# THE URUS (BOS PRIMIGENIUS BOJANUS) AND NEOLITHIC DOMESTICATED CATTLE (BOS TAURUS DOMESTICUS LINNÉ), IN DENMARK 

WITH A REVISION OF BOS-REMAINS FROM THE KITCHEN MIDDENS ZOOLOGICAL AND PALYNOLOGICAL INVESTIGATIONS

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## Synopsis

The main purpose of this treatise is to give concrete data of a comprehensive material of Urus and domestic oxen, and on basis of this to give an account of the evolution of the Urus during postglacial times in Denmark and the earliest appearance of domestic cattle in this area. Well over 200 finds of Urus, about one half of which is dated, comprising, i. a. several complete skeletons, about 50 skulls and brain-cases, and of 30 finds of Neolithic domestic oxen, are examined. - Of special interest is the only extant complete skeleton of an Urus cow, from the Boreal period, Zone V. - In Urus as in domestic Neolithic oxen a great sex dimorphism exists. Measurements of Urus bulls are, with exception of the teeth, outside the range of Urus cows, or a small overlap occurs. Regarding length measurements the domestic oxen are generally considerable smaller than the Urus; only in one male, i. a. the basal length is within the range of Urus cows, wheras most width measures of the skull of domestic bulls are co-extensive with those of Urus cows as also the transversal widths of the limb bones merge with those of Urus cows, but the anterior-posterior widths are smaller, particularly exposed in the metapodials. A characteristic feature in the Urus is the concave frontal profile, behind the orbits. - A trend towards a reduction in size during the ages is stated, particularly seen in the hindmost lower molars of the phylogenetical latest Urus; thus the Bos-remains from the Ertebolle kitchen middens, dated to the Atlantic period, have belonged to Urus. - The earliest dated skull of Urus in Denmark, from the close of the Late Dryas period, is the largest postglacial specimen known. The Urus disappeared from Jutland at the transition to the Subatlantic period or in this period proper. From Zealand it disappeared at the close of the Boreal period, Zone VI, probably because the forest became too dense. On this island the earliest finds of domestic oxen occur at the very Elm decline, zone VIII, represented by smaller females ("longifrons" form) and larger bulls and bullocks ("frontosus" form), these animals imply a long preceding domestication, and must have been imported into this island. At the Late Bronze Age and Early Iron Age large skulls of domestic oxen are present, probably indicating draught animals and use of heavier, but more effective tools, i. a. wheel ploughs.

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## I. ZOOLOGICAL PART

by Magnus Degerbøl

## Introduction

In the Zoological Museum of Copenhagen and some other Danish museums an extensive material of Bos primigenius and Neolithic domestic cattle is kept. Much of the material has come from dated settlements, but unfortunately this part is greatly fragmentary, split open to take out the marrow or converted into implements. Fairly undamaged remains, skulls, or even complete skeletons, however, have been brought to light from peat-bogs, and by means of pollen analysis many of these finds have been dated. A dating, of course, is necessary if you want to state what has happened during the ages, and particularly to demonstrate the first appearance of domestication.

The origin of the domesticated cattle in Denmark has been discussed as long as excavations of prehistoric animal bones have been made in this country, i.e. for more than a century. Was the domesticated cattle imported into Denmark or did it originate here by domestication of the Danish Urus? The answer to this question must be based on a fair amount of excavated bones of Urus as well as of domesticated cattle, and of bulls as well as of cows, thoroughly dated and analyzed by zoologists.

The lack of knowledge of the range of variation in size and shape of the Urus and Neolithic domestic cattle, however, has given rise to great difficulties and confusion. Particularly complete skeletal parts of Neolithic domestic cattle were rare, and until recently (Degerbøl, 1963) only a few incomplete skulls were known.

The main purpose of this treatise thus is to give concrete data of a comparatively large collection of a dated material of Urus as well as of Neolithic oxen, and on the basis of this to give an account of the earliest known domestic cattle and their origin in Denmark.

In the present inquiry about 200 discoveries of Urus are treated, and almost one half of these have been dated, including i.a. several fairly complete skeletons and about 50 skulls and brain-cases.-The Urus must have been a common animal in prehistoric times in Denmark, in Jutland still existing during the Subboreal period, when the farmer culture was fully established in Denmark.-Of domestic oxen thirty dated skulls and brain-cases are at hand.

The majority of the material is preserved in the Zoological Museum of Copenhagen, which is greatly indebted to the many people, who during the years have submitted subfossil bones, and thus highly contributed to the augmentation of the collections and to our knowledge of the prehistoric fauna of Denmark. The names of the contributors are mentioned in "A Survey of the Material". For loan of material from other Danish museums, the names of which also are stated in the "Survey", I express my sincere thanks.

I also beg to express my cordial thanks to the Carlsberg Foundation, which has supported my investigations on prehistoric vertebrates from Denmark.

In several minor museums, school collections and private collections, no doubt further skulls and other remains of Urus as well as of large domestic cattle are kept, though generally not dated. On account of lack of time such collections have not been systematically looked out.

The usual line of procedure has been that before, or during, the zoological investigation of a find, the skull cavities were examined for possible material for pollen-analyses, and the proofs, if any, were sent to the pollen analysts.

The palynological investigation was carried out by the Danish Geological Survey and the National Museum in cooperation with the pollen analysts of the Zoological Museum (Vide Fredskild, Part II).

## Previous Investigations.

In 1904 (V.M. pp. 286-292) H. Winge gave a summary of the known finds of the Urus in Denmark together with a comment on the variations found in the skulls of the species.-From this publication it may be cited that already in 1767 Pontoppidan (Danske Atlas, Bd. III, p. 503) described a frontlet and horn cores of a large bovide, no doubt a Bos primigenius, from Vendsyssel, North Jutland.

A couple of discoveries, brain-cases from Rosenholm N. of Aarhus, Jutland, and from Trøstrup, N.W. of Odense, Funen, were mentioned by Reinhardt senior in 1834 (O.V.S.F., pp. 2-5).

In 1853 the first discovery of an almost complete skeleton of Bos primigenius, from Stokholt Huse, Sorø, Zealand, was published by P. Lorenzen (V.M., pp. 66-68). Its measurements were compared with a complete skeleton of a Urus from Scania, measured by Professor Nilsson, Lund (Skandinavisk Fauna, Däggdjuren 1847, pp. 541-543).

Of particular interest was the observation of the position of the skeleton in the bog: "The bones were found beneath a layer of peat, about 20 feet thick ( $6-7$ Alens Mægtighed), lying in bluish clay". (Cf. its Preboreal age, p. 9).

In the following years several finds of $B$. primigenius were commented on by Japetus Steenstrup in The Royal Danish Society. Steenstrup also excavated a complete skeleton of Urus, from Store Damme, Møen, and its "contemporaneity with the oldest pine woods in Denmark" was stated (O.V.S.F., 1870, pp. 105-110).

Also skulls of domestic oxen (longifrons, frontosus) were mentioned by Steenstrup (Forh. Skand. Naturforskeres Møde, 1847 pp. 946-947, O.V.S.F. 1852, pp. 236-37).

The first comprehensive investigations of Danish prehistoric cattle were published by H. Winge in the great work on the kitchen middens of Denmark (1900); however, from these settlements very few bones of $B$. primigenius were found.

In 1905 another almost complete skeleton of $B$. primigenius was excavated, viz. at Vig, N.W. Zealand. The animal had been wounded and killed by stone implements. The skeleton was described and measured by H. Winge; and by N. Hartz, the geologist, dated at "the transition layer between the aspen zone and the pine zone: at the very beginning of the pine period" (N. Hartz and H. Winge, Aarb. 1906, pp. 225-236. - Cf. its Preboreal age, p. 8).

That the Urus was a common animal in the Boreal period appears from the many bones of this species in the Maglemose settlements: Maglemose at Mullerup (H. Winge, Aarb. 1904, pp. 194-198), Sværdborg (H. Winge, Aarb. 1919, pp. 128133), Holmegaard (H. Winge, Aarb. 1925, p. 30), and Aamosen at Halleby river (M. Degerbøl, Nord. Fortidsminder III 3, 1943, pp. 167, 188-190, 195, 197-198, 201).

Unfortunately, however, bones from the settlements are generally very fragmentary.

In 1927 von Leithner demonstrated the great sex dimorphism in the skulls of Bos primigenius, and 5 brain-cases from Denmark were described as females of the Urus, however, only a few of the finds were dated.

The sex dimorphism in the metapodials of Bos primigenius was described by M. Degerbøl 1942 (Dyrholmen pp. 90-105), and preliminary accounts on the investigations of Danish bovines were given by the same author in 1962, 1963, and 1964.

Dated finds of Urus have so far been rare, particularly regarding Urus cows.

## Survey of the Urus Material

## Remains from the Late Dryas Period (Zone III)

1. Millinge, 6 km . N.W. of Faaborg, Funen (L. B. Deichmann, 1875).
of On this complete skull Winge (1904) remarks: "Uncertain age, from a peat-bog near Faaborg. Presented by Deichmann the school principal in the times of Steenstrup.". Winge, furthermore, gives some measurements and an excellent picture of the skull (1904, Pl. XIII). From posthumous letters of Steenstrup, however, the actual locality has now been established. We are furthermore informed that the skull was found "in blue clay under peat soil", and later that this clay was "ordinary fat and sandfree blue clay". This is in good agreement with the pollen analytical dating, the final phase of Zone III (Krog, 1959, p. 147). - Cf. Fredskild.
This skull, together with a specimen from Bregninge (cf. No. 33) belongs to the largest of the Danish Urus specimens (basal length 612 and 597 mm ., respectively). In the Millinge skull the anterior rim of the premaxilla is damaged. The ant.-posterior length
of the horizontal ramus, from the foramen incisivum to the anterior border is now 27 mm ., as compared with 41 mm . in the older Bregninge skull, 42 mm . in the skull from Rønnebæksholm, 45 mm . in the Store Damme skull, 37 and 38 mm . in the skulls from Langeland and the Min. Museum and 37 mm . in the younger skull from Sorø; all skulls with undamaged premaxilla. Considering the larger size and fairly young age of the Millinge skull, it may be estimated that at least 12 mm . of the premaxilla are missing. In all measurements of the Millinge skull, where the anterior border of the premaxilla is involved thus 12 mm . are added in the tables. - The Bregninge skull, however, represents an old animal with all the features characterizing fairly great age: the horn cores are tuberculated at the base and moderately impressed by longitudinal grooves, the rims of the orbits are granulated and the supraorbital grooves (sulcus supraorbitalis) are roofed. In the Millinge skull these features are missing. The supraorbital grooves are widely open, although the teeth are moderately worn, e.g., the interior column of m 3 is just worn, indicating an age of about 5 years, and the bases of the horn cores are not granulated, or only with a faint granulation anteriorly, characters often absent in skulls with wide spreading horn cores. The Millinge skull is larger than any of the alluvial Urus skulls measured by Leithner (1927); the largest of which, from Frörum, Scania, has a basal length of 593 mm . - Regarding the shape of the horn cores the Millinge-Faaborg skull represents what may be called the "open type", in which the horn cores converge very little and the span of the horns thus is very large, the distance from tip to tip being almost as large as or equal to the largest span. In the Millinge specimen the span of the horn cores is 1140 mm ., as compared with 1004 mm . of an alluvial skull, from Västra Ahlstad, near Sjörup, Scania, which so far had held the record. In these measurements the Millinge bull is within the size range of the large diluvial Urus from Toscana (La Baume, 1958), in which the span of the horn cores varies from 820 mm . to 1230 mm . - Pl. I.

1a. [Transition to Zone IV]
Terp moor. 7 km . N.W. of Randers (Brendstrup, 1863).
ot Posterior part of frontal with horn cores, both premaxillae, 4 upper molars and most parts of the postcranial skeleton.
The horn cores are long, but comparatively slender, not of the size dimensions seen in the Millinge skull. The frontal is fairly broad (Pl. I); as to length measurements of the skull only the premaxilla length may be taken, which is 193 mm ., as in the largest skulls. - According to tooth-wear the individual age of the Terp specimen is similar to that of the Millinge skull. The teeth are small, molar length m $1-\mathrm{m} \mathrm{3}$, is 101 mm . (As the find was excavated by the peat workers it may be questioned, however, whether these solitary teeth in fact belong to the skull, but of course it is most likely). - The limb bones indicate a fairly large bull, almost as large as the mounted skeleton from St. Damme. (Tables 11-20). - Pl. I.

## Remains from the Preboreal Period (Zone IV).

2. Vig, North-west Zealand (J. P. Jensen, the National Museum, 1905).
${ }^{1}$ Skull and almost complete skeleton (fore feet and the phalanges of the left hindfoot are missing). Vide J. Brøndsted, 1957; fig., p. 53.
In two ribs fragments of flint arrow heads were found, and in the peat which filled the chest of the animal, were 3 arrow heads of flint. (Cf. p. 7). - Pollen analysis by K. Jessen 1926, gave the result: "pollen of birch ( 68 per cent.) and pine ( 32 per cent.), which corresponds to an early phase of the Pine Period, earlier than the Maglemose culture" (N. Nordmann 1936, pp. 75 and 210).
3. Stokholt Huse, N.E. of Sorø (P. Lorenzen, 1853).
ô Skull and almost complete skeleton.
In the lower jaw the hindmost molar (m3) is slightly worn, indicating an age of well over three years (cf. previous investigations p. 6). In the limb bones the sutures between epiphysis and shaft are open. - Pl. II.
4. Grænge A, 2 km . S.E. of Sakskobing, Lolland (L. Kring, 1942).
ô ad. jun. Skull and nearly complete skeleton. Open type of horn cores. Cf. No. 1. The posterior column of the mandibular m 3 is only faintly worn, so that an age of about three years may be assumed. Limb bones with free epiphyses. Early Preboreal period. A. Andersen and K. Møller. D.G.U. IV R. Bd 3. Nr. 1. 1946. - Pl. II.
5. Gøderupgaards moor, A., S. of Roskilde (Siegfred Nielsen, 1941).
$\hat{o}$ Skull of a young animal, right part damaged; mandibles. Horn cores porous, sutures open, only interfrontal suture closed far posteriorly. The only upper tooth present, p 2, is slightly worn; in the mandible p 4 and posterior column of m 3 are erupting, and have not been functioning, indicating an age of two to three years. Medial border of sulcus supraorbitalis projecting and sharp. Skeletal parts: right scapula, lower part of right humerus, pelvis, two femora with free epiphyses (three of which are missing), four costae: atlas, epistrophaeus, cervical vertebra). The anterior rim of the premaxilla is damaged; about 15 mm . are missing, added in the tables. - Pl. II.
6. Vieso, Turup, N.E. of Assens (F. Lund, 1942).
of Fragmentary skull of young animal, the palatal region and mandibles are missing. Interfrontal suture posteriorly closed, forming a broad and high crest, well over one cm. higher than the pronounced concavities on each side of the crest. Horn cores porous, "worm-eaten", broken above middle.
7. Vigersted, 7 km . N.E. of Ringsted (H. Nielsen, P. D. Olsen, 1918).
\& Brain-case, broken through orbits. Cf. p. 56. - Pl. VIII.
8. Munke-Bjergby, Tørnegaards moor, 8 km . N. of Sorø (Louise Kloster, 1941).
o Right metacarpus. At the upper end three cm . from the articular surface, there is posteriorly an artificial hole, length 31 mm ., width 16 mm ., probably made for taking out the marrow. Iversen (2.2.1943): Early part of Maglemose period.
9. Knabstrupgaard (No. 1), 10 km . S.W. of Holbæk (Lunn, 1852).
ô Brain-case, broken through orbits, facial region, some skeletal parts: left half of pelvis, right femur, the upper and lower epiphyses of which are missing. - Interfrontal suture fused posteriorly, other sutures open; horn cores porous, tip of left horn core broken. Posterior half of the frontal is concave and the frontal part between the orbits is placed lower than the roof of the orbits. Posterior column of m 3 very slightly worn, hence about three years old. (J. Steenstrup, O.V.S.F. 1853 (p. 25). - Pl. II.
10. Knabstrup (No. 2), 10 km. S.W. of Holbæk (J. Frost, 1941).
\& Brain-case, broken through orbits.
Cf. p. 56. - Pl. VIII.
11. Rode Molle Aa, 13 km . N.E. of Vejle (Høst, 1855).
o Skull, incomplete, the upper part in front of orbits, and the premaxillae are missing, mandibles. Old specimen with base of horn cores and rim of orbits granulated, horn cores with longitudinal grooves. Teeth much worn. Sulcus supraorbitalis completely roofed only as always penetrated by a few foramina. Temporal fossae posteriorly closed by a very high bony bar, thus the width at the posterior borders very large, $240 \mathrm{~mm} .-\mathrm{Pl}$. II.
12. Funen (Appeldorn-Steenstrup).
ô Brain-case, broken through orbits. Old animal, horn base granulated, granulation continued across occipital crest. An osseous lump, 40 mm . long, 25 mm . broad, and 15 mm . high, is found on the right frontal bone, 33 m . from the middle of the horn base, supraorbital groove completely roofed, only with a few holes. - Pl. II.
13. Svebolle, 13 km . E.S.E. of Kalundborg (P. Jørgensen, 1944).
\& Posterior part of brain-case, occipital part fragmentary; tips of horn cores are missing. - From the close of Zone IV. Cf. p. 56. - Pl. VIII.

13a. Tepstrup Lake, 10 km . S. of Skanderborg (Naturhistorisk Museum, Aarhus, 1934). $\hat{o}$ A very heavy skull; right premaxilla, central part of palatal plate and teeth are missing. Old specimen, base of horn cores, middle part of occipital crest, anterior rim of orbit and proc. mastoidei granulated. Supraorbital groove roofed and posterior half of interfrontal suture obliterated. Postcranial skeletal parts. - Pl. II.

13b. Bjerregrav, Kærsted, 11 km. W.N.W. of Randers (Naturhistorisk Museum, Aarhus, 1945). ㅇ Frontlet, broken at nasal base, right orbit missing. Cf. p. 56. - Pl. VIII.

## Remains from the Boreal Period (Zones V and VI). Zone V.

14. Ronnebæksholm, S.E. of Næstved (Francisca de Carlsen, 1857).
ô Skull (left mandible missing), skeletal parts: 11 vertebrates, 10 ribs, pelvis, parts of os coxa. - Old animal, base of horn cores strongly granulated, sulcus supraorbitalis completely roofed. Teeth much worn. In the mandible only the two hindmost molars (m 2 and m 3 ) are present. The first molar, m 1, is irregularly worn down; only the anterior root is still present in its alveole, but its surface is worn, as also the jaw beneath this tooth is worn down with a smooth hard surface. - Pl. III.
15. Ullerslev, 10 km . N.W. of Nyborg.

+ Skull and almost complete skeleton. V. Madsen. D.G.U., 1 R, Nr. 9, p. 121, 1902. Cf. p. 53. - Pl. VIII.

16. Knabstrup (No. 3), 10 km . S.W. of Holbæk.
ô Brain-case, broken through frontals, on left side between horn core and orbit; on the right side the posterior rim of the orbit is present. Horn cores granulated at base, tips missing. On the right side the sulcus supraorbitalis is roofed posteriorly. - Pl. III.
17. Grænge, B., 2 km. S.E. of Sakskøbing (A. V. Nielsen, Teknisk Skole, Nakskov).
ô Skull, nasals missing. Fairly old animal. Sulcus supraorbitalis partly roofed. Posterior $2 / 3$ of interfrontal suture obliterated. Interior column of m 3 worn. Pl. III.
18. Grænge, C., 2 km . S.E. of Sakskøbing (A. V. Nielsen, Teknisk Skole, Nakskov). \& Skull, nasals missing. Cf. p. 54. - Pl. VIII.
19. Grænge, D., Idem. Ibid.

Horn cores, some skeletal parts.
20. In connection with these skulls (Nos. 17, 18, and 19) skeletal parts of three specimens of Urus were excavated: 1 scapula, 2 left humeri, a lower part of a right humerus, right and left antebrachium, a right smaller antebrachium, left metacarpus, 1 costa and 1 thoracic
vertebra. - With the exception of the smaller antebrachium all bones are large, heavily built and a light colour.
In the shoulder-blade a hole is found, no doubt produced by an arrow head, the animal having been struck by hunters (Andersen og Møller loc. cit. figs. 5 and 7), and one of the humeri was artificially opened at its upper end, the tuberculum major and minor being cut off and the inner tissue scraped out, a treatment now and then seen just in this bone. The very upper end of the ulna, of the right antebrachium, has been gnawed, probably by dogs.
21. Bjeverskov, 10 km . W. of Køge (Krebs, 1942).

ㅇ Skull, tip of horn cores, nasals, premaxillae, and mandibles are missing; of teeth only right m 2 is present, very much worn. Horn cores fairly thin. J. Iversen (2.2.1944) Zone V. Cf. p. 54. - Pl. VIII.
22. Tranemosegaard, S.W. of Køge (H. P. Christiansen, 1918).
ô Brain-case, broken through orbits, fragments of facial parts, both maxillae containing teeth. - Posterior half of interfrontal suture obliterated, other sutures open. Horn cores "worm-eaten". Interior column of upper m 2 not worn. - Pl. III.
23. Brændholt, Nyrup, Uggerløse, Aamosen (Brorson Christensen, National Museum, 1937). ô Horn cores, parts of mandibles, postcranial skeleton. Horn cores granulated at base. Horizontal ramus of right mandible, broken in front of p 3 ; m 3 and m 2 present, much worn, length 89 mm . The jaw beneath m 1 and premolars is worn in such a degree that of the alveoles only the bottoms are visible. The left mandible is fragmentary, indicating a similar wear of the jaw proper. (Cf. Rønnebæksholm, No. 14).
24. Flintinge, Lolland, 6 km. W.S.W. of Nykøbing F. (L. Kring, 1940).

ㅇ Brain-case, broken through frontal, between horn cores and orbits. Cf. p. 56. - Pl. VIII.
25. Sakskobing, Lolland (K. A. Jacobsen, Jægershvile, 1948).
of Frontlet, fragmentary, broken in front of left orbit and right lacrymale. Horn cores granulated at base, but fairly "worm-eaten". - Yellow coloured. Skull fragments, part of horn core and frontal, of a second specimen, are present.
26. Hallenslev, S. of Tissø (E. Dige Olsen, 1945).
of Fragmentary skull, left frontal part with horn core is missing, right horn core broken in the middle, porous, interfrontal suture open, forming a high crest; facial part broken off from brain-case. - Skeletal parts: 5 cervical and 1 costal vertebra. - Young animal with p 4 and m 3 erupting. - Pl. III.
27. Niverød, Lerbjerggaard, Nivaa, 12 km . E. of Hillerød (Fr. Wernerson, 1945 Jagt- og Skovbrugsmuseet).
ot Posterior and upper part of brain-case with complete horn cores; broken between horn cores and orbits. Old specimen with not only a heavy tuberculation at the base of the horn cores, but also a distinct granulation of the occipital crest from horn core to horn core. - A broad and robust specimen. - Pl. III.

27a. Kratholm, Bellinge, 8 km. S.S.W. of Odense (Fyns Stiftsmuseum, 1938).
ot Right humerus, right antebrachium, os coxa, two vertebrae cervicales, 9 vert. thoracales, 4 vert. lumbales, 13 costae.
28. Alsønderup, 6 km . N.W. of Hillerød (L. Rasmussen, 1957).
of Part of left horn core, broken about the middle, with a small part of the frontal; fragmentary exoccipital. Diameters at base $118 \times 103 \mathrm{~mm}$.; circumference 365 mm . Width across condyli occipitales very large, about $146 \mathrm{~mm} .(73 \times 2)$.
29. Jonstrup Vang, 15 km . N.W. of Copenhagen (Birte Andersen, 1946).
ot Left horn core with small part of frontal, tip missing. Diameters $120 \times 101 \mathrm{~mm}$.; circumference 348 mm . - Fragmentary parts of right horn core.
30. Falster, locality not specified (F. H. Møller, 1944).
ot Posterior part of frontal roof with complete horn cores; exoccipital; right mandible, left corpus mandibulae, teeth missing, left ramus mandibulae with part of corpus, teeth missing, right antebrachium, right metacarpus, left femur, atlas, epistropheus, vert. cervicalis, 2 vert. thoracales, 3 vert. lumbales, os coxa, 3 costae.
31. Bedsmose, Søborg Lake, North Zealand (Gilleleje Museum, H. C. Terslin, 1944).
ô Brain-case, broken between horn cores and orbits. Frontal fragmentary, horn cores broken in the middle. Two upper molars, m 2, m 3 length 75 mm ., m 3 length 39 mm . Old, strongly built skull, horn cores longitudinally grooved, teeth much worn. Pl. III.
32. Risby, 15 km. E.S.E. of Næstved (J. Ferdinand, D. G. U. 1944). Horn cores.

32a. Ryemarksgaard, Osted, Zealand (National Museum) (Lit. Th. Mathiassen, 1941). Lower half of metatarsus, ornamented. Cf. Fredskild.

## Zone VI.

33. Bregninge, Stensgaard, W. of Faaborg (J. K. Groth, 1953, but found many years earlier). o Skull, nasals missing. Base of horn cores and rim of orbits strongly granulated, sulcus supraorbitalis roofed, teeth much worn. - One of the most strongly built skulls from Denmark, cf. No. 1 from Faaborg and No. 34, from Lorup Hede.
(A. Andersen 31.X.1953: Zone V. Cf. Fredskild). - Pl. IV.
34. Lorup Hede, near Ringe, Funen (Johs. Bredsdorff, 1915).
ô Brain-case, broken between horn cores and orbits. Horn cores very thick, diameters at base $138 \times 113 \mathrm{~mm}$., frontal exceptionally broad; the least frontal width is 270 mm . as compared with 255 in the Bregninge specimen.
From the beginning of the zone. - Pl. IV.
35. Kulemile, moor at Mosegaardsby, 10 km . S.E. of Middelfart (J. V. Nielsen, 1851). ot Upper part of roof of brain-case. With a large, nearly circular artificial hole (diameters $60 \times 57 \mathrm{~mm}$.), particularly cut from the upper surface. The lower part of the brain-case is cut off through the fossae temporales, and all edges are smooth. From the beginning of the zone. - Pl. IV.
About this specimen Winge (loc. cit., p. 209) only says that it was mentioned by Steenstrup in 'Oversigten' 1853, however, Steenstrup there only writes that three finds of Urus have been brought to light, but he does not mention the hole in the frontal. Probably a trophy of the chase.
Very old animal. The complete horn cores are longitudinally grooved and strongly granulated at the base, granulation continuing on the occipital crest. Supraorbital grooves completely roofed (penetrated by foramina). Posterior part of frontal only slightly concave, anterior part fairly bulging. - Pl. IV.
36. Grevinge, Gundestrup, 15 km . S. of Nykøbing S. (Asnæs Realskole, E. Rump, 1943). of Skull, nasals missing, premaxillae damaged, tip of horn cores broken. Interfrontal suture closed posteriorly. Sulcus supraorbitalis partly roofed posteriorly. Horn cores, however, fairly porous, "worm-eaten", but with a few longitudinal grooves. Hindmost
upper molar only slightly worn. A fairly young, but strongly built skull. About 15 mm . of the anterior border of the premaxilla is missing; added in the tables. - Pl. IV.
37. Taageby, 8 km . S.S.E. of Præstö (Chr. Pedersen, 1903).
of Small part of posterior region of brain-case, broken in front of the left horn core; the right horn core almost missing. Width of occipital ridge 200 mm . Diameters of horn core $102 \times 80 \mathrm{~mm}$.; circumference 300 mm .
38. Bisserup, Rude, 13 km . E.S.E. of Skelskör (E. Jørgensen, 1946).
ô Fragmentary left mandible with m 2 and m 3 very much worn. Length 85.7 mm . Length and width at the base of $\mathrm{m} 3=51.8 \times 20.8 \mathrm{~mm}$. Scapula, humerus, and tibia from right side, one costa.
From the beginning of the zone.
39. Goderupgaard B., S. of Roskilde (Sigfred Nielsen, 1941).
ot Metacarpus, with an artificial hole.
40. Gojs moor, Kongsted, W. of Faxe (J. P. Rasmussen, 1943).
of Mandibles, small skull-fragments, (exoccipitale) 9 vertebrae. 16 costae.
41. Kettinge, Lolland (Taxidermist O. Nielsen).

Skull. - V. Nordmann 1944 p. 69. (No zoological examination).
42. Store Damme, Møen (H. C. Nielsen; Japetus Steenstrup, 1864-1865).
ô Old animal. About this skeleton Japetus Steenstrup (O.V.S.F. 1870, pp. 105-110) writes (in translation):
"The ox has obviously been lying on the side; judging from the position of its feet in the substratum it had, presumably, subsided into the mud because of suction or had fallen through the ice without being able to extricate itself again. The time when this took place was during the period the peat began to form along the border of the forest bog. This is evident in view of the fact that the bones of one side of the animal were lying partly surrounded by the fine layer of precipitated clay, mixed with particles of humus or peat and siliceous shells of diatoms, which is usually found at the bottom of our forest bogs.
In this bottom layer as well as in the overlying peat in which other parts of the bones were embedded, it could easily be seen to what extent the body of the ox had by its own weight been sucked down into the layer already formed and how the layer had subsequently been formed over the sunken animal. The position of the vegetable matter in relation to the bones clearly showed that both possibilities had been realized, and in this respect it was of particular interest to observe how the pine needles had in large quantities occurred under and above the bones. They were bent in such a way that they followed the outlines and surface of the bones. Thus there was no doubt that the ox had perished at a time when the fine needles in large quantities were still being thrown on the surface of water beneath which the peat would later form, or rather, continue the process of formation already commenced.
Our animal is, consequently, from the Pine period, and this fact also became obvious to me in another but no less certain way, as there was a very large and darker spot on the lighter layer, due to a brownish mass. This was situated among the hindmost ribs within the outlines of the skeleton, and the peat diggers themselves compared it with "cow-dung".
There was no doubt that this was the contents of the stomach and the intestines; those of the latter were still formed like balls. I examined this mass with my magnifying glass on the spot and found crudely crushed pine needles in it. The contemporaneity existing
between the pine and this ox clearly appears from this factor. As a clue to future investigations, this fact is of great importance, of greater importance perhaps than one would at first be inclined to admit.'" - Pl. IV.
The Urus was hunted by the Maglemosian people. Fragmentary bones of this species are comparatively common on the Maglemose settlements: Maglemose near Mullerup, Sværdborg-mose, Lundby-mose, Holmegaards Mose, and Aamosen on the Halleby River. All in Zealand.
The Maglemose sites are of different ages. To the oldest belongs the classical find from Maglemose near Mullerup. Together with the Lundby and Vinde-Helsinge settlements it is dated at Pollen Zone V, whereas the Sværdborg, Holmegaard, and Øgaarde sites belong to Zone VI.
43. On the bones from Maglemose near Mullerup, midway between Korsør and Kalundborg, near the coast of the Great Belt, Winge writes (1904, English translation):
"Bos taurus urus. Many bones: the greater part of one side of a facial region; several other parts of skulls; a horn core; several vertebrae; thus 2 adjoining posterior lumbar vertebrae; several ribs; parts of at least 5 scapulae; lower end of a radius; carpals of at least 5 animals; a complete metacarpus and lower ends of 3 others (all more or less artificially worked); parts of 5 left and 1 right innominate bones; 2 femur heads; parts of 2 tibiae; 4 patellae; 2 astragali; 4 calcanei, probably all different; 3 right and 3 left navic.-cub., 13 upper ends of 1. phalangeal bones (of hand and foot); 11 of 2 . phalangeal bones; 10 terminal phalanges.
Most of these bones compare completely with those of the Urus; only as regards a few of them the question may arise whether they were exceptionally small Urus specimens or belonged to large domestic cattle. This particularly holds good of two lower ends of metacarpal bones, both artificially handled (from I K 6, 2. layer and from the circular trench or upper part of Square I). Most likely these bones have belonged to domestic cattle."
From this it appears that all parts of the skeleton are represented, which probably indicates that complete animals were brought to the settlement. Bones of cows as well as bulls occur (cf. Tables 19-20). The small metacarpal bones no doubt belonged to Urus cows. (Cf. p. 36).

43a. Maglemose near Mullerup (Northern site). (Else Dige Olsen, 1949).
Scapula (right), damaged; distal half of metatarsus (right) (used as a hammer), calcaneus (r), tuber part of calcaneus (r), astragalus (r), attached to complete calcaneus; (naviculocuboideum (left)), cuneiforme (r), 2 medial phalanges.
44. Lundby, N. of Sværdborg. (Not zoologically worked up).

Complete metacarpus and metatarsus (cf. Table 12), complete horn core (1929, VIII G ${ }^{3}$ ) with small part of frontal, cut off. Adult with longitudinal grooves, but also many holes. (Cf. Table 8).
45. Also the bones from the Sværdborg settlement, between Vordingborg and Næstved, were determined as to species by Winge (1919):
"Bos taurus urus. Remnants in large quantities, both of old as well as of young: several loose teeth, among them 4 right and 4 left lower hindmost molars of at least 7 specimens, and 1 right lower hindmost milk molar and 3 left ones, all four unlike; 4 epistrophei; lower ends of 4 right and 3 left shoulder blades; several carpal bones: 3 right, 4 left scaphoidea; 4 right, 2 left lunata; 2 right, 6 left cuneiforme; 1 right, 5 left multangula \& capitata; 1 right, 5 left hamata; 6 right, 6 left astragali; 6 right, 2 left naviculo-cuboidea. Most of the ox bones are from animals of a gigantic size, but some of them are relatively
small, i.a. a metacarpus (used as grinding surface) the width at the lower trochlea being 71.5 mm . only; another metacarpus of a more usual size is 84.5 mm . in width. The lengths of the existing four right lower hindmost molars are $53 ; 49.5 ; 49$, and 47 mm ., respectively ; of the four left $53.5 ; 50 ; 49 ; 49 \mathrm{~mm}$., and of the lower hindmost milk molars $40 ; 39$; 38,5 and 37.5 mm ., respectively."
It should be noted that a transversal width of 71.5 mm . of the distal end of a metacarpus is not particularly low, but, as we now know, indicates a female. In most females the corresponding width is still lower ( $66,67,67,67,68,70 \mathrm{~mm}$.). (Cf. Table 11).
46. Holmegaard settlement, 8 km . N.N.E. of Næstved.

About the Urus bones from this settlement Winge writes (1925) p. 30:
"Bos taurus urus. Many bones, among others: several pieces of skulls, quite a number of vertebrae, some ribs, some parts of the sternum; several limb bones, among them: 4 left scaphoidea, 3 left lunata, 3 left cuneiforme, 4 left multangula \& capitata, and 1 right, 3 left hamata, and 1 right, 1 pisiforme, 2 right astragali; 5 calcane $i$; probably all different; 4 right naviculo-cuboidea and 1 left; a remarkable number of toe-joints."
From later excavations, 1945 and 1948, a mandibular m 3 and a metacarpus are at hand. The m 3 is 48.8 mm . long and 19.5 mm . broad; the metacarpus is very long, 264 mm ., and has belonged to a very old bull with exostoses at the proximal end of the bone.

In the large moor-complex, Aamosen, near the Halleby River, N.W. Zealand, several settlements have been excavated, dating from the beginning of the Boreal period, Zone V, to the Subboreal period, Zone Vili (Th. Mathiassen, 1943). Here, too, bones of the Urus are common on the sites from the Boreal period (M. Degerbol, 1943).

The oldest of these sites from the early part of Zone $V$ is a small settlement at
47. Vinde-Helsinge, a few km. N. of the Maglemose sites. Upper part of a metacarpus of a cow. (Cf. Table 11).

By far the largest of the settlements is the Øgaarde; together with two other smaller sites from Hesselbjerggaard and Magleø, it is dated at the late Maglemose period, Zone VI.
48. Øgaarde, II, Aamosen near Halleby River, N.W. Zealand.

Three posterior lower molars (m3) from 2 individuals; 3 lower m 2, 2 upper m 2; nasal; parts of 5 scapulae, lower part of humerus; parts of 3 atlases; part of epistropheus; vertebra cervicalis; upper and lower end of metacarpus, part of upper end of do, 3 individuals; almost complete metatarsus; one upper and 3 lower ends of metatarsus; 2 middle parts of metatarsus of 2 subadult individuals; 2 lower ends of metatarsus, cut off and artificially worked up ; part of pelvis; lower end and middle part of 2 tibiae; 4 patellae; 32 carpal bones (naviculare 7 (31 and 4 r) lunatum 7, triquetrum 2, pisiforme 2, capitatum 7 (5 1, 2 r , most of them of young animals) and hamatum 7). Of astragalus no less than 17 complete bones are at hand, measuring: $91,90,89,88,88,85,85,85,85,85,85,85,84,81,80,80,80 \mathrm{~mm}$. in length. Of naviculo-cuboid bones 6 are present, the greatest widths of which are 81 , $80,80,78,70$, and 65 mm .; at least the two last-mentioned specimens have belonged to young animals. 12 2nd phalangeal bones, most of them are large and must have belonged to adult or old animals, several are comparatively small and must have belonged to young animals. 6 terminal phalangeal bones, 3 of which are complete. Several fragments of ribs from 12 squares; 4 proc. spinosi (Degerbøl, 1943).
Also from this site bones of cows as well as of bulls are present. (Cf. Tables 12, 19-20).
49. Hesselbjerggaard, Aamosen.

Free lower epiphysis of metacarpus, 3 capitata, 1. and 2. phalanx, astragalus.
50. Magleø $I$, Aamosen.

Lower part of a scapula; artificially formed.
51. Kongemosen, Bodal, Aamosen, N.W. Zealand.

Lit. Svend Jørgensen 1956, Kuml p. 37. (Not zoologically examined.)
52. Ulkestrup Lyng, Kildegaard-komplex, Aamosen, N.W. Zealand.

Lit. Svend Jørgensen 1963, D.G.U. II, 87, p. 26. (Not zoologically examined.)
52 a. Undlose Bro, Aamosen. N.W. Zealand.
Antebrachium, large. Cf. p. 111.
53. Store Taastrup, 10 km . N.N.W. of Ringsted (Niels Jensen, 1880).

ㅇ "A mandible, several vertebrae and limb bones" H.W. 1904.
The following postcranial skeletal parts are kept in the Zoological Museum, dated 9/9 1880: Right scapula, right humerus, right antebrachium, right tibia, right and left metacarpus, 2 vertebrae thoracales, 5 vertebrae lumbales, os coxa, right half of pelvis, 1 costa. Besides these skeletal parts, mentioned by Winge, a brain-case and a maxilla-palatal part with all teeth are at hand from the same locality, but marked with another date, $/ 2,1880$. From Zone II to V. (Cf. p. 57). - Pl. VIII.
Furthermore, a smaller specimen is represented by a vertebra lumbalis, and an os coxa.

## Remains from the Atlantic Period (Zone VII).

From bogs only a single find is known from this period.
54. Bonnelykke, 7 km . S.E. of Rudkøbing, Langeland (Boesgaard, 1861).
of Skull with mandibles and skeletal parts (part of the hyoid bone, atlas, 2 scapulae, right humerus, fragmentary right antebrachium, lower part of left femur, left patella, 11 bones from carpus and tarsus, part of sternum, most of the costae. - The tip of medial accessory column of m 3 just worn; posterior half of supraorbital grooves roofed and tip of horn cores fairly porous. - Pl. V.
Also some remains of Urus from kitchen middens and other settlements may be dated at the Atlantic and Subboreal period. However, not only is the age of these kitchen middens very disputable, whether of Atlantic or Subboreal age, but also the character of the ox bones, whether belonging to Urus or domestic cattle, may be difficult to make out. It may therefore be expedient to give a revision of these bones, which are still kept in the Zool. Mus., Copenhagen, and a short survey of the kitchen midden problems in general; cf. p. 25. - From this it appears that Urus remains are stated in following settlements to belong to the Ertebølle culture:

| 80 | Ertebølle (on the map marked E) |
| :--- | :--- |
| 81 | Aamølle (Aa) |
| 82 | Havnø (H) |
| 83 | Mejlgaard (M) |
| 84 | Krabbesholm (K) |
| 85 | Virksund (V) |
| 86 | Lovns (L) |
| 87 | Gudumlund (G) |
| 88 | Kolding Fjord (Ko) |
| 89 | Horsø (Ho) |
| 90 | Brabrand (B) |
| 91 | Dyrholmen (D) |
| 92 | Kolind (Kl) |

93 Hjerk Nor (Hj)
94 Norslund (N)
95 Godsted (Go)
For further information compare p. 25.

Remains from the Subboreal Period (Zone VIII).
55. Ørting, 20 km . E.N.E. of Horsens (L. Jensen, 1896).
of Nearly complete skull, nasals missing, some ribs, and vertebrae. Old specimen with completely closed supraorbital sulcus and much worn teeth.
From the beginning of the zone, but later than the beginning of the earliest agriculture. Pl. VI.
56. Østbirk, 13 km . N.N.W. of Horsens.
of Nearly complete skull, most teeth missing, upper hindmost molar almost completely worn down to the roots, horn cores with strongly marked longitudinal grooves, tuberculated at base. Supraorbital sulcus completely closed. - (M. Degerbøl, 1962).
From an early part of the zone. - Pl. VI.
57. Pindstrup, Ryomgaard, Djursland, 30 km . W.S.W. of Grenaa (Naturhistorisk Museum, Aarhus, 1951).
ㅇ Incomplete skull with mandibles, some other skeletal parts: left and right scapula; lower part of left humerus; part of right ulna, parts of left and right pelvis, two lumbar vertebrae; lower part of left femur, right tibia, right astragalus ( $82 \times 52 \mathrm{~mm}$.), left metacarpus, right metatarsus (cf. Tables 11-20), 7 costae (M. Degerbøl, 1962). Cf. p. 58. - Pl. IX.
58. Ugilt, 10 km . S.E. of Hjørring (Sv. Frost, 1947, Vendsyssels historiske Museum).
o Complete skull, mandibles and most parts of postcranial skeleton. This skeleton must have belonged to a fairly young animal, about three years old. In the skull most sutures are open, only the interfrontal suture is posteriorly partly closed. The horn cores are porous, with many small holes, 'worm-eaten'. The lower p 4 is not completely erupted, and is faintly worn; as also in the mandibular m 3, only a faint wear on the hindmost column is indicated. - The teeth are astonishing small; the lower m 3 is only 42.5 mm . long and 18.5 mm . broad at the base, a measurement, which largely extends the range of variation in the Urus, and which is widely overlapping the range of variation in the domestic cattle. In the year 1962 I paid a visit to the Vendsyssels historiske Museum, and my attention was particularly fixed on this skull with the astonishing small teeth. The limb bones however also indicate, that a large bull is represented. Cf. Tables $11-19$. From the first half of the zone. Cf. p. 89. - Pl. VI.
59. Klarup, 9 km . E.S.E. of Aalborg (1954, Vendsyssels historiske Museum).
ot Brain-case, broken through frontal, on the right side just in front of the horn core, on the left side just behind the orbit. An old and strongly built skull. Horn cores granulated at the base and with longitudinal grooves, however, also fairly many holes are present. - In the mandibles no teeth are present, borders of alveoles beneath $m 1-m$ 2 faintly resorbed, and pathologically swollen. Cf. No. 14 and 23. Postcranial skeletal parts. From the beginning of the B-landnam. - Pl. VI.
60. Auning, Lykkegaards moor, 23 km . E.S.E. of Randers, Djursland (Chr. Køhler Christensen, P. Simonsen, Jagt- og Skovbrugsmuseet, 1942).
o Complete skull, and some postcranial skeletal parts. This skull has belonged to an old Biol.Skr. Dan.Vid.Selsk. 17, no. 1


Fig. 1. Map showing the dated finds of Bos primigenius in Denmark.
1 Millinge, Faaborg. 1 A Terp. 2 Vig. 3 Stokholthuse, Sorø. 4 Grænge A. 5 Gøderupgaard A. 6 Vieso. 7 Vigersted. 8 Munke Bjergby. 9 Knabstrup 1. 10 Knabstrup 2. 11 Rode Molle Aa. 12 Fyn (Appeldorn). 13 Svebølle. 13 A Tepstrup. 13 B Bjerregrav. 14 Rønnebæksholm. 15 Ullerslev. 16 Knabstrup 3. 17 Grænge B. 18 Grænge C. 19 Grænge D. 20 Grænge. 21 Bjeverskov. 22 Tranemosegaard. 23 Brændholt. 24 Flintinge. 25 Saxkøbing. 26 Hallenslev. 27 Niverød, Lerbjerggaard. 28 Alsønderup. 29 Jonstrup Vang. 30 Falster. 31. Bedsmose. 32 Risby. 33 Bregninge. 34 Lorup Hede. 35 Kulemile. 36 Gundestrup. 37 Taageby 38 Bisserup. 39 Gøderupgaard B. 40 Gøjsmose. 41 Kettinge. 42 St. Damme. 43 Maglemose, Mullerup. 44 Lundby. 45 Sværdborg. 46 Holmegaard. 47 Vinde Helsinge. 48 Øgaarde II. 49 Hesselbjerggaard. 50 Magleø I. 51 Kongemose. 52 Ulkestrup Lyng. 53 St. Taastrup. 54 Bønnelykkegaard. 55 Ørting. 56 Øst birk. 57 Pindstrup. 58 Ugilt. 59 Klarup. 60 Auning. 61 Toftum. 62 Aarhus. 63 Korinth. 64 Bønnerup. 65 Holme Mose. 66 Hornslet. 67 Hørning. 68 Dlgod. 69 Tranekær, Staus Hede. 70 Skovlund. 71 Kjærsholm. 71 A Læsten Mose. 71 B Grejs Mølle. 71 C Fæsted. 71 D Tinglev Lake. 71 E Ørum Aa. 71 F Bundsø. 72 Rise.


