1950. Фауна Пекуновского городища. Материалы и исследования по археологии СССР, № 13: 133–147.

Boessneck, J. 1960: Zu den Tierknochenfunden aus der präkeramischen Schicht der Argissa-Magula. Germania 38 (3/4), 336-340.

Boessneck, J., von den Driesch, A. & Gejvall, N.-G. 1968: Die Knochenfunde von Säugetieren und vom Menschen.

Boessneck, J., von den Driesch, A., Meyer-Lempennau, U. & Wechsler von Ohlen, E. 1971: Die Tierknochenfunde aus dem Oppidum von Manching. In Boessneck, J.: Die Ausgrabungen in Manching, vol. 6. Steiner. Wiesbaden.

Бекени, Ш. 1969. Новый метод вычисления количества особей животных в остеологическом материале из аргеологических местонахождений. Бюллетень Московское общество испытателей прорды, отдел биологическии, 74(6): 69–71

Bökönyi, S. 1970: A new method for the determination of the number of individuals in animal bone material. American Journal of Archaeology 74, 291-292.

Casteel, R.W. 1972: Some biases in the recovery of archaeological faunal remains. Proceedings of the Prehistoric Society 38, 382-388.

Casteel, R.W. 197 : Characterization of faunal assemblages and the minimum number of individuals determined from paired elements: continuing problems in archaeology. Journal of Archaeological Science (in press).

Chaplin, R.E. 1971: The study of animal bones from archaeological sites. Seminar Press. New York.

Clason, A.T. 1972: Some remarks on the use and presentation of archaeozoological data. Helinium 12, 139-153.

Fitch, J.E. 1969: Appendix A: fish remains, primarily otoliths, from a Ventura, California, Chumash village site (Ven-3). Memoirs of the Southern California Academy of Sciences 8, 56-71.

Flannery, K.V. 1967: The vertebrate fauna and hunting patterns. In Byers, D.S. (ed.): The prehistory of the Tehuacan Valley vol. 1, 132-178. University of Texas Press. Austin.

Gejvall, N.-G. 1969: Lerna, a pre-classical site in the Argolid. Vol. 1: the fauna. American School of Classical Studies at Athens. Princeton.

Grayson, D.K. 1973: On the methodology of faunal analysis. American Antiquity 38(4), 432-439.

Grayson, D.K. 1974a: Minimum numbers and sample size in vertebrate faunal analysis. Paper presented at the 39th annual meeting of the Society for American Archaeology, Washington, D.C.

Grayson, D.K. 1974b: The Riverhaven No. 2 vertebrate fauna: comments on methods in faunal analysis and on aspects of the subsistence potential of prehistoric New York. Man in the Northeast 8, 23-39.

Громова, В. И. 1948. Остатки млекопитающих из раннеславяских городищ вблизи г. Воронежа. Материалы и исследования по археологии СССР, № 8: 113–123.

Higham, C. F. W. 1968: Patterns of prehistoric economic exploitation on the Alpine foreland. Vierteljahrsschrift der Naturforschenden Gesellschaft in Zürich, Jahrgang 113, 41-92.

Иностранцев, А. А. 1882. Доисторический человек каменнаго века побережья Ладожского озера. Стасюлевич. С.-Петербургъ.

Krantz, G. S. 1968: A new method of counting mammal bones. American Journal of Archaeology 72(3), 286-288.

Kubasiewicz, M. 1973: Spezifische Elemente der polnischen archäozoologischen Forschungen des letzten Vierteljahrhunderts. In Matolci, J. (ed.): Domestikationsforschung und Geschichte der Haustiere 371-376. Akadémiai Kiadó. Budapest.

Kuhn, E. 1938: Zur quantitativen Analyse der Haustierwelt der Pfahlbauten in der Schweiz. Vierteljahrsschrift der Naturforschende Gesellschaft 83, 253-262.

Munson, P. J. 1974: Faunal analysis, sample size, differential destruction, and some suggested correction factors. Paper presented at the 39th annual meeting of the Society for American Archaeology, Washington, D. C.

Noyes, M. J. S. & Hill, F. C. 1974: Faunal remains from a Lewis focus stone fort in southern Illinois. Illinois State Academy of Sciences, Transactions, 67, 336-340.

Паавер, К. Л. 1958. К методике определения относительного значения видов и групп млекопитающих в остеологическом материале из раскопок археологических памяиников. Известия академии наук Эстонской ССР, серия биологическая, 7(4): 277–290.

Payne, S. 1972: On the interpretation of bone samples from archaeological sites. In Higgs, E. S. (ed.): Papers in economic prehistory 65-81. Cambridge University Press. Cambridge.

Payne, S. 1975: Partial recovery and sample bias. In Clason, A. T. (ed.): Archaeozoological studies 7-17. North-Holland. Amsterdam.

Perkins, D., Jr. 1973: A critique on the methods of quantifying faunal remains from archaeological sites. In Matolcsi, J. (ed.): Domestikationsforschung und Geschichte der Haustiere 367-370. Akadémiai Kiadó. Budapest.

Shotwell, J. A. 1955: An approach to the paleoecology of mammals. Ecology 36, 327-337.

Shotwell, J. A. 1958: Inter-community relationships in Hemphillian (mid-Pliocene) mammals. Ecology 39(2), 271-282.

Simons, D. D. 1973: Appendix 3. The faunal remains from 4-Cal-276 and 4-Cal-343: reptiles, birds, and mammals. In Peak, A. S. (ed.): "New Melones reservoir archaeological project, Calaveras and Tuolumne Counties, California. Phase III". Report on file, National Park Service, San Francisco.

Sparks, B. W. 1961: The ecological interpretation of Quaternary non-marine Mollusca. Proceedings of the Linnean Society of London 172, 71-80.

Thomas, D. H. 1969: Great Basin hunting patterns: a quantitative method for treating faunal remains. American Antiquity 34(4), 392-401.

Цалкин, В. И. 1956. Материалы для истории скотоводства и охоты в древней Руси. Materialy i issledovaniâ po arheologii CCCP, № 51.

Turnbull, P. F. & Reed, C. A. 1974: The fauna from the terminal Pleistocene of Pelegawra Cave, a Zarzian occupation site in northeastern Iraq. Fieldiana Anthropology 63(3), 81-146.

Верещагин, Н. К. анд А. Д. Колбутов. 1957. Остатки животных на мустерской стоянке под Сталинградом и стратиграфическое положение палеолитического слоя. Труды зоологического института академии наук СССР, 22: 75–89.

von den Driesch, A. 1972: Osteoarchäologische Untersuchungen auf der Iberischen Halbinsel. Frühe Tierknochenfunde von der Iberischen Halbinsel 3. Uni-druck. München.
Watson, J. P. N. 1972: Fragmentation analysis of animal bone samples from archaeological sites. Archaeometry 14(2), 221-227.
White, T. E. 1953: A method of calculating the dietary percentage of various food animals utilized by aboriginal peoples. American Antiquity 18(4), 396-398.
Ziegler, A. C. 1965: The role of faunal remains in archaeological investigations. Sacramento Anthropological Society Papers, No. 3, 47-75.
Ziegler, A. C. 1973: Inference from prehistoric faunal remains. Addison-Wesley. Reading.

The application of contingency table for comparison of archaeozoological materials

ALICJA LASOTA-MOSKALEWSKA AND ZOFIA SULGOSTOWSKA

OSSA

The authors used an analysis of surpluses in a 2-dimensional contingency table for comparison of numbers of animal bone fragments from different archaeological sites. The statistical method excluded from the obtained results the influence of uneven fragmentation of bones belonging to certain species from different sites. The method isolated the materials in which existed the relative predominance of bone fragments of one or two domestic animals species.

Авторы применили метод оценки излишка численности в 2-размерной таблице для сравнительных исследований количества костных остатков животных из разных археологических стоянок. Этот метод ликвидировал значение неравномерного раздробления костей животных различных пород, найденных на разных стоянках, и позволил выделить материалы, в которых найдено относительное преобладание остатков одной или двух пород домашних животных.

Alicja Lasota-Moskalewska and Zofia Sulgostowska, Państwowe Muzeum Arch., DŁUGA 52, 00–950 WARSZAWA, Poland.

Vol. 3/4, pp 153–168, Lund. ISSN 0345–8865.

Introduction

One of the most important tasks of archaeozoology is to reconstruct the breeding preferences of various cultures or inhabitants of various geographical regions. Unfortunately, that aim is difficult to reach because of the poor quality of many archaeozoological materials and the lack of a suitable method of comparison.

An analysis of animal bone remains from any archaeological site usually allows to establish the number of bone fragments belonging to different species. Nevertheless, a comparison of percentage ratios of these numbers between materials from various sites, refered to as "fragment method", may be seriously misleading. The number of bone fragments is determined by deliberate breakage while carcasses were cut for meat and by the uneven resistance of bones to the detrimental action of soil, the resistance varies with age and species. All these factors account for an uneven fragmentation of bones of different species in the same material and an uneven fragmentation of bones of the same species in different materials. Furthermore, even if the above objections were neglected, the direct comparison of percentage ratios of bone fragments in various materials would not make it possible to indicate which differences were significant.

Another method used for comparative purposes is based on the estimation of the minimum number of individuals. It consists in calculating the number of intact bones of a given type or their epiphyses. The number of such bones, however, also depends on the general state of bone preservation and is influenced by their uneven fragmentation.

In view of the above considerations we have attempted to introduce the so-called analysis of surpluses in a 2-dimensional contingency table (Góralski 1966) for comparison of archaeozoological materials. Such an analysis could help to find out which species were favoured at a given site and, at the same time to exclude or minimalize the influence of the variability of bone fragmentation caused by different detrimental conditions on the results.

Method

Construction and the possible interpretations of the tables

A 2-dimensional table consists of several columns (c) corresponding, in our case, to species of domestic animals of economic importance and rows (r) enumerating the sites under comparison. The observed numbers (n) of the recognized bone fragments of each species were recorded in the appropriate squares of the table. From these data, the theoretically expected numbers ($\tilde{n}$) of bone fragments for every species and material were calculated in the following way: at first we add the occurrence values in each column and each row, thus receiving sums, which divided by the total of the sample give - a) mean ratios of sample distribution in species b) ratios of sample distribution in sites. Multiplying their values for each pair of row and column and again by the total number of occurrences (N), the expected occurrence ($\tilde{n}$) for each square in the table is obtained. The simplified formula is:

$$\tilde{n}_{11} = \frac{\sum r_1 \cdot \sum c_1}{N}$$, say, for the first row and column.