Fig. 2. Map showing discoveries of Bos primigenius of uncertain age. ${ }^{1}$ Jylland, pollen analyzed, but not dated: 73 Jelling. 74 Skaarup. 75 Mariager. 76 Mjesing. 77 Asaa. 78 Understed. 79 Julianelyst. - Sjælland: 97 Aagerup. 98 Lyngby. 99 Eskildstrup. 100 Mørkøv. 101 Skellingsted. 102 Tronninge-Kundby. 103 Højby. 104 Gl. Kogegaard. 105 Ollerup. 106 Hove. 107 Vanløse. 108 Hedehusene. 109 Gentofte. 109 A Brønshøj. 110 Jonstrup Vang. 111 Alsønderup. 112 Ganløse. 113 Kirkerup. 114 Viksø. 115 Øresund. 116 Gundsømagle. 117 Strødam. 118 Lille Lyngby. (119 Sjælland). 120 Torpe. 121 Holbæk. 122, 123 Faarevejle. 124 Logismolle. 125 Vedde. 126 Næstved. 127 Holmegaards Mose. 128 Kongsted. 129 Koge Bugt. 130 Sonnerupgaard. 131 Lyngby. - Fyn: 132 Bro. 133 Trostrup. 134 Tevring. 135 Dømmestrup. 136 Næsbyhoved. 137 Vissenbjerg. 138 Broby. 139 Østerby. 140 Kirkeby. 141 Aspedam. 142 Ejsemoseløkke. 143 Bøllemose, Gudbjerg. 144 Barløse. 145 Frøbjerg. 146 Turup. - Lolland: 147 Handermelle. - Jylland: 148 Mors. 150, 151 Ølholm. 152 Fuglekjær. 153 Gjødvad. 154 Formyre. 155 Aakjær. 156 Logenkjær. 157 Odder. 158 Vintved. 159 Olgod. 160 Egum. 161 Barrit. 162 Horsens Fjord. 163 Staugaards Mose, Torring. 164 Rathlousdal. 165 Norre Vissing. 166 Stilling Lake. 167 Aarhus Mølleaa. 168 Aarhus Harbour. 169 Bjornekjær, Lading. 170 Rosenholm. 171 Tjerrild. 172 Thorsager. 173 Benzon Estate. 174 Vindum. 175 Hvidbjerg. 176 Vibholm. 177 Ortoft. 178 Serridslev. 179 Horbylund. 180 Vidstrup. 181 Vittrup. 182 Hastrup. 183 Balslev. 184 Gudsøvig. 185 Kolding. 186 Almind. 187 Grejsdalen. 188 Agersbøl. 189 Løsning. 190 Havstrup. 191 Solbjerg Lake. 192 Silkeborg. 193 Randers Fjord. 194 Skørping. 195 Norlund. 196 Feldborg. 197 Vinderup.
${ }^{1}$ As no remains of dated Urus are known from Zealand later than Zone VI, it is probable that undated remains from this island actually are older than the transition period between Zones VI and VII.
individual. Most sutures are closed, even the internasal suture with the exception of the tip proper. The sulcus supraorbitalis is completely roofed (only as ordinarily penetrated by a few foramina). The bases of horn cores and the rims of orbits are granulated. Teeth worn. - A large specimen with fairly much upwards directed horn cores. - Pl. VI.
61. Toftum (Søltoft, 1878).
\& Brain-case, broken in front of fronto-nasal suture; mandibles. (Cf. p. 60). - Pl. IX.
62. Aarhus, from a bog near the town (Hecquet, J. Steenstrup O.V.S.F., 1853, p. 25). \& Brain-case.
Later than the landnam of the Single-Grave people. Cf. p. 60. - Pl. IX.
63. Korinth, Egneborg moor, 8 km. N.E. of Faaborg, Funen (K. Borne, Jagt- og Skovbrugsmuseet).
\& Brain-case, broken at the middle of the orbits, outer part of right horn core broken off. Old specimen with closed sutures, only interfrontal suture open anteriorly. Beginning of the zone. Cf. p. 60. - Pl. IX
64. Bonnerup, 15 km. N.W. of Grenaa, Djursland (J. Rybner, 1951).
\& Fragments of skull and other skeletal parts of 2 individuals. Outer part of left horn core, left upper m 1 and m 2, worn; left and right m 1 and m 2, much worn, lower part of right humerus, dist. width 90 mm ., of articular surface, anteriorly 84 mm ., middle part of left humerus, right antebrachium, upper inner side of right radius, right femur, middle part of left femur, right and left tibia, lower half of right tibia, middle part of left tibia, 2 right metacarpi, left and right metatarsus, right metatarsus, upper part of left metatarsus, left calcaneus, part of right calcaneus, left astragalus $(80 \times 49 \mathrm{~mm}),$.2 right astragali ( $80 \times 50 \mathrm{~mm}$. and $77 \times 47 \mathrm{~mm}$., respectively), left naviculo-cuboideum, 5 phalanges; several other fragments, thus of the pelvis. Cf. p. 60.
65. Holme moor, 5 km . N.E. of Ebeltoft (Ørting, 1868).
ô Old. Brain-case, broken through frontal, between horn cores and orbits. Tips of horn cores missing, granulated at base.
From the beginning of the zone, between A-landnam and the landnam of the SingleGrave people. - Pl. VI.
66. Hornslet, Djursland, 23 km . S.E. of Randers (Silkeborg Museum).
ot Incomplete skull, broken in front of rows of teeth. Most sutures open, interfrontal suture, however, closed posteriorly. Horn cores 'worm-eaten'. Teeth slightly worn, accessory column of hindmost molar (m3) not yet worn. - In size and individual age the Hornslet skull is similar to the Ugilt skull, about 3 years old. The frontal width, interorbital width, and maxillary width are equal, $220-222 \mathrm{~mm}$., $193-195 \mathrm{~mm}$., and $153-153 \mathrm{~mm}$. , respectively. Also the distance from the occipital condyle to the foramen infraorbitale is the same, 385 and 386 mm ., in the two individuals. However, the distance from the occipital crest to the nasal base is shorter in the Hornslet skull, 305 mm ., as compared with 318 mm . in the Ugilt skull and the same holds good of the distance to the foramen infraorbitale 410 and 425 mm ., respectively; probably the condylobasal length was almost the same in the two skulls, whereas the total length was somewhat shorter in the Hornslet skull. - Pl. VI.
67. Horning, 8 km . N.E. of Skanderborg (Dr. Poulsen, 1868).
o Posterior part of brain-case, with long and slender horn cores, granulated at the base. - Old specimen.
From the beginning of the zone. - Pl. VI.
68. Ølgod, 25 km . N. of Varde (H. Øllgatard, N. Raunkjer, 1941).

Horn core.
69. Tranekær moor, Staus Hede, Gesten, 15 km . N.W. of Kolding (Leo Novrup, 1945).
(a) ô Skull, right side of facial part damaged, left side broken through premaxilla; bases of horn cores and rims of orbits faintly granulated, interior column of m 3 worn, both mandibles, 2 femora, costa.
The mandibles were found about 10 m . from the skull together with a large number of bones. Probably a complete skeleton was present, but with the exception of the said remains it was taken to a refuse dump and was lost before Mr. Novrup arrived at the spot. - Pl. VI.
(b) Part of right mandible with teeth, metatarsus. Sent in together with the abovementioned remains, but of a more yellowish colour (28/5 1945).
(c) Middle part of right mandible, with m 1-m 3, thoracal vertebra, part of juvenile costa (11/5 1945).
(d) Metacarpus, lower m 1 and m 2 (23/7 1945).

Thus 4 specimens are represented by mandibles alone. Only the skull is dated. It is kept at the Koldinghus Museum.
70. Skovlund, Hørby, 10 km . W. of Sæby (Sv. Jørgensen, National Museum, 1962). Atlas.
A little later than the earliest agriculture.
71. Kjærsholm, Kjærs Aa, between Kjærsholm and Kjærsmølle, Torning, 20 km . S. of Viborg (Torning Museum).
ô Almost complete skull, left horn core broken; nasals and some premolars are missing. Horn core with longitudinal grooves. Total length 710 mm ., condylobasal length 660 mm ., basal length 566. Measured by Mr. MøHL with a folding rule.

71a. Læsten, at the source of the Skals river, 12 km . N.N.W. of Randers (Naturhistorisk Museum, Aarhus, 1961).
ô Practically complete skull; nasals present, tips of horn cores complete, anterior border of premaxillaries undamaged, teeth present with the exception of p 2 , which has fallen out. Posterior $2 / 3$ of interfrontal suture closed; however, the supraorbital grooves are only partly roofed, enclosed by sharp edges, and the medial column of the posterior molar is only just worn. Age about 4-5 years. - After the immigration of the Passage-Grave people, $2500-2000$ B. C. - Pl. VI.

71b. Grejs Molle, 5 km . N. of Vejle (R. Mortensen, Vejle Museum; Naturhistorisk Museum, Aarhus).
Skull roof of old bull, left mandible and postcranial skeletal parts. Skull broken transversally through supraoccipital and below orbits. On the right side os premaxillare and upper part of the maxilla are present, but on both sides the maxilla parts, containing teeth, are missing. Horn cores and nasals are complete. Naso-frontal sutures and posterior $2 / 3$ of interfrontal suture are strongly fused. The supraorbital grooves are roofed and the bases of horn cores and anterior rims of orbits are granulated. All characters indicate an old and large animal. The basal length cannot be taken, but the total length is 700 mm ., as in the skulls from Vig and Rønnebæksholm, in which the basal length is 580 and 583 mm ., respectively. Only 5 Danish Urus skulls have larger total lengths: Millinge ( 742 mm. ), Sorø ( 715 mm .), Bregninge ( 716 mm .), Kjærsholm ( 710 mm .), and Lyngby 706 mm . By comparison with these skulls the basal length of the Grejs Mølle skull may
be estimated at about 580 mm . The mandibular teeth are greatly worn, m 1 almost to the root. - The metapodials are uncommonly large (cf. Tables 11-12), the largest in the Danish material. - Later than B-landnam - Pl. VI.

71c. Fæsted, Hygum, 12 km. E.N.E. of Ribe (HaAr, 1944, Antikvarisk Samling, Ribe). ${ }^{\wedge}$ Skull of an old animal; as to the teeth only m 1 and m 2 are present. Supraorbital sulcus roofed. Interfrontal suture very broad and elevated, on each side posteriorly bordered by a well-marked concavity, and anteriorly, between the posterior part of the orbits, ending in a very deep concavity, too. - Pl. VI.

71 d Tinglev Lake, 18 km. S.W. of Aabenraa, Southern Jutland (King Frederik VII, 1858). of Skull. Premaxilla and parts of maxilla are missing. The following posteranical parts are present: 4 vertebrae cervicales, 6 vert. thoracales, 6 vert. lumbales, os coxa, 15 costae, right scapula, both humeri, both antebrachia, both metacarpi, both femora, right tibia, both metatarsi, astragalus.
"The find dates back to the summer of 1858 when the lakes of Tinglev were drained. In 1863 Prefect Heltzen presented it to King Frederik VII, and the King donated it to the Zoological Museum." H.W. 1904, p. 287.
The Tinglev skull is broken at the premaxilla suture. In length it is almost equal to the Østbirk skull. In both the distance from the foramen magnum to the foramen infraorbitale is 360 mm . Also the length from the occipital condyle and the occipital ridge to the suture between premaxilla and maxilla, on the palatal part, is equal in both, 490 mm . and 557 mm ., respectively. However, the distance from the foramen magnum to the said suture is a little larger in the Tinglev skull, 462 mm ., as compared with 455 mm . in the Østbirk specimen. Accordingly, the total length in the Tinglev skull may be estimated at 630 mm ., the condylobasal length at 555 mm ., as in the Østbirk skull, and the basal length at well over 530 mm .
The Tinglev skull thus is also of about the same length as the skull of the large Ullerslev cow, but although the two skulls are almost the same individual age - the interior column of m 3 is almost unworn in the Tinglev skull and only slightly worn in the Ullerslev skull - they are of different shape, the Tinglev skull clearly showing the characteristic features of the male sex. The bases of horn cores and rims of orbits are much more strongly granulated than in the Ullerslev skull, the supraorbital sulcus is roofed and the horn cores are longer, thicker, and more grooved, but particularly all width measurements are larger; this also holds good of the postcranial skeletal parts (cf. metapodials, Tables 11-12, and astragalus, Table 19, fig. 22).
The Tinglev skull is dated at the transition zone between the Subboreal and the Subatlantic periods, or to the last-mentioned period proper. - Pl. VI.

From two Subboreal, farmer settlements some remains of Urus are present:
71 e . Ørum $A a$, at Fannerup, 10 km . W.S.W. of Grenaa, on the north side of Kolind Sund. Of this site Winge states (1900, p. 146):
"Bos taurus urus. Upper end of ulna, calcaneus. - From previous collection: part of upper end of radius and a proximal phalanx of the pes. - In form and size as in Urus." The radius part, the medial half of the articular surface, must have belonged to a strongly built bull, the bone wall at the coalescence with the $u l n a$ is 20 mm . thick. The greatest length of the phalanx is 84 mm .
The great majority of Bos-bones from the Ørum Aa settlement, however, are by Winge grouped among the domestic cattle, and are, as usually in settlements, incomplete or very fragmentary. An exception makes a part of a hind limb (tibia, astragalus, (calcaneus, not present any more), naviculo-cuboideum, metatarsus, phalanx) of a not quite fullgrown animal. According to Winge "these bones greatly surpass in size the main race
in the settlement, and in several measurements approach the Urus, though being of lighter build".
From the material now at hand for comparison it is evident that these limb bones do not belong to a domestic ox, but represent the Urus cow. In form and size they are equal to the corresponding bones of females from Pindstrup and Bonnerup. (Cf. Tables 12, 17, and 19).
In the metatarsus and tibia the suture between the distal epiphysis and shaft is still visible, indicating that the Ørum Aa specimen was a little younger, than the Pindstrup cow.

71 f . Bundso, island of Als, Southern Jutland.
Bos primigenius.
Horn core (Tables 7-8), fragment of horn core; upper m 1-m 3 (length 92 mm .), upper m 3, lower end of humerus (trochlea width 102 mm .), prox. phalanx of pes (greatest length 84 mm .).
M. Degerbøl: Bundsø, 1939.

## Remains from the Subatlantic Period (Zone IX).

72. Rise, 4 km . W. of Aabenraa (Agnete Bisgatad, Aabenraa Statsskole, 1942). From the bank of a brook.
Brain-case, broken in front of orbitac; horn cores together with parts of the frontal bone, cut off by sharp cuts by iron implements, probably removed as a trophy.
This brain-case must have belonged to an old animal. Posteriorly the supraorbital grooves are completely roofed, the interfrontal suture obliterated, and the temporo-frontal and presphenoid sutures are only just visible. It represents a medium-sized bull, probably the size of e.g. the specimens from Ørting and Østbirk from the Subboreal period. The distance from the occipital ridge to the nasal base (in the middle) is 315,314 , and 308 mm ., respectively, and the distance from this ridge to the anterior rim of the orbit is the same in three specimens, 340 mm .; however, these measurements are fairly variable in Urus skulls.
The width of the brain-case is fairly considerable. The postorbital width being 293 mm ., as compared with 314 and 310 mm ., respectively, in the Ørting and Østbirk skulls; but as the Aabenraa brain-case is slightly water-worn, the original width must have been


Fig. 3A and B. Brain-case of Bos primigenius from Rise (Aabenraa). Subatlantic. Zone IX. Horn cores cut off. - A. Frontal view. B. Occipital view. - Scale as in plates.
somewhat greater. The Ørting and Østbirk skulls, however, are the comparatively broadest ones in the Danish material. The Aabenraa brain-case is not by far so heavily built as these two skulls, on the contrary, it is rather light, which may partly be explained by its water-worn condition, but no doubt also indicates that the Rise animal lived under not too favourable conditions. - The smallest frontal width is fairly low, $230(+)$, as compared with 248 and 243 mm ., respectively, and the width across the occipital condyles is 133,142 , and 132 mm ., respectively. The occipital height, from the upper border of the foramen magnum, is 163,171 , and 165 mm ., respectively, from the lower border 210,225 , and 210 mm ., respectively.
The brain-case was excavated from the bank of a brook, in a bog or meadow, about one meter below the surface of the earth. Pollen analyses of material from the interior of the brain-case and of the earth outside the skull were made by Dr. J. Iversen (The Geological Survey of Denmark). The results were identical: Willow $1 \%$, birch $6 \%$, pine $9 \%$, alder $62 \%$, elm $1 \%$, lime $7 \%$, oak $7 \%$, ash $1 \%$, beech $5 \%$, hornbeam $1 \%$, Picea $1 \%$. Besides hazel $11 \%$, herbs $109 \%$, heather $2 \%$.
The pollen flora is greatly influenced by culture, thus $7 \%$ cereals, $7 \%$ plantain, $3 \%$ Rumex, and $2 \%$ Chenopodiaceae. In particular the high per cent. of cereals is remarkable, indicating that rye (wind-pollinator) was cultivated. Coal particles were numerous in the samples. This spectrum no doubt indicates the Subatlantic period.
There is a possibility that the skull is in a secondary position, having originally occurred in older layers, which have been washed away, and new, younger earth deposited, not only around the skull, but also in the interior of the brain-case, which then in advance had to be completely cleaned even in the interior. This is not, however, very likely. Generally speaking, the Rise skull makes a "dry"' appearance, as seen in skeletons of domestic animals which have been kept on comparatively short commons, in contrast to the wellfed large bulls from the Boreal period.

Finds pollen analyzed, but dating uncertain.
73. Jelling, marlpit, 10 km . N.W. of Vejle (H. Bayer, 1947).

Left horn core with part of left frontal bone; right horn core, tip missing, right mandible with molars, lower border of left mandible and ramus ascendens, atlas, epistropheus, Diameters, at the base, of left horn core $106 \times 85 \mathrm{~mm}$., circumference 320 mm ., curvature 330 mm . (tip missing), length of lower m $1-\mathrm{m} 3$ is 111 mm . at the base, length and width, at the base, of m 3 are $48.5 \times 19.5 \mathrm{~mm}$.
Zone VII or Vili.
74. Skaarup, 4 km. S.E. of Skanderborg (Holtet, Skanderborg Museum, now Naturhistorisk Museum Aarhus).
\& Fragmentary brain-case and most parts of facial region.
M. Degerbøl, 1942, p. 97.

Zone VII or Vill.
75. Mariager (Cement works "Dania", 1949).

2 horn cores.
Zone VII or VIII.
76. Mjesing, Skanderborg (A. Andersen, D.G.U., 1917).
ô Part of tibia. - The smallest diaphysis width is 58 mm . Table 17.
77. Asaa, 23 km . S. of Sæby (E. Dalsgatrd, 1947).

Horn core.
78. Understed, 10 km. S.S.W. of Frederikshavn (Hans Jensen, Johs. Boolsen, 1960).
$\hat{\sigma}$ Left half of occipital-frontal region, with horn core broken in the middle, $2 \times 3$ molars. Diameters at the base of horn core $114 \times 90 \mathrm{~mm}$., circumference 330 mm .; width across condyli occipitales 139 mm .
79. Julianelyst, 10 km . N.W. of Horsens (N. Lund, 1882).
of Brain-case, on the left side broken anteriorly to the orbit, on the right side through the orbit. Old animal. Bases of horn cores very strongly granulated. Sulcus supraorbitalis, however, broad and only partly roofed. Frontal concave. - PI. VII.

## Bos-remains in the Kitchen Middens (Shell Mounds)

and other Settlements from the Ertebolle Culture.
In 1851 a committee consisting of a zoologist (Steenstrup), an archaeologist (Worsaae), and a geologist (Forchhammer) made it clear that the shell mounds along the Danish coasts were refuge heaps or "køkkenmøddinger", literally "kitchen middens'-a word coined by Japetus Steenstrup-and not emerged shell beds. In the present chapter the word is primarily used in its original sense, restricted to the classical kitchen middens from the Ertebølle culture, formed of shells (Ostrea, Cardium, Mytilus, Nassa, Littorina) in which the animal bones are scattered. This was the first incident of co-operation in Denmark between archaeology, zoology, and geology. The advantages of this teamwork were so evident that ever since there has been an intimate collaboration between these branches of sciences and humanities in Denmark.

This was also the case in the first great publication on these kitchen middens from the Stone age in Denmark from the year 1900 (A. P. Madsen, et al.). Two kinds of refuse heaps were described, partly older ones containing bones of wild animals, apart from superficial layers, and representing a population of hunters and fishers, the Ertebolle culture; and partly younger kitchen middens, predominantly with bones of domesticated animals, which indicate an agricultural people. It was believed that the Ertebølle culture belonged to the Atlantic period or Pollen Zone VII, when it was succeeded by agriculture in the Subboreal period or Pollen Zone VIII. Later it was proved, however, that the geological guide horizon, the Littorina transgression, was not a single transgression in the Atlantic period, but really four, the latest belonging to the Subboreal period (Rydbeck 1928, Iversen 1937, Troels-Smith 1937, K. Jessen 1937). Furthermore, it was shown that the Ertebolle culture continued far into the Subboreal period. The problem then arose how the connection between these two cultures had been and, particularly from a zoological point of view if any remains of domestic animals apart from the dog were found in the kitchen middens from the Ertebolle culture and to what time did the kitchen middens belong. As to the cattle, it was a question of category: Urus or domestic cattle?

However, as we now know the large sex dimorphism in the Urus and the existence of this species in Jutland in the Subboreal period, it is highly probable that
the smaller bones, which originally were reckoned as belonging to large domestic cattle really were bones of Urus cows, (cf. e. g. the Orum Aa settlement, p. 22). In fact, according to our present knowledge it must be expected that large, as well as small bones, that is bones which may be just as small as seen in domestic cattle, are to be found in Ertebølle kitchen middens. When in a kitchen midden large bones of Urus bulls are found to occur-and they are easily identified-it may a priori be supposed that also smaller bones of Urus cows may be present. In such a case it may be reasonable to group the small bovine bones, if at hand, and not identificable, as belonging to Urus cows.

The existence of domestic cattle can only be proved when bones are with certainty identified as belonging to this form.

Much has been written about these problems right from the days of Steenstrup to the present time (Troels-Smith, Iversen, Th. Mathiassen, cf. Degerbøl, 1961).

In the following Ertebølle kitchen middens, and other settlements, remains of bovine animals are found. (Cf. list p. 16):
80. Ertebolle, on the Limfjord, 18 km . S. of Løgstør.

Winge (1900, p. 87) writes about the bovine bones: "Bostaurus urus. Part of base of os occipitale and basisphenoid. Part of an upper end of a metatarsus and part of a rib probably belong to this species."

The occipito-basisphenoid part is very strongly built and, no doubt, belonged to a large Urus bull. The width of the basisphenoid is 42 mm ., as compared with 39 and 40 mm . in the large bulls from Sorø and Ølholm, respectively, and 34 mm . in the large Ullerslev cow.
The upper part of the metatarsus is from the right side of an adult specimen. It consists of the medial articular surface and the anterior part of the lateral surface. The greatest diameter of the medial part is 44 m ., as compared with 40 mm . in the fairly small Urus cow from Pindstrup, and 44 mm . in the largest of the two small Bønnerup cows. The equivalent measurements in a large B. t. domesticus from Bjerget is 39 mm ., in two metatarsi from the settlements of Troldebjerg and Bundsø, Passage-Grave period, 37 and 35 mm and in the Holmene bull and cow 39 and 35 mm ., respectively.
This fragment thus may have belonged to a fairly small Urus cow; and the same holds good of the part of the rib.
The Ertebølle kitchen midden is placed on coarse, marine sand, and at several places in the shell heap bands of marine gravel were observed. This means that not only was the area flooded by the sea before the Ertebølle people settled there, but also that the kitchen midden was submerged several times.
From an archaeological point of view Th. Mathiassen (1940 and 1942) tried to estimate the comparative age of the kitchen middens from the Ertebolle culture. According to these investigations, the main part of the proper Ertebølle kitchen midden belongs to a fairly early part of the Danish "Older Stone Age",
comparable to Dyrholmen II, the Atlantic period (Group I of Brondsted, 1957, p. 123). Only in the upper layers some archaeological remains from the Dolmen period have been found.
Also from a zoological point of view the Ertebolle kitchen midden seems fairly old. Apart from dog bones, only remains of wild animals were found, 56 species in all.
The animals that particularly provided the settlement with meat were Wild Boar (Sus scrofa ferus), Roe (Capreolus capreolus) and Red Deer (Cervus elaphus), a large number of bones of which is present. In fact it is surprising that so few bones of Urus are reported from the Ertebolle kitchen midden, thus especially considering, that remains of this species are predominating in the settlement of Hjerk Nor, only about 20 km . farther west.

For the sake of completeness I shall add that a few bones of Bos taurus domesticus were found on the Ertebolle kitchen middens, but under such circumstances that Winge was of opinion that they did not belong to the settlement; and they are not mentioned in the publication from 1900:
A lower end of a radius, from the top soil (F 3 '), a metacarpus, not split open, and the lower end of a metacarpus, "the appearance of both bones clearly disclose that they are an intermixture from later times."
81. Aamolle, on the south side of Mariager Fjord.

Winge, 1900, p. 103, writes: "Bos taurus urus. Part of lower end of ulna; metacarpus, with 5 th metacarpus, broken; 3 phalanges. The metacarpus compares completely with the Urus, this also applies to all other pieces, but they are less characteristic."
Winge adds: "Bones, obviously intermixed from later times, are found from Equus caballus, horse: calcaneus from the surface soil. Ovis aries, sheep: a complete metacarpus from the upper layer.
Bos taurus domesticus, domestic cattle. Several upper and lower molars, 2 condyli occipitales, part of premaxilla, part of mandible, part of scapula, part of ulna, some phalanges. All from the upper, partly mould-like layer."

The metacarpus of Urus belongs to a large bull (Table 11 ), and the same applies to the phalanges. The maximum length and width of a complete distal and a mediate phalanx are $104 \times 38 \mathrm{~mm}$., and $54 \times 39 \mathrm{~mm}$., respectively. (Tables $22-23$ ). From the main excavation from 1893 (according to original lists kept in the Zoological Museum) several teeth and a mediate phalanx are present. They are of a clear yellow-brownish colour, different from the dark appearance of the bones from the upper mouldy layer (excavated in 1899). In size the phalanx is equal to the corresponding phalanx in the Bonnerup cows, maximum length 47 mm ., and thus no doubt belonged to an Urus cow.-2 lower and 3 upper molars are at hand. Owing to the fact that in the lower, hindmost molar (m3) the posterior lobe shows no signs of wear, this tooth must have belonged to an adult, but fairly young animal. It is of almost the same size as the lower $m 3$ in the small Pindstrup Urus cow, and thus a little larger than in the Ugilt bull;
the maximum lengths are $44.5,45.5$, and 42.5 mm ., respectively, and the maximum widths at the base are the same in the three specimens (cf. DEGERBøL, 1962, fig. 4). The lower m 2 is comparatively smaller; the length of the grinding surface, it is true, is the same, 32 mm ., as in the 3 specimens mentioned, but in the middle of the tooth the Aamolle specimen is a little shorter.
Also an upper hindmost molar (m 3) shows no sign of wear and is just as large as the equivalent tooth in the Pindstrup cow, 35.5 mm ., as compared with 32 mm . in the Ugilt bull. The two upper molars, are much shorter; thus it appears that the hindmost lower and upper molars may have belonged to a small Urus cow, but the other molars are smaller than hitherto found in the Urus.
Apparently the age of these bones is uncertain; judging from their appearance they do not originate from the superficial layer, as indicated by Winge, which otherwise no doubt applies to the rest of the bones referred to domestic cattle. According to $\mathrm{T}_{\mathrm{h}}$. Mathiassen (1942, p. 57) the Aamølle kitchen midden may, from an archaeological point of view, be placed at the same evolutionary stage as Dyrholmen II and late Dyrholmen III (Dolmen period or later).
"Also in the upper part of this kitchen midden several things from the Younger Stone age were found. However, these were not only, as in Ertebølle and Havnø, from the Dolmen period, but also from later parts of the period, probably originating from accidental visits to this old hunting settlement." (Th. Mathiassen).
82. Havno, on the north side of Mariager Fjord.

Winge (1900, p. 111): "Bos taurus urus. Part of epistropheus, lower end of metacarpus, upper end of a phalanx. All similar to bones of the Urus. A naviculo-cuboideum bone undoubtedly belongs to the same species."

The distal width of the metacarpus is 81 mm ; the proximal width of the innermost phalanx is 44 m .; indicating an Urus bull. The naviculo-cuboideum is similar to this bone in the Ullerslev cow, greatest width 69 mm . (Tabel 20).
Also in this kitchen midden Bos taurus domesticus is represented: "Several teeth and bones of at least 4 specimens, very different in size, some of them large, some small. All from superficial layers." (Winge, loc. cit., p. 111).

All in all, no less than 50 fragments of bones of domestic cattle are present. Thus the distal width of the lower ends of two metatarsi are 55 and 47 mm ., respectively, no larger than in small cows from the Middle Ages.
The distal width of a tibia is 60 mm ., the greatest width of navicolo.-cuboideum is 59 mm ., indicating domestic oxen. (Table 20, No. 67).
From superficial layers furthermore, some bones of horse and sheep or goat are at hand.
Mathiassen (1942, p. 57) states that the older part of the Havno kitchen midden belongs to the Dyrholmen II. phase (including thick-walled Ertebolle pottery), the upper part to the Dolmen period. There are no indications that the settlement was not continuously inhabited.
In the publication on the kitchen middens from 1900 also two settlements from

Zealand belonging to the Ertebolle culture were described, viz. from Faarevejle, on the drained Lammefjord, N.W. Zealand, and Klinteso on the N.W. coast, at the base of Sjællands Odde, but as was to be expected from our present knowledge, no bones of Bos primigenius were found. Klintesø has later been dated at the Subboreal period (K. Jessen 1937).
83. Mejlgaard, N.W. of Grenaa.
"Bos taurus urus. A few bones of a bovid, so large that they probably belong to the Urus: part of a mandible with the three premolars, a hindmost molar (labelled 15.6.1861), jugal, part of epistropheus (labelled 15.8.1861), upper end of femur." (Winge 1904, p. 286).

The lower border of the mandible fragment is split open to take out the marrow. The teeth show only very slight signs of wear, p 4 not quite in place in the jaw They are a little larger than the equivalent teeth in the Pindstrup Urus cow and in the Ugilt bull, length of premolars 63,59 , and 58 mm . (Cf. Table 10). Even if the premolars may be very large in prehistoric domestic cattle (M. Degerbol, 1939, p. 116, fig. 7), they probably do not compare with this specimen from Mejlgaard.
The length and width of the hindmost lower molar is 46.5 mm . and 18.3 mm ., respectively. Also this tooth may belong to an Urus (cf. M. Degerbøl, 1962, p. 249, fig. 4). - The epistropheus is heavily built, as in Urus; it is true, that the greatest width of the anterior border is 114 mm ., as compared with 113 mm . in the large domestic animal from Bjerget; however, this last specimen is much more slightly built: the width of the dens epistropheus, at the base, e.g., is only 50 mm . as against 57 mm . in the Mejlgaard bone. - The diameter of the caput femora is 61 mm ., as in the Tinglev specimen.
Besides these heavy bones (mentioned by Winge) several fragmentary skeletal parts of Bos have been recovered from the Mejlgaard kitchen midden and identified as belonging to domestic cattle; they are still preserved in the Zool. Mus. With our present knowledge of the great sex dimorphism in the skeletal parts of Urus it is likely, however, that most of these bones belong to Urus. This applies to the following bones (labelled 14-15.6.1861): Lower end of metacarpus, the distal width of which is 71 mm ., as compared with 66 mm . in the Pindstrup cow (cf. Table 11), thickness above epiphysis 35 and 34 mm ., respectively, and greatest diameter of trochlea is 40 and 38 mm ., respectively.
Part of medial side of right tibia, heavily built, height at crista anterior, anteriorly - posteriorly, is 59 mm ., as compared with 52 mm . in the domestic oxen from Bjerget and 48 mm . in the Pindstrup cow.
The proximal width of a second phalanx is 40 mm ., as compared with 34 mm . in the Ullerslev cow.
A lower end of a tibia is almost the same size as the tibia of the Pindstrup cow, the distal width being well over 70 mm ., in the Pindstrup cow 73 mm .
An upper half of a metatarsus (marked 0 ) is in size and shape similar to the corresponding part of the Pindstrup cow (Table 12). This also holds good of an
upper, lateral part of a right metacarpus; the length of the lateral articular surface is 38 mm ., greatest width 26 mm ., as compared with 34 and 26 mm ., respectively, in the Pindstrup cow.
In an anterior part of a right mandible the distance from the foramen mentale to the anterior border of the first premolar is fairly long, 75 mm ., as compared with 73 mm . in the Pindstrup cow. The length of the two anterior premolars present is 31 mm ., as compared with 34 mm . in the Pindstrup specimen, thus fairly small, probably too small for an Urus.
A lower m 2 is 33 mm . long at the grinding surface, 25 mm . at the base; in the Pindstrup cow the equivalent measurements are 33 mm . and 27 mm . ; the width at the base is 16.7 mm . in the Mejlgaard tooth. Probably this tooth, too, belonged to a domestic ox. An upper posterior part of a left radius belongs to a small domestic cow. The width, anteriorly-posteriorly, of the lateral articular surface is only 22 mm . ( 31 mm . in the Pindstrup cow). This bone is dark-coloured, probably from the superficial layer, but has been split open for taking out the marrow. An astragalus is also a dark colour, 63 mm . long, belonging to a B. t. domesticus. Besides, 3 carpal bones, 2 upper teeth, 2. premolars and 2 molars, and a free epiphysis of a femur are present.
Mathiassen (1942, pp. 58-59) informs us that the axes in the Mejlgaard kitchen midden belong to a late stage, probably Dyrholmen II. According to H. Andersen (1960, p. 34), however, an early Neolithic intermixture is indicated in the upper and superficial layers.
84. Krabbesholm, N. of Skive, on the Limfjord.
"Bos taurus urus. A few bones, part of a frontal bone, part of a mandible, a few lower teeth, i.a. 2 different hindmost lower molars, upper part of a radius" (Winge 1904).

The following bones of Bos primigenius are kept in the Zoological Museum, Copenhagen: part of horn core ( $\widehat{0}$ ), part of left frontal, with part of orbit ( ${ }^{\wedge}$ ), part of right mandible, distance from the foramen mentale to the anterior border of p 2 is 68 mm ., least height 33 mm .; posterior part of left mandible, width (ant.-post.) below proc. articularis 66 mm .; 4 lower molars (m 1 - m 2); from the left and the right side, length of grinding surface 61 mm ., at the base 57 mm ., as compared with 61 and 59 mm . in the Pindstrup cow, and 60 and 57 mm . in the Ugilt bull; in a mandible of the domestic bull from Vedbæk II (Maglemosegaard) the corresponding measurements are 53 and 52 mm .
The length and width of the two mandibular, hindmost molars ( m 3 ) are $47.1 \times 19.0$, and $43.5 \times 18.5 \mathrm{~mm}$., respectively. Particularly the last-mentioned tooth is remarkably small, however, often seen in m 3 from kitchen middens. (Cf. p. 89). - Scapula, width of collum 75 mm . ("Bjerget" 70 mm .). Upper part of right radius, largest proximal, transversal width $109 \mathrm{~mm} .$, width of articular surface 99 mm ., greatest width anteriorly-posteriorly 54 mm . oै ("Bjerget'" 99 mm ., 90 mm ., and 48 mm ., respectively). Lower part of left antebrachium; distal width 107 mm . ("Bjerget" 87 mm .) ; fibula; 2 carpal bones.

Besides, several bones were classified as Bos taurus domesticus; however, no doubt some of these belonged to Urus cows, as was also the case in the Mejlgaard kitchen midden.
A lower part of a metatarsus is in shape Urus-like, gradually getting narrower upwards, whereas this part in domestic oxen is narrowing more sharply. In Urus the anterior-posterior measurements are larger than in domestic oxen; the diameter of the largest trochlea is in the Krabbesholm specimen 38 mm ., as compared with 38.5 mm . in the Pindstrup cow and 36 mm . in the domestic ox from Borremose and in a large domestic ox from the Neolithic settlement on Lind $\varnothing$, whereas the distal transversal width roughly is the same in the said bones, 65 mm .; the corresponding anterior-posterior width of the diaphysis are: 30 , $30,26.5$, and 24 mm .
'2 complete astragali and an incomplete one are in size equal to these bones in the Pindstrup and Bonnerup cows; total length $80-82 \mathrm{~mm}$. (Cf. Table 19). A lower m 3, $40.8 \times 17.2 \mathrm{~mm}$., is probably too small to be grouped with Urus. Some bones of mould-like colour belong to Bos taurus domesticus: upper part of a radius, the largest transversal width of which is 86 mm ., 80 mm . of articular surface; an astragalus is only 65 mm . long. A small lower m 3 is 34 mm . long and 15.3 mm . broad.
85. Virksund, 15 km . E.N.E. of Skive, on the south coast of the Limfjord.
"Bos taurus urus ? Part of mandible, lower end of humerus, fragment of ulna, caput femoris. The bones are comparatively small, but probably too large to belong to domestic cattle. Bos taurus domesticus. Some isolated lower teeth. Collected partly by Andersen the controller in the year 1861 and through Professor Eschricht forwarded to Steenstrup, and partly by Steenstrup 1865 " (Winge 1904, p. 205, 287).

The fragment of the lower jaw consists of a horizontal part bearing the two hindmost molars, m 2 and m 3, and is broken just in front of and a little behind the teeth, which are much worn. The total length of the two teeth is 72 mm . the length and width of m 3 is 43.5 mm . and 17.4 mm ., respectively. Although the cement layer and the enamel are thick and well marked and the jaw comparatively heavy it is problematic whether this piece belonged to a Urus; the combined m $2-$ m 3 length and the width of m 3 are particularly small. The height between m 2 and m 3 is 57 mm ., behind m 367 mm ., and the greatest thickness of the jaw is 31.5 mm .
It should furthermore be noticed that similar jaw fragments occur, e. g., in the Lyø settlement, and that it also roughly corresponds to the mandible of the Søndersø domestic ox, in which the m $2-\mathrm{m} 3$ length is 70 mm ., the respective heights of the jaw being 59 and 69 mm ., and the thickness 35 mm .
Also the humerus part is fairly large, almost as broad as in the Ullerslev cow, but similar humerus parts occur, e. g., in the Troldebjerg settlement.
The femur head, however, is very large, and no doubt belonged to Urus. The greatest width of the caput, anteriorly-posteriorly, is 59 mm ., of the collum,
anteriorly-posteriorly, 37 mm ., as compared with 57 and 34 mm ., respectively, in the Ullerslev cow.
86. Lovns, on the north side of Lovns Bredning, on the Limfjord, about 15 km . S. of Ertebølle (National Museum, 1908).
Bos primigenius. Upper part of metacarpus, ô. Proximal width, transversal, 85 mm . Bos taurus domesticus. A few bones from superficial layers.
87. Gudumlund, on a small inlet of Lille Vildmose, on the south of the Limfjord, about 15 km . S.E. of Aalborg (H. Winge 1904).
"Bos taurus urus. Part of horn-core", - large, ô.
88. Kolding Fjord. (Museum at Koldinghus).

Bos primigenius. From the dredging in the year 1896: Upper and lower part of metatarsus, proximal width, transversal, 59 mm , anteriorly-posteriorly, 56 mm ., ㅇ; distal width 75 mm ., $\delta^{\text {h }}$; lower part of metacarpus, partly soot-coloured, distal width $80 \mathrm{~mm} ., \delta^{1}$; lower part of metacarpus, distal width 77 mm ., ô; calcaneus, the free epiphysis is missing.
From the year 1900: Part of right mandible, broken in front of tooth row, of young animal with milk premolars and m 2 erupting, showing no signs of use. Right horn-core. ${ }^{\widehat{ }}$.
From the year 1915: Upper half of metacarpus, proximal width 82 mm ., ô. Upper and lower part of metatarsus; prox. width 62 mm. , 0 , dist. width 78 mm., ô; calcaneus, broken posteriorly.

According to Th. Mathiassen (1942, p. 61) it is probable that this settlement belongs to Dyrholmen II (however, a couple of potsherds from the Dolmen period are present).
89. Horsø, Hobro. (K. Jessen, 1927).

Astragalus, lower hindmost molar (m 3) (M.D.).
90. Brabrand settlement, near Brabrand Lake, 5 km . W.S.W. of Aarhus. (Publ.: Th. Thomsen and A. Jessen, 1906).
The bone material from Brabrand was sent to the Zoological Museum, and examined by $H$. Winge. The investigations by $W_{\text {inge, }}$ however, were not published directly, but were reported by Th. Thomsen (loc. cit. pp. 51-52). In the original lists, kept in the Zool. Mus., Winge wrote about B. primigenius: (21.12.1903).
"Anterior and posterior part of mandible, part of atlas, part of one of the hindmost vert. cervicales, some fragments of ribs, part of radius, pisiforme, upper end of metacarpus, lower end of metatarsus, 3 phalanges.
(14.11.1904): parts of 3 horn cores, part of epistropheus, part of two vert. thoracales, a rib, scapula, some carpal-bones, 5 astragali, 2 nav.-cub., a few phalanges. - Some of the bones are relatively small, particularly some of the astragali.


Fig. 4. Upper part of metacarpus from the Brabrand settlement, II C $6^{4-5}$, (No. 2), placed together with a corresponding part from Ogaarde, Boreal period (No. 1), and 2 complete metacarpals, of the Urus cow from Pindstrup (No. 3) and of the domestic bull (bullock) from Holmene, Hillerød. - In shape and size the Brabrand specimen is similar to the metacarpals of the Urus from Ogaarde and Pindstrup. $\times{ }^{1 / 2}$.