Expected occurrence values are therefore the result of the following assumptions: all sites have the same proportions of species occurrence - i.e. the mean proportions are the best estimate of random distribution, and the size of the sample from the site is not influenced by different detrimental conditions, as well as by different butchery or bone employment habits.

Comparing the actual occurrences and the expected ones we can evaluate the

significance of their differences.

Both occurrence and expected values are biased by different preservation ratios of various species' bones. Assuming that these ratios (eg. Cattle to pig) are the same at all sites and independent of the degree of detrition we can eliminate this bias during testing. At the same time, as the size of samples from the sites is not changed for expected values the differences between them and the observed ones reflect these variations only which are due to cultural phenomena i.e.: different butchery and bone use habits, as well as the preferences in husbandry.

In relation to the theoretically expected number, the observed one could be: a) equal, if the bone fragments of a given species in a given material occurred in accordance with the expected distribution, b) smaller (deficiency), if the bone fragments of a given species occurred less frequently in a given material than in others, c) larger (surplus) if the bone fragments of a given species occurred more frequently in a given material than in others.

The deficiency may be accounted for either by smaller interest in breeding of the species or by an unusually moderate fragmentation during meat cutting (e.g. when whole carcasses were roasted) or by destruction of bones beyond recognition.

The surplus may be due either to the preference for a given species by breeders and consumers or to the extensive breakage of bones of a given species (e.g. production of bone tools).

The homogeneity of materials included into each table was tested by χ^2:

$$\chi^2 = \sum \frac{(n - \tilde{n})^2}{\tilde{n}} \qquad (1)$$

with number of degrees of freedom = $(k_1 - 1)(k_2 - 1)$; where

k_1 = number of sites

k_2 = number of species

The content of all tables proved to be highly non-homogenous.

While this calculation was performed to characterize the material generally, it should be stressed that the analysis of surpluses may be performed independently of the results of the homogeneity test (Góralski 1966).

Analysis of surpluses in a contingency table was introduced for anthropological studies. The mathematical foundations of the estimation of significancy of surpluses

were elaborated by Wanke (1953), Olekiewicz (Dzierzykraj-Rogalski and Olekiewicz 1958), and Góralski (1966). Wanke suggested the use of a χ^2 test with 1 degree of freedom. For the surpluses which turned out to be significant additional calculations of the relative values of surpluses were introduced. He decided arbitrarily to consider only the surpluses higher than 50% of the observed number of objects. Olekiewicz raised several objections to the use of χ^2 test and limited its application to certain types of m-dimensional tables only. To overcome these limitations Góralski introduced the new test for estimation of significance of surpluses. This test was used as a first step of analysis in our work.

$$\psi^+ = \frac{n^+ - \tilde{n}}{\delta_{(\tilde{p})} \sqrt{\tilde{n}(1 - \tilde{p})}} \qquad (2)$$

where: n^+ - observed number of bone fragments

$\tilde{n}$ - theoretically expected number of bone fragments

$\delta_{(\tilde{p})}$ - values taken from tables computed by Góralski; they are functions of $\tilde{p}_{i_1}$ and $\tilde{p}_{i_2}$

$\tilde{p} = \frac{\tilde{n}}{N}$

ψ statistic distribution modulated by the incomplete beta function, under given number of dimensions, expected occurrence values, sample size and significance level (in our case $\alpha = 0,01$), gives critical values, which compared to values calculated according to formula (2) test their statistical significance.

This procedure allowed to determine which of the surpluses were formally significant. However, taking into account many factors affecting the degree of bone fragmentation we have decided to limit our concern to the particularly large surpluses only. The latter were detected according to the Olekiewicz's modification of Wanke's formula (Jasicki et al., 1962):

$$R = \frac{n - \tilde{n}}{\tilde{n}} \quad 100 \qquad (3)$$

It was arbitrarly decided to discuss those surpluses only which had the index (R) equal to or higher than 25%.

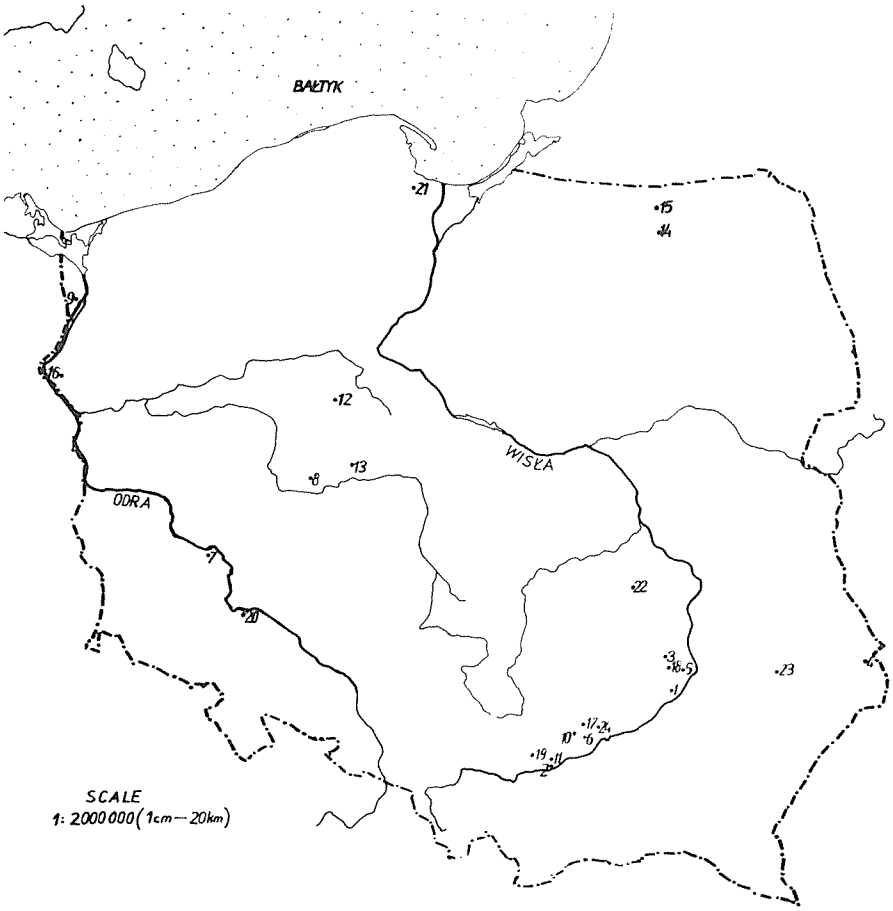


Figure 1. Schematic map of contemporary Poland with marked location of archaeological sites with zoological materials used for construction of contingency tables. The sites are numbered in chronological order.

Materials

The compared materials come from one Swedish and 24 Polish sites. The position of Polish sites is marked on the map (Fig. 1). The sites are numbered chronologically. The materials are presented in four tables. Table 1 contains materials from the Neolithic Funnel Beaker Culture. Table 2 contains materials from other Neolithic cultures: Linear Pottery Culture, Lengyel Culture, Radial Decorated Culture; they are compared with the most typical samples of the Funnel Beaker Culture. Table 3 and Table 4 contain materials from the early Iron Age and Mediaeval sites, respectively.

Results and discussion

The information obtained from the analysis of the tables fall in two categories. To begin with the analysis enabled us to find out which sites contained surpluses of bones and of which animal species. The possible origin of these surpluses may be subsequently traced back to the archaeological or ecological peculiarities of a given site. Secondly, the presence or the lack of surpluses in the tables made it possible to draw certain general conclusions concerning breeding habits of various cultures.

Analysis of surpluses

It is apparent from Table 1 that two sites produced the surpluses of pig bones and one site - sheep/goat bones. The surplus of pig bones was found at both Ustowo, No. 9 and Ksiaznice Wielkie, No. 6. Ustowo is located in the coastal region of the podsolic soil (Siuchninski 1958). Since the predominance of pig bones on the sites of this region appeared also in other tables, possible significance of this find will be discussed later. Ksiaznice Wielkie, first attributed in the archaeozoological report (Sych 1964) to the Funnel Beaker Culture, appeared - according to the archaeological data (Burchard and Eker 1964) - to contain elements of the Radial Decorated Pottery Culture also. It could be important as in another site of the same culture (Table 2) the pig bones were also found in excess. On the other hand, the latter work revealed that one of the pits contained a whole pig skeleton. It is unknown whether the pig was buried or just discarded. Due to the large number of bones contributed by the whole skeleton it is uncertain whether the surplus is real or biased.

The surplus of sheep/goat bones occurred at Nosocice No. 7. Here, again, the

archaeological work reported a large admixture of elements of the Linear Pottery Culture. In other sites of this culture such as Berleben, Thröbsdorf, Gatersleben, Hettstedt (Saxony and Thuringia) located similarly as Nosocice in loess zona, the percentage of bone fragments of those species varied from 28.6 to 70.8% (Wislanski 1969). Thus, the Nosocice surplus could be explained by the Linear Pottery Culture preference for sheep and goat. Another site (Somborzec, No. 1) representing the same culture did not contain any surplus of sheep/goat bones but it belonged to a different geographical region. In Table 2 surpluses of cattle in two cases and of pig in one are eminent. The surpluses of cattle occurred at Samborzec, No. 1 and Pleszow, No. 2. Samborzec represents the Linear Pottery Culture (Kamienska 1964) and Pleszow - the Lengyel Culture (Kulczycka-Leciejewiczowa 1969). The both cultures belong to the same cultural circle which originates from the southern regions of the Carpathian mountains. These sites were located in the loess region with abundance of deciduous woods (Kulczycka-Leciejewiczowa 1969). Such surroundings are particularly suitable for cattle breeding and have probably determined the choice of domestic animals by the ancient inhabitants of the sites. The surplus of pig bones was detected at Zeslawice, No. 11 which represents the Radial Pottery Culture much younger than two latter sites. Archaeological excavations (Godlowska 1968) disclosed that the settlement at Zeslawice underwent two phases of development. The increase in number of pig bones was particularly noticeable in the level belonging to the second phase. The reasons of this change in the breeding pattern are obscure; the more so that the ecological conditions similarly as in previously mentioned Pleszów and Samborzec would favour cattle.