Bos taurus domesticus (?). Upper end of a metacarpus (II C $6^{4-5}$ ) and lower end of a metatarsus, cut off, (II B 81b). In size as that a good-sized domestic ox. May perhaps originate from an unusually small Urus,"
The Brabrand settlement was originally dated at the period just before, during and immediately after the maximum of the Littorina Sea; the deepest part thus older than the kitchen middens built on the highest shore line of the Littorina Sea (Th. Thomsen and A. Jessen, 1906).
Later it was stated that the find was younger, only the deepest part, belonging to the late Atlantic transgression (Troels-Smith, 1937).
Of particular interest is the upper half of the metacarpus from one of the deepest layers (II C $6^{4-5}$ ), which by Winge, although with some reservation, as just mentioned, was determined to be B.t. domesticus. In the publication by TroelsSmith it was characterized as a bone which with a probability amounting almost
to certainty had belonged to a domestic ox, and it was taken as a proof of the existence of domestic cattle in Denmark already at the border line between Zones VII and VIII.
It must be admitted that not until recently, with the appearance of the new material for comparison, have we got a possibility for a real judging of this bone. In size and shape it is similar to the corresponding part of the small metacarpals from, e.g., Pindstrup and Bønnerup A. On the other hand, it should be emphazised that it also is much like the corresponding parts of several metacarpals of Neolithic domestic cattle, e.g. the male from Holmene, Hillerød, the measurements of the proximal end being almost the same in the said specimens.
In the Brabrand fragment the proximal transversal width is 65.5 mm ., as compared with 66.4 mm . and 63.0 mm . in the Pindstrup and Bønnerup specimens, respectively; in the Holmene male, however, the said measurement is even a little larger, 67.0 mm . The anterior-posterior widths are: $41.0,41.0,39.0$, and 41.3 mm ., respectively, and the anterior-posterior width of the articular surface: $36.2,37.5,36.0$, and 36.0 mm ., respectively. - It may be noted, however, that the upper half of a metacarpus from the Ogaarde settlement, Zone VI, is quite conformal with the Brabrand specimen. The transversal, proximal width is similar, 66 mm ., but as the medial articular surface is opened posteriorly, probably for taking out the marrow, the anterior-posterior width cannot be taken. The diaphysis is broken in the middle, just as in the Brabrand metacarpus; its transversal width is 35.5 mm ., as compared with 36.2 mm . in the Brabrand specimen (Fig. 4). - It may also be mentioned that Stampfli (1963) depicts the upper part of a metacarpus, referred to Urus, which is similar to the Brabrand bone; proximal transversal width 66 mm ., and anterior-posterior width 40 mm . The Brabrand fragment seems to have belonged to a comparatively long metacarpus. It is broken 122 mm . from the proximal end, measured on the lateral side, but even at this distance from the upper end the diaphysis has its smallest transversal width, 36.2 mm ., as also the metacarpals from Pindstrup and Bønnerup get their minimum widths, 37.0 and 40.0 mm ., respectively, at that distance. In accordance with the shorter metacarpus of the domestic oxen is the least diaphysis width, 37.5 mm . in the Holmene male placed more proximally, and from there the bone is growing broader; at the said distance, 122 mm . from the proximal end, the width is 38.5 mm .
Also the very thick bone walls of the Brabrand piece indicate the Urus; the anterior wall in the median line is 11 mm . thick, the lateral wall 10 mm .
To sum up, it must be said that the Brabrand fragment not only may have belonged to an Urus cow, but that no doubt it represents this animal. At least, on the basis of the much larger reference material now at hand the said bone cannot serve as a proof of the existence of domestic cattle in Denmark prior to the Ulmus decline.
Another proximal end fragment of a metacarpus is posteriorly cut just below the
articular surface. The transversal width is 72 mm ., the anterior-posterior width is 45 mm . and of the articular surface 40 mm . On the lateral part there is a faint granulation, the bone wall is thick, about 11 mm . Also this fragment no doubt belonged to an Urus cow, an old, robust animal. In size and shape this fragment is comparable to the corresponding part of the large St. Taastrup metacarpus, but here too it may be noticed that the measurements correspond very well with those of the metacarpal of a domestic male, e. g., from Borremose. (Table 11).
The thick bone walls, about 11 mm . thick, and a general impression, e.g., based on a more clear-cut relief, may indicate its belonging to $B$. primigenius. Furthermore, as already emphasized, when large bones belonging to Urus bulls are present in a settlement, it must a priori be expected that smaller, and perhaps questionable Bos-bones from the same site belong to female Urus specimens. No less than 5 astragali occur, representing 5 individuals. They are all, as mentioned by Winge, comparatively small, i.e. representing Urus cows, the largest are in size as the astragalus of the Ullerslev cow, the 2 smallest as the astragali of the Bønnerup cows, length 76 and 79 mm ., as compared with 77 and 80 mm . in the Bonnerup specimens, but outside the upper range in domestic oxen: 74 mm . (Cf. Table 19). Two (Nos. 72 and 74 , Table 19) belonged to young animals, as appears from the porous consistency of the bone; however, even with growing size these two specimens would not have attained the large width characteristic of males. Cf. e.g. the astragalus of the Ullerslev cow, which is almost as long as the astragalus of the small bull from Tinglev, lengths 82 and 84 mm . respectively, but is much narrower, distal widths 52 mm . and 57 mm ., respectively.
A naviculo-cuboid from Brabrand is 61 mm . broad, as in the Bønnerup cow; it has belonged to a young animal, and, together with a second fragmentary na-viculo-cuboideum represents the Urus cow. (Cf. Table 20).
A medial part of a $1^{\text {st }}$ phalanx of a hindlimb is of similar size as the corresponding part of the Ullerslev cow; the smallest length is 65 mm . in both; the greatest heights are 62 and 61 mm ., respectively.
Four 2. d. phalanges are at hand. In two, probably from the forelimb, the smallest lateral lengths are 38 and 36 mm ., respectively, as compared with 38 mm . in the Ullerslev specimen; the diaphysis widths are $32 \mathrm{~mm} ., 27 \mathrm{~mm}$., and 28 mm ., respectively, the largest one thus probably belonging to a bull, the smallest one to a cow. The other two phalanges, from the hind limb, measure $39 \times 26 \mathrm{~mm}$. and $35 \times 27 \mathrm{~mm}$., as compared with $41 \times 29 \mathrm{~mm}$. in the Ullerslev cow.
Also the mandibular fragments may find their place among Urus cows; the length from the foramen mentale to p 2 is 75 mm ., the height of this part 28 mm . Of the many fragments of horn cores present it has been possible to form a measurable left horn core, which on the frontal side bears a number of longitudinal, deep and narrow furrows. In size it is comparable to the horn cores of


1


2


3


4

Fig. 5. Distal parts of the two metatarsals from Dyrholmen settlement (Nos. 2 and 3) placed together with corresponding parts from Ogaarde (No. 1) and Maglemose 1949 (used as a hammer), Boreal period (No. 4). - Nos. 5 and 6 (opposite side). Complete right metatarsals of the Urus cow from Pindstrup (No. 6) and of the domestic Holmene bull (bullock). $\times{ }^{1 / 2}$.
The distal transversal width of the metatarsals of Urus cows falls within the size range of the domestic oxen, but e.g. the anterior-posterior width is larger in Urus. - Cf. fig. 6.
the young bull from Hallenslev, but must have belonged to an adult animal. Diameters at the base are $98 \times 80 \mathrm{~mm}$., the circumference at the base 285 mm ., and the length along the outer curvature 500 mm . It should particularly be emphasized that this specimen by pollen analysis has been dated at the Atlantic period, Zone VII.
A fragment of the frontal side of a horn core, broken at the base, represents a large, young bull, as indicated by the porous, "worm-eaten" appearance. Also the cervical vertebra mentioned belonged to a bull.
Summary: In the Brabrand settlement Bos remains are comparatively numerous. They may be identified as belonging to the Urus, bulls as well as cows, but females are predominant amongst the specimens recovered. Owing to the astragalus alone, 5 specimens of cows are represented.
91. Dyrholmen settlement, Djursland.
(Publ. Th. Mathiassen, M. Degerbøl og Troels-Smith, 1942).


Fig. 5, continued.

As at the Brabrand settlement comparatively many bones of Bos occur at the Dyrholmen site, several of these being so small that they are comparable with the corresponding bones of domestic Neolithic oxen. At the time of the publication of 1942 the measurements of some of these small bones fell outside the size range of Urus cows then known. However, on the basis of the frame of comparison now procured, most of these dubious bones may be referred to Urus cows. This holds good, i. a., of two incomplete horn cores, from the earliest part of the settlement, Dyrholmen I, (cf. p. 63). It is not so much the width of the horn core as the length, which is indicative of Urus cows as compared with domestic cattle. - Also two distal parts of metatarsals now find their natural place within the size range of Urus cows. The distal transversal width, it is true, falls within the


Fig. 6. Distal ends, from below, of metatarsals of the Urus cow from Dyrholmen, at the top (No. 3 in fig. 5), and of the domestic bull (bullock) from Holmene, Hillerod, at the bottom (No. 5 in fig. 5). - In the Urus the anterior-posterior width of the sagittal ridge of the trochlea is larger than in domestic oxen. Further information in text. $\times^{1 / 1} / \mathbf{1}$.
size range of domestic cattle, but the anterior-posterior width is larger in the Urus, e.g., measured as the smallest width of the distal part of the diaphysis or as the greatest width of the sagittal ridge of the trochlea of metatarsus No. 3. In domestic oxen the outer half of this trochlea (on the medial side of the cannon bone) is very broad, considerably broader than the outer half of the trochlea of metatarsus No. 4 (on the lateral side of the cannon bone). In Urus this difference in width is not at all so pronounced, and particularly the lateral width is anteriorly small. Also the height of the trochlea, from below-upwards, is greater in the Urus. In shape of the distal end of metatarsus thus a considerable difference exists between Urus cows and domestic oxen; figs. 5-6. (Cf. p. 158).
Furthermore, two proximal ends of metatarsals are present; one (from Squares II D1 and II E1) belonging to a bull (transversal width 67 mm ., anterior-posterior width 61 mm .) ; the other (from Squares P 5 and M 45) to a cow (width 56 mm . and 52 mm .) respectively.
Also regarding other skeletal parts from Dyrholmen similar differences in size occur, the larger bones representing bulls, the smaller ones cows. Of 4 calcanei 2 belong to bulls, 2 to cows (cf. Table 18) and of 2 astragali from the oldest part of the site one is representing a bull (total length 87 mm .), whereas the smaller
one, with a total length of 81 mm ., is only slightly smaller than the astragalus in the Ullerslev cow ( 82 mm .).
Two naviculo-cuboidea belong to bulls; the greatest transversal width is 75 and 73 mm ., respectively; a third specimen is small, the greatest width 60.5 mm ., and it was originally considered as probably belonging to a domestic ox. However, in size and shape it is conformal with a naviculo-cuboideum of the Urus cow from Bonnerup, the greatest width of which is 61 mm . A similar external width, 62 mm ., it is true, is also found in the naviculo-cuboideum of the old domestic male from Holmene, but the upper articular surface proper in this specimen is smaller than in Urus cows.

Particularly small are the teeth from Dyrholmen, the interpretation of which has involved great difficulties (Degerbøl, 1963).
Only the appearance of the Ugilt skull with the astonishingly small teeth has brought most of the Dyrholm teeth within the size range of the Urus. Of the 4 hindmost mandibular teeth (m3) present at Dyrholmen (also from the oldest layers, Dyrh. I) 2 are a little larger than m 3 in the Ugilt skull, length and width $42.7 \mathrm{~mm} . \times 18.7 \mathrm{~mm}$., as compared with $42.5 \times 18.5 \mathrm{~mm}$. in the Ugilt skull, but the 2 other specimens are smaller, $41 \times 18 \mathrm{~mm}$., that is, within the range of B. $t$. dom., however, as certain remains of domestic cattle are not found in this settlement, it is probable that these teeth, too, may be referred to Urus cows. Also the very small maxillary fragment from Dyrholmen, bearing teeth, premolars and first molar, p $2-\mathrm{m} 1$, is similar to the corresponding part of the Ugilt skull, in fact a little larger. The p $2-\mathrm{m} 1$ length at base, is 85 and 82 mm ., respectively.
Accordingly it is probable that the small teeth from the Dyrholmen settlement, as well as several other small teeth from the Atlantic and Subboreal sites, represent the Urus.
Summary: The bovine bone material from the Dyrholmen settlement represents the Urus; it naturally falls into two groups, larger bones representing males an smaller ones females; however, some of the smaller remains, particularly teeth, are very small, some teeth scarcely reaching the size range of the exceptionally small teeth in the Ugilt skull. However, bones of distinct domestic oxen do not occur.
92. Kolind, on the now drained Kolind Sund, Djursland, about 20 km . S.E. of Dyrholmen. (Th. Mathiassen, M. Degerbøl, and J. Troels-Smith 1942).
As regards almost complete, measurable bones of Urus two astragali and a proximal phalanx are at hand. The astragali are of almost equal size, representing females (Table 19), one is from Stage I, older than the Dyrholm find, the other is from Stage III (= Dyrholmen 1 and 2). The phalanx, from Stage I, has been opened for taking out the marrow, the lateral length (shortest) is 69 mm ., as compared with 66 mm . in the Ullerslev cow.
93. Hjerk Nor, east side of Salling Sund about 16 km . N.N.W. of Skive (M. Reffsgaard. Skive Museum).
Bos primigenius.
Lower part of right horn core with small part of frontal bone, diameters $85 \times 63 \mathrm{~mm}$. . . Left premaxilla and maxilla. Fragment of mandible with m 3, worn, $43.8 \times 19.0 \mathrm{~mm}$. Anterior part of mandible, the distance from foramen mentale to the anterior border of p 2 is 55 mm ., height 26 mm ., thickness $15.5 \mathrm{~mm} .$, , small. Left lower p 2, much worn, and p 3, worn; left upper molar. Proximal part of right antebrachium, transversal width 95 mm . (articular surface 87 mm .), anterior-posterior width 49 mm ., , , a little smaller than in the Ullerslev cow. Proximal end of left radius, corresponding measurements 113 mm . (101 mm.), 60.5 mm . (art. 52.5 mm .), ô, large. Medial side of upper end of radius, anterior-posterior width 53 mm ., $\mathrm{J}^{2}$. Lower part of right antebrachium, distal width 110 mm., ${ }^{\boldsymbol{*}}$, large. Distal end of right antebrachium., $97 \mathrm{~mm} .,+$, , a little larger than the Ullerslev specimen. Distal end of left antebrachium 101 mm . (art. 90 mm .), ot, as the Tinglev specimen. Proximal end of left metacarpus, prox. width 86 mm . (trans.) $\times 49 \mathrm{~mm}$. (art. 45 mm .), anterior-posterior, ${ }^{2}$, large. Distal end of metacarpus, distal width 66 mm ., diameter of trochlea 37.5 mm ., . Medial side of upper end of metacarpus. 3 distal ends of metatarsus, distal width $64-64-75 \mathrm{~mm}$., respectively, diameters of trochlea 39-38 and 44 mm ., respectively, representing two females and a male. Distal end of tibia, distal width, transversally 86 mm ., $\hat{\mathbf{o}}$. Posterior part of shaft of tibia, $\hat{\mathbf{o}}$. Right astragalus, greatest length 90 mm ., distal width 56 mm ., height 46 mm ., of. Right astragalus $81 \times 53 \times$ 42 mm ., respectively; anteriorly soot coloured, +.2 right naviculo-cuboidea, greatest width $79 \mathrm{~mm} .$, of, and 70 mm ., $\frac{+}{}$. Left naviculo-cuboideum 67 mm . long, ${ }^{\circ}$. Lunatum, Proximal phalanx (pes), greatest length, lateral 74 mm ., diaphysis width 29 mm ., proximal width $34.8 \mathrm{~mm} ., \circ$, similar to the Ullerslev cow ; proximal halves of two proximal phalanges, width 41 and 42 mm ., ô, ơ ; medial phalanx, proximal width 42 mm ., diaphysis width 33 mm. , ô; two distal phalanges, greatest length 96 mm ., ot, and 87 mm ., + . Fragments of a small foetus.
The Hjerk Nor settlement is submarine and has been privately excavated by ketching. It has not yet been worked up, but here for the first time zoologically treated. An extraordinary feature of this settlement is the very high number of bones of Wild Cat and Lynx. The Hjerk Nor settlement leaves the impression of being a particular fur station where people hunted for the purpose of procuring skins for winter clothing or perhaps even for sale.
94. Norslund, on Norsminde Fjord, about 15 km. S. of Aarhus.
(Lit.: S. H. Andersen and C. Malmrose, 1966).
As mentioned above, the age of the kitchen middens proper is questionable, but the fact that the Urus was a common animal in Jutland during the Atlantic period is evident not only from the many Urus bones from the Brabrand and Dyrholmen settlements, but also from a site at Norslund.
According to MøнL, who has examined the osseous material from this site, no bones of domestic cattle were found. The bones of Urus, together with bones of Wild Boar and Red Deer, predominated. The bulk of the bones originate from Stratum 3, i.e. that they are contemporaneous with Dyrholmen I, from the beginning of the High Atlantic transgression, the transgression between Zones

VIIa and VIIb. A C-14 analysis of charcoal from the layer gave ages of $3780 \pm 120$ and $3730 \pm 120$ B.C.
As Møнl does not give any measurement I shall call attention to some of the more remarkable bones.
Two mandibular hindmost molars (m3) are present, they are comparatively small, as also pointed out in several kitchen middens mentioned: $45.2 \times 18 \mathrm{~mm}$. and $43.5 \times 18.2 \mathrm{~mm}$.
Also a third lower hindmost molar, which earlier, in 1962, from the same locality, by the physician A. Jørgensen was sent to the Zoological Museum for examination, is small, $44.5 \times 18 \mathrm{~mm}$. emphasizing the common occurrence of small mandibular m 3 from Zone VII.
The proximal width of an upper part of a metatarsus, transversal, is 67 mm ; anteriorly-posteriorly, 66 mm ., $\widehat{0}$, almost as in the Sorø bull; the lower part of a metatarsus is 75 mm . broad, distally, and the diameter of the largest trochlea is 43 mm ., as compared with 78 and 45 mm ., respectively, in the Sorø bull. An astragalus is 88 mm . long and 57 mm . broad, distally, as compared with 84 mm . and 57 mm . in the Tinglev bull; in a slightly porous astragalus, from a young animal, the measurements are $84 \times 50 \mathrm{~mm} . ;+$ almost as in the Pindstrup cow. The transversal width of two naviculo-cuboidea is 75 mm . in both ( $\delta_{0}^{1}$ ). 2 fragments of the upper end of a metacarpus are similar to the corresponding parts in the Pindstrup cow.
95. Godsted, at Hejrede Lake, Lolland. (National Museum, 1904).
"Bos taurus urus. Parts of three lower molars probably from the same individual. Furthermore, an upper molar, of Urus or large domestic ox." (Winge det., 1907). - The length of the 2 . lower molar is 34 mm ., at the grinding surface, 27 mm . at the base; width at the base 19 mm . - May have belonged to Urus.

## Summary of the Bos-remains in the Kitchen Middens.

From these investigations it appears that in some kitchen middens particularly in the old classical finds (Ertebølle, Aamølle, Mejlgaard, Krabbesholm, Lovns, Gudumlund, Virksund) only a few bones of Urus were recorded, whereas in another group of settlements (Brabrand, Dyrholmen, Hjerk Nor, Kolding Fjord, Norslund) comparatively many Urus bones are present. - Thus it was just the large number of Urus bones which originally were assumed to endow the Brabrand settlement with a stamp of comparatively old age and which also in working up the bone remains from Dyrholmen were particularly emphasized. Later the settlements from Hjerk Nor and Norslund were attached to this last-mentioned group.

Only one of these settlements, from Norslund, is not only relatively dated, the bones chiefly belonging to the High Atlantic transgression, like Dyrholmen I, but also absolutely dated: C 14 -analysis $3780 \pm 120$. The settlements from Hjerk Nor, Kolding Fjord, Brabrand, and Norslund are today subaquatic.

When in the older publications on kitchen middens Urus bones are recorded, it generally only means bones of large Urus bulls; the smaller bones of Urus cows were referred to domestic cattle.

It is a remarkable fact that the Urus teeth from the kitchen middens are very small; the mandibular $m$ 3-length, e.g., only slightly passing the minimum length of this tooth from the Maglemose settlements, Zealand (cf. fig. 17). This isolated position, however, is now partly broken by the discovery of similar small Urus teeth in mandibles attached to skulls (Pindstrup, Toftum, Gesten) or in single finds of mandibles (Kundby), from the Subboreal period; the lower m 3 is exceptionally small in the large Ugilt bull, 42.5 mm . (Table 10 ).

But what is the explanation of these comparatively small teeth? Are they due to a difference in time, Preboreal-Boreal as against Atlantic-Subboreal? or are they caused by a difference in space, Zealand as against Jutland? The Urus disappeared from Zealand at the close of Zone VI and apart from the Subboreal finds just mentioned only a few lower m 3 teeth are known from Jutland, and those are of uncertain age; but a couple of them belong to the largest known ones, well over 52 mm . long. This might indicate that in Jutland a decrease in the size of teeth took place during the ages. It is, a well-known fact that many species of prehistoric mammals on an average are larger than the corresponding recent ones, as I have pointed out, e.g., regarding the Danish carnivores from the Boreal period (Degerbøl, 1933) and as Kurtén later (1959) has calculated at the rate units of "Darwins".

It is likely that a similar fast, short-term rate of evolution has taken place regarding the Urus, particularly at the close of its existence. (Cf. p. 91).

Remains of Uncertain Age.
More than a hundred finds are undated or have not been dated with certainty. As no remains of Urus are known from Zealand later than Zone VI, it is, however, highly probable that undated Urus remains from this island in fact are actually older than the transition period between Zones VI and VII.

## Zealand.

Skulls and parts of skulls.*
97. Aagerup, 7 km . N.E. of Roskilde (Qvistgandi, 1850).
$\delta^{\top}$. Complete skull. Old specimen, sulcus supraorbitalis roofed. Bases of horn cores, occipital crest, anterior rims of orbits and proc. mastoidei highly granulated. Interfrontal suture obliterated. Teeth worn. - Premaxilla damaged, about 12 mm . are missing, added in tables. (Cf. p. 8) - Pl. VII.
98. Lyngby moor, 10 km . N. of Copenhagen (Steenstrup).
$\hat{0}$. Almost complete skull; nasals missing. Old animal of about the same individual age as the Aagerup skull. Open type of horn cores. - Pl. VII.
99. Eskildstrup (Zoneredningskorpset, 1946).
ô. Skull, kept by the regional salvage corps.

* Regarding measurements cf. Tables 1-23, and I-III.

100. Morkov, 15 km . S.W. of Holbæk (FR. Wulff, 1875).

ㅇ. Brain-case, broken through orbits; tip of right horn core and outer half of left horn core are missing. (Cf. p. 61). - Pl. IX.
101. Skellingsted, S. of Mørkøv (R. Andersen, 1932).
\}. Right horn core with small part of frontal. Diameters at base $118 \times 96 \mathrm{~mm}$., circumference 350 mm ., outer curvature about $610(575+) \mathrm{mm}$.
102. Tronninge, Kundby moor, 10 km . W. of Holbæk (G. H. Thomsen, 1943).
f. Right mandible, femur, part of os sacrum.
103. Højby, 4 km. S.W. of Nykøbing S. (R. Madsen, 1884).

Some upper molars (H.W. 1904, p. 291: It has not been stated whether more was sent in; a complete skeleton was apparently found, one also in 1885 , according to a letter to Steenstrup from Mr. Madsen).
104. Gammel Kogegaard, W. of Køge (Carlsen, 1872).
os Part of horn core. Found by ditching.
105. Ollerup Vestermose, 6 km . N.N.E. of Slagelse (P. L. Peitersen, 1903).
of Part of horn core.
106. Hove, 15 km . N.E. of Roskilde (Mertz Nielsen, 1942).

Part of left maxilla.
107. Vanlose, 15 km . N.N.E. of Sorø (National Museum, 1944).
ô Mandible, metacarpus, right humerus (upper part missing), 6 vertebrae (lumbales), 3 ribs.
108. Hedehusene, W. of Copenhagen (Hög, 1941).
$\hat{\sigma}$ Part of right horn core with small part of frontal. Diameters at base $100 \times 94 \mathrm{~mm}$.
109. Gentofte, 7 km . N. of Copenhagen (Steenstrup).

0 Horn core with small part of frontal. Diameters at base $109 \times 85(+) \mathrm{mm}$.
109 a. Bronshoj, Copenhagen (P. Juhl, 1923).
of Part of horn core.
110. Jonstrup Vang, 15 km . N.W. of Copenhagen (Birte Andersen, 1946).
$\widehat{\sigma}$ Left horn core with small part of frontal, tip missing. Diameters $120 \times 101 \mathrm{~mm}$. circumference 348 mm . - Fragmentary parts of right horn core.
111. Alsønderup, 6 km . N.W. of Hillerød (L. Rasmussen, 1957).,
$\hat{o}$ Part of left horn core, broken about the middle, with a small part of the frontal; fragmentary exoccipitale. Diameters at the base $118 \times 103 \mathrm{~mm}$; circumference 365 mm . Width across condyli occipitales about $144 \mathrm{~mm} .(72 \times 2)$.

Postcranial skeletal parts (Not previously mentioned).
112. Ganløse. 20 km . N.W. of Copenhagen (Aa. Nemming, National Museum, 1959).
$\widehat{o}$ Left humerus, upper end missing; left antebrachium, lower end missing.
113. Kirkerup, Stengaardens mose, 13 km . N. of Roskilde (National Museum, 1945).
\& Left femur. Greatest length from caput 428 mm . (Cf. Table 16).
114. Ostrup, Vikso, Stengaardens mose, 13 km . N. of Roskilde (National Museum, 1946). Right scapula, atlas, epistropheus, parts of vertebrae.
115. Øresund (I. J. Kristiansen, 1960).

Right humerus, upper end missing; right antebrachium, lower end laterally mutilated, $\circ$.
116. Gundsømagle Nordmark, 12 km . N. of Roskilde (E. Henriksen, E. Madsen, 1939). of Left tibia (Table 17), astragalus (Table 19), phalanx (innermost, prox. width 42, length, lateral, from incisure, 69 mm .).
117. Strodam, Hillerød. (Jarl, 1944).
of Left radius; lower end missing, upper end mutilated. Width at middle 66 mm .; large, but fairly young bull.
118. Lille Lyngby, south side of Arresø (C. Becker, National Museum, 1947).
\& Right tibia, upper end missing.
119. Sjælland (Visby, 1847).

Epistropheus, 2 vertebrae thoracales.
Probably from a moor by Arresø, Frederiksværk, together with a skull; mentioned by Steenstrup. V. M. 1851, p. 65. H. W. 1904.
120. Torpe, 10 km . E.N.E. of Kalundborg (Hofman Bang, 1849).
o Antebrachium.
121. Holbæk. From a moor below the road to Roskilde (Holbæk Museum, 1955). Metatarsus.
122. Faarevejle, 20 km . S.W. of Nykobing S. (M. Knudsen, 1951).
ô Left antebrachium.
123. Faarevejle, 20 km . S.W. of Nykøbing S. (Troels-Smith, 1942).

Below the Faarevejle kitchen midden (together with remains of Lagenorhynchus).
o Part of left humerus, very stout, smallest width of diaphysis 60 mm .
124. Logismolle, Rerslev, 17 km . N. of Slagelse (Berthelsen, 1891).

Costa, upper end missing.
125. Vedde, Bødal, 10 km . N.N.W. of Sorø (M. Rasmussen, 1942). Costa, upper end broken off.
126. Næstved (Frederiksen, 1960).
ot 2 vertebrae cervicales, fragment of costa.
127. Holmegaards moor, N.E. of Næstved (A. M. Petersen, 1942).

6 costae, in all of which the upper part is broken off; 2 have been gnawed by squirrels.
128. Kongsted moor, Ronnede, 15 km . E. of Næstved (L. Jensen, 1907).
ô Left scapula, metacarpus, 3 vertebrae thoracales, 2 phalanges (middle), 2 costae.
129. Køge Bugt, Solrød (G. Olafson, 1947). Submarine.

Distal end of tibia, water-rolled, distal width, transversally 83 mm . (Cf. Tinglev bull 83 mm .), medial upper half of radius, fragment of rib.
130. Sonnerupgaard, Hvalsø (N. C. Breit, S. Jensen, 1946).
ô Tibia, upper end mutilated, astragalus, calcaneus, upper end gnawed by dogs, metatarsus.
131. Lyngby Rørdamsvej 26. 10 km . N. of Copenhagen. (P. Hansen, National Museum). Metatarsus, worked up into an axe.

## Finen

132. Bro, 7 km . S.W. of Bogense (Mineralogical Museum, 1839)
ô Almost complete skeleton. - (Lit. Hofman Bang, 1843 and H.W. 1904). Hindmost molar worn almost to the tip of medial column.
133. Trøstrup, 10 km . N.W. of Odense (Kühl, 1833).
ô Brain-case, broken in front of horn cores; horn cores greatly granulated at base. Pl. VII.
134. Tevring, 12 km . S.S.E. of Bogense (National Museum, 1851). 2 horn cores (H.W. 1904).
135. Dommestrup, Nr. Lyndelse, 10 km . S. of Odense (J. Nielsen, 1941). 5 vert. costales, 5 vert. lumbales.
136. Næsbyhoved Molle, 2 km . N. W. of Odense (Trolle, 1848).
ô Horn core with part of frontal, left femur, left tibia, metatarsus. J. Steenstrup O.V. S.F., 1848 (H.W. 1904).
137. Vissenbjerg, 14 km . W. of Odense (King Frederik VII, 1850).
ot Brain-case (cast).
138. Broby, 14 km . N. of Faaborg (Steenstrup and Lütken, 1852). ô Antebrachium, lower part missing.
139. Osterby, from calcareous deposit. 4 km . N.N.W. of Faaborg (H. Rasmussen, 1919). $\hat{\sigma}^{*}$ Right femur, upper and lower end missing, vertebra cervicalis. Large, width of diaphysis 54 mm .
140. Kirkeby, 7 km . N.N.W. of Svendborg (Svendborg zoologiske Museum).
\& Right femur, upper end mutilated; left half of pelvis, part of os coxa. In size almost as the Ullerslev cow, smallest width of diaphysis 44 mm ., length from trochanter major 346 mm .
(Skeletal parts of calf: left scapula, right femur, both epiphyses missing, costa; species?).
141. Aspedam, 6 km . N.E. of Svendborg.

Horn core. - (H.W. 1904).
142. Ejsemoselokke, Broholm, 10 km . N.E. of Svendborg (Broholm Collection). Scapula. (Sehested, 1878, pp. 237, 280; H.W. 1904, p. 289).
143. Bollemose, Gudbjerg, 10 km . N.N.E. of Svendborg (Broholm Collection). Some teeth and skeletal parts. Ibid. Idem., p. 280.
144. Barlose, 7 km. N.E. of Assens (Vedel Simonsen, 1858).
of Horn core with small part of frontal.
145. Frobjerg, 15 km . N.E. of Assens (Johansen, 1912). ot Right scapula, right humerus, os coxa, vertebra lumbalis, costa.
146. Turup, Viesø, 7 km. N.E. of Assens. (F. Lund, 1942). of Lower end of humerus, greatest width of trochlea 106 mm .

## Lolland

147. Handermelle, V. Ullerslev (G. Larsen, 1945).
${ }^{\star}$ Left scapula, left antebrachium, left femur, costa.
147 a. The Baltic Sea, 6 km . S.W. of the lighthouse of Møen (Fisherman Aksel Jacobsen, Bagenkop, Langeland).
In a fishing net at a depth of 22 meters. - Left horn core with part of frontal, tip broken off. Very large. Cf. Table III. (Not on map).

## Jutland.

Skulls and part of skulls.
148. Mors. (Steenstrup).
ot Skull, broken through maxilla; hind limb. - Teeth much worn. - Pl. VII.
150. Ølholm, 4 km . E.S.E. of Torring (Amtsvejvæsenet, 1961).
ot Skull, nasals missing. Brought to light by road work. Teeth much worn. - Pl. VII.
151. Olholm (Ibid. Idem., 1961).
\& Brain-case, broken in front of fronto - nasal suture. Cf. p. 61. - Pl. IX.
152. Fuglekjær, 7 km . S. of Horsens (Therkildsen, 1921).
\& Incomplete skull; one vert. thoracalis. Cf. p. 61. - Pl. IX.
153. Gjødvad, 5 km . E.N.E. of Silkeborg (Silkeborg Museum).
\& Brain-case, broken through orbits. Cf. p. 62. - Pl. IX.
154. Formyre. Slope at Tjele Aa, 12 km . N.E. of Viborg, about 1920 (Børge Jensen, 1956). of Horn core (tip missing) with small part of skull.
155. Aakjær, Falling, 15 km. E.N.E. of Horsens. (Frode Neergaard. Jagt- og Skovbrugsmuseet, 1915).
\& Frontlet, cut off between horn cores and orbits. Cf. p. 62. - Pl. IX.
156. Logenkjær, Astrup, 10 km. E. of Skanderborg (J. Kr. Jensen).
\& Left mandible, teeth much worn (Table 10).
157. Odder moor, S. of Odder (Odder Museum, Didriksen, 1953).
of Brain-case, broken just in front of horn cores. Fig. 7.
158. Tonder, Vintved Canal (F. Jensen, 1932. Jagt- og Skovbrugsmuseet).
${ }_{0}$ Two horn cores with part of frontal. Yellow coloured.
ot Part of horn cores of a second specimen. Dark coloured. Porous. Diameters at the base $107 \times 85 \mathrm{~mm}$. A young but large specimen.
159. Ølgod, Egknud, 23 km. N.N.E. of Varde (J. Bondesen, H. Øllgaard, 1945). ot Brain-case with horn cores (Photos seen). "Circumference of horn core, at the base 37 cm ., largest span of horn cores 78 cm ." On a level with the skull, $3^{1 / 2} \mathrm{~m}$. away, a Younger Stone-age axe was found.
160. Egum, 4 km. N.N.W. of Fredericia (O. Iversen, about 1917. Fredericia Museum).
ơ ơ 2 right horn cores. (1) Fragmentary at the base, length along outer curvature 600 mm .
(2) Length along outer curvature about 525 mm ., circumference at the base 305 mm ., diameters $104 \times 86 \mathrm{~mm}$.


Fig. 7. Brain-case of Bos primigenius from Odder (No. 157). $\times$ ca. ab. 1/6.
161. Barrit Forest, 22. km. E. of Vejle (Brockenhuus Schack).
ô Right horn core with small part of frontal, tip missing. Diameters at the base $117 \times 96$ mm . ; circumference 320 mm . Part of left horn core. Os occipitale, the width across condyli occipitales is 120 mm .; tibia, proximal end missing, length 398 mm ., distal width 85 mm ., diaphysis width 55 mm . From calcareous deposit, at the bottom; 125 cm . beneath the surface of the earth. (Table 17).
162. Horsens Fjord (National Museum, Seligmann, 1896).

Horn core.
163. Staugaards moor, Torring, 22 km . W. of Horsens (P. Jensen, 1943).
\& Left mandible (Table 10), vert. cervicalis, left calcaneus (Table 18).
164. Moor between Randlev and Rathlousdal 20 km . N.E. of Horsens (Holm, 1850).
ô Occipital part. Width across condyli occipitales 134 mm .
165. Norre Vissing. 12 km. N.N.W. of Skanderborg (Danmarks geologiske Undersøgelse, 1941). of Left and right horn core with small parts of frontal, granulated at the base. Diameters at the base $121 \times 99 \mathrm{~mm}$., circumference 355 mm . Exoccipital part, width across condyli occipitales 134 mm ., other small parts of skull with 4 upper molars; parts of left and right mandible. 4 vertebrae cervicales.
166. Stilling Lake, in a moor, 6 km . N.E. of Skanderborg (Steenstrup).
ô Brain-case, metatarsus, phalanx (Table 12).
167. Aarhus Mølleaa (C. M. Poulsen, Steenstrup).

Horn core.
168. Aarhus Harbour. (Müller and Braem, 1859).

Part of mandible with 3 hindmost molars.
169. Bjornekjær, Lading, 15 km . N.W. of Aarhus. (SaAbye, 1843).

Posterior part of frontal, with horn cores. Old specimen.
170. Rosenholm, Ulvemosen, Rodskov, 15 km . N.N.E. of Aarhus. (Hübertz, 1834). ot Part of frontal with horn cores.
At the bottom of the moor, depth of two metres. Pl. VII. (Reinhardt sen. O.V.S.F. 1834).
171. Tjerrild, 25 km . W.S.W. of Grenaa ( $\emptyset_{\mathrm{rnees}}$ Christensen, 1947).
$\overbrace{}^{\lambda}$ Small part of frontal with right horn core broken in the middle; diameter $113 \times 90 \mathrm{~mm}$., circumference 328 mm . Fragment of left horn core; part of 2 horn cores, diameters $100 \times 97 \mathrm{~mm}$.
\& Left radius, left metacarpus, small; total length 231 mm ., proximal width $69 \times 42 \mathrm{~mm}$; width of diaphysis 38 mm .
172. Thorsager, Søndervang moor, Djursland, 26 km . N.W. of Kalø Vig. (Jagt- og Skovbrugsmuseet, 1948).
ot Posterior and upper part of brain-case; horn cores complete, granulated at the base and with longitudinal grooves.
173. Benzon Estate, 10 km . N.N.E. of Grenaa (Benzon, 1864).

Premaxilla, atlas, 1 vert. thoracalis, ribs.
174. Vindum, 13 km . S.E. of Viborg. - No information.
\& Left mandible.
175. Hvidbjerg, 7 km . W. of Skive (P. Sølling, 1944).
\& Both mandibles with teeth, atlas, 1 costa.
176. Vibholm moor, 17 km . N. of Ringkøbing (Nørregaard, Mineralogical Museum, 1903). 1 upper and 4 lower molars.
177. Ørtoft, 6 km. W. of Sæby (Chr. Kjersgaard, Sæby 1945). Part of brain-case, broken between horn cores and orbits. Mandible. Pl. VII.
178. Ulvhøj moor, S. of Serridslev, 14 km . S. of Hjørring (Vendsyssels historiske Museum). Horn core. (H.W., 1904).
179. Horbylund, 10 km . N.W. of Sæby (Vendsyssels historiske Museum). Horn core. (H.W. 1904).
180. Vidstrup, 3 km . N.W. of Hjørring (Vendsyssels historiske Museum). Horn core. (H.W. 1904).
181. Vittrup. (No further information).
\& Metacarpus.
182. Hastrup. Road S. of Frederikshavn (Oluf Sørensen. Jagt- og Skovbrugsmuseet).
$\hat{o}$ Posterior and upper part of brain-case with almost complete horn cores, broken in front of horn cores.
183. Balskov, Løgstør (Baron Rosenkrantz, 1922). Part of horn core, 2 molars.

## Postcranical skeletal parts.

184. Gudsø Vig, Kolding Fjord (Deleuran and Thure Schachner, 1935).

Lower part of left femur.
Found one m . below surface of the bottom. ${ }^{3} / 4 \mathrm{~m}$. water.
185. Kolding (E. Walther, 1957).
$\hat{o}^{\star}$ Left scapula; upper part missing. Width of collum 83 mm .
186. 186. Almind-dalen, Stagebjerggaard. (J. Jensen, 1954).
\& Metacarpus. By cleaning of a brook. (Table 11).
187. Grejsdalen, N.W. of Vejle (N. Hartz, 1906).
\& Right tibia, upper end missing; middle part of femur.
Found under calcareous deposits.
188. Agersbøl, forest between Ø. Snede and Lindved, 10 km . N. of Vejle (E. V.B. Eriksen, 1937).

Atlas, ô large. Calcareous deposits.
189. Losning, 15 km. N.E. of Vejle (Naturhistoriske Museum Aarhus, 1934).
o Metacarpus.
190. Havstrup Lake, Torring, 25 km . W. of Horsens (O. Voss. National Museum, 1945).

+ Metatarsus, upper part of radius (greatest width 102 mm .).

191. Solbjerg Lake, 5 km . N.E. of Skanderborg (M. Martin, 1951).
ot Right scapula.
192. Silkeborg (Godske Nielsen, 1922).
ot Calcancus. Washed together with other bones at the paper-factory, from stone age or later.
193. Randers Fjord (M. Brunse, 1951).
ot Lower part of left humerus. At drainage work. Smallest diaphysis width 61 mm .
194. Skørping Holme, Skørping, 20 km . S. of Aalborg (Aalborg historiske Museum. Peter Riismoller, 1945).
4 vertebrae cervicales.
195. Norlund Forest, in a moor, 14 km . N.N.W. of Hobro (H. Hansen, 1897).
$\delta^{\star}$ Metacarpus. In marl, about a depth of two metres; ${ }^{1} / 3 \mathrm{~m}$. from the bottom.
195 a. Norlund Forest.
$\hat{\sigma}$ Left humerus, upper end missing. Smallest diaphysis width 55 mm ., trochlea width 105 mm .; anterior-posterior medialis 117 mm .
196. Feldborg Plantation, in a moor, 18 km . E. of Holstebro. (Jensen Tusch, and Gad, 1881).
ot Left humerus, upper end damaged, antebrachium, upper end of ulna missing.
197. Vinderup, 20 km . N.E. of Holstebro. (Stehr-Larsen, 1947).
\& Metatarsus, tibia, upper free epiphysis missing, calcaneus.
198. Auning, Pindstrup, Djursland, 30 km . W.S.W. of Grenaa. (Cf. No. 57).
\& Metacarpus.

Several specimens are preserved from ancient times, without any information, they no doubt, however, originate from Denmark.
199. Danmark. (From Steenstrup's time. Deposited at the Jagt- og Skovbrugsmuseum, C.N., 1891).
ot Part of brain-case with complete horn cores, broken between base of horn cores and orbits. A very heavy and strongly built skull. The tuberculation at the bases of the horn cores is exceptionally developed, high and up to 45 mm . broad, longitudinal grooves. Diameters at the base of the right horn core are $160 \times 147 \mathrm{~mm}$., of the left horn core $146 \times 140 \mathrm{~mm}$.; just laterally to this swelling the diameters are $130 \times 116$ and $130 \times 110 \mathrm{~mm}$. respectively.
Also the greatest span of horn cores is remarkable, 950 mm .
According to the high individual age the occipital width, at the posterior border of the fossae temporales, is great, 245 mm ., only outdistanced by a specimen from Auning (No.60) with an occipital width of 260 mm . In contrast, the width of the occipital condyles is very small, 122 mm . - Pl. VII.
200. Danmark. (Mineralogical Museum).
o Complete skull of an old animal. The bases of the horn cores and rims of orbits are granulated. Tips of horn cores compact and teeth very much worn.
Pl. VII.
201. Danmark. Marked 2. Afd. (i.e. Steenstrup's old division).
o Brain-case; broken through lacrymals; base of skull just below upper border of the foramen magnum is sawn off; probably indicating that it has been mounted on a shield. Left horn core broken below middle. A very old skull, sutures obliterated, with the exception of the lacrymal sutures which are visible. The bases of the horn cores are highly granulated and the tip of the right horn core is compact. The region between the orbits is domed and the two concavities in front of the occipital ridge are only slightly marked. Pl. VII.
202. Danmark. (2. Afd.) 2.
of Posterior part of brain-case of old animal, on the right side broken just behind the orbit, the right horn core complete, tip compact; left frontal partly cut off, and of the left horn core only the posterior rim of the base is present.
203. Danmark. (From Study Collection).
of Also this brain-case must have belonged to a very old bull. The bases of the horn cores are highly granulated; granulation continuing across occipital crest. Tips of horn cores compact; supraorbital grooves highly roofed. - Pl. VII.
204. Danmark.

2 antebrachia.

## Zoological Investigation of the Material

## Females.

The great variation in size of the Urus skulls has caused great trouble to zoollogists. Some have been of opinion that different subspecies or even species were represented. Leithner was the first who clearly demonstrated the great sex dimorphism in the Urus (1927); but although Leithner studied the Bos material in several European zoological museums, he was able to describe only five complete skulls and 12 brain-cases of the Urus cow, none of which were dated. However, two from Romanuppen and Pogrimmen in Poland probably belonged to animals which the Teutonic Order had preserved in its territory, probably analogous to the preservation of the European bison in the forests of Biatowies, and thus of a very late date.

An explanation of the fact that relatively few cow skulls are kept in the museums should undoubtedly, at least in Denmark, be sought in their small size. Most of the Danish Urus skulls and skeletons originate from bogs, having been brought to light by peat cutters. Generally, the small skulls were considered by the workers as belonging to simple domesticated cows, whereas the big bull skulls attracted their attention, and the local authorities were informed. However, it is worth noting that most female skulls known have belonged to old or fairly old animals; young skulls with their open sutures in which the bones easily fall to pieces have not been noted by the workers.

Leithner made a survey of the differences in the skulls of bulls and cows. As in other mammal species the females are, so to say, retarded in their development, are more juvenile-like. As compared with the bulls, their skulls are shorter and particularly narrower, the sutures are closed later or not at all. The orbits are generally less protruding, the horn cores in particular are reduced in length and thickness, and the occipital ridge is much slighter. All these characters, however, are correlated to age, and are not so decisive as generally stated by Leithner.

Later several other Urus skulls have been described as belonging to cows (La Baume, 1958), and an incomplete skull, from Star Carr, Yorkshire, England, is dated as belonging to the Preboreal period (Fraser and King, 1954).

The sex dimorphism is also clearly demonstrated in the size and shape of the metapodials. In the cows the metapodials are much slighter and narrower than in the bulls, but almost the same length; on this last-mentioned point easily distinguishable from the much shorter metapodials of domestic cattle (Degerbøl, 1942).

From Denmark Leithner mentioned five brain-cases of Urus cows, but none of these were then dated. Later a complete skull and skeleton from Ullerslev, a complete skull from Grænge, three incomplete skulls, from Bjeverskov, St. Taastrup and Pindstrup (with several skeletal parts), and a couple of brain-cases of females have been unearthed in Denmark; all in all skull remains of 27 specimens are at hand and most of this material is now dated.

Bos primigenius
List of skulls and parts of skulls of females (apart from settlements).

| Material | Locality |  | Zone | Remarks |
| :---: | :---: | :---: | :---: | :---: |
| 1. Complete skeleton | Ullerslev | (15) | V |  |
| 2. Skull | Grænge | (18) | V | Nasals missing. |
| 3. Incomplete skulls | Bjeverskov <br> Pindstrup <br> St. Taastrup <br> Skaarup <br> Bonnerup | (21) <br> (57) <br> (53) <br> (74) <br> (64) | V <br> VIII <br> II-V <br> Not dated <br> VIII | Broken in front of rows of teeth. Broken in front of rows of teeth. Mandible and parts of postcranial skeleton are present. <br> Mandible present. <br> Fragmentary parts. <br> Very fragmentary horn cores, 6 upper molars, postcranial skeletal parts. |
| 4. Brain-cases | Vigersted <br> Knabstrup <br> Svebølle <br> Bjerregrav <br> Flintinge <br> Toftum <br> Aarhus <br> Korinth <br> Fuglekjær <br> Morkov <br> Gjødvad <br> Aakjær <br> Olholm | $\begin{aligned} & (7) \\ & (10) \\ & (13) \\ & (13 \mathrm{~b}) \\ & (24) \\ & (61) \\ & \\ & (62) \\ & (63) \\ & (152) \\ & (100) \\ & (153) \\ & (155) \\ & (151) \end{aligned}$ | IV <br> IV <br> IV <br> IV <br> V <br> VIII <br> VIII <br> VIII <br> Not dated <br> Not dated <br> Not dated <br> Not dated <br> Not dated | Broken in front of horn cores. <br> Frontlet. <br> Broken between horn cores and orbits. Mandibles present. Broken in front of nasal base. <br> Broken in the middle of orbits. <br> Broken through nasal base. <br> Broken through orbits. <br> Broken through orbits. <br> Broken between horn cores and orbits. <br> Broken in front of nasal base. |
| 5. Horn core | Barlose | (144) | Not dated |  |
| 6. Mandibles | Kundby-Trøn <br> Tørring <br> Gesten B <br> Hvidbjerg <br> Logenkjær <br> Vindum | $\begin{aligned} & \text { nninge } \\ & (102) \\ & (163) \\ & (69) \\ & (175) \\ & (156) \\ & (174) \end{aligned}$ | Not dated <br> Not dated <br> Not dated <br> Not dated <br> Not dated <br> Not dated |  |

Considering the above-mentioned rarity of female skulls generally kept in the museums, this number is astonishingly large, which indicates that cow skulls, when determined and taken care of are not at all so rare as ordinarily indicated. Probably the numbers of cows and bulls in the population were almost equal. (Cf. p. 121).

Only one complete skeleton of a female outside Denmark has so far been known, viz. from Stockholm. - In discussing the size and morphology of the Urus cows we shall start with the almost complete skulls from the Boreal period: Ullerslev, Grænge, and Bjeverskov.

The Ullerslev skull. The Ullerslev skeleton belonged to a powerful animal, which had just passed the prime of its development. The teeth are worn, but not much; in the lower jaw the roots of the 1 . molar are visible. At the base of the horn cores and at the rim of the orbits the bone is tuberculated or bead-formed, however, to a lesser degree than seen in old bulls.

The surface of the skull is not so smooth or china-like as, according to Leithner, is characteristic of the female skull, and as e.g. seen in the young Grænge skull of a bull.

The fairly high individual or ontogenetical age also partly explains why the orbits in the Ullerslev cow are just as protruding as in old bulls, particularly pronounced on account of the small frontal width. Most of the sutures, however, are open. Only the sutures of the occipital part, the posterior third of the interfrontal suture and the posterior half of the suture between the lacrymal and the frontal are completely closed. The frontal or supraorbital groove (sulcus supraorbitalis) is open, not covered with a bony roof as in old bulls. The fossa temporalis, however, is posteriorly bound by a low bone bar, as also seen in several other female skulls.

It is worth noting that of full-grown bull skulls only one, the particularly small skull from Ørting has as small a cranial length as the Ullerslev cow, (fig. 8). A comparison with the subadult Gøderup bull clearly demonstrates the sex dimorphism in the Urus skulls. The two skulls are of the same length, basal length 525 mm . (Ullerslev), and 527 mm . (Gøderup), but even in the young Gøderup bull the skull is more heavily built, and the brain-case in particular is much broader. The smallest frontal width is 230 and 203 mm ., respectively.

Significant is furthermore the great width of the occipital condyles in the bull, 138 mm ., as compared with 125 mm . in the Ullerslev cow; and the height of the occipital region, from the upper border of the foramen magnum, is 172 mm . and 142 mm ., respectively.

According to the greater developmental age the width across the posterior edge of the orbits (postorbital width) is, however, greater in the Ullerslev female, 268 mm ., than in the Gøderup bull, 255 mm .; and the diameters of the orbits are smaller, $66 \times 66 \mathrm{~mm}$., as compared with $83 \times 66 \mathrm{~mm}$. in the Gøderup specimen. Partly as a consequence of the greater orbits, the distance from the anterior border of the orbits to the foramen infraorbitale is shorter in the last-mentioned animal, 163 mm ., than in the Ullerslev cow, 182 mm ., but in accordance with the younger age, the facial region, on the whole, is shorter in the Gøderup bull, as is also seen in the shorter palatal lengths, 190 and 198 mm ., respectively.

The horn cores in the young bull are much bigger, longer, and thicker, but more porous, of a "worm-eaten" appearance, than in the older cow, where the horn cores are compact right to the tip, and grooved, as generally seen in adult bulls. The teeth in the bull are longer; the length of the upper tooth row is 180 mm . and 162 mm ., respectively. The determination of the Ullerslev skull as belonging to a female is unmistakably also emphasized by the rest of the skeleton, i.a. by the width of the metapodials (Tables 11 and 12).

The Grcenge skull is almost complete, only the nasals are missing. It is of almost the same developmental age as the Ullerslev skull, perhaps a little older, the right supraorbital groove being completely roofed posteriorly, a character generally found in old bulls only. From side to side the occipital ridge is nearly straight, only with a small concavity at the bases of the horn cores; the concavity from behind, however, is deeper than found in the Ullerslev specimen. The contouring of the posterior third of the frontal is less pronounced than ordinarily seen; the interfrontal suture is not elevated, and this part of the frontal, anteriorly-posteriorly, forms an unbroken concavity; the roof of the orbits is placed higher than the frontal part between the orbits.

The Grænge skull is fairly small and narrow. The basal length is 496 mm ., (condylobasal length 527 mm .), thus belonging to a group of skulls which generally has been characterized as extraordinarily small. Among Danish Urus cows, however, the specimen from Fuglekjær has about the same skull length, and the Pindstrup cow, from Zone VIII, is a little smaller (cf. Table 1), and the same holds good of several brain-cases (Olholm, Korinth, Aarhus, Gjødvad).

The smallest frontal width of the Grænge skull is 180 mm ., as compared with 203 mm . in the Ullerslev skull. However, several of the Danish Urus cows have about the same small width: Vigersted 183 mm ., Aarhus 182 mm ., Pindstrup 178 mm ., Fuglekjær 177 mm ., Ølholm 177 ., and Korinth 175 mm .

Also the horn cores are noticably small in the Grænge cow. The largest span is 580 mm .; a measurement, however, also found in several Danish skulls: Bjeverskov 580 mm ., Ølholm 580 mm ., and Fuglekjær 585 mm .

The circumference of the horn core at the base is 225 mm . in the Grænge specimen, as compared with 270 mm . in the Ullerslev skull. However, the very small cows from Pindstrup, Ølholm, and Aarhus have still smaller measurements: 181, 195, and 195 mm ., respectively.

The well-proportioned Grange skull is thus of particular interest as it clearly indicates that, already in the Boreal period, a fairly small Urus cow existed. That is, from a time prior to any possibility of morphological change caused by domestication or by intermixture with domestic cattle. Through this skull a new light is thrown on several incomplete Danish skulls of similar size, the understanding of which was till now fairly problematic. Such "small" Urus cows have been no rare exceptions, but they find their natural place within the size variation, as also seen in the small Urus cow from Star Carr (cf. p. 64) and the Stockholm cow (basal length 496 mm .).

By further comparison in the present treatise the Grænge skull will be taken as the "type" of a distinctly pure Urus cow of comparatively small size. - This skull was excavated in 1943. It was passed to Mr. A. V. Nielsen, Technical School, Nakskov, who later donated it to the zoological museum.

The Bjeverskov skull is incomplete. On the right side it is broken immediately in front of the tooth row, and on the left side, anterior to the first molar. As regards teeth only m 2 and the lateral half of $m 1$ are present. They are very much worn; $m 1$ is worn right down to the roots. The Bjeverskov skull thus must have belonged to a very
old animal, the oldest of the Danish Urus cows. The left supraorbital groove is partly roofed posteriorly. The interfrontal suture is broad, and the two concavities on its sides are pronounced. The occipital ridge is slightly convex, raised in the middle.

From length measurements which can be taken of this incomplete skull it appears that it must have been somewhat longer than the Grænge skull. The distance from the occipital ridge to the nasal base is almost the same in the two specimens measured in the middle line 286 and 280 mm ., respectively (laterally 278 and 274 mm ., respectively), it is true; but the distance from the occipital ridge to the anterior border of the row of teeth is 465 mm . in the Bjeverskov skull, as compared with only 445 mm . in the Grænge skull; measured from the occipital condyles, the distances are 388 and 370 mm ., respectively. In the Ullerslev cow the three corresponding measurements are 315 mm ., 485 and 395 mm ., respectively. On the basis of this, the basal length of the Bjeverskov skull may be estimated at about 515 mm .

Also most of the width measurements are larger in the Bjeverskov specimen than in the Grænge cow. The smallest frontal widths are 188 and 180 mm ., respectively; the postorbital widths 250 and 244 mm ., respectively. The interorbital width, in particular, seems to be very large in the Bjeverskov cow, but this is partly explained by the fact that the incisures generally found there in the rim of the orbit, and between which the measurement is taken are closed in the Bjeverskov skull, because of its great age. The zygomatic width and the greatest maxillary width are comparatively great in the Bjeverskov specimen, 214 mm . and 175 mm ., respectively, as compared with 201 and 165 mm . in the Grænge cow.

The mastoid width and the supraoccipital width, however, are identical in the two specimens; and the condylus width is even a little smaller in the Bjeverskov cow. The occipital height (from upper rim of foramen magnum) is great, 154 mm ., as compared with 140 mm . in the Grænge skull. - The horn cores are broken below the middle; they are fairly small, although a little thicker than in the Grænge specimen; the circumferences at the base are 235 and 225 mm ., respectively. Also the span of the horn cores must originally have been larger. It is now in its incomplete state 580 mm ., but the greatest span in the undamaged skull may be estimated at about 600 mm . - To sum up, it may be said that the Bjeverskov skull is more coarsely built than the Grænge skull. It is somewhat longer and particularly broader. The horn cores are fairly small. - All in all, the Bjeverskov skull also emphazises the fact that fairly small Urus cows existed in the Boreal period.

Actually the Bjeverskov skull on several points is not larger than the large domestic cattle from the Neolithic period, and provisionally it was labelled as belonging to a domestic animal. However, the concavity and typical relief of the frontal, the immediately upward bend of the horn cores, and the length of the tooth row, etc. clearly show that it represents an Urus cow. (Cf. p. 151).

On the following pages the discoveries will be mentioned in conformity with their geological age.

From the Preboreal period, Zone IV, parts of four brain-cases are at hand, from Vigersted, Knabstrup, Svebølle, and Bjerregrav, belonging to old animals.

The Vigersted skull is broken through the orbits, the occipital ridge is almost straight, only with a small concavity in the middle; the concavity on each side of the interfrontal ridge is distinctly formed. The Vigersted brain-case is somewhat larger than the corresponding part of the female skull from Grænge, the gracefully curved horn cores in particular are longer. The greatest spans of horn cores are 666 mm . and 580 mm ., respectively. Even in the large Ullerslev cow the corresponding span is 645 mm . only; but the horn cores are thicker; the circumference at the base in the Ullerslev cow is 270 mm ., as compared with 240 mm . in the Vigersted cow, and 225 mm . in the Grænge cow.

The Knabstrup brain-case is broader than in the Vigersted and the Grænge specimens; the smallest frontal width is 192 mm ., as compared with 183 and 180 mm ., respectively, and the smallest occipital widths are 169 mm ., 153 mm ., and 157 mm ., respectively. The span of the horn cores, however, is somewhat smaller, about 640 mm ., than in the Vigersted cow, 666 mm .

The Svebølle brain-case belonged to a fairly old animal with almost closed cranial sutures. The surface of the horn cores is smooth, but with small holes, clearly indicating a female. The brain-case is broken in front of the horn cores. Tips of horn cores are missing, and the occipital part is fragmentary. As in the Flintinge female the horn cores converge little, the greatest span thus being fairly large, about 715 mm . ; after the Flintinge specimen the largest measurement in Danish Urus cows. The diameters of horn cores at the base are $82 \times 71 \mathrm{~mm}$., the circumference at the base 245 mm . The width across the occipital condyles is 121 mm ., also indicating a female.

The Bjerregrav frontlet is broken at the nasal base; the right orbit is missing. The interfrontal suture posteriorly obliterated for about 60 mm . The posterior frontal concavities are deep, separated by a 25 mm . broad interfrontal ridge. The occipital crest is exceptionally concave, that is, in a degree not otherwise seen in any other Urus skull, and only rarely in domestic cattle (cf. No. XXII). The supraorbital sulcus is partly closed, bordered by a sharp, projecting edge. Both horn cores are complete, with undamaged, compact tips, and fairly granulated at base. All features indicate a fairly old animal. According to the concave occipital ridge, the distance from this ridge to the nasal base is short, but otherwise this specimen may be characterized as a medium-sized cow skull with fairly thick horn cores.

It is a most remarkable fact that already at this early period, Preboreal, such an aberrant Urus skull occur.

The Flintinge brain-case (Zone V) is broken through the frontals, between horn cores and orbits. It belonged to an old animal with almost closed frontal-parietal suture, which is just visible below the horn cores. The interfrontal suture is broad and elevated, and the concavity on each side is well marked, anteriorly the suture is secondarily open owing to exsiccation while kept in the museum. According to the great developmental age, the fossa temporalis is posteriorly bound by a seven mm . high
bone bar, and the right sulcus supraorbitalis is partly roofed. The surface of the horn cores is smooth and solid but with deep longitudinal furrows; many small holes, however, are present, producing a "worm-eaten" appearance. The horn cores converge very little; a shape also seen in the large bull skulls from Faaborg and Grænge, from the Late Dryas and Preboreal periods, respectively, and from about the same area. Consequently, the span of the horn cores is large; although the outer part, probably about one fourth, is missing, the span now measured is 770 mm ., as compared with 640 mm . in the complete skull of the Ullerslev cow, and 680 mm . in the Toftum skull. In size the Flintinge brain-case is fairly similar to the 2 lastmentioned specimens, only a little larger. The circumference at base of the horn core is 275 mm ., as compared with 270 and 270 mm ., respectively. The smallest frontal width is 205 mm ., as compared with 203 mm . in the Ullerslev skull, and 200 mm . in the Toftum skull. The breadth between the occipital openings of the temporal fossae is very large, 185 mm ., as compared with 171 mm . in the Ullerslev cow and 176 mm . in the Toftum cow; however, this is partly explained by the great age of the Flintinge skull. Also the breadth across the occipital condyles is considerable, 127 mm ., thus overlapping the width of the condyles in bulls (fig. 13). This might give rise to the question whether the determination of this skull as belonging to a cow is correct.

In order to give a simple means of sex determination in Bos primigenius, M. Howard (1962, fig. 6) plots the frontal breadth against the occipital breadth/ occipital height-index. Thus plotted, it appears that the Flintinge skull is placed in the interval between bulls and cows, however, nearer the cows. Also the comparatively thin and smooth horn cores and the small frontal width, the measurements of which are within the size range of females, no doubt indicate that this skull belonged to a cow.

The Store Taastrup brain-case, Zones II to V, is broken through the nasal base, and the horn cores are broken about 15 cm . from the base. It belonged to a young animal, with all sutures wide open (secondarily exaggerated) only the interparietal suture is not visible. The linea nuchalis sup. and protuberantia occipitalis externa, however, are fairly well marked. This skull must have belonged to an individual which was about 3 years old.

The occipital ridge is concave at the base of the horn cores, and highly elevated between these parts. The posterior half of the frontal, between the horn cores and orbits, is concave anteriorly-posteriorly; still more than seen in the Grænge specimen. The interfrontal ridge is fairly broad, about 25 mm ., but low. The frontal part between the orbits is placed lower than the roof of the orbits; as found in the Grænge skull, although in a less degree.

Also in size the Taastrup brain-case is similar to the Grænge specimen. However, considering the young age of the Taastrup animal, this specimen is of a more robust type, and with growing age it would have grown larger; particularly the horn cores are larger than in the Grenge specimen. The distance from the occipital ridge to the middle of the nasal base is the same, 285 mm ., in the two skulls, and this also
holds good of the smallest frontal width, 180 mm . The width of the occipital ridge, between the horn cores, however, is 200 mm . in the Taastrup cow, as compared with 180 mm . only in the Grænge specimen. The circumferences at base of the horn core are 240 and 225 mm ., respectively. The diameters $84 \times 67 \mathrm{~mm}$. and $80 \times 60 \mathrm{~mm}$., respectively. The young age of the Taastrup specimen, however, is clearly expressed in its small occipital width, 145 mm ., as compared with 157 mm . in the old Grænge cow.

From St. Taastrup also a facial part, comprising parts of the two maxillae and palate, and a right mandible are at hand. In the upper jaw the 2. and 3. premolars have not fully erupted, and are only very faintly worn, as also the posterior column of the posterior molar (m3) is very slightly worn. Regarding length, this facial part, too, is similar to the corresponding part of the Grænge skull. The length of the palate, in the middle, from the posterior incisura to the premaxillar suture, being 190 mm . in both. Corresponding to the higher individual age of the Grænge cow, the greatest maxillar width is in this specimen greater than in the Taastrup skull, 150 and 146 mm ., respectively.

Also the Taastrup mandible must have belonged to a young specimen, in which the posterior column of m 3 is unworn, and the premolars slightly worn. The Taastrup mandible, however, is longer than the Grænge mandible, the total lengths being 470 and 460 mm ., respectively, which indicates that this mandible may have belonged to a larger skull than the Grænge one. The basal length of the full-grown skull may be estimated at 510 mm ., as compared with 496 mm . in the Grænge skull.

However, as the occlusion of the mandible teeth fits into the maxillar teeth, the Taastrup jaws probably originate from the same individual. There may be some doubt about this connection with the brain-case, as in Steenstrup's correspondence regarding the discovery - kept in the Royal Library - the sender of the remains is referring to a possible intermixture of two specimens. It should be noted, too, that there is a slight difference in size between the two metapodials, (cf. Table 11).

From the Subboreal period, Zone VIII, when the farmer culture was established in Denmark, five finds of Urus cows are present, from Pindstrup, Aarhus, Korinth, Toftum, and Bonnerup.

The Pindstrup cow is represented by an incomplete skull, the left mandible, and some limb bones. It is the smallest known Urus cow from Denmark; particularly the horn cores are thin.

As the Pindstrup specimen has been discussed earlier (Degerbøl, 1962). I shall here give only a short description of the specimen.

On the upper side the skull is broken at the naso-frontal suture and on the palatal side just in front of the rows of teeth, which are undamaged. The teeth are worn, and indicate an age of $3-4$ years. Most sutures are open, only quite posteriorly the interfrontal suture is closed. The mandible is broken a little in front of the foramen mentale. The distance from the condylus occipitalis to the broken tip of the mandible
is 490 mm ., from the foramen magnum to this tip 460 mm ., and from the crista occipitalis 555 mm . On the basis of similar measurements of length and a comparison with domestic cattle and Urus, the basal length was estimated at 490 mm ., at most. After this was written (loc. cit. 1962, p. 246) the female skull from Grænge has become available (basal length 496 mm .), and a comparison with this complete skull emphasizes that the said estimate is fairly correct. The length from the occipital condyle to the anterior border of the tooth row is 367 mm ., as compared with 371 mm . in the Grænge skull. The corresponding length from the occipital crest is 435 and 445 mm ., respectively. Also the mandibles of the two skulls are almost the same length, the Pindstrup specimen being only about 5 to 10 mm . shorter. The Pindstrup skull thus is a little shorter than the longest skull of a domestic ox, Holmene bull (basal length 497 mm .). However, the shape of the Pindstrup skull is conformal with the Urus skull, thus the characteristic contouring of the frontal region: a well marked concavity on each side of the interfrontal suture, in front of the occipital ridge, and the typical relief between the orbits with a concavity or furrow in the middle line, on each side limited by a longitudinal swelling usually situated higher than the rim of the orbits.

The horn cores are fairly large with a beautiful double curvature, but they are remarkably thin, the circumference at the base being smaller, 181 mm ., than in domestic bulls from the Subboreal period. As long as the Pindstrup skull was the only find with so thin horn cores, it might be regarded as unique. However, the Bjeverskov and Grænge skulls have shown, as already mentioned, that even in Zone V a reduction of the strength of the horn cores took place. Furthermore, horn cores almost as thin are found in some other skulls (cf. the Aarhus and Ølholm specimens).

The same holds good of the narrow forehead; the smallest frontal width is 178 mm ., as compared with, e.g., 175 mm . in the Korinth skull, 177 mm . in the Fuglekjær skull, 178 mm . in the Ølholm skull and 180 mm . in the Grænge skull. All in all, it must be said that on the background of the new finds of Urus cows, the Pindstrup skull belonged to a small, but typical Urus, there is no reason to suppose that any intermixture with domestic cattle has taken place.

The lengths of the tooth rows are great, in the upper jaw 162 mm ., the same as in the Ullerslev cow; in the lower jaw 165 mm ., as compared with 170 mm . in the Ullerslev specimen. Nevertheless, the hindmost molar is much reduced in the Pindstrup cow, the length and width at the base of the lower m 3 being only $45.5 \times 18.7 \mathrm{~mm}$., as compared with $48.5 \times 19.8 \mathrm{~mm}$. in the Ullerslev cow. Furthermore, it should be noted that the teeth are much narrower in the Pindstrup_skull than in the Ullerslev cow, (cf. p. 89).

For the determination Bos primigenius versus Bos taurus domesticus the lengths of the metapodials are decisive. The long metapodials of the Pindstrup cow are quite similar to the proportions found in the Urus, and are different from the short metapodials in domestic cattle, (cf. Tables 11-12).

Of almost similar shape and size as the Pindstrup skull is a brain-case from Aarhus. The horn cores are nearly as thin as in the Pindstrup specimen, diameters at the base are $65 \times 57 \mathrm{~mm}$. and $60 \times 52 \mathrm{~mm}$., resp., and circumferences at the base 195 and 180 mm ., respectively. The length of the horn cores, too, is a little greater in the Aarhus skull, 410 mm ., as compared with 365 mm . in the Pindstrup cow. As the posterior part of the interfrontal suture is closed, the Aarhus brain-case must have belonged to a fairly old animal. It is very heavy; although it is broken behind the orbits and the outer half of the left horn core is missing, the weight is 1820 g . (cf. e.g. the Toftum skull).

The Korinth brain-case, which is broken in the middle of the orbits, must have belonged to an old animal, in which most sutures are closed; only the interfrontal suture is open anteriorly (secondarily exaggerated), posteriorly forming a broad, elevated crest, on each side bordered by a well-marked cavity. In the middle of the occipital ridge there is a faint concavity. Despite the high individual age the supraorbital sulcus is open, thus indicating a female skull. In size the Korinth skull is almost equal to the corresponding part of the Grænge skull. The frontal widths are 175 and 179 mm ., respectively; the zygomatic widths 204 and 201 mm ., respectively, and the occipital height, from the upper border of the foramen magnum, both 137 mm . Also the thickness of the horn cores is the same, 220 mm . in circumference, but the span of horn cores is considerably larger in the Korinth specimen, 630 mm ., as compared with 577 mm . in the Grænge skull.

This specimen is the only one known from the island of Funen later than Zone VI.

In the Subboreal period, however, also large cows of Bos primigenius existed, as demonstrated by the incomplete skull and mandibles from Toftum, which is broken immediately in front of the fronto-nasal sutures. The length from the occipital ridge to the base of the nasals is 295 mm ., as compared with 315 mm . in the Ullerslev skull. The Toftum skull, however, is not nearly so heavily built. The weight is only 2450 g . The smallest frontal widths are similar in the two specimens, 200 and 203 mm ., respectively, and the same holds good of the interorbital width, 190 and 193 mm ., respectively. The greatest span of the horn cores is a little larger in the Toftum specimen, 680 mm ., as compared with 640 mm . in the Ullerslev skull; but the circumference at the base of the horn cores is the same in both specimens, 270 mm . As also the mandibles of the two specimens are alike, the basal length of the two skulls must have been almost the same, 525 mm ., probably the Toftum skull, however, with its shorter brain-case having been a little shorter (about 520 mm .).

The Bonnerup skull is very fragmentary; only a horn core may be measured. In size and shape it is almost similar to the horn core of the Grænge female. The lengths of the inner and outer curvature are 280 and 350 mm ., respectively, as compared with 270 and 380 mm ., respectively in the Grænge specimen; however, as the very base is missing in the Bonnerup horn core, this must originally have been somewhat larger; 290 mm . from the tip the diameters of the horn cores are the same in the two specimens, $55 \times 65 \mathrm{~mm}$.

Six finds, from Skaarup, Mørkøv, Fuglekjar, Olholm, Gjodvad, and Aakjar, are of uncertain age.

Skaarup. The Skaarup skull is so fragmentary that the pieces cannot be put together, however, they belonged to a small skull. A left frontal half is broken along the interfrontal suture, indicating a smallest frontal width of 186 mm . The circumference of the horn core, which is broken almost at the base, is small, 206 mm ., diameters $73 \times 57 \mathrm{~mm}$. The molars are fairly large, the length of $\mathrm{m} 1-\mathrm{m} 3$ is 97 mm ., but as the length of the premolars is very small, 54 mm ., the entire length of the row of teeth becomes comparatively small, too, 148 mm . The width across the occipital condyles is just as small as in the Toftum skull, 107 mm ., the minimum width in Urus cows.

Morkov. As no Urus find is known from the island of Zealand later than Zone VI it is probable that the Morkov brain-case belongs to the Preboreal or Boreal period. It is broken through the orbits. In the shape of the frontal, the upper part of which is fairly concave, this brain-case is similar to the Grænge specimen, though broader, just as broad as the Knabstrup specimen. The smallest width of frontal is 195 mm . The greatest span of horn cores is about 600 mm ., as compared with 577 mm . in the Grænge specimen; the circumferences at the base of the horn core are 227 mm . and 220 mm ., respectively.

The Fuglekjor skull is, on the upper side, broken through the base of the nasal bones; of the palatal part only the alveole of the left hindmost molar is present. In size and individual age it is much like the Grænge skull. The distance from the occipital ridge to the nasal base is a little shorter, 270 mm ., than in the Grænge skull, 278 mm ., as measured to the posterior curvature of the nasals; but the distances from condylus occipitalis and the foramen magnum to the posterior border of the palate, in the middle line, are a little larger, 235 mm , and 198 mm ., respectively, than in the Grænge skull 230 and 190 mm . The distance from the occipital condyle to the anterior border of the hindmost molar (m3) is 260 and 257 mm ., respectively. The basal length thus may be estimated at about the same size in the two specimens, or perhaps a little greater in the Fuglekjær specimen, 500 mm ., as compared with 496 mm . in the Grænge skull. The horn cores, too, are almost identical; the greatest span is 585 and 577 mm ., respectively, and the circumferences at the base are 227 and 225 mm ., respectively. The horn cores are at the base fairly compressed, as also found in the Grænge and Mørkøv specimens (cf. Degerbøl, 1962, fig. 3). - Also the smallest frontal widths are the same, 177 and 180 mm ., respectively.

The Olholm skull is broken a little in front of the fronto-nasal suture; the palatal part is missing. It belonged to a very old animal; the sutures of the lacrymal are only just visible or have completely disappeared, and the same applies to the upper half of the interfrontal suture, the posterior part of which is strongly elevated, forming a small boss. The surface of the bones is very hard, as in old bulls. The anterior part of the frontals, behind and medially to the orbits, is so severely corroded that the air-sinuses are opened, particularly when seen on the left side. The occipital ridge is fairly undulating. The swelling of the interfrontal suture or ridge,-immediately in
front of the two posterior concavities, - and which in the Urus skull may be more or less marked - is so large that the frontal region here is distinctly domed.

The length of the Olholm brain-case is almost similar to the corresponding part of the Pindstrup skull, estimated at a basal length of about 490 mm . The distance from the occipital ridge to the anterior border of the os lacrymale is 340 mm . in both skulls. According to greater developmental age, however, several measurements of width are greater than in the Pindstrup cow. Mastoid width, e.g., 240 and 225 mm ., postorbital width 240 and 230 mm ., respectively, whereas the smallest frontal width is similar, 178 mm . Of particular interest are the thin horn cores in the Olholm specimen which next to the Pindstrup cow - but together with the horn cores of the Aarhus cow, - are the smallest in the Danish material; the circumference at the base is 195 mm . in both, as compared with 181 mm . in the Pindstrup cow. As in Urus cows the horn cores are well upward directed.

The Gjodvad brain-case is broken through orbits. It belonged to an old animal; the left sulcus supraorbitalis is roofed posteriorly, as also the interfrontal suture posteriorly is completely fused, forming a broad ridge, on each side of which there is a distinct concavity. The frontal is concave anteriorly-posteriorly and the occipital crest is concave at the base of the very compact horn cores. These are asymmetrically, the left one anomalously bent, forming about $2 / 3$ of a circle, the tip of which is turned inwards to only 66 mm . from the posterior rim of the orbit, a unique instance in Urus. This brain-case is a little larger than the corresponding part of the Grænge skull. The frontal widths are 188 mm . and 179 mm ., respectively.

The Aakjar frontlet is cut off between horn cores and orbits. Although it belonged to an old animal with obliterated interfrontal suture and a hard and shining surface of the bone, no granulation at all is seen at the base of the horn cores, and only a few longitudinal grooves are present. The occipital crest is almost straight.

The Aakjær frontlet, like the skulls from Svebølle and Flintinge, represents the "open type" of horn cores, but it is smaller than these specimens.

The smallest width between horn cores is 174 mm ., as compared with 215 mm . in the Flintinge skull, and the smallest frontal widths are 195 mm . and 205 mm ., respectively.

Barlose. Left horn core with a small part of the frontal, which is broken at the interfrontal suture. Tip of horn core broken off, occipital crest elevated in the middle, with a concavity at the base of the horn core. The smallest width between horn cores at the occipital ridge is 220 mm . $(110 \times 2)$, in the middle of the frontal 240 mm . The circumference at the base of the horn core 233 mm ., diameters $76 \times 65 \mathrm{~mm}$. Outer curvature of broken horn core 365 mm . (the complete length probably $1 / 3$ more). Apart from a thinner horn core, this specimen is almost a reflected image of the Svebolle specimen.

Dyrholmen. From Dyrholmen I, i.e. from the earliest part of the settlement, two comparatively small incomplete horn cores are present (Degerbøl 1942, p. 92, fig. 5). At the time of publication the determination Urus versus domestic animal caused great difficulty, however, on the basis of the material now at hand, they must
no doubt be referred to Urus cows. The oldest specimen, belonging to an adult animal, is broken 150 mm . from the base, but the small curvature indicates a fairly long horn core (probably almost as in the large Svebolle horn core). The circumference at the base is 215 mm ., diameters $71 \times 61 \mathrm{~mm}$., thus in fact larger than seen in several female Urus skulls (fig. 14). Cf. p. 37.

Regarding mandibles and postcranial skeletal parts cf. Tables 10-23
To sum up, it may be said that skulls and parts of skulls of no less than 27 Urus cows have been recorded. Of particular interest are the two complete skulls, from Ullerslev and Grænge, the largest, and one of the smallest of the Danish females. The basal lengths are 525 and 496 mm ., respectively (condylobasal lengths 556 and 527 mm .). On the basis of incomplete skulls, with mandibles, the lengths, however, may with fairly certainty, be estimated in several other skulls: The Toftum skull at a basal length almost as in the Ullerslev skull, the Bjeverskov skull at 515 mm ., the Taastrup skull at 510 mm . Of about the same length as the Grænge skull, are the Fuglekjær skull 500 mm ., and the Pindstrup skull 490 mm . A determination of the basal length on the basis of brain-cases alone is not possible, but it may be noted that the brain-cases from Vigersted, Korinth, Ølholm, and Aarhus are almost similar to the Grænge skull; whereas the Knabstrup and Mørkøv specimens are a little broader, but not so broad as the large Ullerslev skull.

Also in shape the skulls of Urus cows are fairly variable. In sturdily built skulls, the standard type, so to say, e.g., from Ullerslev and Grænge, the occipital crest is almost straight, but in more slightly built skulls this crest tends towards getting more or less wavy, generally convex, in a few specimens, however, concave, as exceptionally seen in the Bjerregrav skull.

Characteristic of the female skulls are the comparatively narrow and concave forehead, and the thinner and shorter, but generally more upwards turned, rising horn cores.

As compared with the skulls of the large bulls, the female skulls are small. The narratives of the legendary size of the Urus no doubt are based on large bulls, and particularly on the enormous head and horns. Probably the said features were still more pronounced in living animals as may be seen in the palaeolithic paintings at Lascaux, where particularly the concave profile of the forehead in cows is surprisingly accentuated, perhaps indicating a local trait (F. Windels, 1948).

Comparison between males and females.
(Sex dimorphism)
A. Skulls.

After the survey of skulls of Urus cows we shall make a comparison with the remaining Danish Urus skulls representing bulls; besides brain-cases and other parts of skulls, thus 15 complete, or almost complete skulls are present. For further information and particularly to find out the range of variations, measurements of skulls from adjacent countries are included in the investigations.

The length of the cranium is indicated by the total length or profile length, the condylobasal length, and the basal length. Of these measurements the total length is most affected by the developmental age and sex of the animals, being proportionally large in old bulls in which the occipital part is sloping greatly backward. As now the basal length and now the condylobasal length are used in different publications, the basal length mostly in German and condylobasal length particularly in English publications, I have for the sake of comparison stated both.

The basal length is given in Table 1 and plotted in fig. 8. From this it appears, as mentioned above and as seen in other measurements, that a very large sex dimorphism exists in the Urus. The basal length of the largest female skull (Ullerslev) from Denmark just comes up to the smallest male skull from Ostbirk, measuring 525 mm . In males the basal length varies between 612 and 525 mm .; in females between about 490 mm . ( 496 mm . in the complete Grænge skull) and 525 mm .

However, a still larger female skull, the basal length of which is 534 mm ., has been mentioned by Leithner from Skåne, Sweden, now kept in the Riksmuseum, Stockholm. - Smaller skulls of females, too, have been described. The basal length of a complete, but undated skull from Rethen, Hannover, Germany, is only 475 mm . (La Baume, 1958).

An astonishingly small measurement is stated for the incomplete skull from Star Carr which is broken a little in front of the tooth row and the foramen infraorbitale (Fraser and King, 1954). Thus by comparison i. a. with domestic cattle the condylobasal length was estimated at 459 mm . The distance from the occipital ridge to the upper end of the nasals is, however, stated to be 265 mm ., which is fairly large, as compared with 242 mm . in the Rethen skull, 255 mm . in the Pindstrup skull, and 278 mm . in the Grænge skull. In contrast the distance from the condyle to the "anterior edge of 4th upper molar" is exceptionally short, 293 mm . In the Pindstrup skull this length is 310 mm ., in the Grænge skull 320 mm . - Similar proportions occur in the other length measurements. In the Star Carr specimen the distance from the foramen magnum (basion) to the middle point of the line between the front of the first premolar, p 2, is 309 mm ., from condylus occipitalis to the same point 344 mm . (C. Crigson in lit.). In the Grænge cow the corresponding measurements are 337 mm . and 369 mm ., in the Pindstrup cow 332 mm . and 364 , respectively.

In the complete skull from Grænge the distance from the said middle point of the line between the front of p 2 to the anterior rim of the premaxilla is 159 mm ., corresponding to a basal length of 496 mm . and a condylobasal length of 528 mm . The Pindstrup skull is, like the Star Carr skull, broken in front of the row of teeth, but using the said length of the missing part, 159 mm ., as found in the Grænge skull, we find the basal length of the Pindstrup skull to be 491 mm . and the condylobasal length 523 mm .

The length of the corresponding missing premaxilla part in the Star Carr specimen may be estimated in proportion to the said overall length, from the basion or condylus, thus : $159 \times 309 / 337$ and $159 \times 344 / 369$, which gives a length of 146 mm . and

Nr. 1


Fig. 8. Basal length. Males are placed above the line; females below. - Measurements in 10 mm . groups: 401/410-411/420 etc. The largest female skull from Denmark (Ullerslev, Zone V), just reaches the smallest male skull (Ostbirk, Zone VIII). Only one skull (from Holmene) of domestic cattle (male or bullock) is within the size range of Danish Urus cows.

148 mm ., respectively, averaging 147 mm . Accordingly the basal length of the Star Carr skull is 456 mm ., the condylobasal length 491 mm ., at least, probably a little larger, corresponding to the fact that the premaxilla may have been longer than estimated here. Still the Star Carr skull must be characterized as small, if the association of the facial part with the cranial portions is right, and it is stated to be so. It is quite outside the range of other Urus skulls, a remarkable exception, but similar exceptions are now and then seen in other measurements. (Cf. p. 77, fig. 13).

As to the size of the Urus during prehistoric times, it is worth noting that the earliest specimen, from the Late Dryas period, is not only the largest male known from Denmark, but in fact the largest postglacial specimen known. The smallest males, from Østbirk and Tinglev Lake are the youngest, from the Subboreal period or the beginning of the Subatlantic period. Similarly, the largest complete female skull (Ullerslev) and the very large brain-case from Flintinge, with its exceptionally large span of horn cores, belong to the Boreal and Preboreal periods, respectively; the smallest female (Pindstrup) to the Subboreal period. This would seem to indicate a reduction in size during the ages. However, also large and smaller skulls are known from the intermediate periods.

For the sake of comparison also measurements of domestic cattle are recorded in the tables and graphs, fig. $8-16$ (cf. the capter on domestic cattle).

Biol.Skr. Dan.Fid. Selsk. 17, no. 1.


## Bos taurus domesticus



From Table 1 and fig. 8 it appears that the basal lengths of large domestic oxen and Urus cows are overlapping, inasmuch as the exceptionally large male skull from Holmene is just as large as skulls of medium-sized Urus cows.


Fig. 9. Least frontal width is in Urus cows outside the range in Urus bulls, but co-extensive with the range in domestic bulls. Here, too, the largest measurements of females come from the geologically oldest skulls (Ullerslev, Flintinge, Zone V).

## Least frontal width.

The narrow frontal of the female skulls is demonstrated in Table 2 and fig. 9. This shows that the range of the frontal width in females is just outside the range of the male skulls.

Furthermore, the largest measurements of females come from the two geologically old skulls, Flintinge and Ullerslev, belonging to the Boreal period.

Table 2.

## Least frontal width. <br> Bos primigenius.

| むơ |  |
| :---: | :---: |
| Ølholm. | 207 |
| Fæsted. | 210 |
| Klarup. | 212 |
| Tinglev. | 214 |
| Tranekær. | 216 |
| Mors. | 217 |
| Hornslet | 220 |
| Hallenslev (jun.) | 220 |
| Danmark (Stud. Coll.) | 220 |
| Ugilt (ad. jun.). | 222 |
| Danmark (2. afd.) . | 225 |
| Knabstrup 1. | 226 |
| Tepstrup | 226 |
| Læsten. | 228 |
| Fyn. | 230 |
| Store Damme. | 230 |
| Gøderup (subad.) | 230 |
| Aabenraa. | 230 |
| Holme Mose | 230 |
| Vig. | 231 |
| Danmark (CN. 1891). | 232 |
| Julianelyst | 232 |
| Knabstrup 3. | 234 |
| Grevinge . | 234 |
| Rode Molle Aa. | 235 |
| Bro. | 236 |
| Tranemosegaard. | 237 |
| Lading. | 237 |
| Grejs Molle | 237 |
| Soro. | 238 |
| Auning. | 238 |
| Grænge A (ad. jun.). | 240 |
| Grænge B . | 240 |
| Niverød. | 240 |
| Lyngby . | 240 |
| Faaborg. | 241 |
| Bønnelykke. | 242 |
| Aagerup. | 242 |
| Østbirk. | 242 |
| Kulemile | 242 |
| Ørting. | 245 |
| Hørning. | 246 |
| Sakskobing. | 247 |
| Danmark (Min. Mus.) . | 247 |
| Hastrup. . | 250 |



Table 2 (continued).
Bos taurus domesticus.

|  | đô | ¢\% |
| :---: | :---: | :---: |
| Gammellung I | .... 177 | Sandhuse I. . . . . . . . . . . . . . . . . . . . . . . . . . . . . 148 |
| [St. Lyng (subad.) | . . . . . 180] | Øgaarde II. . . . . . . . . . . . . . . . . . . . . . . . . . . . . 148 |
| Gammellung III | 183 | Gammellung II .............................. . . 151 |
| Veddinge | 184 | Nyrup III.................... . . . . . . . . . . . . . 153 |
| Logtved Enge | . 184 | Nyrup I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 158 |
| Snoldelev I . | ... 184 | Holmene. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 159 |
| Vedbæk II. | . 188 | Nyrup II. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 164 |
| Vedbæk III. | . 191 | Sandhuse II.................................. . 170 |

Bodal. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 192
Verupgaard. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 193

Søndersø. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 208
Holmene . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 208

Sandhuse I................................... 148

,
Nyrup I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 158
Holmene . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 159

Sandhuse II . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 170

It should be noted that even in the subadult bull skull from Gøderup and the not full-grown skull from Grænge (A), the frontal widths are great, 230 and 240 mm ., respectively (Table 2 ).

The range of variation of the smallest frontal widths in Urus cows is co-extensive with the range of variation in domestic males.

## Postorbital width.

The width across the posterior edge of the orbits also emphasizes the relative narrowness of the frontal part in Urus cows. The postorbital width, however, particularly depends on the individual age, fairly small even in almost adult animals. Thus, it should be noted that of the three bulls which have the smallest postorbital widths (fig. 10) two, from Ugilt and Hornslet, are young animals. In the Ugilt skull the lower p 3 has not fully erupted, and the brain-case from Hornslet is of about the same age. In this case there is a slight overlapping. The subadult skulls from Hallenslev and Gøderup are not incorporated in the graph, fig. 10. Their postorbital widths are 254 and 260 mm ., respectively, indicating that the protruding orbits are established fairly late. Here, too, the ranges of variations in Urus cows and domestic males are largely overlapping.

## Mastoid width.

From Table 4 and graph fig. 11 it appears that the mastoid measurements of skulls of cows and bulls do not overlap. Here, too, the greatest width in females originates from the Ullerslev skull, from Zone V. The smallest mastoid width in bulls plotted (fig. 11) are found in fairly young animals: Hornslet, Ugilt (cf. postorbital width), Knabstrup I and Tranemosegaard, in which the interior column of m 2 is unworn. In old bulls the mastoid process is strongly granulated, forming a great lump.

Table 3.