The perusal of Table 3 disclosed two surplus cases, each of the following species: pig, sheep/goat and horse. The pig bone surpluses were spotted at Cedynia, No. 16, and Mogila, No. 19. Cedynia is located in the coastel region with that type of soil which hinders the extensive pasture of cattle (Wolagiewicz 1960). It was impossible to interpret the Mogila find because of the lack of the archaeo-ecological data. Sheep/goat surpluses were observed at Jeziorko, No. 14 and Tarlawki, No. 15. These settlements lay in close vicinity. The climate in the Early Iron Age became much colder and its change must have caused the expansion of coniferous woods (Okulicz 1973). Such conditions limit the possibility of cattle raising and favour goats or sheep which are more resistant to hardships. The surpluses of horse bones were found at Slupca, No. 13 and Jeziorko, No. 14. The ecological conditions of both sites are quite different

(Batkowski 1957-58, Malinowski 1958), Both settlements, however, are of defensive type and have kept horses for military purposes. In Table 4 case of pig surplus, another of sheep/goat and one more of horse were found. The surplus of pig bones was found in Gdańsk, No. 21. Gdańsk, even at that time, was a large sea harbour and trade center. The preference for pigs may be explained by the fact that the species could have been kept within the town and fed on discarded food. The sheep/goat surplus occurred at Lund, but this find will be discussed later. Horse bones were found in significant quantities at Sasiadka, No. 23 which was a large border castle, probably accomodating a number of mounted soldiers.

General conclusions

It is interesting to note that all the sites of the homogenous Funnel Beaker Culture which are situated in the central and southern Poland revealed a very similar pattern of distribution of domestic animals with the small excess of cattle (Table 1). The large surpluses of cattle bones were found in the materials representing the Linear Pottery Culture and the Lengyel Culture (Table 2). It may indicate that the cattle was a favoured species in the primitive breeding, provided that the ecological conditions did not hinder the raising of cattle. The above pattern of breeding may be considered, as a sort of background for
1) analysis of breeding preferences of other cultures on one hand and
2) of breeding preferences of inhabitants of territories with specific ecological conditions on the other. Ad 1. At Zeslawice (Radial Decorated Pottery Culture) situated in the such ecological surroundings, which should have favoured the raising of cattle the predominance of pig bone might have resulted from the culture preference.

Undoubtedly, the validity of this suggestion must await confirmation which can only be furnished by the analysis of materials of this culture discovered in the future.

Ad 2. The deficiency of cattle at Ustowo may depend on the soil conditions. Cedynia and Gdańsk located at the coastal region and dated to the early Iron Age and the Middle Ages had, similarly as Ustowo, a surplus of pig bones. Taking into consideration the fact that in other materials from the same region which are not included in the tables (Kedrzyn-Wyrost 1965, Gardziec - Kubasiewicz 1959, Szczecin - Mściecino - Kubasiewicz 1955, Wolin - Kubasiewicz 1956,

Szczecin - Kubasiewicz 1957) the percentage of pig bones was very high, it seems that the coastal territory either favoured pig breeding or hampered pasture of cattle. The second supposition is more probable as pig is an animal of great adaptability. The breeding of cattle may have been discouraged by the lack of microelements in the soil of the coastal region (Krysiak 1967).

Analysis of the sites dated to the early Iron Age and the Middle Ages suggests that the given breeding preferences could have been caused not only by the ecological factors, but also by the character of the site (settlement, defensive settlement, castle or town).

The value of surplus analysis may be particularly well illustrated by the Nosocice finds. The percentage ratio of sheep/goat bones at this site would place these particular species at the end of the domestic animal list. The contingency table analysis disclose that the relative number of these bones in comparison with other sites is unusually high and indicates importance of these species for the Nosocice inhabitants.

The material found at Lund differs considerably from the materials found on the Polish territory. It shows a large deficiency of pig and horse bones. Though the comparison of one particular case is only of incidental interest, it points out that the combination of materials involving large territories may uncover interesting differences in cultural, geographical and historical conditioning of breeding patterns.

Summary

It is suggested that the archaeozoological materials can be compared with the use of an analysis of surpluses in 2-dimensional contingency table. Such table would contain as variables both archaeological sites and species of domestic animals such as cattle, pig, sheep/goat and horse. In order to test the applicability of the method in practice - four tables were built. Table 1 included only the materials belonging to the Neolithic Funnel Beaker Culture. Table 2 compared materials from the four Neolithic Cultures: Linear Pottery Culture, Lengyel Culture, Funnel Beaker Culture, and Radial Decorated Pottery Culture. Tables 3 and 4 contained materials dating the early Iron Age and the Middle Ages, respectively. The distribution of bone fragments observed in these materials was compared with the theoretically expected distribution. In this way, we have been able to exclude or minimalize the influence of the variability of bone fragmenta-

tion caused by different detrimental conditions on the results. Each table revealed the surpluses of bones actually occurring over values expected of particular species. The possible causes of the observed surpluses were traced back to the archaeological or ecological peculiarities of a given site.

The distribution of bone fragments in the materials representing the Linear Pottery Culture, Lengyel Culture and Funnel Beaker Culture and coming from central and southern Poland reflects certain uniformity of breeding pattern. In this pattern the cattle seems to be favoured, provided that the ecological conditions did not hinder the raising of this species. However, in another Neolithic Culture (Radial Decorated Pottery Culture) the relative prevalence of pig bones seems to indicate that this species was favoured probably for certain unknown cultural and non-ecological reasons.

In the early Iron Age and the Middle Ages the character of the breeding pattern was also connected with the type of settlement. For example, in defensive settlements and castles, the number of horse bones was relatively larger than in other sites. Furthermore, the perusal of the tables indicates that the ecological factors have a significant bearing on the breeding pattern. If these factors were more or less "average" i.e. did not particularly favour or hinder raising of certain species, the cattle would usually dominate among domestic animals. The change of breeding pattern towards the preference of other species may have been caused by unsuitable conditions for cattle pasture. Such situation existed, for example, at the sites of the coastal region, where the relative predominance of pig bones was observed independently of the chronological period. This fact may be accounted for by the lack of microelements needed by cattle in the soil of this region.

Acknowledgement

The authors are indebted to Mr. J.K. Milencki for the revision of the English manuscript.

References:

Bartkowski, T. 1957–1958: O krajobrazie pierwotnym w rejonie Słupcy. Fontes Arch. Posn. 8–9 p 98.
Burchard, B. and Eker, A. 1964: Osada kultury czasz lejowatych w Książnicach Wielkich, pow. Kazimierza Wielka. Studia i materiały do badań nad neolitem Małopolski 4 p 191.
Chmielewski, K. 1957–1958: Zwierzęce szczątki kostne z grodziska kultury łużyckiej w Słupcy. Fontes Arch. Posn. 8–9 p 115.
Dzierżykraj-Rogalski T. and Olekiewicz M. 1958: Barwa oczu i włosów a grupy krwi. Prace i Mat. Antrop. 44 p 1.
Ekman, J. 1973: Early Mediaeval Lund–The Fauna and the Landscape. Archaeologica Lundensia 5.
Godłowska, M. 1968: Osada kultury ceramiki promienistej w Nowej Hucie- Zesławicach (Dłubnia). Z badań nad kulturą ceramiki promienistej. Kraków p 39.
Góralski, A. 1966: Kryterium Ψ oceny istotności nadwyżki i niedoboru liczebności w elementarnej koste wielodzielczej m–wymiarowej tablicy. Zeszyty Naukowe Politechniki Warszawskiej 131 p 7.
Jasicki B., Panek S., Sikora P., Stołyhwo E. 1962: Zarys Antropologii. Warszawa.
Kamieńska J. 1964: Osada kultur wstęgowych w Samborcu, pow. Sandomierz. Studia i Mat. do Badań nad Neolitem Małopolski 4 p 77.
Krysiak, K. 1950: Szczątki zwierzęce z Biskupina wydobyte z warstwy kultury łużyckiej w sezonie wykopaliskowym 1948. III Sprawozdanie z prac wykoplaiskowych w Biskupinie. Poznań p 39.
Krysiak, K. 1950, 1951–1952: Szczątki zwierzęce z osady neolitycznej w Ćmielowie. Wiad. Arch. 17 p 165 and 18 p 251.
Krysiak, K. 1956: Materiały zwierzęce z osady neolitycznej w Gródku Nadbużnym, pow. Hrubieszów. Wiad. Arch. 23 p 49.
Krysiak, K. 1958: Charakterystyka materiału zwierzęcego ze stanowiska w Jeziorku, pow. Giżycko. Mat. Starożytne 3 p 171.
Krysiak, K. 1966: Szczątki zwierzęce z grodziska we wsi Sąsiadka, pow. Zamość. Światowit 27 p 171.
Krysiak, K. 1967: Wyniki badań nad materiałem zwierzęcym z wykopalisk w Gdańsku. Gdańsk Wczesnośredniowieczny 6 p. 7.
Krysiak, K.: and Lasota, A. 1971: Zwierzęce materiały kostne z osady Kamień Łukawski, pow. Sandomierz. Wiad. Arch. 36 p 187.
Krysiak, K. and Lasota, A. 1972: Szczątki zwierzęce z osady z okresu rzymskiego w Mierzanowicach, pow. Opatów. Wiad. Arch. 38 p 293.
Krysiak, K. and Lasota-Moskalewska, A. and Świeżyński, K. 1975: Analiza zwierzęcych szczątków kostnych z wczesnośredniowiecznej osady w Radomiu. Arch. Polski 20 p 377.
Kubasiewicz, M. 1955: Szczątki kostne zwierzęce z osady wczesnośredniowiecznej Szczecin — Mścięcino. Mat. Zachodnio-Pomorskie 1 p 73.
Kubasiewicz, M. 1956: Szczątki kostne zwierzęce z Wolina-Przedmieścia. Mat. Zachodnio-Pomorskie 2 p 211.
Kubasiewicz, M. 1957: Dotychczasowe badania nad materiałem kostnym z wczesnośredniowiecznego podgrodzia w Szczecinie. Mat. Zachodnio-Pomorskie 3 p 189.
Kubasiewicz, M. 1958: Szczątki zwierzęce ze stanowiska neolitycznego w Ustowie, pow. Szczecin. Mat. Zachodnio-Pomorskie 4 p 41.
Kubasiewicz, M. 1959: Szczątki zwierzęce z wczesnośredniowiecznej osady Gardziec, pow. Kamień Pomorski. Mat. Zachodnio-Pomorskie 5 p 157.
Kubasiewicz, M. and Gawlikowski, J. 1969: Szczątki zwierzęce z osady rzymskiej w Cedyni. Mat. Zachodnio-Pomorskie 5 p 145.
Kulczycka-Leciejewiczowa, A. 1969: Nowa Huta-Pleszów. Osada neolityczna kultury ceramiki wstęgowej rytej i lendzielskiej. Mat. Arch. Nowej Huty 2 p 7.
Lasota-Moskalewska, A.: Kości zwierzęce ze stanowiska w Tarławkach. Wiad. Arch. /in press/.
Malinowski, T. 1957–1958: Osadnictwo kultury łużyckiej wczesnej epoki żelaznej w Słupcy. Fontes Arch. Posn. 8–9 p 1.