## Postorbital width.

## Bos primigenius.

|  |  | ¢¢ |
| :---: | :---: | :---: |
| [Hallenslev, jun. | 254]* | Korinth. . . . . . . . . . . . . . . . . . . . . . . . . . . . . 222 |
| [Gøderup, (subad.). | 260] | Pindstrup . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 230 |
| Ugilt (ad. jun.). | 262 | St. Taastrup . . . . . . . . . . . . . . . . . . . . . . . . . . . . 233 |
| Fæsted. | 266 | Fuglekjær. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 235 |
| Hornslet | 268 | Gjødvad................ . . . . . . . . . . . . . . . . . 240 |
| Tranekær. | 274 | Ølholm. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 240 |
| Ølholm. | 275 | Vigersted. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 240 |
| Tinglev. |  | Mørkøу . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 242 |
| Læsten. | 280 | Grænge . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 244 |
| Knabstrup 1. | 285 | Kærsted. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 248 |
| Holme Mose. | 286 | Bjeverskov. . . . . . . . . . . . . . . . . . . . . . . . . . . . 250 |
| Tranemosegaard. |  | Toftum. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 253 |
| Tepstrup | 287 | Knabstrup................... . . . . . . . . . . . . . . 260 |
| "Stud. Coll.". | 289 | Ullerslev . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 268 |
| Bonnelykke. | 290 |  |
| Bro.. |  |  |
| Mors. |  | Leithner ở̛̀: 261, 270, 270, 270, 273, 280, 285, |
| Aabenraa. | 293 | $288,290,290,290,292,295,296 \text {, }$ |
| Grevinge . |  | $297,297,298,299,300,301,302 \text {, }$ |
| Aagerup. . . . . . . . . |  | $302,303,303,304,305,308,310 \text {, }$ |
| Grænge A (ad. jun.) |  | $314,315,316,320,324,326,336 .$ |
|  |  | 운: 232, 233, 236, 240, 242, 247, 249. |
| Auning. "2. Afd." |  | La Baume ơơ: $286,295 . \quad$ ¢¢¢: 221, 243. |
| Vig. .... |  | Higgs <br> ठ): 305. |
| Knabstrup 3. | 300 | Fraser q: 231 (No. 2). |
| Røde Molle. |  |  |
| Lyngby . |  |  |
| Sora. |  |  |
| Grænge B . |  |  |
| Grejs Molle . | 303 |  |
| Julianelyst. |  |  |
| "Min. Mus.". | 307 |  |
| Rønnebæksholm. |  |  |
| Østbirk. |  |  |
| Ørting. |  |  |
| Faaborg. | 315 |  |
| St. Damme |  |  |
| Bregninge . | 328 |  |
| * [ ] not plotted. |  |  |

Fig. 10. Postorbital width. There is a small overlapping, particularly caused by the small postorbital widths of the young bulls from Ugilt and Hornslet; the protruding orbits of the bulls are established fairly late. In Urus cows and domestic males the ranges of variation are largely overlapping.

Table 3 (continued).
Bos taurus domesticus.


$$
\text { Verupgaard . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . } 235
$$

$$
\text { Vedbæk II (Maglemosegaard) . . . . . . . . . . . . . . . } 237
$$

Erø. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 239
Bodal. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 244
Holmene . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 257
Søndersø. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 260



Table 4.
Mastoid width.
Bos primigenius.

Korinth ..... 210
Pindstrup ..... 225
Fuglekjær ..... 227
St. Taastrup (ad. jun.) ..... 232
Bjeverskov ..... 234
Mørkøv ..... 234
Grænge ..... 236
Gjødvad ..... 240
Ølholm ..... 240
Vigersted ..... 240
Knabstrup ..... 242
Ullerslev ..... 267
From Leithner ơờ: 280, 285, 295, 300, 301, 304,304, 306, 307, 308, 310, 310,310, 311, 312, 312, 313, 314,315, 315, 316, 316, 317, 320,320, 321, 322, 325, 325, 326,327, 328, 337, 346, 350" " $\quad$ ¢ : $222,226,230,231,236,243$,246, 251, 261.
From Requate ot: 323, Q: 255

Fig. 11. Mastoid width. The measurements of Urus bulls and cows do not overlap; whereas the measurements in Urus cows coincide with those of domestic bulls.

Table 4 (continued).
Bos taurus domesticus.
[Vedbæk I (jun.) . . . . ............................ . . 188]
[Snoldelev II (jun.). ..... 191]
[St. Lyng (subad.) ..... 215]
Gammellung III ..... 215
Gammellung I ..... 216
Snoldelev I ..... 227
Vedbæk III ..... 230
Verupgaard. ..... 230
Vedbæk II (Maglemosegaard) ..... 232
Ærø ..... 245
Veddinge ..... 249
Bodal. ..... 256
Søndersø ..... 256
Holmene ..... 263
[Viksø I (subad.) ..... 178]
Sandhuse I ..... 184
Sandhuse II ..... 186
Ogaarde II ..... 194
Nyrup III ..... 200
Nyrup I. ..... 202
Holmene ..... 205
Nyrup II ..... 207


| 180 | 190 | 200 | 210 | 220 | 230 | 240 | 250 | 260 | 270 | 280 | 290 | 300 | 310 | 320 | 330 | 340 | 350 | mm |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
|  |  | Mastoid width |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |



Fig. 12. Width between temporal fossae, posteriorly. The width in the young Ugilt bull is slightly smaller than in the large Flintinge cow, 183 and 185 mm ., respectively. - As in most other width measurements the ranges of variation in Urus cows and domestic bulls are overlapping.

The subadult skulls from Gøderup ( 262 mm ) and Hallenslev ( 244 mm ) are not plotted.-As in the smallest frontal width and postorbital width the absolute measurements of the mastoid width in Urus cows coincide with the absolute measurements in domestic males.

Width between temporal fossae, posteriorly (Supraoccipital width).
In this measurement the females and males are slightly overlapping. Here, too, the individual age of the animals plays a considerable rôle. In old animals, particularly bulls, the temporal fossae are posteriorly closed by a bony bar, missing in young

Table 5.
Width between temporal fossae, posteriorly.
Bos primigenius.


## Table 5 （continued）．

Bos taurus domesticus．

| むすへ |  |
| :---: | :---: |
| ［Vedbæk I（jun．） | 130］ |
| ［Snoldelev II（jun．）． | 135］ |
| St．Lyng（subad．）． | 151 |
| Snoldelev I． |  |
| Gammellung I． |  |
| Logtved Enge． | 145 |
| Verupgaard． | 154 |
| Vedbæk III． |  |
| Gammellung III． |  |
| Bodal． |  |
| Vedbæk II（Maglemosegaard） |  |
| Sonderso． |  |
| Ero． |  |
| Veddinge． | 171 |
| Holmene ． | 179 |

Sandhuse I．．．．．．．．．．．．．．．．．．．．．．．．．．．．．． 108
Øgaarde II．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．． 116
Nyrup III．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．． 126
Sandhuse II．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．． 127
Gammellung ．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．． 128
Nyrup II．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．． 129

Holmene．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．． 137
individuals．The largest supraoccipital width measured in female skulls originates from the very large Flintinge brain－case from the Boreal period，Zone V．

Leithner indicates a very low supraoccipital width of 125 mm ．，which，how－ ever，no doubt is a misprint，as also seen from the very large mastoid width （ 246 mm ．）in the same individual．This measurement therefore is not plotted here． In males the two smallest measurements plotted originate from the young skulls from Ugilt（width 185 mm ．）and Knabstrup（ 189 mm ．），cf．the postorbital width（these young skulls are in the graph marked with an asterisk．Of the 4 Danish skulls in the next size column（fig．12）two from Tranemosegaard（width 198 mm ．）and Grænge （width 200 mm ．），also belong to relatively young animals．Leithner does not indi－ cate the individual age of his material，however，as an exception，he states that a supraoccipital width of 180 mm ．occurs in a skull of an Urus calf．

As in most other measurements of width the ranges of variation in Urus cows and domestic males coincide．

## Condylus width．

Also regarding the width across the occipital condyles there is an overlapping of measurements of males and females．It occurs from Table 6 and the graph fig．13， however，that there is a great variation in this measurement．The greatest width is not always found in the largest or broadest skulls．In the very large and strongly built Danish skull from Bregninge，e．g．，the condylus width is fairly small（ 129 mm ．）， and the same applies to the large and broad female skull from Toftum，which together with the small Skaarup skull has the smallest condylus width known （ 107 mm ．）；on the contrary the smallest，but broadest bull skull from Orting，has a very great condylus width（ 142 mm ．）．


Fig. 13. Condylus width. Much overlapping occurs. - Particularly small is the condylus width ( 110 mm .) in a robust Urus bull skull from Mors.

An exceptionally small measurement quite outside the range of other males, occurs in a robust bull skull from Mors ( 110 mm .). If only the exoccipital part of this skull had been found, it would no doubt have been recorded as belonging to a female. Similar remarkable exceptions are now and then seen in other measurements. - It may be noted, that the condylus width is comparatively great in young animals, in the subadult skull from Gøderup, e. g., 138 mm .

The ranges of variation of condylus width in Urus cows and domestic males are largely overlapping.

Horn cores, circumference at the base.
In smooth horn cores this measurement may be taken without difficulty, but in the large horn cores of bulls, in which the base is highly granulated, this measurement is more or less inaccurate.

From Table 7 it appears that in young adult or even subadult bulls, the horn

## Table 6. <br> Width across condyli occipitales. <br> Bos primigenius.



Table 6 (continued).
Bos taurus domesticus.



Fig. 14. Circumference at the base of horn cores. Even in young Urus bulls the horn cores are comparatively thick, being outside the range in Urus cows. It is remarkable that the width of horn cores in domestic bulls almost coincides with that of Urus cows.

Table 7.
Circumference at the base of the horn cores.
Bos primigenius.

|  |  | ỡ |  |
| :---: | :---: | :---: | :---: |
| [Hallenslev (jun.) | 285] | Danmark (3).. | 335 |
| [Viesø (subad.). | 290] | Bønnelykke. | 337 |
| Læsten. | 283 | Ulvemose, Rosenholm. | 338 |
| Ugilt. | 283 | Barrit Skov. | 338 |
| Fæsted. | 285 | Ørting. | 340 |
| Brabrand. | 285 | Thorsager. | 340 |
| Hornslet | 290 | Hastrup . | 340 |
| Olholm. | 295 | Horning. | 340 |
| Tinglev | 295 | St. Damme | 341 |
| Næsbyhoved | 295 | "Mus. Min." | 345 |
| Tranemosegaard. | 295 | Sakskøbing. | 345 |
| Lundby . | 298 | Kulemile | 345 |
| Holme Mose. | 300 | '2. Afd.(1)". | 345 |
| Taageby. | 300 | Knabstrup 3. | 345 |
| Danmark 1 | 305 | Aagerup. | 345 |
| Knabstrup 1. | 305 | Danmark (4). | 346 |
| Vintved. | 305 | Jonstrup Vang. | 348 |
| Dyrholmen | 305 | Fyn. | 350 |
| Egum. | 305 | Rønnebæksholm. | 350 |
| Hedehusene | 308 | Skellingsted. | 350 |
| Danmark (5). | 308 | Danmark (6). | 354 |
| Grænge A | 310 | Norre Vissing. | 355 |
| Terp Mose. | 315 | Mors. | 355 |
| Gøderup (subad.) | 315 | Danmark (7). | 357 |
| Grænge B . | 315 | Lyngby | 358 |
| Grevinge | 315 | Alsønderup | 365 |
| Gentofte | 315 | Auning. | 365 |
| Bro. | 318 | Horsens Fjord | 368 |
| Soro. | 320 | Bregninge | 375 |
| Jelling. | 320 | Trøstrup. | . 375 |
| Bedsmose | 322 | Danmark (Lotze) | . 375 |
| Klarup. | 323 | 2. Afd. | 385 |
| Østbirk | 325 | Julianelyst. | 385 |
| Vig. | 325 | Danmark (2). | 395 |
| Falster | 325 | Lorup Hede | 397 |
| Røde Mølle | 325 | Østersøen | 398 |
| Danmark (9). | 325 | Faaborg. | 400 |
| Tepstrup | 325 | Brændholt, Nyrup. | .. 405 |
| Tjerrild. | 328 |  | ( (right) 445 |
| Understed | 330 | Danmark (CN. 1891) | ( $\mathrm{left)} 420$ |

Table 7 (continued).


$320,320,323,324,328,330$,
$330,333,333,334,334,339$,
$340,340,343,345,350,350$,
$350,357,358,360,360,361$,
$363,367,368,370,370,378$,
378, 398.
222, 222, 223, 225, 227, 237,
246.
From La Baume ơ: $320 . \quad$ +q: 190, 205.
From Requate ôô: 275, 298, 304, 307, 309, 316,
$325,325,330,331,333,341$,
$351,352,354,360,365,365$,
290, 392.
切: 200, 224, 228, 232, 235
From Grigison ơơ: $343,355$.
From Higgs ô: 342.
From Fraser.
(Star Carr) $\subset q: 189,224$.

Bos taurus domesticus.

## か̊ơ

St. Lyng (subad.)........................... . . . . . . . 205
Veddinge............................................ . . . 214
Gammellung III.................................. . . . . 215
Vedbæk III........................................... . . 215
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cores are comparatively thick, being outside the range in females; this applies, e.g., to the subadult bulls from Hallenslev and Vies $\varnothing$, circumference 285 and 290 mm ., respectively, which are plotted in fig. 14.

Probably also the smallest measurements given by Leithner come from young animals.

As the granulation at the base of the horn cores continues even in very old bulls, Biol.Skr. Dan.Vid.Selsk. 17, no. 1.

## Table 8

## Horn core，outer curvature，length．

Bos primigenius．

Ugilt．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．． 495
Brabrand．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．． 500
Sakskøbing ．．．．．．．．．．．．．．．．．．．．．．．．．．．．．． 515
Grevinge．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．（475＋） 515
Bro．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．． 525
Fæsted．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．． 540
Lundby ．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．． 540
＂Stud．Coll．’．．．．．．．．．．．．．．．．．．．．．．．．．．．．．． 548
Hornslet．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．． 550
Olholm．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．． 552
Aagerup．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．． 555
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Knabstrup 1．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．． 570
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Tranemosegaard．．．．．．．．．．．．．．．．．．．．．．．．．． 570
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Thorsager ．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．． 580
Vintved．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．． 580
Sorø ．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．． 590
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Tinglev ．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．． 610
Skellingsted．．．．．．．．．．．．．．．．．．．．．．．$(575+) 610$

Knabstrup 3．．．．．．．．．．．．．．．．．．．．．．．．．．．．（580＋） 615
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か〇す
No information ..... 680
Ørting ..... （600 ..... 680
Danmark（CN．1891） ..... 685
Horn core 1 ..... 685
St．Damme ..... 686
Røde Molle ..... $(600+) 690$
＇Min．Mus’ ..... 695
Dyrholmen（VII H2）． ..... 700
Odder ..... 710
＇2．Afd．（2）＂ ..... 710
Terp ..... 750
Faaborg． （700 ..... 780
qㅇ
Pindstrup ..... 365
Gjodvad ..... 380
Olholm． ..... 385
Morkov ..... 385
Grænge ..... 395
Aarhus ..... 410
Fuglekjær ..... 412
Bjerregrav ..... 430
Ullerslev ..... 450
Korinth ..... 465
Toftum ..... ab． 480
Vigersted． ..... 495
Aakjær． ..... $(445+) 500$
From Leithner ôô：460，490，530，540，545，549，$550,556,559,575,578,580$ ，$580,583,597,600,604,607$ ，
$608,610,610,612,615,626$,
$631,639,640,643,646,650$,
$657,658,670,680,688,720$,
$730,730,736,740,780$.
우: $335,357,371,377,395,396$,
$420,426,445,450,488,530$
(r), (488 1.).
From La Baume ơ: 555 . q: 360 .
From Requate ôô: $548,588,601,605,618,655$,
660, 693, 695, 720, 752.
ㅇ: 415 .
From Higgs ô: 785 ,
From Grigson ôơ: 705, 735

Table 8 (continued).
Bos taurus domesticus.

| ¢0 |  |
| :---: | :---: |
| [Snoldelev II (jun.). | 2351 |
| [Vedbæk II (subad.). | 235] |
| Veddinge | (295) |
| Gammellung III. | (295) |
| Holmene | 305) |
| [St. L.yng (subad.) . | (310)] |
| Gammellung I | (335) |
| Vedbæk II (Maglemosegaard) | (340) |
| Verupgaard | (375) |
| Snoldelev I | (380) |
| Bodal | (385) |
| Sonderso | . (415) |
| Ero | (430) |

[ Øgaarde III (subad.). . . . . . . . . . . . . . . . . . . . 153]
Sandhuse I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . (185)
Øgaarde II . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 210
Nyrup III. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 215
Gammellung II. . . . . . . . . . . . . . . . . . . . . . . . . . 215
Holmene . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 230
Nyrup II. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 255
Sandhuse II . . . . . . . . . . . . . . . . . . . . . . . . . 285

Verupgaard. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . (375)
Snoldelev I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . (380)
Bodal . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . (385)
Sonderso . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . (415)
Ero . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . (430)
the shape of the graph fig. 14 differs from the other graphs given by a less pronounced drop.

It is remarkable that in domestic males the horn cores are just as thick as in Urus cows.

Length along the outer curvature of the horn core.
From graph, fig. 15 , it will be seen that the largest complete horn core in cows, that of the Vigersted cow, just comes up to the length of the smallest horn cores in bulls. However, these specimens originate from the young bulls from Ugilt and Brabrand. As the incomplete horn cores of females from Svebolle and particularly from Flintinge probably originally surpassed the length of the horn cores from Vigersted there is a small overlapping.

The ranges of variation in domestic males overlap the range in Urus cows, but do not come up to the upper limit in these animals.

Length of upper tooth row.
In Urus cows the teeth are comparatively large; the length of the row of upper teeth falls within the range of Urus bulls. - There is a small overlapping between teeth of large domestic males (Ærø, Søndersø, Vedbæk III) and small Urus males (Ostbirk, Fæsted, Læsten) ; however, the width of the teeth in domestic cattle is smaller. The widths at the base of the hindmost molar, e.g., are: Søndersø 26,7mm., Æro 24 mm., Vedbæk III 23 mm . ; in Urus cows: Ullerslev 28, Grænge 30 and Bjeverskov 30 mm . As also known from other species the length of the row of teeth varies to no small extent during the life of the animal; greatest at the close of the eruption of the teeth, when the premolars, p 3 and p 4, have not fully erupted, and comparatively small in old animals (Ostbirk).



Fig. 15. Length along outer curvature of horn core. In fully adult Danish animals no overlapping between Urus bulls and cows exists. The range in domestic bulls largely overlap that in Urus cows.


Fig. 16. In Urus cows the length of upper tooth rows falls within the range in Urus bulls, not, however, reaching the maximum length in bulls. Between small and old Urus bulls and large domestic males there is a small overlapping.

Table 9.

## Length of upper tooth row ( $\mathrm{p} 2-\mathrm{m} 3$ ).

Bos primigenius.

| O |  | Zone |
| :---: | :---: | :---: |
| Ostbirk | 143 | VIII |
| Fæsted | 143 | VIII |
| Læsten | 145 | VIII |
| Ølholm | 147 | - |
| Min. Mus. | 151 | - |
| Ugilt | 154 | VIII |
| Orting | 155 | VIII |
| Tinglev | 155 | VIII/IX |
| Auning | 156 | VIII |
| Hornslet | 158 | Vili |
| Tepstrup | 158 | IV |
| Rode Molle | 158 | IV |
| Rønnebæksholm | 160 | V |
| St. Damme | 161 | IV / V |
| Bonnelykke | 163 | VII |
| Lyngby | 168 | (Sjælland) |
| Aagerup | 168 | (Sjælland) |
| Knabstrup | 170 | IV |
| Bro | 172 | (Fyn) |
| Grænge A | 173 | IV |
| [Hallenslev (jun.) | 174] | V |
| Bregninge | 174 | VI |
| Soro | 174 | IV |
| Grænge B | 175 | V |
| Faaborg | 179 | III |
| Vig | 180 | IV |
| Tranemosegaard | 180 | V |
| [Gøderup (subad.) . | 180] | IV |
| Grevinge . | 182 | V |
| Maglemose ( $\mathrm{IIJ} 10^{2}$ ) | 182 | V |



Bos taurus domesticus.

| ઠิすో |  |
| :---: | :---: |
| Snoldelev I. |  |
| Verupgaard. |  |
| Veddinge |  |
| Holmene I. |  |
| Vedbæk II (Maglemosegaard) | 138 |
| Bodal. |  |
| Gammellung I |  |
| Sonderso |  |
| Ero. |  |
| Vedbæk III. |  |
| [St. Lyng (subad.) . | 149] |

In the subadult domestic male from Store Lyng, e.g., the length of the row of teeth is 149 mm. , and the same holds good of the Vikso I cow, 141 mm . (Table 9), these two animals have not been graphed.

Table 9 emphasizes the remarkable fact that the shortest rows of teeth occur in the geologically latest skulls, from the Subboreal period, Zone VIII. All Subboreal bull skulls, bearing teeth, 8 in all, are placed at the top of this table.

It should also be noted that the tooth row in the comparatively large skull from Lowe's farm (Great Britain) from the Bronze Age, is fairly short, 159 mm . (Higgs). Cf. p. 129 .

## Mandibles and mandibulary dentition.

As was to be expected, the mandibles of Urus bulls are generally larger than the mandibles of the cows, corresponding to the length of the skulls, e.g. basal length; only a small overlapping may exist. It should be noted, however, that the length of mandibles stated (Table 10) - as measured from the hind border of the medial incisor (i 1) - are not quite reliable because the anterior border of the mandibles is more or less damaged, and the same applies to the measurements of length from the foramen mentale, as this foramen is variable in size and even may be double (Ullerslev).

A sex determination of isolated finds of mandibles of a size that is on the borderline between bulls and cows, may be very difficult, if possible at all. The mandible of the Ullerslev cow, e.g., is almost similar to the mandible of the Tinglev bull, in fact a little more sturdy, with stronger teeth. The overlapping area between mandibles of bulls and cows may be placed at about $485-490 \mathrm{~mm}$. It seems, however, that the symphysis tends to be longer and more strongly built in the bulls. In the example mentioned the length of the symphysis, when the two mandible branches are brought together, is 81 mm . in the Tinglev bull, as compared with 70 mm . in the Ullerslev cow, as measured at the lower boundary; measured along the inner side of the mandible half, from the hindmost elevation, the lengths are 104 mm . and 90 mm ., respectively. - It should be emphasized that the mandibles which in Table 10 are grouped with females have - with the exception of Gesten B and Logenkjær-been found together with skeletal parts which also indicate females.

The mandibles proper of small Urus cows, Pindstrup, e.g., are in size and shape almost equal to the mandibles of large domestic oxen (Sondersø, Maglemosegaard); on several points, however, somewhat larger, cf. e.g. the smallest length, anteriorposteriorly, of the vertical ramus just below the processus condyloideus (Table 10). An exception is the distance from the hind border of $m 3$ to the posterior border of the vertical ramus, which may be longer in the domestic oxen, in accordance with the fact that the tooth row is shorter in these animals. The longer row of teeth is a character which distinguishes the Urus from domestic cattle (DegerbøL, 1962, fig. 2).

Also the entire lengths of the premolars and molars are longer in the Urus, whereas the difference in lengths of the individual teeth in the Urus and domestic cattle are variable and there is an overlapping, particularly marked in the hindmost


Fig. 17. Urus teeth marked originate from single finds of teeth from Maglemose sites; Boreal period. Teeth attached to skulls or mandibles, the sex of which is stated, are marked as to sex, or or A filling in the sex signatures indicates animals older than Zone VII. From Zone VII only one skull is at hand, marked by a cross in the sex signature. Animals from Zone VIII, the Subboreal, are marked by a dot in the symbols. Open symbols indicate undated animals.
Ertebolle culture: localities marked by their initials. (Cf. p. 16).
B. t. domesticus: teeth marked are single teeth from prehistoric settlements (Degerbøl, 1963). Sex signatures indicate teeth from skulls of Neolithic domestic cattle examined in the present treatise.
molar (m3). In fig. 17 the greatest length of this tooth, measured at the basal part is shown. The length of the individual tooth varies considerably according to the place where the measurement is taken. As an example the m 3 in the Gesten B mandible may be mentioned. This tooth is only slightly worn, the posterior column is still unworn. Measured when placed in the jaw the greatest m 3 length that may be found, is 42 mm ., but when it is sawn out of the jaw, it appears that the length in the middle is 45 mm . and at the base 46 mm . The corresponding measurements of width are $16.5,17$, and 18.8 mm . By comparison it is thus quite decisive that the teeth investigated are measured in the same way. The measurement at the base is easily taken in isolated teeth, and in strongly worn teeth even when placed in the jaw, but otherwise the teeth must be taken out of the jaw and that, of course, may give rise to some difficulties.

Table

|  | Bos primigenius ôơ |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Zone | IV |  |  |  |  | V |  |  | V I |  | IV/V |
| Mandibles | - | $i$ |  |  |  |  | \% | $\frac{ \pm}{\frac{y}{4}}$ | \# 0 0 0 | \% |  |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 1. i 1, post. bord. - proc. condyloidius | 510 | - | 520 | 480 | 500 | 532 | - | 495 | - | 495 | 525 |
| 2. For. mentale - proc. condyloideus | 445 | - | 450 | 420 | 440 | 465 | - | 435 | - | 433 | 463 |
| 3. i 1, post. bord. - proc. angularis | 470 | - | 475 | 455 | 465 | 480 | - | 455 | - | 460 | 485 |
| 4. For. mentale - proc. angularis . | 395 | - | 400 | 383 | 400 | 415 | 405 | 388 | - | 385 | 420 |
| 5. For. mentale - p 2 | 87 | - | 90 | 74 | 93 | 98 | - | 87 | 87 | 77 | 96 |
| 6. Smallest length of ramus verticalis | 67 | - | 70 | 72 | 75 | 69 | - | 71 | - | 69 | 73 |
| 7. Smallest depth of diastema. | 32 | - | 36 | 34 | 37 | 39 | - | 38 | 35 | 34 | 38 |
| 8. Depth at m 2, medial. | 72 | - | 72 | 76 | 73 | 76 | 77 | 75 | - | 73 | 72 |
| 9. Depth behind m 3 , medial. | 82 | - | 84 | 88 | 85 | 84 | 80 | 81 | - | 81 | 81 |
| 10. Largest thickness. | 34 | - | 35 | 33 | 35 | 36 | 37 | 34 | 35 | 35 | 37 |
| 11. p $2-\mathrm{m} 3$ length. | 179 | - | 173 | 194 | 160 | 172 | - | 177 | 168 | 186 | 167 |
| 12. p $2-\mathrm{p} 4$ length. | 64.5 | - | 60 | (70) | 58 | (66) | - | 62 | - | 62 | 61 |
| 13. m 1 - m 3 length. | 114.5 | - | 114 | 119 | 103 | 111 | - | 114 | 109 | 124 | 105 |
| 14. m 3 length at lower half. | 50.4 | 48.5 | 46.5 | 48.5 | 47.5 | 48.5 | 52.2 | 49.8 | 51.8 | 52.2 | 47.2 |
| 15. m 3 width, at base | 19.5 | - | 20.5 | 20.2 | 21.5 | 19.8 | 20.8 | 19.5 | 20.8 | 20.4 | 20 |
| 16. m 3 - ramus verticalis | 128 | - | 135 | 116 | 141 | 133 | 13.3 | 124 | - | 123 | 150 |
| Skull present $=\times$ | $\times$ | $\times$ | $\times$ | $\times$ | $\times$ | $\times$ |  | - |  | - | + |

* No. 9 associated with scapula, humerus, and tibia.

In fig. 17 the Urus teeth marked originate from Maglemose sites, Boreal period, and indicate single or isolated finds of teeth, the sex determination of which is not possible. Teeth belonging to skulls or mandibles, the sex of which is stated are marked to sex, $\widehat{\delta}$ or $\neq$. A filling in of the sex signatures indicates that the animal in question originates from a period before Zone VII. With this group are, in this connection, also placed some not directly dated skulls from Zealand. (Cf. p. 42).

From Zone VII only one skull is at hand; it is marked by a cross in the symbol. Animals from Zone VIII, the Subboreal period, are marked by a dot in the symbols. Open sex symbols indicate undated animals.

From this figure it appears that the range of sizes of $m 3$ length in Urus cows falls within the range of variation in Urus bulls. The m 3 in the small Grange cow is a little longer than in the large Ullerslev specimen ( 49.8 mm . and 48.8 mm .) , but it is a well-known fact that length of teeth does not always correspond to the length of the
10.

| Bos primigenius ${ }^{\text {ôo }}$ |  |  |  |  |  |  |  |  |  |  |  |  |  | Bos primigenius |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| VII | V III |  |  |  |  | Uncertain age |  |  |  |  |  |  |  | V |  | II/V | V III |  | U. a. |
|  | $\begin{aligned} & \stackrel{0}{6} \\ & =0 \\ & 0 \\ & 0 \\ & 0 \end{aligned}$ | $\stackrel{F}{\stackrel{0}{b}}$ | $\begin{gathered} \hat{\#} \\ \\ \end{gathered}$ | $\begin{aligned} & 4 \\ & \frac{5}{5} \\ & 0 \\ & 0 \end{aligned}$ | $\begin{aligned} & \frac{\vdots}{0} \\ & \frac{0}{E 0} \\ & E \end{aligned}$ | $\begin{aligned} & \stackrel{0}{3} \\ & \frac{1}{6} \\ & 0 \\ & 0 \end{aligned}$ |  |  | " |  |  |  |  |  |  |  |  | E | $\begin{aligned} & \text { N } \\ & \text { 感 } \end{aligned}$ |
| 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 492 | 520 | 485 | 490 | 495 | (490) | 505 | (510) | (480)/ | (520) | - | - | - | - | 485 | 450 | 470 | - | 480 | - |
| 425 | 464 | 420 | 422 | 432 | 427 | 445 | 450 | 430 | 455 | - | - | 457 | - | $\left\{\begin{array}{l} 410 \\ 425 \end{array}\right.$ | 387 | 415 | 380 | 425 | 405 |
| 455 | 487 | 450 | 455 | 460 | (450) | 470 | 460 | 450 | 465 | - | - | - | - | 455 | 420 | 445 | - | 450 | - |
| 383 | 417 | 380 | $\left\{\begin{array}{l} 372 \\ 1395 \end{array}\right.$ | 390 | 385 | 395 | 400 | 400 | 400 | - | - | 408 | - | $\left\{\begin{array}{l} 375 \\ 395 \end{array}\right.$ | 350 | 380 | 345 | 390 | 355 |
| 88 | 96 | 90 | $\left\{\begin{array}{l} 63 \\ 71 \end{array}\right.$ | 85 | 83 | 96 | 90 | 95 | 90 | - | - | 83 |  | $\left\{\begin{array}{l} 91 \\ 78 \end{array}\right.$ | 71 | 78 | 74 | 90 | 71 |
| 74 | - | 70 | 70 | 72 | 65 | 65 | 70 | 68 | 71 | - | - | 77 | 70 | 68 | 65 | 70 | 68 | 71 | 72 |
| 36 | 33 | 35 | 35 | 34 | 33 | 34 | 34 | 33 | 37 | - | - | 39 | - | 32 | 30 | 30 | 29 | 32 | 32 |
| 73 | 73 | 67 | 54 | 70 | 66 | 76 | 71 | 65 | 73 | 75 | 75 | 70 | 70 | 72 | 72 | 71 | 58 | 72 | 61 |
| 86 | 78 | 82 | 81 | 80 | 74 | 83 | 76 | 80 | 78 | 86 | 86 | 86 | 86 | 80 | 78 | 84 | 76 | 82 | 73 |
| 35 | 36 | 33 | 40 | 33 | 32 | 33 | 34 | 34 | 38 | - | 35 | 36 | 35 | 34 | 32 | 33 | 31 | 32 | 32 |
| 173 | 168 | 158 | 174 | 171 | 166 | 179 | 176 | 167 | 170 | - | 176 | 175 | 168 | 170 | 169 | 178 | 165 | 166 | 167 |
| 59 | (63) | 58 |  | 63 | 57 | (65) | (62) | 56 | (60) | - | (67) | 62 | 56 | 57 | 56.5 | 65 | 59 | 58 | 63 |
| 111 | (102) | 100 | - | 107 | 106 | 114 | 114 | 111 | 112 | 107 | 107 | 109 | 110 | 111 | 110 | 113 | 104 | 105 | 105 |
| 47.3 | 47.0 | 42.5 | - | 46.9 | 46.6 | 48 | 50.8 | 48.5 | 52.3 | 51.5 | 46.9 | 47.2 | 50.6 | 48.8 | 49.8 | 47.4 | 45.5 | 44.3 | 45.9 |
| 19.6 | 19.3 | 18.5 | - | 20.0 | 20.5 | 183 | 19.5 | 19.4 | 21.5 | 20.5 | 19.5 | 18.2 | 20.5 | 19.8 | 19.5 | 18.7 | 18.7 | 18.6 | 18.8 |
| 121 | 148 | 127 | (138) | 132 | 137 | 117 | 133 | 136 | 140 | - | - | - | - | 130 | 112 | 119 | 110 | 132 | 120 |
| $\times$ | $\times$ | $\times$ |  |  | $\times$ | $\times$ | - | - | - | - | - | - | - | $\times$ | $\times$ | $\times$ | $\times$ | $\times$ |  |

jaw. The largest m 3 in cows just passes 52 mm . The smallest m 3, attached to a mandible, was until recently known from the Pindstrup cow ( $45.5 \times 18.7 \mathrm{~mm}$.). In the present material two more m 3 teeth are of about equal length: Kundby 45.8 mm . and Gesten B 45.9 mm ., and a still smaller m 3 is found in the Toftum cow $(44.3 \times$ 18.6 mm .). A most remarkable deviation, however, is the Ugilt bull with an m 3 length of only 42.5 mm .; width 18.5 mm . If this tooth had been found isolated, it probably would have been referred to domestic animals. As previously mentioned, for the first time, however, it is here definitely proved that so small an m 3 may occur in Urus, and even in a large bull. A fact which throws new light on the isolated $m 3$ from several kitchen middens, and which must involve a new examination and judgment of these teeth.

From the Krabbesholm kitchen midden (No. 84) three mandibular m 3 specimens are at hand, the largest of which, 47.1 mm ., clearly belongs to a young Urus,-the

Table 10

| Zone |
| :--- |

* No. 32 associated with femur; No. 33 ass. with metatarsus; No. 34 ass. with atlas.
posterior half of the hindmost column is unworn, indicating an age of about 3 years. The next in size is comparatively short, 43.5 mm ., but broad 18.5 mm ., which together with the clear-cut shape no doubt indicates an Urus, too (about 4 years old). The third is very small ( $40.8 \times 17.2 \mathrm{~mm}$.) and light-coloured, of quite another tinge than the rest of the remains, it represents a domestic cow, but obviously does not belong to the kitchen midden proper and was not mentioned by Winge either.

The m 3 from Mejlgaard (p.29) is 46.5 mm . long, and no doubt originates from a Urus.-Two m 3, from Hjerk Nor ( $43.8 \times 19.0 \mathrm{~mm}$.) and Aamølle ( $44.5 \times 18.7$ ), also may be representing the Urus (cf. Table 10). The tooth from Hjerk Nor is much worn and belonged to a fairly old animal, whereas the unworn posterior column in the Aamolle tooth, indicates an age of about 3 years.

From the much discussed Dyrholm settlement four m 3 teeth are at hand. On the basis of the above-mentioned material the two largest of these ( $42.7 \times 18.7 \mathrm{~mm}$.) no doubt must be grouped with the Urus. The two smaller ones ( $41 \times 18 \mathrm{~mm}$.) are,
(continued).

| Bos primigenius |  |  |  |  |  |  |  |  |  |  | Bos taurus domesticus |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Kitchen middens |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | Var. |
| $\begin{aligned} & E \\ & \frac{E}{0} \\ & 0 \\ & 0 \\ & E \\ & \vdots \end{aligned}$ | * |  |  | $\begin{aligned} & \text { E } \\ & \text { E } \\ & 0 \\ & \text { E. } \\ & \text { 2. } \end{aligned}$ |  | $\begin{aligned} & \text { g } \\ & \text { E } \\ & 0 \\ & 0= \\ & \text { ES } \\ & 0.5 \end{aligned}$ |  |  |  | $\begin{aligned} & \underset{\Xi}{\Xi} \\ & \substack{x \\ \text { 亿 } \\ \hline} \end{aligned}$ |  |  |  |  |  |  |  | $\begin{aligned} & 8 \\ & \frac{8}{3} \end{aligned}$ | 隹 | ถึठ |
| 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |  |
| - | - | - | - | - | - | - | - | - | - | - | 400 | 425 | 435 | 425 | 420 | 380 | 340 | 326 | 375 | 400-435 |
| -- | -- | - | - | - | -- | -- | - | - | -- | - | 357 | 371 | 380 | 372 | 365 | 340 | 300 | 276 | 358 | 357-380 |
| - | - | - | - | - | - | - | - | - | - | - | 390 | 405 | 415 | 413 | 405 | 355 | 355 | 310 | - | 390-415 |
| - | - | - | - | - | - | - | - | - | - | - | 337 | 345 | 360 | 350 | 340 | 305 | 285 | 254 | - | 337-360 |
| 68 | - | 55 | - | - | - | - | -- | -- | -- | - | 62 | 77 | 70 | 68 | 70 | 56 | 50 | 49 | 68 | 62-77 |
| 66 | - | - | -- | - | - | - | - | - |  |  | 64 | 63 | 70 | 61 | 66 | 52 | 55 | 50 | - | 61-70 |
| - | - | - | - | - | -- | - | - | - | - | - | 31 | 31 | 32 | 29 | 34 | 26 | 28 | 20.5 | 27 | 29-34 |
| - | - | - | -- |  |  |  |  |  | - | - | 53 | 61 | 61 | 52 | 63 | 56 | 56 | 49 | - | 52-63 |
| - | - | - | 67 | - |  |  | - | - | - | - | 69 | 70 | 70 | 69 | 74 | 70 | - | 62 | 73 | 69-74 |
| - | - | - | 31.5 |  | - | - | - | - |  | - | 31 | 33 | 33 | 35 | 33 | 29 | 26 | 24 | - | 31-35 |
|  |  | - | - | - | -- | - | -- | - | -- | - | 147 | 145 | 148 | 148 | 138 | 159 | 148 | 128 | 133 | 138-148 |
| - | - |  |  |  |  |  |  |  | - | - | 54 | 51 | 56 | 54 | $(40)^{*}$ | 59 | (58) | 47 | 47 | 51-56 |
| - |  |  | - |  | - |  |  | - | -- | - | 92 | 91 | (91) | 94 | 95 | 100 | 91 | 81 | 85.5 | 91-95 |
| 47.1 | 43.5 | 43.8 | 43.5 | 42.5 | 42.7 | 41 | 40.5 | 45.2 | 43.5 | 44.5 | 37.3 | 37.5 | 40.5 | 38.9 | 41.5 | 39.5 | 37.2 | 35.0 | 39.5 | 37.3-41.5 |
| 19.0 | 18.5 | 19.0 | 17.4 | 18.7 | 18.7 | 18 | 17.5 | 18 | 18.2 | 18 | 16.5 | 16.5 | 15.8 | 17.5 | 18.8 | 16.8 | 15.8 | (14) | 17.5 | 15.8-18.8 |
|  |  | - | 73 | - |  | - | - | - | - | - | 125 | 120 | 139 | 126 | 130 | 89 | - | 78 | -- | 120-139 |

it is true, smaller than the m 3 in the Ugilt bull skull; however, this specimen is not at all a small skull, so it is probable that still smaller m 3 may occur, in a Urus cow, e.g. These teeth from the earliest part of the Dyrholmen site, Dyrholmen I, thus tentatively may be placed with the other primigenius remains from the period, (cf. p. 39).

It should be noted that the smallest dated m 3 teeth originate from the geologically latest period, the Subboreal period: Pindstrup, $q, 45.5 \mathrm{~mm}$.; Toftum, $q, 44.3 \mathrm{~mm}$; Ugilt, ${ }^{\top}, 42.5 \mathrm{~mm}$., and from the Ertebølle settlements: Aamølle, 44.5 mm . Krabbesholm, 43.5 mm ., Hjerk Nor, 43.8 mm ., and Dyrholmen 42.7 mm ., whereas the largest m 3 belong to the Boreal period. This might of course be accidental, but together with the short rows of upper teeth in all subboreal skulls (Table 9, p. 85) it no doubt indicates a trend towards a reduction in size of the hindmost molar in the phylogenetically latest Urus. Cf. p. 42.

It may seems strange, too, that so many small m 3 teeth, dated and undated,

belonged to morphologically young animals, in which the posterior column is unworn or but slightly worn. As teeth, however, do not increase in size after eruption, because the enamel is developed before that time, the small size has nothing to do with the individual age. It is true that the cement which surrounds the tooth, may be thicker in old animals, but this increase is comparatively small and may, at least as to length, be disregarded.

These slightly worn teeth may indicate that the Ertebolle people particularly hunted young Urus, perhaps preeminently cows.

Only seven mandibles attached to skulls of domestic cattle examined here are at hand, five belonging to adult bulls (or bullocks) and two to subadult animals. From previous excavations only one complete mandible from the Subboreal period, the Bundsø settlement, occurs, probably belonging to a cow; cf. Table 10.

Isolated hindmost molars, however, are present in a comparatively large number in prehistoric settlements. To give an idea of the size variation of domestic cattle during prehistoric periods I have previously (1963, fig. 14) stated the measurements of a series of these teeth in domestic cattle. In fig. 17 in the present treatise I have

| Bos primigenius ơo |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| VI |  | VII | V III |  |  |  |  | Uncertain age |  |  |  | Settlements |  | ts (Fragmentary |  | ry bones) |
|  |  | $\begin{aligned} & \cong \\ & \\ & \hline \end{aligned}$ | $\underset{\sim}{\overline{\mathrm{b}}}$ | 気 |  |  | $\begin{aligned} & \stackrel{\rightharpoonup}{b} \\ & \stackrel{\rightharpoonup}{B} \\ & \stackrel{y}{E} \end{aligned}$ | ¢ | ت 0 0 0 0 | $$ | 㜢 |  | \% | $\begin{aligned} & \text { en } \\ & = \\ & \hline \end{aligned}$ |  |  |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| 264 | 248 | 248 | 264 | 249 | 244 | 278 | 249 | 250 | 252 | 256 | 260 | - | - | - | - | - |
| 250 | 233 | 231 | 250 | 235 | 230 | 262 | 236 | 238 | 242 | 242 | 247 | - | - | - | - | - |
| 83 | 87 | 82.5 | 86 | 81 | 83 | 88 | 81 | 87 | 78 | 86 | 90 | - | - | - | 86 | 78 |
| 54 | 51.5 | 51.5 | 53 | 52 | 49 | 54 | 46 | 53 | 49 | 49 | 54 | - | - | - | 52 | 51 |
| 47 | 47 | 43 | 47 | 47 | 43 | 48 | 43.5 | 46 | 46 | 44 | 45 | - | - | - | 45 | 45 |
| 51 | 51 | - | 49 | 49 | 47 | 52 | 45 | 52 | 49.5 | 53 | 53 | - | - | - | - | (48) |
| 34.5 | 35 | - | 33 | 33 | 35 | 38 | 33.3 | 32 | 30.5 | 33.5 | 35 | - | - | - | - | 31.5 |
| 31 | 29.5 | - | 32 | 30 | - | 36 | 31 | 30 | 30 | 32 | 31 | - | - | - | - | - |
| 83 | 84.5 | 82 | 84 | 81 | 80 | 88 | 80 | 84 | 81.5 | (83) | 83 | 84.5 | 85 | 80 | - | - |
| 45 | 42 | 45 | 45 | 46 | 42 | 46 | 42.5 | 45.5 | 43.5 | - | 43 | - | 46.5 | - | -- | - |
| 31.4 | 35.1 | 33.3 | 32.6 | 32.5 | 34.0 | 31.7 | 32.5 | 34.8 | 31.0 | 33.6 | 34.6 | - | - | - | - | - |
| 19.3 | 20.6 | - | 18.6 | 19.7 | 19.3 | 18.7 | 18.1 | 20.8 | 19.6 | 20.7 | 20.4 | - | - | - | - | - |
| 31.4 | 34.1 | 33.1 | 31.8 | 32.5 | 32.8 | 31.7 | 32.1 | 33.6 | 31.9 | (32.4) | 31.9 | - | - | - | - | - |

inferred the new measurements marked by sex signatures. It should be noted that although the mandibles under consideration are large, the $m 3$ teeth are of modest length, being outside the size range of Urus and not reaching the maximum of this tooth in domestic cattle from the Subboreal settlements.

This might give rise to the question whether the largest of the said isolated finds of teeth in fact belong to domestic animals?

The quoted teeth in graph fig. 17 come from Subboreal farmer settlements, in which with two exceptions, from Ørum Aa and Bundsø, no remains of Bos primigenius are stated. From Orum Aa five m 3 specimens exist, the largest measuring $41.5 \times 18.4 \mathrm{~mm}$. They, no doubt, all belong to Bos taurus domesticus. From Bunds $\varnothing$ only two m 3 teeth are longer than 40 mm . : $44.4 \times 18.2$ and $44.0 \times 18.2 \mathrm{~mm}$., respectively. In fact it is impossible to distinguish the first of these from the Ugilt and Dyrholmen m 3 specimens, and of course it may have belonged to a Urus. In the other the large measurements are found only at the very base, which is tuberously swollen, whereas the rest of the crown is fairly small. No doubt it belongs to a Bos taurus domesticus.

|  | Bos primigenius $q 9$ |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Zone | V | V I |  |  | II-V |  | V III |  |  |  |
| Metacarpus |  |  |  |  |  |  |  | $\begin{aligned} & \text { O} \\ & \text { O} \\ & 0 \\ & 0 \end{aligned}$ | ¢ |  |
|  | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 |
| I. Total length | 246 | 235 | 243 | 244 | 249 | 245 | 235 | 245 | 230 | 240 |
| Length, smallest, medial. | 235 | 227 | 239 | 234 | 238 | 231 | 225 | 234 | 219 | 228 |
| 1. Transversal | 74 | - | 67 | 72 | 75.5 | 70 | 66.4 | 70 | 63.0 | 71 |
| 2. Anterior-posterior, greatest | 45 | - | 42 | 45 | 46.5 | 42 | 41.0 | (44) | 39.0 | 43 |
| 3. Articulation, anterior-posterior | 39 | - | 40 | (40) | 43 | 39 | 37.5 | (40) | 36.0 | 38 |
| III. Diaphysis width: <br> 1. Middle, transversal, smallest. | 40 | - | 38 | - | 41 | 38.5 | 37 | (40) | 40.0 | 39 |
| 2. Middle, anterior-posterior. | 28 | - | 26 | 29 | 29 | 26.7 | 28.4 | (28) | 28 | 28 |
| 3. Smallest width, anterior-posterior. | 27.5 | - | 25.8 | 27.8 | 29 | 26.7 | 27 | - | 26 | 27 |
| IV. Distal width: <br> 1. Transversal. | 73 | 70 | 69.5 | 72 | 77.5 | 70.0 | 66 | 67 | 67 | 68 |
| 2. Trochlea medialis, anterior-posterior | 41 | 37.5 | 38.7 | 39 | 41.2 | 38.5 | 38 | 39 | 37 | 38 |
| Index: |  |  |  |  |  |  |  |  |  |  |
| II/I. | 30.0 | - | 27.8 | 29.5 | 30.3 | 28.6 | 28.3 | 28.6 | 27.4 | 29.6 |
| III/I. | 16.3 | 17.9 | 15.6 | - | 16.5 | 15.8 | 15.7 | - | 17.4 | 16.3 |
| IV/I . . . | 29.7 | 29.8 | 28.6 | 29.5 | 31.1 | 28.5 | 28.1 | 27.3 | 29.1 | 28.1 |

* Probably bullock.

Most teeth graphed come from settlements on Langeland (Troldebjerg, Blandebjerg, Lindø) and from Lyø, a small island S.W. of Funen. From these settlements we have bones of large domestic oxen. The largest m $3(45.5 \times 18.5)$ originates from Lindø, but it is highly curved from side to side, indicating a Bos taurus domesticus (H. Winge, 1928, p. 48). From Lyo an m 3 measures $42.8 \times 17.5$, thus fairly thin also indicating a B.t. domesticus. From the same settlement a mandibular fragment with highly worn m 2 and m 3 occurs. It is split open to take out the marrow. The m 3 is large $44.8 \times 18.5 \mathrm{~mm}$., but the $\mathrm{m} 2-\mathrm{m} 3$ length is fairly short 72 mm ., as compared with 78 in the Pindstrup Urus and 89 mm . in the Nyrup Urus, also this tooth no doubt belonged to a $B . t$. domesticus. A large $\mathrm{m} 3(43.1 \times 19.3 \mathrm{~mm}$.) is furthermore known from the Troldebjerg settlement, but although it is similar to the Ugilt m 3 , the occurrence at this particular settlement in which a large amount of remains of large domestic cattle, but none of Urus, has been reported, and where in a series of mandibular m 3 a gradually increasing tooth length is demonstrated, makes it probable that it belonged to a domestic ox.
(continued).


On the other hand, it should be noted that the only discovery of Urus on Funen later than Zone VI-the Korinth brain-case from Zone VIII, the Subboreal period, just originates from southern Funen, with which Langeland and Lyo at that time probably were connected. These examples stress the importance of working with complete skulls or mandibles.

To sum up, it may be stated that the large teeth from Langeland and Lyø no doubt belong to domestic cattle and thus there is an overlapping in size of the mandibular m 3 in Urus and domestic oxen.

## Limb Bones.

Limb bones belonging to complete skeletons or attached to comprehensive skeletal parts are of particular interest, as the sex eo ipso is settled. - Several complete or almost complete skeletons of Urus bulls are available (Vig, Sorø, Grænge, Store Damme, Nyrup, Langeland, Terp, Tinglev, etc.). Complete skeletons of Urus cows, however, are very rare. Leithner has depicted a fairly young individual, preserved

Table 11

|  | Bos taurus domesticus |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Zone |  |  |  |  |  | V III |  |  |  |  |
| Metacarpus | $\begin{aligned} & 0 \\ & 0 \\ & =0 \\ & z_{0} \end{aligned}$ |  |  |  | $\begin{gathered} 8 \\ \underbrace{8}_{0} \\ 0 \end{gathered}$ |  |  | $\begin{aligned} & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \end{aligned}$ | $\begin{aligned} & \stackrel{\infty}{0} \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 4.0 \\ & =0 \end{aligned}$ | $\begin{aligned} & \underset{5}{7} \\ & \underset{5}{5} \\ & 0 \\ & 0 \\ & \text { E. } \\ & \text {. } \end{aligned}$ |
|  | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 |
| I. Total length. | 187 | 177 | (215) | 204 | 196 | 202 | 196 | 210 | 212 | 210 |
| Length, smallest, medial. | 180 | - | 205 | 192 | 185 | 192 | 190 | 199 | 201 | 199 |
| 1. Transversal | 48 | 52.5 | 67 | 62 | 60.5 | 60 | 53.3 | 66.5 | 68 | 69 |
| 2. Anterior-posterior, greatest | 30 | 31 | 39 | 37 | 40 | 34.5 | 34 | 40 | 42 | 41 |
| 3. Articulation, anterior-posterior. . | 28 | - | 36 | - | - | - | - | 38 | 38 | 38 |
| III. Diaphysis width: <br> 1. Middle, transversal, smallest | 22.5 | 26.5 | 36.6 | 35 | 35 | 30 | 27.5 | 40 | 38 | 36 |
| 2. Middle, anterior-posterior. | 18.5 | - | 25.7 | 22.2 | 23,4 | 23.6 | 21.8 | 28 | 28.5 | 26 |
| 3. Smallest width, anterior-posterior. | 18.7 | - | 25.2 | - | - | - | - | 26 | 23 | 25 |
| IV. Distal width: <br> 1. Transversal . | 48 | 48.5 | 63.7 | 63.5 | 63.5 | 57.8 | 58.8 | 67.5 | 70 | 69 |
| 2. Trochlea medialis, anterior-posterior | 27.5 | 27 | 34.5 | 34.2 | 34.7 | 29.6 | 31 | 35.7 | 37 | 35.7 |
| Index: |  |  |  |  |  |  |  |  |  |  |
| II/I. | - | - | (31.1) | 30.4 | 30.9 | 29.7 | 27.2 | 31.7 | 32.1 | 32.8 |
| III/I. | - | 15.0 | (17.0) | 17.2 | 17.9 | 14.9 | 17.3 | 19.0 | 17.9 | 17.1 |
| IV/I. | - | - | (29.6) | 31.4 | 32.6 | 28.6 | 30.0 | 32.1 | 33.0 | 32.8 |

* Probably bullock.
in Stockholm, but the postcranial parts are not described, nor measured. A unique specimen, to the best of my knowledge, is the complete and dated skeleton of the Urus cow from Ullerslev, from the Boreal period (Zone V), treated here. From Denmark furthermore comprehensive skeletal parts of females are at hand from Pindstrup, Bonnerup, and Store Taastrup.

A considerable number of fragmentary limb bones of Bos originate from the Maglemose settlements, the age of which is so considerable, that bones of domestic cattle are excluded. Particularly for comparison with corresponding bones from kitchen middens proper this material is included in the present investigations.

Metapodials. In bulls the metapodials are considerably more robustly formed than in cows. They are not only on an average longer, (figs. 18 and 19), but a distinct sex dimorphism exists regarding width (Table 11).

The metapodials of a bull from Grejs Molle are exceptionally long, astoundingly dated at the Subboreal period; the metacarpal length is 278 mm ., as compared with
(continued).

| Bos taurus domesticus |  |  |  |  |  |  |  |  |  | Bos primigenius <br> Var. |  | $\frac{\text { B.t. dom. }}{\text { Var. }}$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| VIII |  |  |  |  |  | Recent |  |  |  |  |  |  |  |
|  |  | $\begin{aligned} & 4 \\ & \text { H } \\ & \text { E } \\ & \text { E } \\ & 0 \end{aligned}$ | $\begin{aligned} & \text { H } \\ & \text { H } \\ & \text { H } \\ & \text { E } \\ & 0 \end{aligned}$ |  |  |  |  | $\stackrel{Y}{1}_{4}^{4}$ | $\begin{aligned} & \infty \\ & \infty \\ & \ll \\ & <0+ \end{aligned}$ | $\begin{gathered} \text { ôठ } \\ \text { (Nos. 22) } \end{gathered}$ | $\begin{gathered} \text { ¢¢ } \\ \text { (Nos. 13) } \end{gathered}$ |  | $\begin{gathered} \hat{0} 0^{2} \\ (\operatorname{Nos.} 6) \end{gathered}$ |
| 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 |
| - | 210 199 | $\left\{\begin{array}{l} 179- \\ 221 \end{array}\right.$ <br> (Nos. 45) | $\left\{\begin{array}{l} 186- \\ 218 \end{array}\right.$ <br> (Nos. 13) | $\left\{\begin{array}{l} 175-215 \\ (\text { Nos. } 15) \end{array}\right.$ | $\begin{gathered} 200 \\ - \end{gathered}$ | 228 217 | 223 219 | 205 194 | 214 204 | $244-278$ $230-262$ | $230-253$ $219-242$ | 205 195 | $199-217$ $189-207$ |
| - | 71 | - | - | - | 71 | 65 | 73 | 75 | 66 | 77-90 | $63-75.5$ | 61 | $63-72$ |
| - | 45 | - | - | - | - | 43 | 47 | 47 | 43 | 46-55 | 39-46.5 | 36 | 38-45 |
| - | 37 | - | - | - | - | 37 | 39 | 41 | 34 | 43-50 | 36-43 | 31 | 34-38 |
| - | 39.5 | - | - | - | 39.5 | 40 | 39 | 42 | 36 | 45-53 | 36-43 | 33 | 36-40 |
| - | 27 | - | - | - | - | 28.7 | 28 | 27.5 | 26 | 31-35 | 26-32 | 24.5 | 23.8-28.5 |
| - | 25 | - | - | - | - | 28.4 | 29 | 27 | 26 | 30-36 | 26-32 | 22.0 | 21.8-26 |
| $\left\{\begin{array}{l} 57- \\ 66.5 \end{array}\right.$ | 71 | - | - | - | 71 | 66 | 67 | 72 | 64 | 80-88 | 66-77.5 | 59 | 63.7-73 |
| - | 38 | - | - | - | 39 | 38.5 | 39 | 42 | 37 | 42-46.5 | 37-41.2 | 32.0 | 34.5-38 |
| - | 33.8 | -- | - | - | 35.5 | 28.5 | 32.0 | 36.6 | 30.8 | 31-35.7 | 27.4-30.3 | 29.8 | 30.9-33.8 |
| - | 18.8 | - | - | - | 19.8 | 17.5 | 17.1 | 20.5 | 16.8 | 18-21.6 | 15.6-17.9 | 16.1 | 17.1-19.6 |
| - | 33.8 | - | - | - | 35.5 | 28.9 | 29.4 | 35.1 | 29.9 | 31.4-35.9 | 27.3-31.1 | 28.8 | $32.2-33.8$ |

264 mm . in the longest specimen but one from the Holmegaard settlement, from the Boreal period and Ugilt, from the Subboreal period. Again, one of these deviations mentioned above, e.g., regarding the width of the occipital condyles (p. 77). In this connection also the small skull from Star Carr may be referred to.

As compared with earlier statements (Degerbøl, 1942, p. 99) it should be noted that the lower limits of the range variation of metacarpal lengths in Urus cows are displaced downwards, from 243 mm . to 230 mm . The metacarpal bones from Bønnerup, Tjerrild, and Auning (No.60), are exceedingly small, the lengths of them being 230,231 , and 232 mm ., respectively (Table 11, No. 36, 38, and 40). These measurements are not, however, unprecedented, as Hilzheimer (1909) mentions a metacarpus length of 233 mm ., but that was until now an isolated example. The metacarpal of the Pindstrup cow, originating, like the Bønnerup cows, from the Subboreal period is also comparatively small ( 235 mm .) (Degerbøl, 1962). It should be emphasized that small metapodials occur already in the Boreal period. From Holmegaard settlement

|  | Bos primigenius $\widehat{0}$ ơ |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Zone | III | IV |  |  | V | V I | IV／V | VIII |  |  |  |  |  |
| Metatarsus | $\stackrel{-}{5}$ | $>$ | \％ |  | 合 |  | 咗 | \％ | 寿 |  | 淢 | $$ | ¢ $\stackrel{0}{60}$ $\vdots$ |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| I．Total length（posterior） | 287 | 293 | 304 | 288 | 280 | （285） | 295 | 295 | 283 | 285 | 270 | 315 | 283 |
| Length，lateral，smallest | 274 | 287 | 291 | 276 | 271 | 275 | 288 | 284 | 269 | 276 | 254 | 298 | 266 |
| II．Proximal width： <br> 1．Transversal | 71 | 68 | 69 | 67 | 71 | － | 73 | 68 | 68 | 73 | 65 | 72 | 65 |
| 2．Anterior－posterior． | 66 | － | 66 | 67 | 65 | － | 71 | 67 | 66 | 67 | 63 | 68 | 60 |
| III．Diaphysis width： <br> 1．At middle，transversal | 43 | 44 | 42 | 41 | 41 | 37 | 42 | 39 | 41 | 43 | 38 | 42 | 39 |
| 2．At middle，anterior－posterior ．．．． | 41 | － | 41 | 41 | 42 | 37 | 42 | 40 | 39 | 45 | 38 | 43 | 39.5 |
| 3．Smallest，anterior－posterior，distal． | 36.4 | － | 35.5 | 35.5 | 34.5 | 32.5 | 35 | 35 | 33 | 37 | 34 | 39 | 33.2 |
| IV．Distal width： |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1．Transversal | 79 | 82 | 78 | 79 | 73 | 77 | 81 | 79 | 74 | 75 | 73 | 79 | 74 |
| 2．Trochlea medialis，ant．－post． | 44.5 | － | 45.5 | 45 | 44.2 | 44.5 | 47 | 45 | 45 | 44 | 41 | 45 | 41.6 |
|  | 56.3 | － | 58.3 | 57.0 | 60.5 | （57．8） | 58.0 | － | 60.8 | 58.7 | （56．9） | 57.0 | 56.2 |
| Index： |  |  |  |  |  |  |  |  |  |  |  |  |  |
| II／I． | 24.7 | 23.2 | 22.7 | 23.3 | 25.4 | － | 24.7 | 23.1 | 24.0 | 25.6 | 24.0 | 22.9 | 23.0 |
| III／I． | 15.0 | 15.0 | 13.8 | 14.2 | 14.6 | － | 14.2 | 13.2 | 14.5 | 15.1 | 14.1 | 13.3 | 13.8 |
| IV／I． | 27.5 | 28.0 | 25.7 | 27.4 | 26.1 | （27．0） | 27.5 | 26.8 | 25.1 | 26.3 | （26．7） | 25.1 | 26.1 |


$\begin{array}{lccccccccccccccc}\frac{1}{m} & \frac{1}{200} & 1 & 1 & 1 & \frac{1}{210} & 1 & \frac{1}{230} & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 240 & 1 & 1 & 1\end{array}$
Metacarpus length
Fig．18．Metacarpus length．The metacarpal lengths of domestic oxen are widely outside the range of that in Urus．
12.

| Bos primigenius ôơ |  |  |  |  |  |  |  |  |  |  | Bos primigenius +q |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Uncertain age |  |  |  |  | Settlements |  |  |  |  |  | V | VIII |  |  |  | U. age |  |  |  |
|  |  |  |  | $\frac{0}{0}$ |  | \% |  |  |  |  |  | O | $\begin{aligned} & \text { M } \\ & 0 \end{aligned}$ | C | $\begin{aligned} & \pi \\ & E \\ & \vdots \\ & 0 \end{aligned}$ | - |  |  |  |
| 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 |
| 293 | 308 | 290 | 278 | 293 | - | - | - | - | 280 | 302 | 280 | 275 | 283 | 268 | 275 | 281 | 270 | - | - |
| 275 | - | 282 | 265 | 275 | - | - | - | - | - | - | 269 | 260 | 270 | 257 | 263 | 267 | 255 | - | - |
| 72 | 68 | 68 | 64 | 69 | - | - | - | 67 | 67 | 67 | 62 | 56 | 56 | 50 | 56 | 54 | 58 | - | - |
| 67 | 62 | 65 | 61.5 | 68 | - | - | - | 66 | - | - | 57 | 56.5 | 56.5 | 50.5 | 56 | 55 | 57 | - | - |
| 43 | 42 | 46 | 38.5 | 41 | - | - | - | - | 40 | 45 | 35.5 | 31.8 | 34 | 34 | 33 | 33 | 31 | 35 | - |
| 43 | - | 42.5 | 40.5 | 42 | - | - | - | - | - | - | 37 | 35.2 | 37 | 36 | 33 | 34 | 33 | 35 | - |
| 37 | - | 37 | 31 | 34 | - | - | - | - | - | - | 31.5 | 31 | 34 | 31 | - | 29.5 | 30 | 30.5 | - |
| 78 | 77 | 80.5 | 75 | 75 | 77 | 74 | 75 | 75 | 76 | 76 | 68 | 64 | 62.5 | 62 | 63 | 66 | 68 | 66 | 67.5 |
| 45 | 44 | 46.5 | 43.5 | 44 | 44 | 43 | 44 | 43 | - | - | 41.5 | 38.5 | 39.5 | 36 | (38) | 38 | 40 | 40 | 40.5 |
| 57.7 | 57.1 | 57.8 | 58.0 | 58.7 | 57.1 | 58.0 | 58.7 | 57.3 | - | - | 61.0 | 60.2 | 63.2 | 58.1 | 60.3 | 57.6 | 58.8 | 60.6 | 60.6 |
| 24.5 | 22.1 | 23.5 | 23.0 | 23.5 | - | - | - | - | 23.9 | 22.1 | 22.1 | 20.4 | 19.8 | 18.7 | 20.4 | 19.2 | 21.5 | - | - |
| 14.7 | 13.6 | 15.9 | 13.8 | 14.0 | - | - | - | - | 14.3 | 14.9 | 12.7 | 11.6 | 12.0 | 12.7 | 12.0 | 11.7 | 11.5 | - | - |
| 26.6 | 25.0 | 27.7 | 27.0 | 25.6 | - | - | - | - | 27.1 | 25.1 | 24.3 | 23.3 | 22.1 | 23.1 | 22.2 | 23.5 | 25.2 | - | - |



## Metatarsus length

Fig. 19. Metatarsus length. Cf. fig. 18.

Table 12


* Probably bullock.

Zone VI (Table 11, No. 29), e.g., a metacarpus is of a similar length, 235 mm ., as that of the Pindstrup specimen. In the Holmegaard bone the lateral side is split open for taking out the marrow, so only the distal width can be measured; partly according to the higher individual age of this bone the transversal width is comparatively large, 70 mm ., as compared with 66 mm . in the younger Pindstrup specimen. - A metacarpal length of 235 mm . is also recorded by Stampfli (1963) in two specimens from the Neolithic Age at Seeberg Burgäschisee-Süd, Switzerland.-Complete metatarsal bones of Urus cows are of rare occurrence. In 1942 none was at hand; however, in the present treatise measurements of 7 complete metatarsals are reported, four of which belong to skulls or other skeletal parts the sex of which is evident. On the basis of most width measurements it is possible to distinguish the two sexes. The metapodials of cows are narrower than those of bulls. The range of variation of some measurements, however, may meet, or an overlapping may just occur, but if other measurements available are considered, a determination as to sex may be established. Thus is may be mentioned that two metatarsals from Egolzwil, published by Hesche-
(continued).

| domesticus |  |  |  |  |  |  |  |  |  |  |  |  | Bos prim. <br> Var. |  | Bos t. dom. <br> Var. |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| VIII |  |  |  |  |  |  |  |  |  | U. age |  |  |  |  |  |  |
|  | $\begin{aligned} & s_{0}^{\prime} \\ & \hat{y}_{3}^{\prime} \end{aligned}$ | $\begin{aligned} & \Xi \\ & \vdots \\ & \vdots \end{aligned}$ | $\begin{aligned} & \stackrel{\otimes}{E} \\ & \underset{\sim}{\Xi} \end{aligned}$ |  |  |  |  |  |  |  | $\begin{aligned} & \stackrel{\rightharpoonup}{u} \\ & \stackrel{0}{\omega} \\ & \stackrel{\sim}{n}_{+0} \end{aligned}$ |  | ơo <br> (Nos. 18) | $\text { (Nos. }{ }^{\circ f} \text { 7-16) }$ | $\begin{aligned} & \text { む } \\ & \text { E } \\ & \text { © } \\ & \text { O+ } \end{aligned}$ | \% ${ }^{\circ}$ |
| 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 |
| 250 | 212 | 230 | - | 237 | 224 | - | - | - | - | 239 | 244 | 230 | 270-315 | 268-283 | 236 | 235-250 |
| 240 | 204 | - | - | - | - | - | - | - | - | 230 | (233) | - | 254-298 | 255-270 | 228 | 224-240 |
| 55 | 39.5 | 49 | - | 47 | 43 | - | - | - | - | 52 | 59 | 66 | 64-73 | 50-62 | 49 | 49-59 |
| - | 38.5 | 46 | - | 45 | 41 | - | - | - | - | 50 | 56 | - | 60-71 | 50.5-57 | 47 | -56 |
| 29.5 | 20.3 | 27 | - | 26 | 23 | - | - | - | - | 28 | 34 | 34 | 36.5-42 | 31-35.5 | 27 | 28-34 |
| 36 | 21.5 | 29 | - | 29 | 26 | - | - | - | - | 32 | 35 | 33.3 | 37-45 | 33-37 | 29 | 29-36 |
| 27 | 20 | - | - | 24 | - | - | - | - | - | 28.5 | 29 | - | 31-39 | 29.5-34 | 25 | 25-29 |
| 64 | 44.5 | 56 | $\left\{\begin{array}{l}55 \\ 47\end{array}\right.$ | 53 | 52 | 63 | 59.5 | 64 | 71 | 61 | 68 | 68 | 73-82 | 62-68 | 55 | 58-71 |
| 34.5 | 26.8 | 35 | , | 32 | 31 | 35.7 | 35 | 35.5 | 38 | 34 | 36.6 | 37.7 | 41-47 | 36-41.5 | 31.5 | 33.5-38 |
| 53.9 | 60.2 | 55.4 | - | 60.4 | 59.6 | 56.6 | 58.8 | 55.5 | 53.5 | 55.8 | 53.9 | 55.4 | 56.2-60.8 | $\begin{array}{r} 56.8-61 \\ (63.2) \end{array}$ | 57.3 | 55.1-57.8 |
| 22.0 | 18.6 | 21.3 | - | 19.8 | 19.2 | - | - | - | $\square$ | 21.8 | 24.2 | 28.7 | 22.1-25.4 | 18.7-22.1 | 20.8 | 20.8-24.2 |
| 11.8 | 9.6 | 11.7 | - | 11.0 | 10.3 | - | - | - | - | 11.7 | 13.5 | 14.8 | 13.5-15.9 | 11.5-12.7 | 11.4 | 11.3-14.5 |
| 25.6 | 21.0 | 24.3 | - | 22.4 | 23.2 | - | - | - | - | 25.5 | 27.9 | 29.6 | 25-28 | 22.1-25.3 | 23.3 | 24.6-27.9 |

ler and Rüeger, 1942, p. 483, but without sex indication, must belong to males (Table 12, Nos. 23-24). The absolute width measurements of these two bones are large, distinctly indicating bulls, and the same holds good of the distal and diaphysis index; only the proximal index is fairly small ( 22.2 mm .) in the longest of the two metatarsals, as compared with a maximum index of 22.1 in females. When Nobis (1954, p. 168) was of opinion that these bones together with two metatarsals from Denmark, labelled as belonging to males (Degerbøl, 1942), in fact were of females, this was just based on the proximal index; however, the said Danish metatarsals, from Sorø and Tinglev, are attached to skulls and skeletons distinctly indicating bulls. In addition the augmented material now at hand has etablished a distinct borderline between measurements of metatarsals of males and females.

In Tables 11-12 I have stated the measurements of metapodials of domestic cattle investigated here, and which, with the exception of the Borremose specimen, are attached to skulls. Furthermore, the measurements of some complete and dated metapodials from Denmark, 5 metacarpals and 2 metatarsals, from the Bundsø

Table

|  | Bos primigenius ${ }^{\text {ôo }}$ |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Zone | III |  |  |  |  |  |  |  |  |
| Scapula | 气. | $\underset{\sim}{x}$ | $\begin{aligned} & 9 \\ & 0 \\ & 0 \end{aligned}$ |  |  |  | 亿 |  |  |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 1. Greatest width of cavitas glenoidalis: <br> a. anterior-posterior (lateral) <br> b. Transversal | 85 71 | 79 69 | 85 75 | 82 74 | 78 67 | 82 72 |  | 84 69 | - |
| 2. Smallest width of collum, ant.-post....... | 87 | (81) | 84 | 82 | 74 | 78 | 86 | 80 | 82 |
| 3. Greatest width of collum, from proc. coracoideus to post. border of cavitas...... | 106 |  | 107 | 94 | 99 | 98 | 99 | 103 | - |
| 4. Width of upper end, greatest. | 305 | 290 | 303 | - | - | 270 | - | - | - |
| 5. Max. height. . . . . . . . . . . . . . . . . . . . . . . . | 515 | 520 | 470 | -- | - | 517 | 475 | - | -- |
| 6. Height from middle of cav. glenoid. to margo dorsalis at top of the spina scapulae | 490 | - | 450 | 440 | 400 | 495 | (450) | - | - |



* Probably bullock.

13. 

| Bos primigenius ơơ |  |  |  |  |  |  |  |  |  |  |  |  | q |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| IV/V | V II |  | VIII |  |  | Uncertain age |  |  |  |  |  |  | V | VIII |
|  |  |  | $\begin{aligned} & \stackrel{0}{3} \\ & \substack{n \\ 0 \\ 0 \\ 0} \end{aligned}$ | - | 雨 | \# 0 0 0 | $\begin{aligned} & \tilde{0} \\ & 0 \\ & 0 \\ & 0 \\ & 0 \end{aligned}$ | $\begin{aligned} & \stackrel{0}{0} \\ & \frac{0}{3} \\ & \frac{0}{4} \\ & \hline \end{aligned}$ |  | $\begin{aligned} & \frac{\infty}{3} \\ & \frac{1}{0} \\ & 0 \end{aligned}$ |  | 范 |  | O |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| $\begin{aligned} & 87 \\ & 71 \\ & 82 \end{aligned}$ | $\begin{aligned} & 87 \\ & 70 \\ & 84 \end{aligned}$ | - <br> 75 | $\begin{aligned} & 88 \\ & 77 \\ & 84 \end{aligned}$ | $\begin{aligned} & 79 \\ & 64 \\ & 80 \end{aligned}$ | $\begin{aligned} & 86 \\ & 68 \\ & 79 \end{aligned}$ | $\begin{gathered} (80) \\ 74 \\ 85 \end{gathered}$ | $\begin{aligned} & 76 \\ & 70 \\ & 70 \end{aligned}$ | $\begin{aligned} & 88 \\ & 73 \\ & 92 \end{aligned}$ | $\begin{aligned} & 91 \\ & 77 \\ & 78 \end{aligned}$ | $\begin{aligned} & 86 \\ & 74 \\ & 83 \end{aligned}$ | $\begin{aligned} & 81 \\ & 73 \\ & 84 \end{aligned}$ | $\begin{aligned} & 84 \\ & 74 \\ & 76 \end{aligned}$ | $\begin{aligned} & 70 \\ & 60 \\ & 69 \end{aligned}$ | $\begin{aligned} & 70 \\ & 58 \\ & 63 \end{aligned}$ |
| $\begin{aligned} & 110 \\ & 295 \end{aligned}$ | $\begin{aligned} & 102 \\ & 275 \end{aligned}$ | - | 100 | $\begin{array}{r} 95 \\ 260 \end{array}$ | 105 | 102 | 93 | $\begin{aligned} & 113 \\ & 295 \end{aligned}$ | 105 | 98 | 96 - | $\begin{array}{r} 96 \\ 270 \end{array}$ | $\begin{gathered} 89 \\ (245) \end{gathered}$ | 82 |
| 505 | 486 | - | 520 | 490 | - | - | - | (503) | - | - | - | 495 | (445) | - |
| 495 | 463 | - | 500 | 465 | - | - | - | 491 | - | - | -- | 475 | (430) | - |


|  |  | Bos prim. |  | Bos taurus domesticus |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Var. |  |  |  |  |  |  |  |  |
| \% |  | $\begin{gathered} \hat{0} \hat{o}^{\prime} \\ (\operatorname{Nos.~9-19)} \end{gathered}$ | $\begin{gathered} \text { 와 } \\ \text { (Nos. } 10) \end{gathered}$ | $\begin{aligned} & \underset{\sim}{\tilde{E}} \\ & \text { E } \\ & 0 \\ & 0 \end{aligned}$ |  | $\begin{aligned} & \text { Bundsø } \\ & \text { (Nos. 12) } \end{aligned}$ | $\begin{aligned} & \stackrel{\rightharpoonup}{\circ} \\ & \stackrel{\Delta}{\omega} \\ & \stackrel{A}{0}+0 \end{aligned}$ | From <br> Hescheler \& Rüeger (Nos. 3) |  | 954 <br> fels) |
| 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
| $\begin{aligned} & 75 \\ & 58 \\ & 68 \end{aligned}$ | 67 56 - | $\begin{aligned} & 76-91 \\ & 64-77 \\ & 70-92 \end{aligned}$ | $\begin{aligned} & 66-75 \\ & 58-62 \\ & 59-69 \end{aligned}$ | $\begin{aligned} & 56 \\ & 49 \\ & 56 \end{aligned}$ | $\begin{aligned} & 65 \\ & 55 \\ & 58 \end{aligned}$ | $\begin{gathered} 52-64 \\ - \\ 45-63 \end{gathered}$ | $\begin{aligned} & 74 \\ & 63 \\ & 70 \end{aligned}$ | $\begin{aligned} & 52-58 \\ & 45-48 \\ & 47-55 \end{aligned}$ | $\begin{aligned} & 50 \\ & 40 \\ & 37 \end{aligned}$ | $\begin{aligned} & 53 \\ & 45 \\ & 51 \end{aligned}$ |
| 88 | 78 - | $\begin{array}{r} 93-100 \\ 260-305 \end{array}$ | $\begin{gathered} 81-89 \\ (235-245) \end{gathered}$ | $\begin{array}{r} 69 \\ 200 \end{array}$ | $\begin{array}{r} 74 \\ 195 \end{array}$ | $61-77$ - | 85 | - | - | - |
| - | - | $470-520$ | (380-445) | 375 | 400 | - | - | 295-330 | 233 | 321 |
| - | - | 440-505 | - | 357 | 385 | - | - | - | --. | - |

settlement (Degerbol, 1939), and two of the largest metacarpals from Troldebjerg, probably also belonging to the Subboreal period, are added. It will be seen that regarding length the metapodials of domestic cattle are widely separated from those of Urus (figs. 18-19); the width measurements from side to side, however, are so great that they merge with the corresponding measurements in Urus cows. The distal transversal metacarpal width of the Holmene domestic male, e.g., is greater ( 70 mm .) than the corresponding width measurements in several Urus cows : Pindstrup ( 66 mm .), Bønnerup ( 67 and 67 mm .), Auning ( 67 mm .), Almind ( 68 mm .), or of similar size as in two metacarpi from the Boreal period, Sværdborg ( 70 mm .) and Holmegaard ( 69.5 mm .). - The anterior-posterior width of the sagittal ridge of the trochlea medialis, however, is smaller in the Holmene specimen, 36 mm ., than in the said Urus cows, $37-39 \mathrm{~mm}$. In domestic cattle the trochlea width ranges from 32 mm . (Holmene o) to 37 mm ., as compared with $37-41 \mathrm{~mm}$. in Urus cows.

Metatarsal bones show similar proportions. The transversal widths of the two much discussed distal parts of the metatarsi from Dyrholmen are 66 and 64 mm ., respectively, as compared with 64 mm . in the Holmene male, but the anterior-posterior widths are 39.3 and 37.5 mm . in the Dyrholmen individuals, and only 34.5 mm . in the Holmene specimen. Cf. figs. 5 and 6, p. 36-38. The range of the anterior-posterior widths in domestic oxen is 31.5 (Holmene cow) and 36 mm ., in Urus cows $36-41 \mathrm{~mm}$., and in Urus bulls $41-47 \mathrm{~mm}$.

An expression of the correlation between the said distal widths, transversal and anterior-posterior, exists in the "distal width index" (trochlea width $\times 100$ /transversal width. Degerbøl, 1942). In the Dyrholm individuals this index is 59.5 and 59.1 ,


Fig. 20. Metatarsus, distal end. - Ordinate axis: absolute measurements, anterior-posteriorly, of the largest (medial) sagittal ridge of the trochlea; abscissa: absolute transversal width. Prize bull marked by a square. D. Dyrholmen. The transversal width in domestic cattle may be just as large as in Urus cows, but the anterior-posterior width is smaller. The two broadest specimens of domestic cattle represent the largest one known from the kitchen middens ( 71 mm ., Aalborg) and the very old bull from Bjerget.
respectively, as compared with 53.9 in the domestic male from Holmene. This index is fairly variable, however, in the Holmene female, e.g., 57.3 ; in females-as also in small and young animals-the distal part is more rounded than in old males; however, in this connection it is the large domestic males versus Urus females that may cause difficulties; the Urus males are recognizable by their large transversal widths. In diagram fig. 20 the absolute width measurements (anterior-posterior) of the trochlea is plotted against the absolute transversal, distal, width. Hence, an identification, as to Urus or domestic cattle, of distal parts of metalarsi, which often occur in prehistoric sites, is normally possible.

## Scapula.

18 scapulae of Urus bulls are available, 10 attached to skeletons from peat bogs and 8 isolated specimens. Attached to skeletons of Urus cows only two pairs, from Ullerslev and Pindstrup, occur. From Maglemose sites a surprisingly small number of scapulae are measurable, 5 distal parts, 4 of which originate from Urus cows, (cf. astragalus p. 121). Probably the most robust scapulae were sorted out by the Maglemose people for later use, just as was the case regarding metapodials. (Cf. the Brabrand settlement, 1904, pp. 37-38, fig. 11).

The scapulae of males are considerably larger than those of females (Table 13). The anterior-posterior width of the collum, e.g., varies from 70 to 92 mm . in males, as compared with 59 to 69 mm . in females; this also applies to the scapula of the subadult Goderup bull, the collum length of which is 74 mm . The individual age of the scapula is indicated by the development of the muscular attachments; the lateral side of the collum, e.g., in the Gøderup bull is smooth, whereas the muscular attachments in older animals are strongly marked.

Hence it may be noted that the comparatively small Ogaarde scapula (Table 13, No. 33) belonged to a young individual.

Only two scapulae of domestic cattle, from Holmene, $q$, and Sondersø, occur in the material examined here.

For the sake of comparison I have added the corresponding measurements of the scapulae from Bundsø (Degerbøl, 1939); the largest collum width given by Winge (1900) from Orum Aa is 69 mm ., from Lejre Aa 59 mm . - From this it appears that the scapulae in domestic cattle from these kitchen middens are comparatively small. A very large scapula, however, originates from the old but undated bull from Bjerget, the measurements of which can compare with those of the largest Urus females. Stampfli mentions 62 mm . as minimum width of collum scapulae of Urus, and the maximum width in domestic cattle as 55 mm . only (Hescheler and Rüeger).

## Humerus.

The measurements of the small number of humeri of Urus cows available are outside the range in bulls. In the comparatively large upper arm of the St. Taastrup

Table


* Probably bullock.
cow-attached to the Taastrup antebrachium-the proximal epiphysis is still free, and the same holds good of the Soro specimen.

In old bulls the humerus is very large and particularly broad and thick-walled. In the two humeri, from Turup and Grænge D, broken at the narrowest part of the diaphysis, the bone walls are 16 mm . and 19 mm . thick, respectively.

A humerus, however, without upper end, of the small Pindstrup cow is in width within the range of domestic cattle, and the same holds good of the corresponding humerus parts from Bonnerup. The greatest distal widths are 86 and 85 mm ., respectively, as compared with 86 mm . in the domestic ox from Aamosen (Holbæk) and 90 mm . in the Borremose specimen. From single finds of humeri Stampfli gives still smaller measurements. In 9 specimens, referred to Urus, the following trochlea width has been stated: $81,82,84,85,86,86,92,95$, and 97 mm ., whereas Requate, Nobis, and Hescheler \& Rüeger indicate 91, 93, and 90 mm ., respectively, as minimum widths of the trochlea in Urus.

For the sake of comparison, furthermore, some measurements of domestic oxen from the farmer settlements from Bunds $\varnothing$ and Blandebjerg (Degerbøl, 1943, p. 24) may be recorded: Bunds $\varnothing$ 81, 73, 69, and 69 mm .; Blandebjerg 85, 85, 81, 79 mm . The humeri from Borremose and Bjerget represent large domestic animals, the diaphysis and distal widths of which are largely overlapping the range of variation in Urus cows, in length, however, they are outside, below, the range in Urus cows.


## Antebrachium

Only one antebrachium is attached to a complete skeleton of an Urus cow, from Ullerslev. It is very short, the length of the radius is 320 mm ., as compared with other forearms present (Table 15) and in contrast to its metapodials, which are comparatively long (Tables 11-12).

In an antebrachium from Høje Taastrup, found together with a female skull, the radius length is considerable greater, 345 mm ., almost as large as the one in the Tinglev bull, 350 mm ., but as ordinarily seen regarding limb bones considerably narrower than in bulls, the diaphysis width, e.g., is in the Taastrup and the Ullerslev specimens 57 mm ., as compared with 63 mm . in the Tinglev bull.

In the three animals, however, the metacarpals are similar in length, 245 mm . in the Taastrup cow, 246 (Ullerslev) and 249 (Tinglev).

The Taastrup antebrachium belonged to a not quite full-grown animal. The suture between the lower epiphysis and the shaft is closed, but the upper epiphysis of the ulna is not fused with the diaphysis, which indicates an age of about $3^{1 / 2}$ years, It is attached to a comparative large humerus, which, however, also indicates a female.

The forearms of the cows from Bønnerup and Pindstrup are extraordinarily small, radius lengths 312 and 314 mm ., respectively, only a little greater than that of the forearm of the very old domestic ox from Bjerget, the radius length of which is 310 mm ., whereas the lengths of the metacarpus of the three specimens are 230,235 , and 210 mm ., respectively.

Table

|  | Bos primigenius ơơ |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Zone | III |  | IV |  |  |  |  |  | V／VI |
| Antebrachium |  | $\Rightarrow$ | 壬 |  |  | 号 | 言 | － |  |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Ulna： <br> 1．Greatest length． <br> 2．Olecranon width，greatest <br> 3．Olecranon width，smallest． | $\begin{array}{r} 478 \\ 96 \\ 82 \end{array}$ | 500 | $\begin{gathered} 481 \\ (90) \\ 77 \end{gathered}$ | $\frac{(485)}{-75}$ | $\begin{array}{r} 461 \\ 93 \\ 78 \end{array}$ | 470 96 82 | － | $(485)$ 77 | $\begin{array}{r} 487 \\ 94 \\ 81 \end{array}$ |
| Radius： <br> 4．Length，medial <br> 5．Prox．width，transv． <br> 6．Prox．width，articul． <br> 7．Prox．width，medial，ant．－post． <br> 8．Prox．width，medial，articul． <br> 9．Diaphysis width，middle <br> 10．Distal width，greatest <br> 11．Distal width，articul． | $\begin{array}{r} 363 \\ 121 \\ 108 \\ 64 \\ 52 \\ 70 \\ 113 \\ 99 \end{array}$ | $(367)$ 121 - - 68 109 - | $\begin{array}{r} 362 \\ 122 \\ 110 \\ 60 \\ 53 \\ 64 \\ 109 \\ 97 \end{array}$ | $\begin{array}{r} 355 \\ 118 \\ 108 \\ 60 \\ 53 \\ 65 \\ 110 \\ 101 \end{array}$ | 345 114 100 56 51 67 113 93 | 357 115 102 62 52 63 106 95 | 355 107 97 52 48 68 104 96 | 357 109 96 53 48 64 101 91 | $\begin{array}{r} 363 \\ 121 \\ 107 \\ 60 \\ 54 \\ 69 \\ 108 \end{array}$ |


|  | Bos primigenius $¢$ ¢f |  |  |  |  |  |  |  | Bos |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Zone | V |  | II／V | VIII |  | Uncertain age |  |  |  |
| Antebrachium | $\frac{\frac{\vdots}{n}}{\frac{!}{5}}$ |  |  | 弟 | 鲀 |  | 弱 | T |  |
|  | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 |
| Ulna |  |  |  |  |  |  |  |  |  |
| 1．Greatest length． | 421 | － | （465） | － | 407 | － | － | － | － |
| 2．Olecranon width，greatest． | 75 | － | － | － | 64 | － | － | － | － |
| 3．Olecranon width，smallest． | 66 | － | 73 | － | 59 | － | － | － | － |
| Radius： |  |  |  |  |  |  |  |  |  |
| 4．Length，medial． | 320 | 335 | 345 | 312 | 314 | － | － | － | － |
| 5．Prox．width，transv． | 100 | 102 | 110 | 91 | 92 | 102 | 95 | － | 109 |
| 6．Prox．width，articul． | 90 | 93 | 98 | 83 | 84 | 93 | 86 | － | 99 |
| 7．Prox．width，medial，ant．－post． | 52 | 52 | 54 | 46 | 46 | 51 | 48 | 56 | 54 |
| 8．Prox．width，medial，articul．． | 46 | 47 | 49 | － | 42 | － | － | － | － |
| 9．Diaphysis width，middle ． | 56.5 | 56 | 57 | 47 | 50 | 56 | 50 | 56 | － |
| 10．Distal width，greatest | 92 | 91 | 93 | 84 | 78 | － | － | － | $\begin{gathered} \hat{8} \\ 107 \end{gathered}$ |
| 11．Distal width，articul．．． | 83 | 80 | 84 | 75 | 73 | － | － | － |  |



Table

|  | Bos primigenius ${ }_{\text {ơo }}$ |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Zone | U．a． |  |  |  |  |  |  | IV／V | VII |
| Femur |  | $\Rightarrow$ | 发 |  |  | 言 | 䒼 |  |  |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 1．Greatest length，to condyle <br> 2．Length，caput－condyle <br> 3．Prox．width，transversal． <br> 4．Diameter of caput <br> 5．Diaphysis width <br> 6．Distal width，greatest | $\begin{aligned} & 475 \\ & - \\ & 67 \\ & 145 \end{aligned}$ | $\begin{gathered} 518 \\ 495 \\ - \\ 57 \\ 138 \end{gathered}$ | $\begin{array}{r} 470 \\ \hline 66 \\ 54 \\ 136 \end{array}$ | $\begin{array}{r} 467 \\ 174 \\ 68 \\ 57 \\ (133) \end{array}$ | $(460)$ $\begin{gathered} 47 \\ (126) \end{gathered}$ | 509 465 168 65 59 | $\begin{array}{r} 470 \\ 440 \\ 164 \\ 61 \\ 52 \\ 130 \end{array}$ | $\begin{array}{r} 524 \\ 470 \\ - \\ \hline 57 \\ 141 \end{array}$ | $139$ |

＊Upper and lower epiphysis free．

|  | Bos primigenius 우 |  |  |  | Bos prim． |  | B．t．dom． |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Zone | Uncertain age |  |  |  | Var． |  | Var． |  |
| Femur | 合 | O | 管 |  | $\left(\begin{array}{c} \text { ơo } \\ (\text { Nos. } 8-17) \end{array}\right.$ | $\stackrel{\text { ¢ㅇ }}{\text { (Nos. 2-8) }}$ | $\begin{gathered} \text { €if } \\ \text { (Nos. 2) } \end{gathered}$ | $\begin{gathered} \text { to } \\ \text { (Nos. 2-5) } \end{gathered}$ |
|  | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 1．Greatest length，to condyle <br> 2．Length，caput－condyle <br> 3．Prox．width，transversal <br> 4．Diameter of caput <br> 5．Diaphysis width <br> 6．Distal width，greatest | $\begin{array}{r} 427 \\ 405 \\ 138 \\ 54 \\ 45 \\ (105) \end{array}$ | $\begin{gathered} \overline{428} \\ \overline{59} \\ 50 \end{gathered}$ | $\overline{(428)}$ - - 45 $(110)$ | $\begin{aligned} & - \\ & - \\ & - \\ & 48 \end{aligned}$ | $\begin{gathered} 470-524 \\ 440-482 \\ 157-183 \\ 61-69 \\ (47) 51-60 \\ 122-146 \end{gathered}$ | $\begin{gathered} 427-445 \\ 400-428 \\ 138-147 \\ 52-59 \\ 39-50 \\ 105-116 \end{gathered}$ | $\begin{gathered} 370 \\ 341 \\ 119 \\ 44.5 \\ 36 \\ 98 \end{gathered}$ | $\begin{gathered} 358-(430) \\ 340-(395) \\ 108-133 \\ 49.5-51 \\ 31-49 \\ 98-118 \end{gathered}$ |

＊Probably bullock．

In the Pindstrup and Bønnerup specimens the proximal articular widths of the radius are 83 and 84 mm ．，respectively．For the sake of comparison it may be men－ tioned that Stampfli gives 79 mm ．as the minimum width of this articular surface in Urus，whereas Boessneck and Requate state 86 mm ．and Hescheler and Rüeger 91 mm ．as lower limit．

It should be noted that the large bull from Grejs Mølle with the large meta－ podials，also has very large forearms；the total length of the ulna is 500 mm ．；radius length，medially 372 mm ．
16.

| Bos primigenius ôơ |  |  |  |  |  |  |  |  |  | Bos primigenius ¢q |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| VIII |  |  |  | Uncertain age |  |  |  |  |  | V | VIII |  |  |
| $\stackrel{y}{6}$ |  | $$ | $\begin{aligned} & \vdots \\ & \frac{\vdots}{00} \\ & \vdots \\ & \hline \end{aligned}$ |  |  |  |  |  | $\frac{\vdots}{\square}$ | $\begin{aligned} & \frac{\vdots}{n} \\ & \frac{\vdots}{む} \\ & = \end{aligned}$ | 年 |  | O |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| $(470)$ | $\begin{gathered} 470 \\ (440) \end{gathered}$ | $\begin{aligned} & 518 \\ & 482 \end{aligned}$ | $\begin{aligned} & 476 \\ & 450 \end{aligned}$ | $\begin{aligned} & 505 \\ & 478 \end{aligned}$ | $\begin{aligned} & 510 \\ & 475 \end{aligned}$ | $\overline{476}$ | 466 | - | - | $\begin{aligned} & 445 \\ & 418 \end{aligned}$ | $(400)$ | 400 | - |
| - | - | 180 | 157 | 173 | 183 | 174 | - | - | - | 147 | - | - | - |
| 62 | - | 65 | 61 | 63 | 67 | 69 | 63 | - | - | 57 | - | 52 | - |
| 51 | 53 | 59 | 51 | 57 | 53 | 59 | 53 | -- | 54 | 54 | 39 | 45 | 47 |
| 132* | 129 | 140 | 122 | 136 | 146 | 142 | 135 | 132 | - | 116 | -- | - | - |

Bos taurus domesticus

| $\begin{aligned} & \stackrel{\otimes}{\Xi} \\ & \stackrel{y}{\Xi} \\ & \underset{\sim}{0} \end{aligned}$ |  |  |  | $\begin{gathered} 0 \\ \stackrel{0}{0} \\ \stackrel{y}{y} \\ \vdots=0 \\ \overbrace{0}^{*} \end{gathered}$ |  | $\stackrel{\stackrel{\sim}{0}}{\stackrel{0}{\infty}}$ |  |  | $\stackrel{8}{6}$ <br> $\stackrel{8}{=}$ <br>  <br>  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 |
| 370 | - | 358 | 399 | (420) | 408 | (430) | - | - | - | - | - | - | - |
| 341 | 335 | 340 | 375 | 384 | 382 | (395) | 360 | 349 | 321 | 314 | 333 | 307 | 306 |
| 119 | 113 | 108 | 128 | - | 133 | - | (120) | (125) | (110) | (84) | 110 | - | - |
| 44.5 | 46 | - | 49.5 | 51 | 50 | - | 43 | 43 | 37 | 37 | 34 | 31 | 31 |
| 36 | 36 | 31 | 40 | 44 | 38 | 49 | 37 | 37 | 29 | 28 | - | - | - |
| 98 | 94 | 98 | 108 | 118 | 106 | 118 | (95) | 96 | 79 | 78 | 88 | 85 | 84 |

Only a radius from Undløse Bro can compare with this specimen, length 371 mm . The ulna has been cut off, and on the radius there is distally a small artificial hole, enclosed by radial furrows, just visible.