Okulicz, J. 1973: Pradzieje ziem pruskich od późnego paleolitu do VII w. n. e. Wrocław-Warszawa-Kraków-Gdańsk p 253.
Siuchniński, K. 1958: Dotychczasowe wyniki badań na osadzie kultury pucharów lejkowatych w Ustowie, pow. Szczecin. Mat. Zachodnio-Pomorskie 4 p 17.
Sobociński, M. 1960: Zwierzęta udomowione i łowne z młodszej epoki kamienia w Nosocicach w pow. Głogowskim. Przegląd Arch. 13 p 122.
Sobociński, M. 1961: Szczątki kostne zwierząt z osady z II–III w. n. e. w Słupie, pow. Środa Śląska. Silesia Antiqua 3 p 150.
Sobociński, M. 1970: Materiał kostny zwierzęcy z wykopalisk w Kobylnikach i Aleksandrowie, pow. Busko Zdrój. Studia związane z badaniami w Wiślicy 5 p 257.
Sobociński, M. 1970: Szczątki kostne zwierzęce z wykopalisk w Wiślicy. Studia związane z badaniami w Wiślicy 5 p 221.
Sych, L. 1960: Szczątki kości zwierzęcych z późnolateńskiej i rzymskiej osady w Mogile k/Krakowa. Mat. Arch. 2 p 231.
Sych, L. 1964: Szczątki zwierzęce z neolitycznej osady w Książnicach Wielkich, pow. Kazimierza Wielka. Studia i materiały do badań nad neolitem Małopolski. Wrocław-Warszawa-Kraków p 329.
Świezyński, K. 1966: Szczątki zwierzęce z neolitycznej osady bagiennej w Szlachcinie w pow. Średzkim. Przegląd Arch. 17 p 80.
Wanke, A. 1953: Metoda badań częstości występowania zespołów cech czyli metoda stochastycznej korelacji wielorakiej. Przegląd Antrop. 19 p 106.
Wiślański, T. 1969: Podstawy gospodarcze plemion neolitycznych w Polsce północno-zachodniej. Wrocław-Warszawa-Kraków.
Wołągiewicz, R. 1960: Osada i grób z okresu rzymskiego w Cedyni nad Odrą. Mat. Zachodnio-Pomorskie 6 p 97.
Wyrost, P. 1965: Zwierzęce szczątki kostne z wczesnośredniowiecznego grodziska w Kędrzynie, pow. Kołobrzeg. Przegląd Zool. 9 p 301.

Table 1.

Surpluses and deficiencies of animal bone fragments in materials from the Neolithic Funnel Beaker Culture.

Site name Map number		Cattle	Pig	Sheep and goat	Total
ĆMIELÓW	n	1626	570	284	2480
3	ñ	1542	605	333	
(Krysiak, 1950,51,52)	n-ñ	+ 84	- 35	- 49	
	ψ^+	2,746¶			
	R	5,45%			
GRÓDEK	n	1265	453	252	1970
4	ñ	1226	480	264	
(Krysiak, 1956)	n-ñ	+ 39	- 27	- 12	
	ψ^+	1,327			
	R	3,18%			
KAMIEŃ ŁUKAWSKI	n	1676	582	403	2661
5	ñ	1655	649	357	
(Krysiak, Lasota, 1971)	n-ñ	+ 21	- 67	+ 46	
	ψ^+	0,688		1,942	
	R	1,27%		12,88%	
KSIĄŻNICE WIELKIE	n	150	137	25	312
6	ñ	194	76	42	
(Sych, 1964)	n-ñ	- 44	+ 61	- 17	
	ψ^+		4,692¶		
	R		80,26%		
NOSOCICE	n	383	206	189	778
7	ñ	484	190	104	
(Sobociński, 1960)	n-ñ	-101	+ 16	+ 85	
	ψ^+		0,898	5,58ó¶	
	R		8,42%	81,73%	
SZLACHCIN	n	57	14	11	82
8	ñ	51	20	11	
(Swiezynski, 1966)	n-ñ	+ 6	- 6	0	
	ψ^+	0,732			
	R	11,76%			
USTOWO	n	383	268	76	727
9	ñ	453	177	97	
(Kubasiewicz, 1958)	n-ñ	- 70	+ 91	- 21	
	ψ^+		5,315¶		
	R		51,41%		
ZAWARZA	n	489	133	60	682
10	ñ	424	166	92	
(Sych, see Wiślański 1969)	n-ñ	+ 65¶	- 33	- 32	
	ψ^+	2,929			
	R	15,33%			
	total	6029	2363	1300	9692

$\chi^2 = 281,6 > \chi^2_{\alpha=0.01} = 29,1$; $(k_1 - 1)(k_2 - 1) = 14$

¶means that $\psi^+ > \psi^+_{\alpha=0.01}$

Table 2.

Surpluses and deficiencies of animal bone fragments in materials representing four Neolithic cultures (arranged in chronological order)

Site and culture name Map number		Cattle	Pig	Sheep and goat	Total
SAMBORZEC	n	185	42	15	242
1	$\tilde{n}$	148	65	29	
Linear Pottery	$n-\tilde{n}$	+ 37	- 23	- 14	
Culture	ψ^+	2,671¶			
(Sych, see Wiślański, 1969)	R	25,00%			
PLESZÓW	n	514	48	10	572
2	$\tilde{n}$	351	155	66	
Lengyel Culture	$n-\tilde{n}$	+ 163	-107	- 56	
(Sych, see Wiślański, 1969)	ψ^+	8,666¶			
	R	46,44%			
CMIELÓW	n	1626	570	284	2480
3	$\tilde{n}$	1521	674	285	
Funnel Beaker	$n-\tilde{n}$	+ 105	-104	- 1	
Culture	ψ^+	3,715¶			
(Krysiak, 1950,51,52)	R	6,90%			
GRÓDEK	n	1265	453	252	1970
4	$\tilde{n}$	1208	535	227	
Funnel Beaker	$n-\tilde{n}$	+ 57	- 82	+ 25	
Culture	ψ^+	2,105		1,316	
(Krysiak, 1956)	R	4,72%		11,01%	
ZESLAWICE	n	990	914	302	2206
11	$\tilde{n}$	1352	598	256	
Radial Decorated	$n-\tilde{n}$	- 362	+316	+ 46	
Pottery Culture	ψ^+		12,595¶	2,281	
(Sych, see Wiślański, 1969)	R		52,84%	17,97%	
	total	4580	2027	863	7470

$\chi^2 = 536,5 > \chi^2_{\alpha=0.01} = 20,1;\ (k_1 - 1)(k_2 - 1) = 8$

¶means that $\psi^+ > \psi^+_{\alpha=0.01}$

Table 3.

Surpluses and deficiencies of animal bone fragments in materials from the Iron Age.

Site and period name Map number		Cattle	Pig	Sheep and goat	Horse	Total
BIKUSPIN	n	297	127	117	59	600
12	ñ	298	130	123	49	
Hallstatt	n-ñ	- 1	- 3	- 6	+ 10	
(Krysiak, 1950)	ψ^+				0,952	
	R				20,41%	
SLUPCA	n	873	206	278	185	1542
13	ñ	766	334	317	125	
Hallstatt	n-ñ	+ 107	- 128	- 39	+ 60	
(Chmielewski, 1957-58)	ψ^+	4,136¶			3,927¶	
	R	13,97%			48,00%	
JEZIORKO	n	70	66	148	143	427
14	ñ	212	92	88	35	
La Tenne	n-ñ	- 142	- 26	+ 60	+ 108	
(Krysiak, 1958)	ψ^+			4,464¶	11,688¶	
	R			68,18%	308,57%	
TARLAWKI	n	868	408	571	70	1917
15	ñ	952	415	394	156	
La Tenne	n-ñ	- 84	- 7	+ 177	- 86	
(Lasota-Moskalewska,	ψ^+			7,128¶		
in press)	R			44,92%		
CEDYNIA	n	325	194	119	26	664
16	ñ	330	143	137	54	
Roman	n-ñ	- 5	+ 51	- 18	- 28	
(Kubasiewicz,	ψ^+		3,121¶			
Gawlikowski, 1959)	R		35,66%			
KOBYLNIKI	n	827	300	216	97	1440
17	ñ	715	312	296	117	
Roman	n-ñ	+ 112	- 12	- 80	- 20	
(Sobociński, 1970)	ψ^+	4,480¶				
	R	15,66%				
MIERZANOWICE	n	466	210	195	34	905
18	ñ	499	196	186	74	
Roman	n-ñ	+ 17	+ 14	+ 9	- 40	
(Krysiak, Lasota, 1972)	ψ^+	0,752	0,739	0,483		
	R	3,79%	7,14%	4,84%		
MOGILA	n	121	162	3	27	313
19	ñ	155	68	64	26	
Roman	n-ñ	- 34	+ 94	- 61	+ 1	
(Sych, 1960)	ψ^+		7,886¶		0,126	
	R		138,24		3,85%	

SLUP	n	182	84	21	20	307
20	ñ	152	67	63	25	
Roman	n-ñ	+ 30	+ 17	+ 42	- 5	
(Sobociński, 1961)	ψ^+	2,083	1,441			
	R	19,74	25,30%			
	total	4029	1757	1668	661	8115

$\chi^2 = 1044,9 > \chi^2_{\alpha=0.01} = 43,0$; $(k_1 - 1)(k_2 - 1) = 24$

¶ means that $\psi^+ > \psi^+_{\alpha=0.01}$

Table 4.

Surpluses and deficiencies of animal bone fragments in materials from the Middle Ages.

Site name Map number Century		Cattle	Pig	Sheep and goat	Horse	Total
GDAŃSK	n	3518	4583	1491	384	9976
21	ñ	4061	3398	1283	1234	
XII - XIII	n-ñ	- 543	+ 1185	+ 208¶	- 850	
(Krysiak, 1967)	ψ^+		17,939¶	4,251¶		
	R		34,87%	16,21%		
RADOM	n	2524	1880	690	493	5587
22	ñ	2274	1903	718	692	
IX - XII	n-ñ	+ 250	- 23	- 28	- 199	
(Krysiak, Lasota,	ψ^+	4,535¶				
Świeżyński, 1975)	R	10,99%				
SASIADKA	n	11920	9372	3646	5647	30585
23	ñ	12451	10419	3931	3784	
XI - XIII	n-ñ	- 531	- 1047	- 285	+1864	
(Krysiak, 1966)	ψ^+				28,414¶	
					49,26%	
WIŚLICA	n	3226	2362	544	431	6563
24	ñ	2673	2235	843	812	
X - XIII	n-ñ	+ 553	+ 127	- 299	- 381	
(Sobociński, 1970)	ψ^+	9,122¶	2,142			
	R	20,69%	5,68%			
LUND	n	1780	1021	880	25	3706
XI - XIV	ñ	1509	1263	476	458	
(Ekman, 1973)	n-ñ	+ 271	- 242	+ 404	- 433	
	ψ^+	5,670¶		12,006¶		
	R	17,96%		84,87%		
	total	22968	19218	7251	6980	56417

$\chi^2 = 3480,0 > \chi^2_{\alpha=0.01} = 26,2$; $(k_1 - 1)(k_2 - 1) = 12$

¶ means that $\psi^+ > \psi^+_{\alpha=0.01}$

Solving a mystery death

NILS-GUSTAF GEJVALL AND GUNNAR JOHANSON

OSSA

This paper presents a unique case of identification of bones found by some American school-children and handed over through Interpol from the American Police to the Swedish.

A combined method of very intricate physical and chemical treatment of an almost destroyed passport, the figures of which just two or three could be identified, the comparison of a series of photographs of the cranium with portraits of the suspected deceased person and his father (superimposition) and the discovery of enamel hypoplasia together with obvious signs of cribra craniae & orbitae (pathological changes in the skull vault and the eye sockets) and many other unexpected details of identification, e.g. from the cuorir vivre of the deceased person led to a valid identification of a Swedish student missing after a journey to the States, and, beeing found with a gun-shot through the temples, probably the victim of murder.

В статье представлен уникальный случай идентификации костей, найденных несколькими американскими школьниками и переданных американской полицией в шведскую через посредничество ИНТЕРПОЛ'я.

Совместный метод очень сложной физической и химической обработки почти распавшегося паспорта, в котором удалось идентифицировать всего лишь две или три цифры, сравнение серии фотографий черепа с портретами предполагавшегося умершего лица и его отца (суперпозиция), а также обнаружение гипоплазии зубной эмали одновременно с очевидными признаками cribra craniae и orbitae (патологические изменения в своде черепа и в глазных впадинах) и многие другие неожиданные детали, выявившиеся при идентификации, например, – из образа жизни умершего лица, вели к надёжной идентификации шведского студента, пропавшего во время путешествия по США и найденного с пулевым отверстием в виске, позволяющим предположить, что он стал жертвой убийства.

Nils-Gustaf Gejvall, University of Stockholm, Osteological Research Laboratory, S–171 71 Solna, Sweden.
Gunnar Johanson, Government Institute of Forensic Medicine, Fack, S–171 20 Solna, Sweden.

Vol. 3/4 pp 169–181, Lund. ISSN 0345–8865.

After a great deal of hard work, Swedish scientists and criminal investigation experts have succeeded in solving the mystery surrounding a death in Colorado Springs in the USA, where portions of a human skeleton were found in May 1975 together with various personal belongings. It came to be suspected that the deceased might be a young Stockholmer who had disappeared from Sweden in 1968. The Swedish team called in by the FBI have now been able to establish that this was the case, though the question of murder or suicide remains unanswered.

The following article is a summary of the Swedish team's report, which has resulted from a long process of patient deduction and which offers a

number of important lessons in the field of identification techniques. This article, which is to be sent to the US police authorities, has been published by permission of the parents of the deceased. The mother of the deceased is in fact a research scientist and has herself taken part in certain stages of the inquiry.

The scientific experts in the team were forensic odontologist Professor Gunnar Johansson and osteologist Professor Nils-Gustaf Gejvall. The police personnel taking part were Detective Superintendant Sten Sture Sandberg, Detective Inspectors Evert Sundman and Ingemar Wahlberg of the Swedish Homicide Commission, Lilian Tufvesson, who is a photographer at the Forensic Department of the Stockholm Police, and members of the National Laboratory of Forensic Science and of the Passport Registry Department at the National Police Board.

A parcel arrived containing a skull and fragments of a passport which the US authorities had found was Swedish. Det. Insp. Ingemar Wahlberg began by forwarding the passport to the National Laboratory of Forensic Science. Although the passport was in such a bad state, Det. Sgt Sten Isaksson was able to identify certain strategic letters. The National Police Board then combed the records of their Passport Registry Department and were able to trace the full name of the holder of the passport.

Starting point: a skull and fragments of a passport. The first clue came from the passport records.

On 18th May 1975 Detective Constable James Ivey at the El Paso Sheriff's Office in Colorado Springs, USA, was informed that six young people had found the remains of a dead body the previous day close to the Big Tooth reservoir west of Moniton Springs. More exactly, they had found skeletal remains completely devoid of soft tissue.

The thigh bones protruded from a pair of cut off jeans, while the lower legs appeared to be missing altogether.

The thorax was in an advanced state of disintegration and was only held together by a white wollen jersey.

The lower jaw was missing from the skull, and the upper jaw retained a few molars.

Beside the skeleton the young people who made the discovery noticed among other things a comb and various other personal belongings.

The skeleton lay in a rock crevice. Both shin bones and one fibula lay about 3.5 metres below the trunk. The skull was found apart from the trunk. A blue airline bag marked "Capitol International Airline" appeared to have been placed under the head as a cushion. The lower jaw was found further away together with parts of the skeleton which had probably been dragged there by animals.

An ingoing bullet hole was found in the right temple (cf. fig. 1) and an exit hole in the left temple. The entry hole is 1 cm in diameter while the exit hole measures 1.2 cm. Beside the skeleton was found a box of Remington ammunition containing forty-four 0.22 short bullets. The standard content of this type of box is fifty rounds. Presumably a six-chamber revolver magazine was loaded from the box, but no weapon has been found, which means that the possibility of foul play cannot be discounted.

In addition to articles of clothing, the following objects were found close to the skeleton: a wrist watch, a black comb, spectacles, a map of Colorado and Utah, a dark blue umbrella, a hunting knife (with a wooden handle and of the kind known as a Mora knife), a long-sleeved blue shirt, a white knitted V-necked pullover, blue swimming trunks, a windcheater, a pair of half-length socks, a pair of shoes and the bag and the box of ammunition which have already been referred to.

Fragments of a passport

Fragments of a passport were found about 12 metres away from the skeleton, but it was impossible to distinguish any number of name identifying the person to whom the passport had been issued.

The only things that could be deciphered were the stamp of the Mexican Consulate General in Los Angeles and a US entry stamp. The remains of the passport were scientifically examined at the Berlitz School, 36 Steele Denver Colorado.

This examination showed that it was impossible to bring out particulars concerning the identity of the passport holder, but it was established, on the strength of watermarks and the printer's mark on the back page, that the passport was Swedish.

Died in 1974

The coroner, Dr. Ulrich, was notified of the discovery of the skeleton by Sgt. Tinsley, who was in charge of the preliminary investigation. Dr. Ulrich requisitioned all the evidence discovered, in the hope of establishing the identity of the deceased and the circumstances of death. He was able to establish that the skeleton was that of a white man of about 25 (definitely aged between 20 and 30 cf. fig. 3). The length of the thigh bones indicated that when alive the deceased had been about 172-177 cm tall.

The skull had perfectly visible bullet holes in the squamous part of the temporal bone. Concerning the ammunition (0.22 short-plated, dipped in brass), Dr. Ulrich doubted, in the light of inquiries he had previously conducted, whether ammunition of this kind would have sufficient impact to pass through a body, especially if the projectile struck bone. The estimated time of death was August or September 1974.

Swedish assistance requested

On account of the result of the examination of the passport by the Berlitz School, a request was made, via the Swedish Consulate General in Minneapolis (and the Swedish Ministry for Foreign Affairs), to the Swedish police authorities for help in identifying the skeleton.

This request was received on 16th October 1975 by the Interpol Section of the National Police Board, which referred the matter to the Homicide Commission. The passport fragments were forwarded to the National Laboratory of Forensic Science, which succeeded in deciphering three letters of the holder's surname, one letter of one of his Christian names and four letters of another Christian name.

A routine check of police records to see whether persons having these Christian names had been fingerprinted failed to produce any result.

First clue in the passport records

A systematic review of the records of the Passport Registry Department revealed one person whose Christian names and surnames tallied with the deciphered letters.

This person had been born in 1946. His latest passport had been issued on

5th April 1968 and was valid until 5th April 1973. An inquiry addressed to the authorities in the parish where this person was registered as a resident revealed that he had been reported missing on a journey in the USA in 1968.

After the identification process had thus been completed the Colorado Springs police were asked to send the jawbones of the deceased to Sweden for forensic odontological examination. The skull arrived in Sweden for odontological examination in February 1976.

New localization system

The reason for this request was as follows. The USA has thirty or forty different registration systems for determining the location of the teeth in the jawbones. Sweden uses the Haderup system, in which the teeth are designated 8+, 7+, -2, -3 and so on. A new international system, the FDI system, has been introduced in Sweden and many other European countries during the past few years but is insignificantly applied in the USA. The FDI system divides the mouth into four squares, numbered off 1, 2, 3 and 4. The number of each tooth is then preceded by the number of its square.

The purpose of the new system is to provide a simple international means of communication which presents no risk of confusion and which can, for example, be used telegraphically in connection with major disasters.

To avoid all possibility of error, therefore, the skull was sent to Sweden, where it was examined and compared with the written records and X-ray photographs kept by the dentist who had treated the person now presumed to be the deceased.

Odontological and osteological examination

The cranium is in a good state of preservation. The soft tissues have disappeared completely. Most of the single-rooted teeth have disappeared since death, the alveoli being empty.

The four wisdom teeth are completely formed but are still in the jawbones. This fact, revealed by X-ray examination, indicates that the deceased was over 20. The small number of fillings points to an unusually low caries frequency.

The deceased person's father is a dentist and his mother is a trained archaeo-

logist.