The forearms belonging to the large bulls from Grænge and Sorø are comparatively narrow, the diaphysis widths of the radius are 65 and 64 mm ., respectively; but this is due to the young age of the animals. In the Grænge ulna the upper epiphysis is free, and the suture between the lower epiphysis of the antebrachium and shaft is open. In the Sorø specimen this last-mentioned suture is partly closed laterally,

|  | Bos primigenius ôơ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Zone | III | IV |  |  | V I | IV/V | VII | V III |  |  | Uncertain age |  |  |  |  |  |  |
| Tibia | 芯 | $i$ |  |  | $\begin{aligned} & \text { A } \\ & \text { H } \\ & 0 \end{aligned}$ |  |  |  | \% | $\begin{aligned} & 0 \\ & \frac{0}{0} \\ & \frac{n}{0} \\ & 0 \end{aligned}$ |  |  |  | $\frac{0}{0}$ | - |  | 器 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| 1. Greatest length, middle . | 480 | 471 | 475 | 460 | 463 | 486 | 452 | 457 | 480 | 480 | 474 | (475) | 480 | 468 | - | - | 470 |
| 2. Length, lateral, greatest. | 422 | - | 420 | 418 | 415 | 420 | 408 | 415 | 425 | 425 | 420 | - | 430 | 421 | - | (400) | 424 |
| 3. Length, medial | 463 | - | 454 | 442 | 442 | 467 | 438 | - | 460 | 467 | 452 | - | 458 | 448 | - | - | 452 |
| 4. Prox. width, transversal. | 145 | 140 | 141 | 137 | - | 140 | 139 | 129 | 139 | 145 | 141 | - | 140 | 132 | - | - | 139 |
| 5. Diaphysis width, middle transversal. | 63 | - | 60 | 59 | 60 | 60 | 58 | 60 | 58 | 68 | 60 | 65 | 65 | 62 | - | 57 | 63 |
| 6. Diaphysis width, smallest. | 60 | 61 | 58 | 58 | 56 | 58 | 56 | 55 | 54 | 60 | 56 | 61 | 58 | 56 | 58 | 55 | 61 |
| 7. Distal width, greatest | 93 | 90 | 89* | 90 | 86 | 91 | 84 | 83 | 85 | 88 | 88 | 90 | 88 | 87 | - | 85 | 90 |

* Suture of prox. epiphysis open.
whereas the epiphyses of the ulna are bordered by open sutures. - Several isolated forearms are large, probably on this account having been sent to the Zoological Museum.

Only two antebrachia, of the Holmene and Nyrup cows (radius length 274 mm . and about 290 mm ., respectively) are attached to the remains of Neolithic domestic cattle examined here. From the Neolithic farmer settlement of Bunds $\varnothing$, however, a comparatively large radius, length 307 mm ., is recorded. It is almost as long as a radius of the large, but undated, bull from Bjerget, not, however, nearly so broad as seen in this old animal. The measurements of 4 radii of domestic cattle from Egolzwil (Hescheler \& Rüeger 1942) are, as generally seen in remains from this locality, considerably smaller than in the said Danish animals, the length, e.g., varying between 242 and 275 mm . (Table 15).

Femur.
Femora, or parts of femora, of no less than 8 Urus cows are available, 4 of which belong to skulls (Ullerslev, Pindstrup, Bønnerup), one to a mandible (Kundby). The femur of females is considerable shorter than that of males. The length from caput to the medial condyle varies in 4 adult females from 400 to 428 mm ., as compared with 440 to 482 mm . in 14 femora of bulls.

Of the young Pindstrup cow only one femur is at hand, and the upper end is missing; however, the length from trochanter minor to the condylus is 318 mm ., as compared with 315 mm . in the adult Bønnerup femur and 322 mm . in the Kundby specimen, indicating a length from the caput of about 400 mm . In the incomplete

| Bos primigenius of |  |  |  |  |  |  |  |  | $\frac{\text { Bos prim. }}{\text { Var. }}$ |  | Bos taurus domesticus |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| V | IV／V |  | V I | II |  | Unc | rtai | age |  |  |  |  |  |  |  |  |  |  |  |  |
| $\frac{\vdots}{\stackrel{\vdots}{\omega}}$ |  | 会 | $\begin{aligned} & \text { Ey } \\ & 0 \\ & 0 \end{aligned}$ | $\begin{aligned} & \hat{\#} \\ & \text { en } \\ & \text { en } \\ & 0 \\ & 0 \end{aligned}$ |  |  | 䔍 |  |  | $\begin{gathered} \text { ¢? } \\ \text { (Nos. 3-9) } \end{gathered}$ |  | 高 | $\begin{aligned} & \stackrel{\rightharpoonup}{0} \\ & \stackrel{0}{\dot{b}} \\ & \stackrel{\sim}{\sim} \end{aligned}$ |  |  |  |  |  |  | res |
| 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 |
| 420 |  | 400 | 415 | － | － | － | － | － | 452－480 | 400－420 | 350 | 338 | 400 | － | － | 328 | 309 | 321 | 347 | 350 |
| 375 |  | 350 | 350 | － | － | － | － | － | 408－430 | 350－375 | 312 | 295 | 350 | － | － |  |  |  |  |  |
| 400 |  | 382 | 387 | － | － |  | － | － | 438－467 | 352－400 | 336 | 325 | 387 | － | － |  |  | － |  |  |
| 126 |  | 111 | 110 |  |  |  | － | － | 129－145 | 110－126 | 99 | 95 | 120 | － | － | 89 | （86） | 90 | （90） | 96 |
| 52 | 53 | 46 | 49 | 51 | 48 | 54 | 52 | 46 | 57－68 | 46－54 | 42 | 43 | 50 | － | － |  | － |  | － |  |
| 50 | 51 | 44 | 46 | 48 | 47 | 52 | 49 | 44 | 55－63 | 44－52 | 38 | 41 | 48 | － | － | 37 | 335 | 33 | 35 | 36 |
| 78 | 83 | 73 | 68＊ | 73 | 73 | 79 | 79 | 73 | 83－93 | 68－83 | 62 | 62 | 76 | 57－70 | 59－62 | 60 | 53 | 54 | 58 | （56） |

＊Sut．of prox．epiphysis anteriorly open．
femur from Kirkeby，the length from the said trochanter is about 340 mm ．，as in the corresponding part of the Kirkerup femur，in which the length from caput to condyle is 428 mm ．－A femur from Grejsdalen，missing the upper and lower end，is of about the same length as that of the Ullerslev cow，but is more strongly built；the diaphysis widths are 48 and 46 mm ．，respectively．

The femur length in domestic cattle is outside the range in Urus cows．
The femur of the domestic bull from Maglemosegaard（Vedbæk II）like the other limb bones of this animal，is short；the length from caput to condylus is 340 mm ．，as compared with 375,382 ，and 384 mm ．in the specimens from Sønders $\varnothing$ ，Borremose， and Aamosen（Holbæk），which probably represent bullocks．

From outside Denmark only a few complete femora are known．Imhof，however， gives the measurements of four specimens，one of which is so long， 360 mm ．，that he is of opinion that it represents a bullock，another is a little longer than the Maglemose femur， 349 mm ．，whereas the remaining two are small， 321 and 314 mm ．long．Also three femora measured by Hescheler and Rüeger are small：333， 307 ，and 306 mm ．， respectively（Table 16 ）．

Regarding the tibia there is a well marked sex－dimorphism；in all measurements taken（Table 17）the size range in Urus cows is outside the range in Urus bulls．With the exception of the Holmene and Nyrup cows，no complete tibia of Neolithic domestic cattle is at hand，length 350 and 338 mm ．，respectively．The tibia from the undated find from Bjerget is exceptionally robust， 400 mm ．，in length，as in Urus cows from Pindstrup and Bonnerup．


18.

| q\％ |  |  | ôơ |  |  |  | q\％ |  | ふ0® |  |  |  |  |  | ¢\％ |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| VIII | U．a． |  | Maglemose settlement（Z．V） |  |  |  |  |  | Sværdborg settlement（Z．VI） |  |  |  |  |  |  |  |
| 气 |  |  |  | $\begin{aligned} & \text { i } \\ & \sim \\ & \sim \end{aligned}$ | $\stackrel{9}{9}$ | \％ $=$ $=$ | ® \％ \＃ | $\stackrel{9}{9}$ | $\stackrel{\infty}{\infty}$ |  | $\begin{aligned} & 2 \\ & 0 \\ & 5 \\ & 4 \\ & y \end{aligned}$ | $\stackrel{\infty}{\sim}$ | $\stackrel{\infty}{\infty}$ | $\stackrel{\infty}{\infty}$ |  | $\begin{aligned} & \text { N } \\ & \text { y } \\ & \text { 市 } \end{aligned}$ |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| 168 | 165 | （145） | 188 | － | － | － | 166 | 162 | 192 | － | － | － | － | － | 166 | 164 |
| 164 | 161 | － | 182 | － | － | － | 162 | 156 | 187 | － | － | － | － | － | 160 | 160 |
| 64 | 63 | （62） | 70 | － | － | － | 62 | 64 | 77 | － | － | － | － | － | 66 | 66 |
| 18 | 19 | （17） | 26 | － | － | － | 18 | 20 | 24 | － | － | － | － | － | 19 | 19 |
| 46 | 44 | （42） | 60 | 55 |  | － | 46 | 47 | 57 | 57 | 53 | － | － | －－ | 44 | 44 |
| 97 | 100 | （89） | 108 | 107 | 105 | － | 97 | 92 | 112 | 105 | （103） | － | － | － | 97 | 93 |
| 110 | 110 | － | 124 | 119 | 116 | － | 109 | 105 | 123 | 116 | （116） | － | － | － | 109 | 106 |
| 22 | 21 | （19） | 31 | 26 | 27 | 27 | 23 | 26 | 30 | 29 | 26 | － | － | 28 | 23 | 23 |
| 42 | 38 | （37） | 48 | 48 | 49 | 46 | 44 | 41 | 51 | 51 | 48 | 49 | 49 | 48 | 41 | 44 |
| 38 | 37 | － | 50 | 48 | 47 | 47 | 41 | 41 | 48 | － | 48 | 47 | 47 | － | 40 | 40 |



## Calcaneus

Only two calcanei attached to skeletons of adult Urus cows are at hand, from Ullerslev and Bønnerup, but from Maglemose sites furthermore 5 complete and 2 tuber parts are available and a single calcaneus comes from Staugaardskær; in size and shape they are of similar lengths, $162-167 \mathrm{~mm}$., greatest widths $44-48 \mathrm{~mm}$., as compared with $178-192 \mathrm{~mm}$. lengths, and $51-60 \mathrm{~mm}$. widths in calcanei of 10 bulls.

Furthermore, 6 calcanei lack the posterior epiphysis, representing young animals, less than about 3 years old. The specimen from Vinderup (Table 18, No. 12), is attached to a tibia which also indicates a female. The five other calcanei come from Maglemose settlements emphasizing that comparatively many young animals were hunted. Judging from the fact that these calcanei are comparatively narrow, the greatest widths $40-45 \mathrm{~mm}$., it is probable that they also belonged to females. According to Dottrens (1947, p. 526) the calcanei of subadult domestic oxen are somewhat broader than those of adult animals.

Only the posterior half of the corpus of no less than 8 calcanei from settlements is present, obliquely cut off or broken for the purpose of obtaining the marrow, which in calcanei of old animals occurs in a medullary cavity placed immediately behind the articular surface, (Fig. 21). 4 calcanei are fragmentary, i. a. missing the posterior half of the corpus just mentioned.

The four calcanei from Dyrholmen all clearly belonged to Urus, two very massive and sturdy ones representing bulls, two smaller ones, with "floured" surface, cows, corresponding in size and shape to the calcanei belonging to the Ullerslev and Maglemose cows.

In domestic cattle the calcaneus does not reach the measurements in Urus cows. In the very large domestic ox from Bjerget the calcaneus is 158 mm . long.

The maximum lengths of 8 calcanei from the farmer settlement Bundsø are: $112,120,145,145,150,153$ (and 160 ) mm. From the literature it may be cited that the range of 31 adult calcanei from the Neolithic settlement at Saint Aubin, Switzer-


Fig. $21 \mathrm{~A}+$ B. A. Posterior half of calcaneus; lateral view. B. Anterior view. - A medullary cavity occurs immediately behind the articular surface. $\times 2 / 3$.


Fig. 22. Astragali of Tinglev bull (A), of Ullerslev cow (B); from Holmegaard settlement, Boreal period (C and D). In Urus bulls the astragali are longer and particularly broader than in Urus cows. $\times 2 / 3$.
land, is from 117 to 134 mm ., and in a calcaneus of the large, recent Simmenthaler ox the length is 152 mm . (Dottrens, 1947). A calcaneus of only 150 mm . in length is by Stampfli referred to the Urus.

## Astragalus

In skeletons from peat bogs the astragali of Urus bulls are longer and particularly broader than in Urus cows. The range in size of bulls is outside the range in size of cows; or only a small overlap may occur. The length, e.g., of the astragalus of

Table

|  | Bos primigenius ડิరิ |  |  |  |  |  |  |  |  |  | Bos primigenius＋q |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Zone | III | IV |  |  | V | V III |  | Uncertain age |  |  | V | VIII |  |  |  |
| Astragalus | E | $i=$ | － |  | 会 | 需 |  |  |  | 会 | 亏 ¢ ¢ S | E | 䔍 | \＃ | $\because 3$ $=$ $=$ |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 1．Maximum length | 93 | 90 | 93 | 90 | 89 | 89 | 84 | 89 | 92 | 92 | 83 | 82 | 80 | 77 | 93 |
| 2．Greatest width，distal． | 63 | 62 | 61 | 62 | 59 | 59 | 57 | 61 | 62 | 63 | 52 | 52 | 50 | 47 | 62 |
| 3．Lateral height，from upper incisure．．． | 48 | － | 48 | 47 | 48 | 46 | 44 | 47 | 47 | － | 43 | 42 | － | － | 48 |


|  | Sværdborg settlement |  |  |  |  |  |  |  |  |  |  |  | $\begin{aligned} & \text { Holme- } \\ & \text { gaard } \end{aligned}$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Zone | ภô |  |  |  |  | ¢¢ |  |  |  |  |  |  | $\bigcirc$ | ¢ |
|  | $\stackrel{\infty}{\stackrel{\infty}{\leftrightarrows}}$ | $\stackrel{\infty}{\underset{\sigma}{\sigma}}$ | $\stackrel{\infty}{\stackrel{\infty}{5}}$ | $\stackrel{\infty}{\Xi}$ | $\stackrel{\infty}{\underset{\sigma}{\sigma}}$ | $\stackrel{\infty}{\underset{\sigma}{\infty}}$ | $\stackrel{\infty}{\stackrel{\infty}{\Xi}}$ | $\stackrel{\infty}{\underset{\sigma}{\sigma}}$ | $\stackrel{\infty}{\underset{\sim}{\infty}}$ | $\stackrel{\infty}{9}$ | $\stackrel{\infty}{\underset{\sigma}{\circ}}$ | $\equiv$ |  |  |
|  | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 |
| 1．Maximum length． | 97 | 92 | 91 | 90 | 89 | 85 | 85 | 81 | 81 | （82） | （83） | 68 | 86 | 84 |
| 2．Greatest width，distal．．．． | 63 | 63 | 60 | 56 | 53 | 50 | 52 | 52 | 52 | － | 54 | 42 | 58 | 51 |
| 3．Lateral height，from upper incisure． | 49 | 50 | 44 | 46 | 45 | 43 | 40 | 40 | 39 | 42 | － | 33 | 44 | 42 |


| Zone | Bos primigenius |  | Kitchen middens（Bos primigenius） |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Maglemose settlements Var． |  | ＋if |  |  |  |  | O | ठ |
| Astragalus | $\text { (Nos. } 34 \text { ) }$ | か大 <br> （Nos．21） | Brabrand |  |  |  |  |  | 碞 |
|  |  |  |  |  | \％ |  | 3 $=$ $=$ |  |  |
|  | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 |
| 1．Maximum length ． | 7986 | 86－97 | 84 | 81 | 81 | 79 | 76 | 90 | 87 |
| 2．Greatest width，distal．． | 49－55 | （53）56－63 | 51 | 51 | 48 | 48 | 49 | 60 | 56 |
| 3．Lateral height，from upper incisure． | $39-45$ | 44－50 | 41 | 41 | 40 | 39 | 41 | 46 | 46 |

19. 

| Maglemose settlement |  |  |  |  | Sværdborg settlement |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| ડิô |  | ¢\％ |  |  | む̧o |  |  |  |  |  |  | ¢¢ |  |  |  |  |  |  |  |
| $\begin{aligned} & \vdots \\ & 0 \\ & = \end{aligned}$ | $\begin{aligned} & \ddot{\infty} \\ & \underset{\sim}{n} \end{aligned}$ | $\begin{aligned} & \stackrel{1}{1} \\ & \vdots \\ & = \end{aligned}$ | $\stackrel{2}{2}$ | $\stackrel{\Im}{\leftrightarrows}$ |  | $\begin{aligned} & 10 \\ & \vdots \\ & \vdots \\ & \vdots \end{aligned}$ | $\begin{aligned} & \infty \\ & 0 \\ & \vdots \\ & \vdots \end{aligned}$ | $\begin{aligned} & \sigma \\ & \vdots \\ & \vdots \\ & \vdots \end{aligned}$ | $\begin{aligned} & \infty \\ & z \\ & z \\ & y \end{aligned}$ | $\begin{aligned} & \vec{n} \\ & i \\ & i \end{aligned}$ | $\begin{aligned} & \text { Î } \\ & = \\ & \vdots \end{aligned}$ | $\begin{aligned} & \dot{n} \\ & i \\ & i \end{aligned}$ |  | $\begin{aligned} & U \\ & U \\ & B \\ & Z \end{aligned}$ | $\begin{aligned} & \text { i } \\ & \text { o } \\ & i \\ & i \end{aligned}$ | $\begin{aligned} & 2 \\ & 2 \\ & 2 \\ & 2 \end{aligned}$ | $\begin{aligned} & \stackrel{\rightharpoonup}{n} \\ & \vec{Z} \\ & \underset{y}{*} \end{aligned}$ | $\begin{aligned} & \text { I } \\ & = \\ & \vdots \\ & i \end{aligned}$ | $\begin{aligned} & \text { a } \\ & < \\ & \frac{2}{x} \end{aligned}$ |
| 16 | 17 | 18 | 19 | 23 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| 89 60 46 | 89 60 46 | 79 49 43 | 82 52 42 | 83 52 42 | 94 62 48 | 94 48 | 93 58 46 | 92 60 47 | 91 56 46 | 89 58 47 | 88 58 46 | 86 52 42 | 86 55 45 | 84 49 40 | 84 51 41 | $(83)$ 53 44 | （83） - 45 | 81 50 40 | $(74)$ $(44)$ 36 |


| Ogaarde settlement |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| す઼す |  |  |  |  | ¢ 7 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3 $=$ $=$ | $\begin{aligned} & \dot{B} \\ & \dot{3} \\ & i \end{aligned}$ | $\begin{aligned} & \dot{0} \\ & \ddot{3} \\ & \vdots \end{aligned}$ | $\begin{aligned} & \Xi \\ & \Xi \\ & \exists \end{aligned}$ | $\frac{3}{x}$ | $\begin{aligned} & \mathrm{Z} \\ & \mathrm{~A} \\ & \underset{Z}{2} \end{aligned}$ | $\infty$ 0 $\vdots$ $\exists$ | $\begin{aligned} & \because \\ & \vdots \end{aligned}$ |  | L L | U $\Xi$ $\Xi$ $\exists$ | $\begin{aligned} & \stackrel{8}{4} \\ & \vdots \end{aligned}$ | $\begin{aligned} & \% \\ & \hat{\sim} \\ & i \end{aligned}$ | $\begin{aligned} & \text { लै } \\ & 0 \\ & = \end{aligned}$ | $\stackrel{\square}{\Xi}$ | $\stackrel{\text { ®̃ }}{\text { ® }}$ | こ B $\square$ | \％ 合 $\Xi$ | ®n in |  |
| 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 |
| 91 | （90） | 89 | 88 | （88） | 85 | 85 | 85 | 85 | 85 | 85 | （83） | （85） | 84 | （82） | 81 | 80 | 80 | 80 | 82 |
| 62 | － | 60 | 60 | 60 | 53 | 53 | 54 | 51 | 51 | 52 | － | 50 | 52 | （51） | 51 | 51 | 52 | － | － |
| 50 |  | 46 | 46 | 46 | 42 | 43 | 45 | 43 | 44 | 44 |  |  | 42 |  | 41 | 41 | 40 |  |  |


| Kitchen middens（Bos primigenius） |  |  |  |  |  |  |  |  |  | Bos taurus domesticus |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| ¢ | ¢ | 아 | $\bigcirc$ | ＋+ | $\overbrace{}^{\circ}$ | ¢ | ¢ | 안 | ¢ | $\overbrace{}^{*}$ |  |  |  |  |  |  |  |
|  | $\bar{Z}$ | $\begin{aligned} & \Xi \\ & = \\ & 0 \\ & 0 \\ & 0 \end{aligned}$ |  |  |  |  | $\begin{aligned} & E \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \end{aligned}$ |  | $\begin{aligned} & \frac{\pi}{4} \\ & \vdots \\ & \vdots \\ & \hline \end{aligned}$ | $\begin{aligned} & \stackrel{\rightharpoonup}{\circ} \\ & \stackrel{0}{0} \\ & \stackrel{y}{0} \end{aligned}$ | $\begin{aligned} & \text { de } \\ & 0.0 \\ & 0 \\ & 0 \\ & 0 \end{aligned}$ |  |  | 荘 |  | $\begin{aligned} & \text { 篤 } \\ & \text { 坛 } \end{aligned}$ |  |
| 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 |
| 81 51 43 | 79 50 40 | 79 50 40 | 90 56 | 81 53 | 88 57 45 | 84 50 40 | 81 51 41 | 80 52 40 | 87 52 43 | 73 49 40 | 73 49 39 | 71 48 39 | 69 46 35 | 72 46 37 | $\begin{gathered} 60-74 \\ \text { (Nos. 19) } \end{gathered}$ | $\begin{gathered} 62-70 \\ \text { (Nos. 15) } \end{gathered}$ | $\begin{gathered} 63-74 \\ (\text { Nos. 4) } \end{gathered}$ |

Table

|  | Bos primigenius ơơ |  |  |  |  |  | ¢\％ |  | Maglemose settlement |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Zone | III | IV |  |  | Y | V／VI | V | VIII | ડิo |  |  |  |  | Q\％ |  |  |
| Naviculo－Cuboideum | － | $\geqslant 0$ | $\begin{aligned} & 0 \\ & 0 \\ & 0 \end{aligned}$ |  | 言 |  | $\frac{\vdots}{\frac{5}{4}}$ |  | $\begin{aligned} & 4 \\ & 0 \\ & \hline \end{aligned}$ | $\begin{aligned} & i \sim \\ & \sim \\ & \sim \end{aligned}$ | $\begin{aligned} & \ddot{\sigma} \\ & \ddot{\eta} \end{aligned}$ | $\begin{aligned} & \because \\ & \vdots \\ & \Xi \end{aligned}$ | $\stackrel{5}{9}$ | 哭 | ＋0゙ム | －＂ |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 1．Greatest width． | 88 | 80 | 78 | 80 | 80 | 81 | 67 | 61 | 82 | 80 | 78 | 78 | 74 | 67 | 66 | 65 |
| 2．Width，prox．articular surface | 68 |  | 61 | 63 | 62 | 65 | 55 | 50 | 61 | 64 | 62 | 60 | 57 | 52 | 52 | 52 |
| 3．Height，greatest，anterior | 31 | － | 31 | 30 | 30 | 31 | 26 | 24 | 29 | 28 | 30 | 30 | 27 | 26 | 26 | 26 |
| 4．Height，greatest，medial | 22 | － | 22 | 20 | 18 | 21 | 17 | 16 | 19 | 19 | 18 | 19 | 18 | 17 | 18 | 17 |
| 5．Length，greatest，ant．－post．medial | 73 | － | 71 | 73 | 71 | 77 | 61 | 63 | 78 | 75 | 72 | 72 | 68 | 62 | 63 | 62 |


|  | Holmegaard settlement |  |  |  |  | Ogaarde |  |  |  |  |  | Var． |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Zone | डิo |  | ¢ 9 |  |  | Oิす |  |  |  | q9 |  | రิ龴⿵ | ¢9 |
| Naviculo－Cuboideum | ® | $\stackrel{1}{0}$ | ì | ® | ถิ | $\stackrel{\square}{2}$ | 8 0 -18 | $\infty$ $=$ $=$ | $\frac{3}{3}$ |  | 3 B － $=3$ | （Nos．18） | （Nos．21） |
|  | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 |
| 1．Greatest width | 76 | 75 | 66 | 66 | 63 | 81 | 80 | 80 | 78 | 70 | 65 | 74－82 | （61）63－72 |
| 2．Width，prox．articular surface． | 59 | 57 | 52 | 51 | 53 | 63 | 62 | 62 | 61 | 54 | 55 | 57－64 | （50）51－57 |
| 3．Height，greatest，anterior | 27 | 27 | 25 | 26 | 27 | 32 | 30 | 29 | 30 | 25 | 24 | 27－32 | 23－29 |
| 4．Height，greatest，medial | 18 | 16 | 16 | 16 | 15 | 21 | 19 | 19 | 20 | 17 | 15 | $16-21$ | 14－19 |
| 5．Length，greatest，ant．－post．medial | 69 | 67 | 66 | 60 | 59 | 75 | 71 | 71 | 70 | 63 | 60 | 67－79 | 58－67 |

Tinglev bull is 84 mm ．，as compared with 83 mm ．in the Ullerslev cow，whereas the distal width is 57 and 52 mm ．，respectively（Fig．22）．

As no epiphyses，and thus no sutures either，exist in the astragalus，a more de－ finite age determination is difficult．In fact，it is possible only to distinguish between adult specimens with a hard and compact bone surface and bones of younger，sub）－ adult or juvenile，animals the bones of which are more or less porous．It should be noticed，however，that already in the fairly young animals from Sorø，$\hat{\jmath}$ ，and Pindstrup， o，the bone－surface is hard and shining．

Furthermore，a considerable number of astragali are known from prehistoric settlements in Denmark．From Maglemose sites about fifty are at hand and，as men－ tioned above，these sites are so old that any intermixture with domestic oxen is ex－
20.


| Kitchen middens (Bos primigenius) |  |  |  |  |  |  |  |  |  |  | Bos taurus domesticus |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 9 | ôô |  | ¢¢ |  | O* | ¢ | ¢ | $\bigcirc$ | $\delta$ | $\bigcirc$ |  |  |  |  |  |  |  |
|  |  |  | $\begin{aligned} & \text { ́․ } \\ & \text { En } \\ & \text { o }= \\ & =\% \end{aligned}$ | $\begin{aligned} & \stackrel{5}{\Xi} \\ & 0 \\ & 0 \\ & 0.0 \\ & 0.0 \end{aligned}$ | $\begin{aligned} & \vdots \\ & \vdots \\ & \vdots \\ & \ddot{y} \\ & \ddot{y} \end{aligned}$ | $\begin{aligned} & \vdots \\ & \bar{y} \\ & \vdots \\ & \vdots \\ & \vdots \end{aligned}$ | $\begin{aligned} & \vdots \\ & \ddot{Z} \\ & \vdots \\ & \vdots \\ & \vdots \end{aligned}$ |  | $\begin{aligned} & \Xi \\ & \vdots \\ & \vdots \\ & \vdots \end{aligned}$ | - | - | $\begin{aligned} & x \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & =0 \end{aligned}$ |  |  | ¢ | \% \% \% 0 | - |
| 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 |
| 61 | 75 | 73 | 61 | 61 | 79 | 70 | 67 | 75 | 75 | 69 | 62 | 60 | 57 | 57 | 57 | 60 | 59 |
| (50) | 60 | 57 | 48 | 52 | 61 | 57 | 54 | 59 | 58 | (56) | 49 | 47 | 47 | 46 | 46 | 49 | 47 |
|  |  | 28 | 24 | 25 | 29 | 26 | 25 | 28 | 30 | 27 | 24 | 22 | 24 | 23 | 23 | 24 | 22 |
| 15 |  | 19 | 15 | 15 | 20 | 17 | 16 | 20 | 22 | 17 | 15 | 16 | 14 | 14 | 16 | 17 | 17 |
| (59) | (69) | 69 | 58 | 60 | 72 | 64 | 64 | 70 | (66) | 66 | 56 | 51 | 50 | 51 | 56 | 62 | 53 |

cluded; these astragali belonged to unquestionable Urus. Just as the astragali attached to skeletons or skeletal parts from the bogs, the Maglemose astragali form two groups, large bones no doubt representing Urus bulls and smaller ones belonging to cows. It deserves notice that in this fairly large material the cows are in the majority, 34 out of 55 individuals.

The variation in the two groups is almost as seen in the astragali from the skeletons, there being only a small overlapping. Typical are the two astragali from the Holmegaard settlement, measuring 86 and 84 mm ., in length, but 58 and 51 mm . in width, no doubt representing a bull and a cow, respectively (Fig. 22). The three astragali from the Mullerup or Maglemose site, from Zone V, are just as small as the astragali of the Pindstrup and Bonnerup cows, from the Subboreal period, Zone VIII,

Table


* Probably bullock.
but several cow-astragali are somewhat longer than the Ullerslev astragalus, 84, 85, and a single 86 mm . in length, as compared with 83 mm . in the Ullerslev cow. Aberrant is an astragalus which is 89 mm . long, but only 53 mm . broad, it probably also belonged to a large cow (Fig. 23).

A determination as to sex of such long, but narrow astragali found single, if belonging to a large cow or a slender bull, as e.g. seen in the Ølholm bull-skull, may be difficult. - Regarding measurements of width, however, a hiatus exists at 55 mm ., probably indicating a distinct limit between female and male astragali, also emphazised by the fact that the astragalus from the almost complete hind limb of the Urus cow from Ørum Aa is 87 mm . long, but only 52 mm . broad (Table 19, No. 88).

In domestic cattle the astragali are shorter than even those in Urus cows. The largest measurements, $73-74 \mathrm{~mm}$., come from the very old bull from Bjerget and the largest astragali out of numerous specimens from farmer settlements, i.a. Bundso and Troldebjerg. The lengths of 19 astragali from Bunds $\varnothing$ vary from 60 to 74 mm . (Degerbøl, 1939), of 15 astragali from Ørum Aa from 62 to 70 mm . (Winge, 1900), and 4 specimens from Aalborg are $63,66,72$, and 74 mm . long.

Stampfli gives 76 mm . as the smallest length in Urus astragali and 64 (72?) as the greatest length in domestic oxen.

The Urus astragali from skeletons, and from the Boreal period are noteworthy
21.

| Bos primigenius（Kitchen middens） |  |  |  |  |  |  |  |  |  | Bos taurus domesticus |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 0 | $\bigcirc$ | ＋ | $q$ | ¢ | $\widehat{0}$ |  | 7 | 3 | $\delta$ | on＊ | $\delta^{*}$ | 7 | 7 | 0 ¢ | $\widehat{ }$ | $\bigcirc$ |
| $\begin{aligned} & \text { 解 } \\ & \text { 而 } \end{aligned}$ | 年 | 드… |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| 84 | － | － | 71 | － | － | 74 | 74 | － | － | 64 | 66 | 61 | 65 | 59 | 61 | 62 |
| 79 | － | 70 | － | － | － | － | － | － | － | 59 | 64 | 57 | 60 | 57 | 60 | 60 |
| 74 | － | － | 67 | － | － | 69 | － | － | － | 58 | 61 | 55 | 58 | 53 | 56 | 58 |
| 75 | － | 65 | － | － | －－ | － | － | － | － | 56 | 60 | 53 | 57 | 52.5 | 56 | 58 |
| 41 | 44 | － | － | 38 | － | 38 | 35 | 41 | 42 | 35 | 32 | 31.5 | 30 | 33 | 30.5 | 39 |
| 38 | 41 | － | － | 38 | － | 35 | － | － | － | 34 | 29 | 29 | 27 | 33 | 29 | 34 |
| 45 | 42 | － | － | － | 43 | 37 | － | － | － | 36 | 35 | 31 | 32 | 35 | 34 | 35 |
| 34 | － | － |  |  | － |  | 29 | － |  | 28 | 26 | 27 | 2.5 | 28 | 25 | 33 |
| 36 | － |  |  | － | －－ | － | － |  | － | 27 | 24 | 26 | 26 | 27 | 25 | 27 |
| 26 | － | 24.5 | － | － | － |  | －－ |  | － | 21 | 19 | 18.5 | 17.5 | 21 | 19 | 22 |
| 38 | － |  | － |  |  |  | － |  |  | 33 | 29 | 26.5 | 26 | 32 | 29 | 36 |



Fig．23．Astragalus．Maximum width plotted against maximum length．Br．Brabrand．Encircled measure－ ments are equal．－Even the small Brabrand astragali join the female group of B．primigenius．The B．t．dom．indicated represent very large animals．

TAble


* Probably bullock.
in that they are so numerous that they provide enough material to arrive at a decision of the old problem of affiliation, whether the astragali from the kitchen middens, Zones VII and VIII, belong to the Urus or domestic oxen. As proved under the respective settlements, the results are unambiguous and important; the astragali from the settlements proper represent the Urus (Table 19).

Brabrand: 5 astragali are present; they all belong to $q$. Length and breadth: $84 \times 51 \mathrm{~mm} ., 81 \times 51 \mathrm{~mm} ., 81 \times 48 \mathrm{~mm} ., 79 \times 48 \mathrm{~mm}$., and $76 \times 49 \mathrm{~mm}$.
Dyrholmen I: 2 astragali are at hand, representing a $\sigma(87 \times 56 \mathrm{~mm}$.) and a $q$ ( $81 \times 51 \mathrm{~mm}$.$) .$
Kolind $I$ (older than Dyrholm I): a single astragalus, $q(79 \times 50 \mathrm{~mm}$.).
Kolind III (Subboreal): $\circ(79 \times 50 \mathrm{~mm}$.).
Hjerk Nor: 2 astragali, $\widehat{o}(90 \times 56 \mathrm{~mm}),. ~ \&(81 \times 53)$.
Norslund: 2 astragali, $\widehat{ } 10(88 \times 57 \mathrm{~mm}$.$) , \uparrow(84 \times 50 \mathrm{~mm}$. $)$.
Krabbesholm : 2 q $q(81 \times 51 \mathrm{~mm}$. and $80 \times 52 \mathrm{~mm}$. $)$.
Orum Aa (Subboreal): a single astragalus, belonging to a $f(87 \times 52 \mathrm{~mm}$.).

Naviculo-cuboideum.
Like the other carpal bones the majority of nav.-cuboidea originate from the Maglemose settlements: Maglemose near Mullerup (Zone V), Sværdborg, Holmegaard, and Ogaarde (Zone VI). In 18 specimens the range of the greatest widths is
22.

| (Kitchen middens) |  |  |  |  |  |  |  |  | Bos taurus dom. |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| + | 7 | + | 0 | 0 | q | q |  | $\bigcirc$ | o** |  | 9 |  |
| 或而 |  |  | $\begin{aligned} & \text { E0 } \\ & 0 \\ & 0 \\ & 0 \\ & 0 \end{aligned}$ |  |  |  |  |  | $\begin{aligned} & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \end{aligned}$ |  | $\begin{aligned} & 0.0 \\ & 0 \\ & \text { E. } \\ & 0 \\ & 0 \end{aligned}$ |  |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| - | - | - | 52 | 50 | 45 | 47 | - | - | 42 | 44 | 40 | 40 |
| - | - | - | 48 | 43 | 42 | 42 | 48 | - | 41 | 41 | 37 | 40 |
| 36 | 39 | 35 | 41 | 38 | 35 | 39 | 42 | - | 34 | 37 | 31 | 35 |
| - | - | - | 44 | 40 | 39 | 42 | 41 | - | 38 | 39 | 35 | 37 |
| - | - | - | 41 | 39 | 35 | 33 | - | 42 | 33.5 | 31 | 28.5 | 27 |
| - | - | -- | 44 | 38 | 36 | 37 | 41 | - | 38 | 3.1 | 33 | 33 |
| 27 | 26 | 27 | 32 | 33 | 26 | 26 | 30 | 33 | 28 | 25 | 22 | 21 |
| - | - | - | 32 | 31 | 27 | 26 | 30 | - | 28 | 23 | 23 | 21 |
| - | - | - | 36 | 35 | 30 | 27 | 32 | - | 31 | 27 | 24 | 22 |

$74-82 \mathrm{~mm}$., in 21 specimens $61-72 \mathrm{~mm}$., no doubt representing bulls and cows, respectively. Less affected by age than this measurement is the upper articular width, the range of which is $57-64 \mathrm{~mm}$. and $50-57 \mathrm{~mm}$., respectively.

In the very old domestic male from Hillerød, in which the nav.-cub. and cuneiforme are fused, the greatest width is 62 mm ., the articular width 49 mm ., thus just reaching the range in Urus cows. In 4 of the largest nav.-cub. from the Troldebjerg and Lindø settlements the corresponding measurements are $57-60$ and $46-47 \mathrm{~mm}$. According to Dottrens (loc.cit.) the range of greatest widths of 44 specimens of domestic Neolithic cattle is $43-57 \mathrm{~mm}$. - Stampfli gives 60 mm . as greatest width in a small nav.-cub. referred to Urus.

All nav.-cuboidea from the kitchen middens, too, belonged to Urus, bulls and cows. - Two nav.-cub. from Brabrand (p.35) originate from young animals, as appears from the porous surface, and the small height and length, anterior-posteriorly. They are corroded, and one of them is fragmentary. They are comparatively small, but judging from the said conditions they should no doubt be referred to Urus cows. The upper articular surface, against os naviculare, is larger than found in domestic oxen; particularly large is the articular length, measured anterior-posteriorly, medially (chord), 41 mm . as compared with 35 mm . in the Hillerød domestic male, and $35-$ 36 mm . in the specimens examined from the Troldebjerg and Lindø settlements.

Two of the 4 naviculo-cuboidea from Dyrholmen (p.38) are comparatively large, representing bulls; two are small, on the borderline to domestic oxen, but as just

Table 23.

|  | Bos primigenius |  |  |  |  | (Kitchen middens) |  |  |  |  | Bos t. dom. |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Zone | ¢ิర |  |  | + |  | o |  |  | $\bigcirc$ | ¢ | $0^{*}$ | $0^{*}$ | q | + |
| Phalanx 3 | $\begin{array}{r} \hat{B} \\ 0.3 \\ 0.0 \\ 0 \end{array}$ |  |  |  |  | $\begin{gathered} \stackrel{0}{6} \\ 0 \\ 0 \end{gathered}$ |  |  |  |  |  |  |  | \% |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 12 | 14 |
| 1. Greatest length | 90 | 86 | 86 | 95 | 93 | 104 | 90 | 92 | 96 | 87 | 85 | 79 | 78 | 73 |
| 2. Length of upper margin | 70 | 69 | 72 | 71 | 68 | - | 73 | 70 | -- | - | 64 | 63 | 58 | 57 |
| 3. Length of rear margin (chord.) | 65 | 63 | 63 | 61 | 57 | - | 61 | (60) | - | - | 56 | 54 | 49 | 46 |
| 4. Greatest width.............. . . | 35 | 32 | 32 | 32 | 29 | 38 | 31 | 34 | - | - | 29 | 28 | 27 | 23 |

* Probably hullock.
mentioned under Brabrand, the chord lengths are great, 41 and 44 mm ., and the medial lengths of the bones are great, too, 58 and 60 mm . Cf. Table 20.