A comparison has been made between the records and X-ray photographs supplied by the father and the dental status and complete X-ray status compiled by the forensic odontologist.

The two sets of records agree perfectly. The X-ray picture received of the front dental area of the maxilla - teeth 12 ... 22 - is directly comparable with the corresponding full status picture. The upper front teeth are missing, it is true, but the direction and appearance of their alveoli are directly comparable.

All of the remaining teeth display light strips in the enamel, known as enamel hypoplasia (fig. 4) and due to disruptions in the supply of nourishment while the teeth were being formed. The position of these strips on the crowns of the teeth - they are differently positioned in different teeth - shows that the deceased suffered from nutritional disturbances of this kind some time between the ages of 7 and 10, due for example to a prolonged feverish ailment. This has been confirmed by the mother of the deceased.

There are also certain changes - in the form of innumerable small holes - in the parietal bones and the orbits. These changes are technically termed Cribra cranii et orbitalia, and like the enamel hypoplasia they are attributed to nutritional disturbances (fig. 5). They can also produce changes - known as retardation lines - in the long tubular bones. Signs of such changes can be detected by X-raying the long shaft bones.

Measurement of long tubular bones gave exact stature. Superimposition confirmed.

Idiosyncrasies compared

The parents of the deceased requested and were given the opportunity of examining the skull.

Certain idiosyncrasies in the skull were directly comparable with their son's appearance and were confirmed by means of photographs.

1. Shape of the head

The son took size 55 in hats and the skull was 50 cm in circumference. These figures tally, because an extra 5 cm or so must be allowed for soft tissues and hair.

2. The chin

The son had a pronounced chin with two tubercles which are clearly apparent in the skull and from photographs (cf. fig. 1).

3. The nose

The son had a prominent nose, and this is confirmed by the unusually long nasal bone of the skull, which is some 30-33 mm long. According to the literature on the subject, the average length of a normal nasal bone is about 25 mm.

4. Frontal lobes

The son had prominent eyebrows, and the skull too displays heavy frontal lobes.

5. Teeth

The father recognizes the shape of both jawbones and the few fillings which he himself administered.

The positive assistance rendered by the parents was solely dictated by their efforts to ascertain what had happened to their missing son. They declared: "We will never allow these remains to be buried as those of our own son unless they have been identified beyond all shadow of doubt."

The osteological examination revealed abrasions in the uppermost part of the frontal bone which may suggest that, after his death, the deceased was dragged by the feet and placed in the crevice where his remains were found. Is it possible for a person committing suicide to take up a position of this kind, fire a fatal shot into his head and then adopt a resting position with his head on the cushion provided by a flight bag?

Same stature

The following measurements were obtained from the long tubular bones, with the aim of deducing the height of the deceased.

Left femur	475 mm	174 cm
Right femur	472 mm	
Left tibia	393 mm	178 cm
Right tibia	396 mm	
Left ulna	260 mm	177 cm
Left radius	246 mm	172 cm
Right fibula	389 mm	176 cm
	Average stature	176 cm

These measurements and calculations were undertaken according to the instructions contained in Per Holck, Skjelettgraving, Oslo 1970.

The passport belonging to the missing Swede stated that he was 176 cm tall.

The skeletal remains were consistently male in character.

Good indications

Judging by the pelvic joints, the age of the deceased could be put at about 27-32 years. At the time of his death the man was 28 years old (cf. fig. 3).

These particulars have provided good indications for the establishment of the identity of the deceased, and nothing has transpired to contradict the result obtained. The identification was finally confirmed by the superimposition of the skull on photographs of the missing person.

Comparison of photograph and drawing

Superimposition is the term for a comparison of an outline drawing, a photograph or an X-ray of a skull and one or more portraits, passport photographs or other photographic (or artistic) images of one or more persons, the purpose of the comparison being to identify the owner of the skull.

Copied onto each other

In practice, superimposition can be done in various ways, but the golden rule is that the skull to be identified and the picture of a head to be compared with it must as far as possible be reproduced from the same angle, and preferably, from more or less the same distance, and the picture of the skull has to be reduced sufficiently to fit the head with which it is being compared.

Superimposition is done in a darkroom in yellow light (the same as is used for photographic printing). The objects to be compared are copied onto each other after aligning certain anthropological points in the portrait and cranium, e.g. the root of the nose (nasion) and point of the chin (gnathion) or, if the mandible is missing (prosthion), the edge of the upper jaw between the front upper teeth (fig. 2).

Tried to efface his identity

The parents of the missing person stated that on Monday 24th June 1968 their son had left on a charter trip to the USA with the American charter company Capitol Airways' flight CL 520. It also transpired that their son had suffered from mental disturbances in 1966-67 while performing his military service. Early in 1967 he absconded from military service after a period of leave and went "bumming" in the south of Europe. He returned to Sweden 1 1/2 months later, and according to his parents it seemed as though during his absence he had "tried to efface his identity" by getting rid of his passport and removing the manufacturers' tags from his clothing. After his return home he was brought before the military authorities for going absent without leave.

The medical examination carried out in conjunction with the investigation which then took place did not reveal any mental illness. According to the doctor, the reason for the young man's absconding seemed to be "a state of mental insufficiency which must be regarded as a desperate short-circuit action on the part of an asthenic-psychosthenic under excessive strain".

Very depressed

The medical records from the missing person's period of military service also show that for some years past he had suffered from general dysphoria (feeling ill) and a subdued basic state, and that he had declared himself to be tired of life. The parents have also stated that their son was "very depressed" at the time of his journey to the USA and that there was no contact between them. They tried unsuccessfully to induce him to consult a psychiatrist in order to discuss his case and, possibly, to undergo treatment.

Appeared screened off

The guide in charge of the charter group with which the missing person travelled to the USA has also been consulted. He stated that on their arrival in the USA he had spent two nights together with the missing man at a hotel in New York because the man had travelled on his own and did not have any contact with the other 121 passengers. They parted company, however, on Wednesday 26th June 1968 at about 11 a.m., when the missing person caught a Greyhound coach for Chicago. The missing person did not turn up at Kennedy Airport on Sunday 18th August 1968

for the return journey to Sweden, as had been agreed. In the course of conversation the guide mentioned that all the members of this charter group had been given a presentation bag by the airline, marked "Capitol Airlines". Concerning the mental state of the missing person on this occasion, the guide stated that he seemed screened off and pensive and that he behaved as though he wanted to get away from something and think things over. It also seemed as though he lacked "joie de vivre".

The right lens of the spectacles found together with the body is intact while the left one is broken. The frames are of the "OWP Americano" brand. Inquiries among the opticians visited by the missing person in Sweden have shown that both the dioptric and the cylinder values tally with the remains of the left hand lens. The right hand lens deviates very slightly (-0.25) from these values. In a word, the values recorded by the opticians in question are practically identical with those of the lenses found near the body. The wholesaler who dealt in frames of the above mentioned make has confirmed that he supplied frames of this kind to the optician last consulted by the missing person.

Wristwatch another piece of evidence

The wristwatch found with the body was a "Consul". One of the strap mountings bore the inscription "4/67 K". It was established that the watch had not been sold by any of the "Star" watchmakers in Sweden. An inquiry was made at the Trade Department of the Swiss Embassy in Stockholm, which stated that there was a firm called "Consul SA" in La Chaux - De Fronde in Switzerland. Consul SA confirmed that 250 watches of the kind in question were manufactured between 1965 and 1966. At that time there were two buyers in Sweden. Further inquiries have revealed that in all probability this particular watch was sold some time towards the end of the 1960s by a Stockholm watchmaker's shop which has since gone out of business.

A watchmaker formerly employed in the shop has confirmed that it sold wristwatches of the make in question and that it used an inscription of the kind illustrated here. The inscription "4/67 K" indicates that the watch was sold in April 1967, while "K" is the first letter of the name of the shop. The shop itself was close by the building in which the missing person was living at the time. As further substantiation of his opinion that the wristwatch had been sold in that particular shop, the watchmaker produced a remaining Consul watch from the same series

and with a serial number not far removed from that of the watch in question.

Although the knife found on the scene was in very bad condition - the blade, for example, being heavily corroded - the National Laboratory of Forensic Science was able to identify it as being made by the firm of Erik Frost, Mora, in Sweden.

Bullet wound investigated

The skull has also been examined at the National Laboratory of Forensic Science in order, if possible, to ascertain whether the wound was inflicted with the muzzle of the weapon held against the head. The presence of lead and barium has been established, not only round the edges of the hole in the right temple but also at a certain distance from them. This may indicate a shot at point blank range, but it is impossible to draw completely reliable conclusions, because not enough is known concerning conditions at the place where the skull was found or concerning the manner in which the skull was stored and handled after its discovery.

The other objects found with the skeleton have not contributed towards its identification.

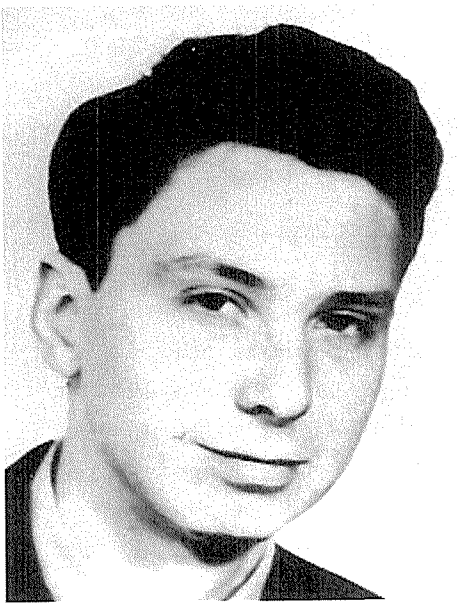


Figure 1. Photo of the missing young person.

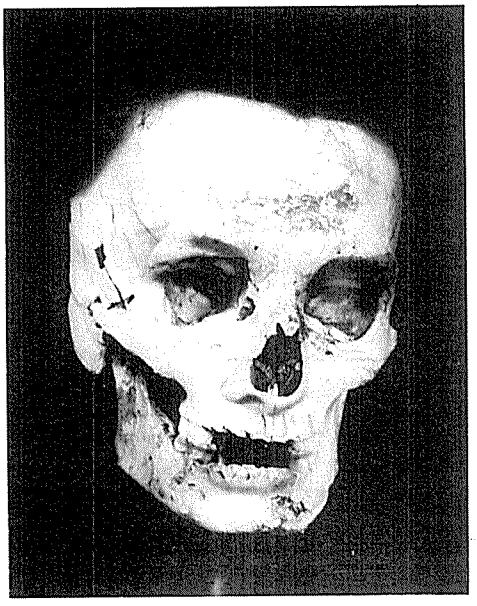
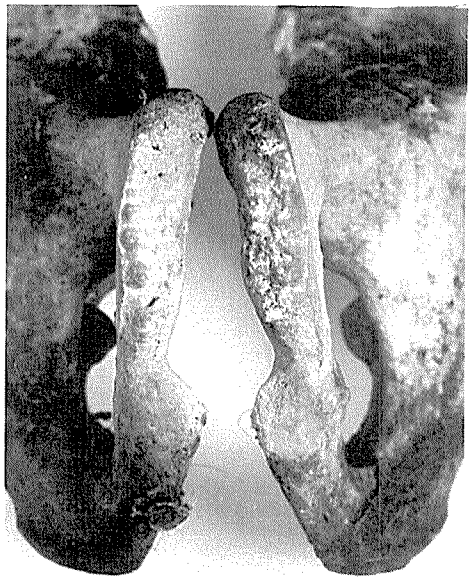
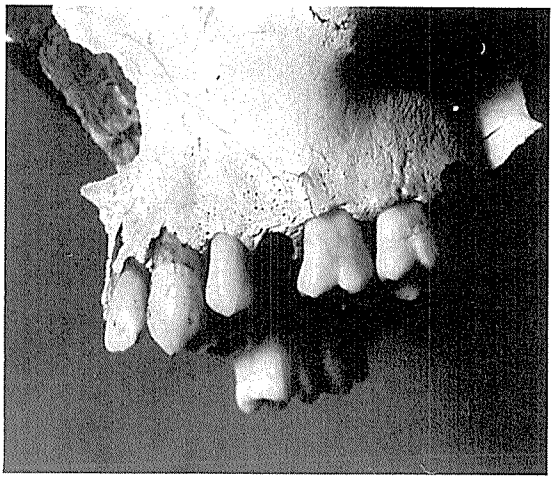


Figure 2. Superimposition of the cranium on the photo in fig. 1.





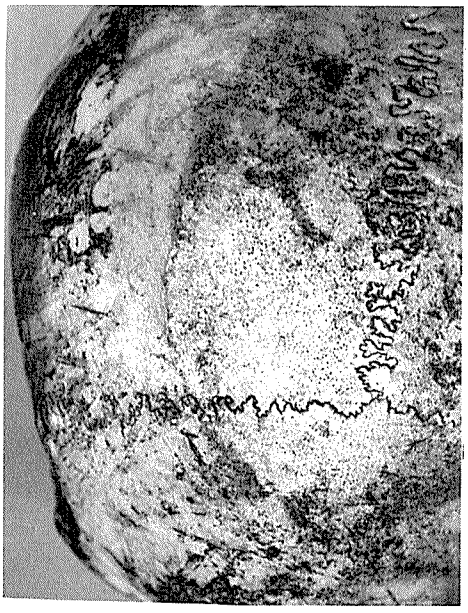


Figure 3. (top left)
The pubic symphysis is of the deceased supporting the age determination.

Figure 4. (top right)
Left maxilla of the cranum showing dental status and enamel hypoplasiae.

Figure 5. (bottom)
Frontal and parietal portion of the cranium with signs of Cribra cranii.

Iron from cannon balls in teeth and jaws

Odontological identification of findings from the War-ship Wasa 1628

GUNNAR JOHANSON

OSSA

Human teeth from individuals deceased when the Swedish flag ship Wasa capsized and sunk in the Harbour of Stockholm in August 1628 have proved to contain small metal-like fragments in their pulp chambers. Analysis shows that these fragments consist of about 95 percent iron-phosphate or vivianite ($Fe_3(PO_4).8H_2O$).

Как было доказано, человеческие зубы, принадлежавшие людям, погибшим на шведском флагманском корабле "Васа", опрокинувшемся и затонувшем в стокгольмской гавани, в августе 1628 г., содержат мелкие, металлоподобные фрагменты в пульпарных камерах. Анализ показывает, что эти фрагменты состоят приблизительно из 95% фосфата железа или вивианита [$Fe_3(PO_4).8H_2O$].

Gunnar Johanson, Government Institute of Forensic Medicine, Fack, S-171 20 Solna, Sweden 1.

Vol. 3/4, pp 183–187, Lund. ISSN 0345–8865.

Perhaps the title of this article seems curious, but in fact particles from iron cannonballs have been shown to have entered the pulp chamber as small radiopaque deposits.

From 1959 and till now, a most important archaeological work has taken place in Sweden to present and preserve one of the most interesting discoveries of the century, an old war-ship, built in 1628. This ship capsized and sank on her maiden voyage.

The Thirty Years´ War was raging in Europe. One of the principle figures was the Swedish King Gustaf II Adolf, who was to bring poor little Sweden to a position as a Great European Power.

But between Sweden and the continent was the Baltic Sea. A strong navy was the vital condition for the Swedish King and his troops. In 1625 the King ordered four ships to be built, two bigger and two smaller. The keel to the second bigger ship - The Wasa - was laid in 1626. However, this new flagship capsized and sank just below Stockholm Castle in August 1628.

In 1959, a young engineer interested in naval history succeeded, using a sounding-lead, in locating what proved to be the wreck of the Warship Wasa. After the salvage operation, the war-ship was hailed as one of the most interesting archaeological and historical discoveries of the century. Fig. 1.

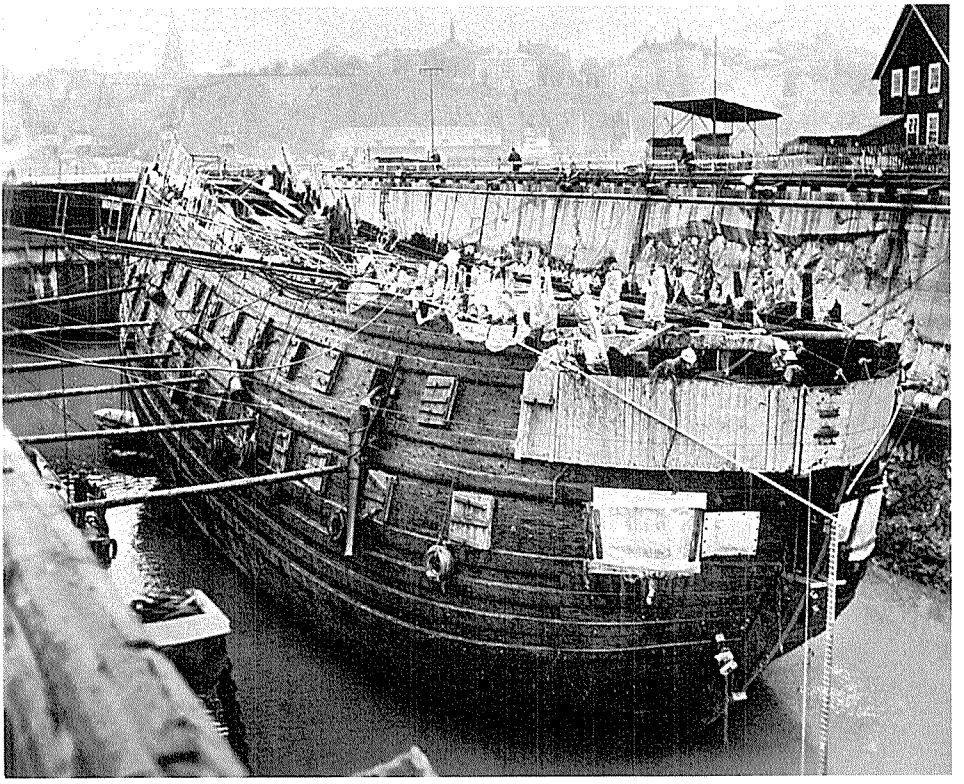


Figure 1. The Wasa resting on the bottom of the dry dock.

The archeological work included an odontological identification of the fairly well-preserved jaws and teeth.

Five crania with teeth and eight separate mandibles and some loose teeth were examined.

As is generally the case, all teeth were like those from archaeological excavations, with pronounced attrition but without signs of caries or profound periodontal disease. Fig. 2.

Figure 2. All the teeth show pronounced attrition.

A visual description of all the teeth was made, photographs in black and white and colour were taken as well as X-rays of all teeth and jaws. The colour of the mandibles varied widely from white-yellow to dark-blue, depending on where they were found in the ship. From the teeth an estimation of the age of the victims was made and the osteological examination determined the sex.

One of the most interesting results of X-ray examination was that in many of the teeth and jaw-bones, small deposits of radiopaque structures were found. In a number of the loose molars some silver-like pins several mm long were discovered in the apical third of the root. Using a smaller diaphragm on the

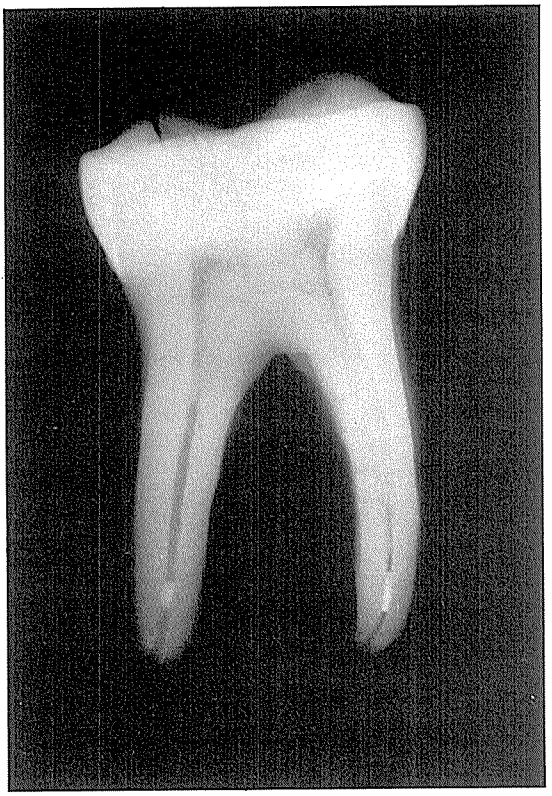


Figure 3. In the apical third of the root small silver-like pins - radiopaque structures - could be recognized.

X-ray (Fig. 3) you can distinctly see these small pins. The tooth is intact, so how is it possible to find metal-like pins in the pulp chamber?

That part of the root was cut off and for microscopical investigation it was ground down to about 75-100 micron thin sections.

X-ray diffraction analyses of the deposits in the teeth showed that these small metal-like fragments consisted of about 95% iron-phosphate, which mineralogists call vivianite ($Fe_3(PO_4)8H_2O$). Fig. 4.

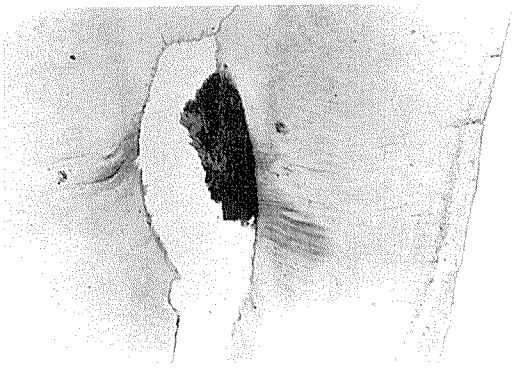


Figure 4. The ground-section showing the deposit on the pulp-chamber wall.

But what has happened here? When a drowned human being decomposes, the decomposition first happens with the skin and other soft tissue. Only the skeleton remains, but in the bone-cavities and above all in the pulp chambers the highly differentiated tissue remains unchanged during a long time.

The iron, which precipitates from cannon balls or other iron-objects, has in this way a longer time to be bound chemically with the phosphates in for example the pulp tissue. This precipitation is probably a reduction of the iron against the protein-amino-acid or aminopolysaccharide in the pulp. First of all a formation of iron sulphate is formed, which then is transformed to ferrophosphate and than by oxidation to ferriphosphate, that is - vivianite. In the closed pulp chamber the final products is collected in the shape of crystals.

In the same way the same final product appears in the jaw-bone cavities if you take out with a trephine a cylindrical section of bone, which is ground down to a thin section.

The presence of vivianite explains the phenomenon of the skeleton rapidly changing colour from white to dark blue upon contact with the oxygen in the air.

However, only a small number of the jaws had changed colour and those that had changed were always found near an iron object such as cannon balls, bolts etc.

Book review

LENNART DIENER

OSSA

R. Ted. Steinbeck: Paleopathological diagnosis and interpretation, Bone diseases in ancient human populations. Charles C Thomas Publisher, Springfield, Illinois, U.S.A. ISBN-0-398-03512-1.

Lennart Diener, Department of Radiology, Central Dispensary of Stockholm. Wollmar Yxkullsgatan 25, S-10462, Stockholm, Sweden.

Vol. 3/4, pp 189–191, Lund. ISSN 0345–8865.

Most diseases do not leave any traces in bones, and it will be possible only in a few cases to tell what an individual has died from when only skeletal remains are available to examine. In archaeology or in forensic medicine this can be a very disappointing fact as for example with the mummy of Pharaoh Tut-ankh-Amen. He lived in a period full of religious upheavals and political intrigues. It has been suggested that he perhaps also died from a conspiracy but this is still conjectural as it has not been possible to obtain a definite answer from his bones. In another special case, that of King Erik XIV of Sweden (†1577), it has been possible to show the presence of an old fracture of the left humerus caused by one of his prison-warders and, by chemical analysis of his bones, to confirm the old rumor that he had been poisoned with arsenic presumably given in peasoup by order of his stepbrother King Johan III.

However exciting it may be to examine the human remains of well-known persons and to be able to solve historical problems in that way, from a paleopathological point of view it is still more interesting to examine whole series of skeletons in order to determine the prevalence of diseases in societies of the past. In performing such an examination one must have a detailed knowledge of diseased bones. Much of the wanted information can be found in text-books of pathology, orthopedia, bone surgery and radiology. But if one is working with archaeological material, dry bones must be examined and all these books deal with pathological changes in bones in the body, not free from muscles and

integuements.

In his book "PALEOPATHOLOGICAL DIAGNOSIS AND INTERPRETATION, Bone Diseases in Ancient Human Populations" R. Ted Steinbock deals with the morbid anatomy of dry bones. After a short chapter about "bone as a living tissue" he discusses the pathological lesions caused by the major infectious, nutritional, metabolic, degenerative, and neoplastic diseases of bone. The gross morphology and radiographic appearance of the macerated bone specimen is emphasized as the most feasible on which to reach a plausible diagnosis when working with archaeological material. Any tissue has a limited number of ways of reacting to stimuli and for bone the number of reactions to injury is very limited. These few and very constant patterns of reaction of bone underlie the fact that different pathogenic agents may result in the same morphological changes. It may be impossible to specify the disease illustrated by excavated dried bones and in such cases one can only point to the most likely diagnosis in a group of possible diseases. In examining his bone specimens the author considers these difficulties and follows a rational approach to diagnosis by stating the most likely one followed by a list of possible alternatives in order of decreasing likelihood.

In the introduction Dr. Steinbock declares that he has "primarily written for physical anthropologists who are the major contributors to the field of paleopathology". Brief outlines of epidemiology and other clinical data and of problems of special diseases as for example the theories relating to the spread of syphilis will give especially the non-medical student a better background for understanding of the prevalence of skeletal pathological lesions and their distribution in ancient human populations. But the book is very useful reading also to every medical man and any scientist interested in the field of history of disease and medicine.

That the study of paleopathology also can be useful to today's practical medicine is demonstrated by the detection of facies leprosa. The characteristic changes of the viscerocranium in leprosy were first described in medieval skulls by Møller-Christensen.

The text is based on examination of material kept in the USA in the extensive skeletal collections of the Army Medical Museum, The Peabody Museum of Archaeology and Ethnology, the Smithsonian Institution and the Warren Anatomical Museum at Harvard. The different types of bone lesions are richly illustrated with carefully choosen pathological specimens mainly from the same collections.

In many cases radiograms of the specimens are presented for comparison with the gross pathology and in some sections the text is also completed with radiograms from the clinic. The schematic figures showing the skeletal distribution of the pathological lesions associated with all of the discussed diseases are worth much appreciation as they make the book easier to read and enhance its usefulness. However, when talking about the brilliant illustrations one cannot omit two small remarks: 1) Would it not be better if the photographs and the radiograms of the specimens always were turned in the same way so that a detail reproduced to the left in the photograph also would be found to the left in the radiogram, and not to the right? 2) Would it not be a good rule when presenting a pair of bones from the same individual (e.g. femora) to reproduce them, if possible, so as if their owner were staying turned to the spectator?

References in the text are not always found in the bibliography of the same chapter but rather in one of the following. Perhaps this discrepancy will be corrected in the next edition.

To conclude, we should be grateful to Dr. Steinbock for having produced an outstanding work that ought constantly to be in the hands of students of osteology and related sciences.

Instructions to Authors

Manuscripts are to be sent to the general editor. The author's permanent and temporary addresses are to be given. The manuscript will not be returned to the author until the article has been printed, and the author is requested to retain a complete copy. Proofs will be sent to the author once; the author is expected to read them carefully and to return them promptly to OSSA, Nils-Gustaf Gejvall, Gnejsvägen 1, S-310 40 HARPLINGE — Sweden. The author will be charged for changes against the manuscript made by him in the proof. Reprints in addition to the 50 free copies are to be ordered with the proofs.

MANUSCRIPT

The manuscript must be typewritten (carbon copy not acceptable) on one side of standard-sized paper, double spaced, and with an ample left margin. The text must be clear and concise, and written preferably in English; German manuscripts may be submitted. Manuscripts should be arranged in the following order: (1) Informative but brief title. Avoid titles with interrogative form, abbreviations, formulae, and parentheses. (2) Author's name; one or more of his forenames unabbreviated. (3) A *short* abstract, always in English, not exceeding 1330 letters and spaces, and starting with a repetition of 2 and 1, with a translation in parentheses of non-English titles. (4) The author's professional address and a dating of the manuscript. (5) The main text. Use three or fewer grades of headings. Indicate in the left hand margin the approximate position of figures and tables. The words 'Fig.' ('Figs.') and 'Table' (unabbreviated) are to be written with capital initials in the text. In the main text, OSSA does not use small capitals or bold-face. Instead of footnotes, insert paragraphs which can be composed in smaller type or use parentheses. (6) References shall conform to the examples given below. Abbreviations used should be consistent; necessary editorial changes will adhere to the usage in *International List of Periodical Title Word Abbreviations* (UNISIST/ICSU AB 1970). It is essential that the punctuation conforms exactly with the examples given below. Use ampersand for joint authorship in the text references and the entries in the reference list (but not elsewhere). (7) Captions of illustrations, if any. Add an English caption below captions in other languages. *Figure captions and tables must be submitted on separate sheets.* (8) Tables, if any, with captions, numbered with arabic numerals. When possible, try to simplify table material so that it can be run in with the text.

ILLUSTRATIONS

Illustrations should be reducible to a maximum size of 14.0×20.3 cm or less. It is recommended that figures be constructed *either* for the entire width of the type area (14,0 cm) *or* for the column width of 6.7 cm. If possible, avoid figures *between* 10.4 and 14.0 cm. On all figures should be the author's name and the figure number. Do not attach captions to the figure. Photographs are to be clear, sharply contrasted, and printed on white paper with glossy finish. Figures may be composed of several quadrangular units separated by 1 mm broad spaces. The items in composite figures should be similar to each other in tone. If the natural background is to be deleted, blackening is preferred.

All illustrations should be termed figures, even if occasionally covering an entire page, and the items of composite figures should be designated A, B, C, etc. (*not* a,b,c, etc.).

REFERENCES

Ballance, P. F. 1964: Streaked-out mud ripples below Miocene turbidites, Puriri Formation. New Zealand. *Jour. Sed. Petrology 34,* 91—101. Menash, Wisconsin.

Pettijohn, F. J. & Potter, P. E. 1964: *Atlas and Glossary of Primary Sedimentary Structures.* 370 pp. Springer-Verlag, Berlin, Göttingen, Heidelberg, New York.

Seilacher, A. 1963: Lebensspuren und Salinitätsfazies. *In* Unterscheidungsmöglichkeiten mariner und nichtmariner Sedimente. *Fortschr. Geol. Rheinl. Westf. 10,* 81—94. Krefeld.

OSSA VOLUME 3/4 1976-1977

PAGES 1—191 · SOLNA 30TH DECEMBER 1977

ISSN 0345-8865. CODEN OSSA 3/4 (1) 1976—1977

CONTENTS:

The authors alone are responsible for the scientific contents of their contributions.

Printed in Sweden by Berlings, Lund 1978