3 nav.-cub. from Hjerk $\operatorname{Nor}(\widehat{\jmath}, ~ ㅇ, ~ ㅇ), ~ 2 ~ f r o m ~ N o r s l u n d ~(~ \widehat{~}, ~ \widehat{)}$ ) and one from Havnø (f) are within the range of nav.-cub. from Maglemose sites. From superficial layers at Havno furthermore a nav.-cub. of a domestic ox is present; greatest width 59 mm ., as compared with 69 mm . in the Urus cow from this locality.

## Phalanges.

To distinguish solitary phalanges from forelimb and hindlimb may be difficult, particularly in the case of small or weak animals, but in complete skeletons this difficulty does not exist, cf. the Sorø bull and the Ullerslev cow. Table 21. The phalanges of the forelimb are shorter, but broader than in hindlimbs, a character probably connected with the fact that the forelimbs must carry the largest weight, the weight of the large forepart of the body and the heavy head. The total length of the phalanges of the forelimb of the Sorø bull is 177 mm ., as compared with 186 mm . of the hindlimb. Furthermore, a slight difference in length between medial (toe-joint 3) and lateral (toe-joint 4) phalanges may occur (Dottrens, 1947).

As in other limb bones the proximal phalanges (Phalanx 1) of Urus cows are considerably smaller than in Urus bulls. The length of Phalanx 1 of the small Tinglev bull, e.g., it is true, is almost of similar length as in the Ullerslev cow (Table 21, Nos. 4 and 5), but is much broader. - A particularly small phalanx is Phalanx 1 of the forelimb of the Bonnerup cow 2, which is almost equal to the corresponding bone of the bullock from Holmene (Nos. 10 and 21), but apart from this the measurements of the proximal phalanges of the Danish Neolithic cattle are outside the range in Urus cows.

The phalanges from the kitchen middens clearly belong to Urus, bulls as well as
cows. From the Brabrand settlement a median part of Phalanx 1 (hindlimb), which longitudinally has been split open for taking out the marrow, is at hand; in size it is equal to the proportions in the Ullerslev cow; and the same applies to a similar piece from Dyrholmen (XXXI, C $9^{2}$ ) and Kolind (IV F $2^{5}$ ). From Dyrholmen, furthermore, a lateral half of the proximal part of a large Phalanx 1 is present, a prox. height of 43 mm . indicates a bull, of the same size as the Sorø bull.

What is said about Phalanx 1 also holds good of Phalanges 2 and 3 (Tables 22 and 23). Also here the phalanges from the kitchen middens belong to Urus.
Summary (limb bones).
From this survey it appears that the limb bones of Urus bulls are considerable larger, particularly broader, than in Urus cows.- In metapodials there is a distinct sex dimorphism regarding width (fig. 20). In domestic oxen the lengths of the metapodials are widely separated from those in Urus (fig. 18-19) ; the transversal measurements of width, however, merge with those in Urus cows, which, however, may be separated from domestic oxen by larger anterior-posterior width.

In other limb bones the size range of Urus cows is outside the range in Urus bulls, or only a slight overlapping may occur.

In domestic Neolithic cattle examined here, the lengths of the limb bones are outside the range in Urus.

## Shoulder Height.

A fairly reliable statement of the shoulder height of the Urus may be based on complete and mounted skeletons of bulls as well as of cows, however, the correctness of the mounting of the skeleton may always be open to discussion. The height of the skeleton of the Urus cow from Ullerslev is 150 cm . (Pl. XIV), of the Urus bulls from St. Damme 175 cm . (Pl. XIV), and Sørø 172 cm . In the living animals with their horny hoofs and layer of muscles, the shoulder height probably was 5 to 10 cm . higher and in wintertime furthermore a thick coat was added.

A calculation of the shoulder height on the basis of single bones must always be tentative and made with reservations; particularly the metapodials have often been used for this purpose.

As mentioned above (p.107), however, the size relation of the various limb bones is very variable.

If the metacarpus length of the St. Damme specimen ( 25.8 cm .), e.g., is taken as a comparatively standard measure in bulls, the shoulder height of these animals will vary between 165 cm . (Gesten) and 189 cm . (Grejs Mølle).

In the St. Damme specimen, however, the radius length is 36.3 cm ., as compared with 37.2 cm . in the Grejs Mølle bull; with the radius length as standard measure the shoulder height of the Grejs Mølle bull is calculated at 179 cm ., thus 10 cm . lower than after a calculation on the basis of the metacarpus.

A more reliable calculation is obtained if the sum of the two bones, metacarpus and radius, is taken as a standard measure. In this case the shoulder height of the Grejs

Molle specimen is calculated at 183 cm . On the same basis the shoulder heights of the adult, but young bulls from Soro and Ugilt are calculated at 174 and 176 cm ., almost as in St. Damme, but with age they would have been somewhat higher. In the still younger bull, Grænge A, the shoulder height is 171 cm ., in the Terp bull 173 cm ., in the Klarup bull 170 cm ., in the Tinglev specimen 169, and in Grænge D, if the bones belong to the same individual, 166 cm . Thus a range of the shoulder height from 169 (166) to 183 cm .

In the rest of the limb bones of bulls measured, only the metacarpus or the radius of the single individual is available. Of these the radius length, as mentioned, is more indicative of the shoulder height than the metacarpus. Several radii are comparatively large (Table 15) ; three (Undlose (No. 10), Ugilt (No. 12) and Danmark II (No. 23)) are just as large as the Grejs Molle specimen 37.1, 37.0, and 37.1 cm . (as against 37.2 cm .) and five are as large as, or somewhat larger than, the St. Damme radius ( 36.3 cm .): $36.2,36.4,36.5,36.7$, and 36.7 cm .

Accordingly the shoulder height in the majority of the Danish bulls was about $175 \mathrm{~cm} . \pm 5 \mathrm{~cm}$.

Before the preparation of this treatise no direct measurement of the shoulder height of a skeleton of an Urus cow was carried out. In the Ullerslev cow it is, as mentioned, 150 cm . Only of two other cows, from St. Taastrup and Bonnerup II, the metacarpus as well as the radius are present; the total sum of which is 59.4 cm . and 55.9 cm ., respectively, as compared with 56.6 cm . in the Ullerslev cow. On the basis of this the shoulder height may be calculated at 157 cm . and 148 cm ., respectively.

An impression of the shoulder height of other cows represented, may be based on the metacarpi only. Practically speaking two metacarpi from Sværdborg are equal to the Ullerslev metacarpus, 24.3, 24.4, and 24.6 cm ., respectively, whereas one from Vittrup is larger, 25.3 cm ., corresponding to a shoulder height of 156 cm ., but probably would this long-leged animal in fact have been somewhat higher. The metacarpi from Bonnerup II, 23.0 cm ., from Tjerrild, 23.1 cm ., and Auning, 23.2 cm ., are very small, indicating a shoulder height of about 140 cm . The height of the Pindstrup cow and a cow from Sværdborg is calculated at 143 cm ., and the cow from Alminddalen at 146 cm .

Several research-workers have discussed the shoulder height of the Urus. Lillijeborg (1874, p. 871) states the shoulder height of a mounted skeleton of a bull from Sweden to be 171 cm . - The length of the metacarpus is 25.5 cm ., and the length of the radius 36.0 cm . The sum total of 61.5 cm ., as compared with 62.1 cm . in the St. Damme bull, gives a calculated shoulder height of 173 cm ., thus emphazising the applicability of the said method of calculation in animals of the same sex, individual age and growthform.

Lilljeborg furthermore gives the measurement of a "somewhat older and larger", but incomplete skeleton the metacarpal length of which is 25.8 cm ., the radius length 39.0 cm ., total sum 64.8 cm . With the total sum of 61.5 cm . in the complete Swedish skeleton as a measure, the shoulder height may be calculated at 180 cm . (on the basis of St. Damme measurements at 183 cm .).

The shoulder heights of two mounted skeletons of bulls from northern Germany have by Nehring (1888) been measured at 165 and 168 cm ., respectively. The radius length was by Nehring measured as the maximum length, but may be reduced to medial length, which is used in the present work, by a deduction of about 20 mm . Calculated on this basis the shoulder height in both is 165 cm . A shoulder height of 165 cm . is comparatively small, but the said individual was also characterized as a small animal, and was in fact originally determined as a cow.

From England the anterior part of a large bull skeleton, dated at the Bronze Age, is at hand. According to Higgs (1961) "The bones fall within the size range of the measured Pleistocene specimens; indeed some parts of the body appear to be larger. The Mesolithic animals are substantially smaller." - However, the metacarpal length ( 26.0 cm .) and the radius length (maximum 39.0 cm .) are equal to those of the St. Damme bull. Thus probably the two animals would be the same height. - In both the teeth are of comparatively moderate size (Table 9).

Considerably greater shoulder heights have been reported; in bulls right up to 2 metres (Lengerken, Herre); and Requate (1957) in summarizing states that the height of cows varies from 160 cm . to 180 cm . - On the basis of extensive studies Boessneck (1957) concluded that in most bulls the shoulder height of living animals was calculated at about 175 cm . (range $165-185 \mathrm{~cm}$.). In Urus cows the minimum height may have been comparatively small, probably less than 150 cm . - A result which indicates that the shoulder height in Central European Urus probably varied within the same size range as in Denmark. As the German material, however, is undated, we do not know the state of variation within the various age periods.

The shoulder height of the Neolithic domestic cattle is difficult to establish with any certainty, as no complete skeleton is at hand, and we do not know whether the proportions between limb bone length and shoulder height in these animals correspond to recent conditions. It should be mentioned, however, that the lengths of the metacarpus and radius of the Holmene cow are equal to those of the corresponding limb bones of the complete and mounted skeleton of the primitive cow which is kept in the Zoological Museum, and the shoulder height of which is 120 cm (cf. p. 139). The shoulder height of bulls is probably somewhat greater than in cows with a similar limb-bone length. This would seen to indicate that the Maglemosegaard bull (Vedbæk II) is of about a similar height as, or a little higher than, the Holmene cow, (metacarpal lengths 199 mm . and 205 mm . respectively).

It is generally accepted that the shoulder height of bullocks is $9-10 \%$ higher than that of cows (Nовıs, Коск), which at a rough estimate would give a shoulder height of $130-140 \mathrm{~cm}$. in the bullocks from Holmene and Borremose (metacarpus length $216-217 \mathrm{~mm}$.).

These measurements are smaller than that calculated by Nobis (1954) on the basis of three metacarpi from the Neolithic site at Weiszenfels; the metacarpal lengths are 193, 204, and 207 mm . and the corresponding shoulder heights are stated to be 125,132 , and 137 cm. ; and similar proportions occur in some generally used tables,

[^0]in which the shoulder height on the basis of the metacarpus is calculated in different breeds of cattle (Boessneck, 1956).

Thus the shoulder heights of the Danish Neolithic cattle are perhaps stated as too small, calculated on the basis of the complete skeleton of the said cow, and may be somewhat raised; the skulls are comparatively large. The cows from Viksø are very small, almost dwarfish (metacarpal length 187 mm .; diaphysis width 22.5 mm .).

It is remarkable to find so small cows dated at Zone VIII, but probably they originate from the end of the zone, or at the transition to zone IX, Bronze Age- Iron Age. Similar small animals otherwise are earliest known from the Roman Iron Age, first century A.D. (metacarpus length from 160-175 mm.; Degerbøl, 1944). Extraordinarily small are the cows from the Rislev find, from the 4 th century A.D. Measured on a complete forelimb the shoulder height is 106 cm . (Length of metacarpus 159 mm .) (Мøнц, 1961).

## The Occurrence in Time and Space and the Ecological Conditions

The earliest dated remains of Bos primigenius in Denmark belong to the close of the Late Dryas period (Zone III). Profound and rapid climatic changes and corresponding adjustments in flora and fauna were characteristic of that time. The lateglacial tundra animals (reindeer, wild horse, alpine hare, ground squirrel (Spermophilus major) pika (Lagomys pusilla) disappeared or were able to survive only into the Preboreal period (tundra bison), while new species immigrated (Degerbøl, 1964). During the transition period between the Late Dryas and the Preboreal period the temperature rose so quickly that the immigration of the heat-demanding species of trees ("the climax species", Iversen, 1960) could not keep pace with the climatic improvement. Denmark was still a fairly open country although the summer temperature was rather high, surpassing $13-14^{\circ} \mathrm{C}$. The pioneer species of trees spread quickly. Juniperus had a striking but short-lived maximum, followed by aspen (Populus tremula). Salix still existed. During the Preboreal period, however, birch predominated, increasingly mixed with pine. According to these conditions grasses, sedges and other herbaceous plants were decreasing. Empetrum, however, also had a short maximum at the transition from Late Glacial to Postglacial. Rapidly acting climate-indicators are found in thermophilous aquatic plants and mobile mammals.

It is remarkable that a forest animal like the Urus already was represented in the Late Dryas period, but it is in good agreement with the fact that remains of three typical forest animals, beaver, wild pig, and lynx, are found at the Late Dryas settlement of Stellmoor, N.E. of Hamburg. It is true that this last locality is situated farther south, at the base of the Cimbrian Peninsula. However, the Faaborg region, on the south coast of the island of Funen, was at that time joined to the European mainland and thus was situated only 150 km . north of Stellmoor.

Previous to the present investigations only a few finds of Urus from the Preboreal period have been analysed, from Vig, N.W. Zealand (No. 2), and from Star Carr,

Yorkshire (Fraser and King, 1954). The comparatively numerous discoveries now known from Denmark, and the large size of the individuals, however, indicate that the open temperate forests of that time offered the Urus particularly favourable natural conditions. From the Preboreal period (Zone IV) 14 finds are known from Denmark, as compared with 20 finds from Zone V and 11 from Zone VI, apart from numerous bones from settlements belonging to the two last-mentioned zones.

Although the temperature during the Boreal period attained a considerably higher maximum than today, as is seen from the occurrence of the mistletoe (Viscum album), ivy (Hedera helix), and pond tortoise (Emys orbicularis) (Iversen, 1944, Degerbøl \& Krog, 1951)), the succession of the species of trees was no doubt still a question of the rate at which the different species were able to immigrate, and was not climatically determined.

At the beginning of the Boreal period (Zone V) hazel (Corylus avellana) was the first shade-tolerant species to immigrate. It soon became dominant as undergrowth under birch and pine. Later, when other shade-tolerant trees, Ulmus and Tilia immigrated, the hazel either succumbed or showed a marked decline. Lime (Tilia) immigrated at the transition to Zone VI.

At the beginning of the Atlantic period (Zone VII) the great changes in the composition of the forest came to an end, and general stability was attained. During this period the mixed oak forest prevailed; besides Tilia and Ulmus the light-demanding oaks were dominants. The distribution of the species was now particularly determined by their edaphic requirements. Oak (Quercus petraea) could thrive on poor soil, and was presumably prevalent on high and sandy ground, i.a. in Central Jutland. Also lime is met with on high, but not too poor soil; elm occurs on rich soil only. The oak species Quercus robur, presumably had its natural habitat on moist clay, lowlying ground, and even peaty soil (Iversen, 1960). On soil with a high ground-water level there was an alder carr (Alnus glutinosus).

During the Boreal period the Urus was of common occurrence, particularly in Zealand and Funen. However, as demonstrated by many bog finds and numerous bones from the Maglemose settlements on Zealand, the Urus seems to have disappeared from that island at the close of the period. No find is known from the Atlantic period or later, although several settlements have been excavated. From South Funen a single find from the Subboreal period occurs.

A similar occurrence is the elk (Alces alces) which, like the Urus was common during the Preboreal and Boreal periods.-But what is the cause of this disappearance? Was it affected by change in the natural conditions, or were the two species exterminated by man's hunting activities?

We shall first discuss the still living species, the elk, the ecological requirements of which are fairly well known (Peterson, 1955). The elk is distributed in the coniferous forests of both the Old and the New World. Its favourite biotope is an open pine forest with moors, swamps, and small lakes, intermingled with deciduous trees. It is a pronounced browser, which prefers leaves, buds, twigs, bark, etc., whereas grasses
are less significant in the diet. In winter it bites off the terminal twigs and branches and chews the bark. Among important food plants, aspen (Populus), willow (Salix), birch (Betula), oak (Quercus), hazel (Corylus), and Sorbus may be mentioned. However, a variety of foods, i.a. aquatic and semiaquatic plants, too are important factors in a balanced diet. Quality more than quantity is necessary for a healthy elk population.

These food habits clearly indicate that the young and open forest, the pioneer forest, is essential for the elk, whereas the dense, mature, or climax forest is avoided, even if small clearances there may be maintained by heavy browsing. - Transferred to prehistoric times, this means that the food conditions of the elk were excellent in the Preboreal, and very good in the greater part of the Boreal period, but in the course of time, as the forest grew darker, environmental conditions became increasingly poor.

But are the ecological requirements of the Urus similar to those of the elk? It has been much discussed whether the Urus was a browser (i.a. Zeuner, 1963) or a grazer (Неск, 1952). A priori it might be supposed that wild oxen, having high-crowned, hypsodont teeth, would be less pronounced browsers than deer with brachyodont teeth. The Urus, no doubt, was primarily a grazer rather than a browser, even though leaves, twigs, etc., in forested areas may have formed an important part of its food. The graminovorous nature of the Urus is also indicated by the very wide distribution of the species, from Great Britain and the Atlantic coast in the west, to China in the east, and from, i.g., Väster- and Östergötland, Sweden, $59^{\circ}$ lat. N., to Egypt and North Africa. According to Gromova (1931), the occurrence of the Urus in USSR was particularly bound to the mixed or deciduous forest zone, but discoveries are also known from the transition area to the steppes (cited by Reguate, 1957).

Little is known about the ecological requirements of the Urus at the time when the species was still genuinely wild. The conditions under which the last specimens lived before the final extinction of the species actually tell us only about the conditions in the reserves, where the now semi-wild animals died, but they probably indicate, in a reduced or limited form, how the original biotopes looked.

The last Urus, a cow, died in the year 1627, when 30 years old, in the forest of Jaktorówka some 60 km . southwest of Warsaw, but in most European countries the species was almost exterminated centuries before that time.

On the basis of newly discovered sources from Polish archives, Lukaszewicz (1952) has given the detailed history of the extinction of the species within Polish reserves. The Jaktorówka reserve occupied an area of about 200 square km . and consisted of a great number of tree species, including pine, oak, ash, alder, maple, elm, hornbeam, and birch. The forest environs were marshy.

From very early times, at least from the beginning of the 16th century, herds of Urus in the Jaktorówka forest were under the protection of special gamekeepers. In the winter months the animals were fed with hay from the adjoining meadows. Occasionally hybrids with domesticated cows occurred, but these animals were not robust and most of them died in severe winters. On the whole, severe winters caused a
great mortality in the Urus herds. Also several bulls were killed when, in the mating season, they fought for the cows. In the year 1557 the total number of Urus cattle at Jaktorówka is said to have been over 50, but twelve years later the number was reduced to $38: 8$ old and 3 young bulls, 22 adult cows, and 5 calves. Owing to timbercutting and pasturing of horses, cattle, and domestic pigs, which especially consumed acorns in autumn, the biotope was gradually devastated. In 1599 , after the severe winter of 1598 , the total number was only 24 . On account of the complete collapse of the protection of the animals many specimens were now killed by poachers, a fact which together with epidemics sealed the fate of the last animals. Two years later, in 1601, only 4 Urus specimens were left in the Jaktorówka forest: three bulls and a cow.

The importance of the acorns in the diet of the Urus is emphasized by Gesner (1551), who writes that in the autumn the Urus cattle eat acorns, which leads to increased weight and shinier coats. Gesner also states that in winter the animals forgathered in small herds browsing on leaves and buds.

On the basis of the associated fauna in Central Europe, Lehmann (1949) also concludes that the preferred biotopes of the Urus had been open forests together with the adjoining grassland.

From this survey it must be stated that the increase of the deciduous trees during the Boreal period in Denmark did not reduce the quality of the natural environment to the Urus. On the contrary, the increase in oak trees with their acorns offer a valuable food supply. This, however, only holds good as long as the forest was so open that grass and other herbs were available in fairly large quantities. The distribution in time of the Danish Urus discoveries during the Boreal period clearly confirms this view. The great number of finds of large animals in the early half of the Boreal period, Zone V, (cf. the survey of the material), indicate a most favourable habitat for the Urus.

It seems that the animals in Zealand were strongly decreasing in number at the end of Zone VI. From the latest settlements in Aamosen from this period only a few Urus bones are known (Magleø, Hesselbjerggaard, Verup).

For the sake of completeness it may be mentioned that a single Urus bone, a hamatum, and 2 astragali of Alces, are known from the Tingbjerggaard settlement in Aamosen (Degerbøl, 1943). This site is of Mesolithic age with a faint intermixture from the Dolmen period. However, according to the excavator, Dr. Th. Mathiassen, the said bones no doubt belong to the old phase, e.g. with microliths, thus dating back to Maglemose times.

It is remarkable to note that the Urus already disappeared from Zealand before the density of the mixed oak forest culminated, in the Atlantic period, Zone VII. This might indicate that the forest already at the end of the Boreal period was so dark that it was difficult for the Urus to survive. It is probable, however, that the activities of man have played a considerable rôle in the decrease of the Urus. The great number of bones of this species known from the great Maglemose settlements indicates that the Urus was a favoured quarry. With the increasing density of the forest the Urus
would seek out the more open areas, e.g., where oak trees, filled-up lakes, and driedup moors dominated. These places, no doubt, were soon known to men, and the animals were severely hunted.

The continous existence of the Urus and elk in Jutland is in accordance with the more open country in this region (Jonassen, 1950), and, furthermore, an immigration from Central Europe was still a possibility.

From a zoological point of view, it may be difficult to elucidate in detail the problem of the density of the forest. It should be emphasized, however, that the two ungulate species, the red deer (Cervus elaphus L.) and the roe (Capreolus capreolus L.), still survived on the island of Zealand; the open forest being for the roe in particular the preferred habitat.

On the other hand, it is a remarkable fact that from the Atlantic period only one discovery of Urus from bogs is recorded, from Langeland, which at that time was connected with the south-eastern corner of Funen. However, Urus remains are known from several kitchen middens, representing a population of hunters of the Ertebolle culture. It is true that this culture continued well into the Subboreal period, but it is probable that most bones of the Urus from these settlements originate from the Atlantic period, as i.a. has been proved regarding a horne core from Brabrand.

The existence of the Urus in the Subboreal period was, as noted by Winge, demonstrated from a kitchen midden at Ørum Aa, Jutland (cf. p. 22), and later from the Bundsø settlement (cf. p. 23). However, only a few bones were present, and the Urus was considered a rare animal in the Subboreal period. Surprisingly enough, pollen analytical investigations have now proved that this species is represented in no less than 23 Jutland discoveries.

Regarding the question of the origin or later changes of the domestic cattle in Denmark, this implies that the Urus in Jutland may have formed part of the domestic cows, but no indication of this is found; whereas in Zealand these animals must have been introduced, and any hybridization with the Urus was impossible.

The earliest Subboreal finds of Urus belong to the beginning of the period, the latest find, from Tinglev Lake, to the transition to the Subatlantic period or to this period proper.

The Subboreal skulls are on an average smaller than the geologically earlier skulls, even if the Subboreal skulls from Grejs Mølle and Auning are fairly large, and the limb bones from Grejs Molle belong to the largest ones known. The tooth rows in all Subboreal skulls are comparatively short (cf. p. 85) as also the Urus teeth known from the Ertebolle kitchen middens are small.

The find from Rise (No. 72, p. 23) makes it probable that the Urus still existed in southern Jutland in the Subatlantic period (Zone IX).

According to Requate (1957, p. 305) part of a horn core of Urus was excavated at Haithabu from the period 800 to 1050 A.D. This is not, however, a conclusive proof of the occurrence of the Urus in Schleswig-Holstein at that time. Haithabu was a famous commercial centre, and this piece may have come from a cut-off trophy-furthermore,
the horn sheath was used as a drinking horn - and it may have been imported from far away.

A pollen analytical dating of the Swedish finds of Bos primigenius was made by O. Isberg, and a treatise on the subject was almost finished at his death 1950 ; it was later revised and published by E. Mohrén 1962. No osteological examination of the material has been made, but some of the finds had earlier been examined by Leithner (1927). As in Denmark most Swedish discoveries belong to the Boreal period. From the Atlantic period only one find exists and from the Subboreal period a few finds are known. The most remarkable of the last-mentioned finds is an almost complete skeleton from Hammarlöv, Scania, belonging to the Bronze age or perhaps to the close of the Neolithic age. According to Leithner this skull is very large, basal length 593 mm . ; however, no teeth measurements have been published. - The latest Swedish find is from the Subatlantic period, the Iron age or Late Bronze age, just as the Danish Tinglev specimen.

According to Adam of Bremen the Urus was still living in Scandinavia in the 11 th century; however, the interpretation of his Latin text must have been incorrect, as clearly shown by the additional information that the Urus lived under water, just as the white bears (cf. Prell 1939, Degerbøl 1945, p. 31; and Isberg \& Morén 1962).

In the Netherlands Urus remains are recorded from the Terpen, the finds of which belong to the beginning of our era and the early mediaeval period (Clason, 1965).

It is remarkable that no discovery of the Urus is known from the island of Bornholm in the Baltic. During the Dryas periods the reindeer (Rangifer tarandus) was very common in that area, which at that time was part of the European continent. Also the elk (Alces alces) was well represented. (Degerbøl and Krog, 1959). The duration and extent of the Bornholm landbridge have often been discussed (Isberg, 1950), but the non-existence of the Urus on Bornholm would seem to indicate that the Bornholm area was already isolated at the beginning of the Preboreal period (Zone IV).

From the maps (figs. 1 and 2) it will be seen that only a few discoveries are recorded from South-Western Jutland. This is not expressive of the commonness of the Urus, but is only to emphasize the fact that most bogs in this area are so acid that no bones will keep.

## Domesticated Cattle (Bos taurus domesticus L.)

Survey of the Material.
The question when domestic cattle may be demonstrated with certainty for the first time, must be answered on the basis of a certain zoological identification of a reliably dated osseous material. In the following more detailed study of domestic cattle in Denmark, I shall begin with skulls of such a character that it is absolutely certain that domestic oxen are represented:

Dated finds. Arranged according to time-scale. (Cf. B. Fredskild).
I. Ogaarde complex, Undløse, Aamosen, N.W. Zealand (National Museum). q juvenile (Heifer). Skull with mandibles and parts of postcranial skeleton. (Marked "Øgaarde I'"). A-landnam. Zone VIII.
II. Store Lyng, Undløse, Holger Jørgensen's moor, Aamosen, N. W. Zealand (National Museum, 1941).
of subadult. Skull with mandibles and posteranial skeleton-parts - B-landnam. Zone VIII.
III. Verupgaard, Niløse, Aamosen, N.W.Zealand (National Museum, 1942). of skull with mandibles. The very beginning of B-landnam.
IV. Ogaarde complex, Undlose, Aamosen (National Museum 1943).
\& Skull (Marked " Ogaarde II'"). Beginning of B-landnam.
V. Ogaarde complex, Undlose, Aamosen (National Museum 1943). \& subadult. Brain-case (Marked "Øgaarde III"). Beginning of B-landnam.

VI-VIIIA. Gammellung moor. Troldebjerg, Langeland (Langelands Museum). B-landnam. I $\widehat{\sigma}$, skull. II $q$, incomplete skull. III $\hat{\sigma}$, brain-case. IV ô, brain-case, subad.

IX-X A. Nyrup moor. 16 km . W. of Næstved (J. Ferdinand, Herlufsholm). About Blandnam.
I $q(85 / 1945)$, incomplete skull and some limb bones. I $q(87 / 1945)$, brain-case. III $\circ$ Skull.
XI. Snoldelev. 8 km. S.S.E. of Roskilde (V. Mortensen, 1904).
of Skull. B-landnam.
XII. Vedbæk. I. 20 km . N. of Copenhagen (1942).
ot Skull. Subboreal transgression; the middle of Zone VIII.
XIII. Vedbæk II, Maglemosegaard. (P. Lorentzen, 1942).
$\jmath_{0}$ Skull with mandibles, metapodials, and toe-joints, vertebrae. - Subboreal transgression. - Probably just below the border of Zones. VIII-IX.

XIIIA. Vedbæk III. Idem.
of Skull. - Regression period after the Subboreal transgression in the middle of the Subboreal period.
XIV. [Ordrup moor. (Litt. J. Iversen, 1941, p. 61).

A bone. - B-landnam.]
XV. Holmene, Hillerod. I (C. B. Jacobsen, E. Jensen, 1941).
ot Skull and limb bones. - Zone VIII. - B-landnam oldest possible dating.
XVI. Holmene, Hillerod. II (C. B. Jacobsen, E. Jensen, 1941). of Skull and postcranial skeleton. Zone Vili, B 1. J. Iversen in litt. 2.2.1943. (Vide: XXXIII, Søndersø.)
XVII. Borremose, Midt-Falster (I. Kring, 1949). Postcranial skeleton. - Zone ViII, B 1.
XVIII. Sandhuse moor. Jordløse. Lille Aamosen. N.W.Zealand (Harald Andersen). o Incomplete skull. - End of Zone VIII, Subboreal.
XIX. Sandhuse moor. Jordløse. Lille Aåmosen. N.W.Zealand (Harald Andersen). of Skull. - Late Bronze Age or beginning of Iron Age.
XX. [Vejlby. Kiselgurværk. 5 km . N.N.W. of Fredericia. (S. Th. Andersen, Danmarks geologiske Undersøgelse).
Parts of fragmentary skeleton. - Bronze Age.]
XNI. Ero. In the cove of Ærøskøbing (Assessor Steenstrup, 1862).
of Skull. - Zone VIII.
XXII. Logtved Enge. 17 km . E. of Kalundborg. (Saltofte).
ot Brain-case. The middle or late part of Zone VIII.
XXIII. Vikso, Lindebjerggaard, Smørum. 18 km . W.N.W. of Copenhagen. (Thomsen, 1943).
of Fragmentary skull. - Zone VIII.
XXIV. Vikso, Lindebjerggaard, Smørum. 18 km. W.N.W. of Copenhagen. (Simonsen, 1940).
if Fragmentary skull with mandible, parts of postcranial skeleton. Zone VIII.
XXV. [Holt, Alme, Græsted. 5 km . S. of Gilleleje. (Gilleleje Museum, 1941-42). (Lit. A. Andersen, 1943, pp. 64-65 (No. 64). Zone Vili.]
XXVI. [Odense river. N. of Odense, between Seden and Skibshuse. Zone VIII.]
XXVII. Veddinge. 4 km . N. of Faarevejle. N.W.Zealand. (P. Rasmussen, 1909). ô Skull. - Late Bronze Age or early Iron Age. Zones VIII-IX.
XXVIII. Snoldelev II. 8 km. S.S.E. of Roskilde. (Th. Mölby, 1945). ô juvenile. Skull and postcranial skeleton. End of Zone VIII.
XXIX. Bodal. Ondløse. Aamosen. N.W.Zealand. (O. Schram, M. Rasmussen, 1940). ô Skull. Late Bronze Age or early Iron Age. - J. Iversen.
XXX. Mors. (1891).
\& Skull. Beginning of Zone IX. Litt.: Degerbøl, 1963.
XXXI. Gundsomagle. 12 km . N.N.E. of Roskilde (Mosegatrd, 1945). Horn core. Zone Vili.
XXXII. [Rislev. Litt.: U. Møнl, 1962].
XXXIII. Sonderso, Vestergaards moor. (O. A. Andersen, 1941).
ot Skull, skeletal parts. As the pollen analytical dating was uncertain, a C-14 dating was made with the result: $4070 \pm 120$ (before 1950 ) or 2120 B.C. (H. Tauber, in lit. 21.7.1966).

## The Ogaarde Complex I

The earliest skulls of domestic cattle in Denmark are 2 specimens, from a heifer and a subadult bull, at the Ogaarde Complex I, St. Lyng, Aamosen, from the border line between the Atlantic and the Subboreal periods, or Zones VII and VIII, i.e., at the very characteristic Elm decline in the Danish pollen diagrams, or the A-landnam contemporaneous with the first-known agriculture. By C-14 dating tests the age was established to be about 2800 B.C. $(2930+160,2820+80$, Tauber, 1961$)$. From the same locality, but from a little later, the B-landnam or Iversen's landnam, are 2 skulls, belonging to a subadult and an adult cow (Øgaarde II and III).

No. I. (Øgaarde I) comprises considerable parts of a skeleton of a heifer. The skull is almost complete, only the occipital, the right nasal bone and the left premaxilla are missing. All sutures are open, even the suture between the parietale and frontale. The deciduous or milk dentition is present, and of the permanent teeth the 1st and 2nd molar are at hand. In the upper jaw the 1 st molar is slightly worn, whereas the 2 nd molar has not broken through the gum. In the mandible the incisors and the canine teeth have dropped out and a permanent incisor is visible at the bottom of the alveole of the median milk incisor. The 1st molar is worn, but of the 2nd molar only the first lobe is slightly worn. Accordingly the age may be estimated at about a year and a half (Pl. X, No. I).
As the occipital is missing from all-over measurements of length, only the profile or "total-length" can be taken. It is 362 mm ., but when allowance is made for probable changes with growth, the adult length may be estimated to have increased by about $13 \%$ (Klarer, 1953, Table 5, p. 20). Klarer studied the growth in living Allgäuer Braunvieh, of the Bos taurus longifrons group. The increase of the total length of the head (from the top of the head to the hairless part of the muzzle) from the age of one year to the full grown animal, may be calculated at about $20 \%$; from the age of a year and a half to about $13 \%$.
It may thus be estimated that the total length of the Øgaarde skull as an adult would have increased to about 410 mm . or to the size of a fairly small Jersey cow. Also by a comparison with specimens of equal individual age, it appears that the Øgaarde skull is small. The mandible, e.g., is of the same size as the smallest mandibles from the Bundsø settlement, in fact not larger than some mandibles from medieval settlements in Denmark (Table III, No. 1).
The Øgaarde skull No. I has previously been briefly referred to as representing a small cow of the Bos taurus longifrons type (Degerbøl, 1963, p. 74, and 1962, p. 71).

The existence of this type in Denmark at the beginning of the late Stone Age, is furthermore emphasized by an almost complete skull of a cow, and that of an adult specimen, Øgaarde Cow II.

No. IV. Øgaarde-complex, Cow II. In this skull both premaxillae and both nasals are missing, and the left maxilla is anteriorly a little injured. The two anterior premolars of the left side and the first right premolar have dropped out. The posterior third of the
interfrontal suture is closed, however still visible. This in addition to the fairly worn teeth, even the interior column of the posterior molar is worn, indicates an individual about 8 years old (Pl. X, No. IV).
The shape of the skull shows the features ordinary stated as characteristic of the longifrons type, the occipital crest is wavy with a concavity at the base of the horn cores and seen from behind a forward directed Cupid's bow at the middle convexity. The horn cores are very small, but are not set close into the frontal. No doubt, this feature only holds good of weak specimens of the longifrons type. As the premaxilla is missing, the overall length of the skull must be established by comparison with complete skulls of a similar size. A comparison with 3 recent female skulls kept in the Zoological Museum of Copenhagen for more than a hundred years is of particular .nterest. Two of these skulls (No. 860 and No. 861), are labelled "Jydsk Ko" (Jutland cow) and arrived at the Museum in the years 1847 and 1849, respectively. The third skull, attached to a complete skeleton (No. 296), has come from the "Zoo-tomical-Physiological Museum'", which was abolished 1841. Previously this last skull has several times been used at a comparison with a prehistoric material (Degerbol 1939 and 1948, fig. 183).
The greatest length to be measured in Øgaarde Cow II, is the distance from the occipital crest almost to anterior point of the maxilla-premaxillary suture on the palatal plate, medial; it is 435 mm .; exactly the same as in the recent skull No. 296, the total length of which is 475 mm . The distance from the condylus occipitalis to the same point of the maxilla is 395 mm . in Cow II, as compared with 400 mm . in the recent skull, whose condylobasal length is 445 mm . Similarly the distance from the foramen magnum to the point mentioned is 368 and 375 mm ., respectively, and the basal length of the recent skull is 415 mm .
Accordingly, the total length, the condylobasal length and the basal length of the Øgaarde skull may be indicated to $475 \mathrm{~mm} ., 440 \mathrm{~mm}$., and 410 mm ., respectively, thus in fact the same in the two specimens. The Jutland cow (No. 860) is of the same size: condylobasal length 440 mm ., basal length 410 mm . According to the less posteriorly sloping occipital part, however, the total length is shorter, 460 mm . For the sake of comparison, it may be stated that the three above-mentioned measurements, to the maxilla-intermaxillary suture, in this Jutland skull are 415, 395; and 373 mm ., respectively. It should be noted, however, that the length of the frontal (from occipital ridge to nasal base) in the Øgaarde cow is particularly great 235 mm ., as compared with 224 mm . and 200 mm . in the two recent cows. No. 296 and No. 860 ; thus being consistent with the name of longifrons.
Also regarding most width measurements the three skulls, Øgaarde II, Nos. 296 and 860 are similar, e. g., zygomatic width 184,185 , and 191 mm ., respectively, mastoid width 194,200 , and 200 mm ., respectively, palatal width, across $\mathrm{m} 1: 128$, 130 , and 125 mm ., respectively ; interorbital width anteriorly 146,146 , and 143 mm ., respectively, however, the smallest frontal width is fairly narrow in the Øgaarde skull, 148 mm ., as compared with 161 and 159 mm ., in the two recent skulls. As the horn cores in the Øgaarde cow have long "pedicles", the intercornual distances, however, are fairly alike in the three specimens.
When considering these measurements, it should be noted that regarding individual age the Jutland cow (No. 860) is the oldest of the three as seen from the almost closed sutures, more worn teeth, and the partly roofed sulcus supraorbitalis. In this specimen the horn sheaths are present, having conspicuous circular furrows, 13 in all, which probably indicates an age of more than 15 years.
In Øgaarde and the recent skull No. 296 the horn cores are of equal size and fairly
small, the outer curvature about 200 mm ., as compared with 255 mm . of the large horn cores of the Jutland cow (No.860). The corresponding greatest spans of horn cores are 396,397 , and 480 mm . In the Jutland cow the horn sheaths, as already mentioned, are present ; the length along the outer curvature is no less than 425 mm ., the greatest span is 495 mm . With their double curvature, black tips and upward direction they are beautifully shaped, actually in miniature recalling the pictures of the Urus cows from Lasceaux (cf. F. Windels, 1948).
The second specimen of a Jutland cow, No. 861, is smaller. It was said to be a smallholder's cow.

No. V. Of the same geological age as Øgaarde Cow II is a brain-case of a young cow, Øgaarde III. On the frontal side it is broken anteriorly at the nasal base (Pl. X). The sutures are open, almost as in the complete skull from St. Lyng, which indicates an individual age of well over two years. In shape it is similar to Øgaarde Cow II. It is smaller (Table 1), but when fully adult it would have been almost of the same size. This skull thus, furthermore, emphazises the existence of a small cow at that time.

It is a most remarkable fact that these earliest known skulls, and brain-cases, from Denmark represent a Bos taurus longifrons type, in size similar to skulls from the 19 th century. For about 5000 years this phenotype thus has existed in Denmark.

The existence of these small and well characterized domestic cattle clearly emphasizes that the starting of the domestication of cattle must have taken place much earlier than the date of the sites, about 3000 years B.C. These cattle from the Ogaarde complex either must have been imported into Denmark, or evidence of a possible domestication of the large Urus in Denmark must be sought for in much earlier deposits.

No. II. From the very beginning of Zone VIII (A- and B-landnam) furthermore two skulls are at hand, from St. Lyng and Verupgaard, Aamosen.
Holger Jørgensen's bog, St. Lyng.
This skull belonged to a young animal.
In the maxilla the posterior molar (m3) has not fully erupted, only the lateral points show signs of wear. The milk premolars dp. 3 and dp. 4, have been functioning, but have dropped out. Of the permanent premolars, p. 3 has partly erupted, and p. 4 is just visible in the jaw. In the mandible the permanent first premolar, p. 2, has dropped out, the second premolar (p.3) is very slightly worn, whereas p. 4 is concealed in the jaw, which indicates that dp. 4 was still used. The 1 st and $2 n d$ molar are moderately worn, and of the last molar the posterior column is unworn. Hence, the age may be estimated at about $2^{1} / 2^{-3}$ years. With the exception of the maxillo-zygomatic suture, which is almost closed, all sutures, even the suture between supraoccipital and frontal are wide open; no doubt post mortem exaggerated. In the upper part of the supraoccipital bone three large openings into the frontal sinuses are seen.
This skull differs from Øgaarde Skull II by its larger size and particularly broader and posteriorly convex frontal and heavier horn cores. - Pl. X, Table III.
The smallest frontal widths are 180 mm . and 148 mm ., respectively, and the intercornual widths 200 and 148 mm ., respectively. The horn cores are fairly large, at base a little downwards and backwards directed, whereas the smaller horn cores in Øgaarde II are more upturned.

The circumferences at the bases of the horn cores are of the two specimens 205 mm . and 153 mm ., respectively, and the lengths of the outer curvatures are about 250 and 205 mm ., respectively. When full-grown the St. Lyng skull would almost in size and partly also in shape have been similar to an adult skull from Verupgaard, from a slightly later period, the transition to or the beginning of the B-landnam.
No. III. The Verupgaard skull represents a "B. t. frontosus type" with a posteriorly domeshaped frontal, and the occipital crest formed as a projecting boss between the horn cores. The profile is convex, increased by a pronounced elevation medial to the anterior part of the supraorbital sulcus. Although the teeth are fairly much worn the posteriorly molar (m3) just down to the tip of the interior column, which indicates an age of about 7 years - most sutures are unfused. In the occipital area, the temporal sutures are open, as also the suture below and behind the horn cores are unclosed. The interfrontal suture is only fused in its posterior 60 mm . (cf. bullocks p. 152).
For comparison it may be mentioned that in two 4-year old Spanish fighting bulls, in which m 3 is very slightly worn, all sutures in the occipital area are completely closed.

Thus it appears that from the same time, the beginning of the Neolithic Age, and from the same narrow territory, Aamosen, N.W. Zealand, two kinds of skulls of domestic cattle are at hand, originally accepted to represent two different breeds or races: B.t. longifrons and B.t. frontosus. - However, the existence of two breeds of cattle living so to say side by side, under these circumstances is very unlikely. A simple and natural explanation would be, that the small skulls belonged to cows, and the large skulls to bulls; what generally have been considered different races, may be explained as sex dimorphism, a view now generally accepted.

The sex determination of prehistoric domestic cattle must be based on the same characters as mentioned in the Urus. Particularly characteristic of the bull is the broad frontal (smallest frontal width, the inter- and postorbital widths) and the large horn cores. Also the total length of the skulls of prehistoric cattle seems to be larger in bulls than in cows, in contrast to what is the case in modern cattle breeds (Bohlken 1962, p. 600). All in all, the sex dimorphism in prehistoric cattle is fairly large, considerably larger than in recent breeds.

Also from other dated, and many undated, finds of skulls of cattle from Denmark, the difference in shape and size is naturally explained as depending on sex and not on race.

Large skulls as well as smaller skulls are found together in the same settlement and belonging to the same time, as will appear from the following.

No. VI-VIII A. From the "village"'site Troldebjerg, Langeland, from the lower part of Zone VIII, the Early Passage Grave Period, J. Winther (1935, p. 57) has depicted three "sacred bullheads". - Two of these were found already in 1906 in Gammellung bog by peat ketching at the bottom of the moor at a depth of about 4 metres. They were identified by $H$. Winge as "domestic cattle, killed by a blow on the frontal bone, if anything belonging to the brachyceros race, the small one rather typical, the larger one approaching the typical frontosus." The third skull (No. III) was
found later in the same bog, which at the time of the site was a lake. According to Winther these heads must have been sailed out into the lake and sunk there as an offering to the gods.
On a visit to the Langelands Museum I had the opportunity of examining these skulls and of taking samples of the gytja in the skull cavities for pollen analythical examinations. The samples were handed over to Dr. J. Iversen, Danmarks geologiske Undersøgelse, and the result of the analyses (Iversen 1941, p. 58) clearly proved that at Troldebjerg, too, there had been a pronounced occupation phase, Iversen's landnam or the B-landnam.

No. VI. Gammellung moor I, Troldebjerg (Langelands Museum).
$\sigma^{\hat{c}}$ By the blow on the forehead, the frontal bone was fractured, the posterior part was pressed somewhat downward and the left part with the horn core was turned a little forward. The worn teeth and longitudinal ridges on the horn cores indicate a fairly old animal. At the middle of the occipital crest is a faint boss. The nasals are narrow. This skull is somewhat smaller and less robustly built than the Verupgaard skull. (Vide bullocks, p. 160). - Pl. XI, Tab. III.
No. VII. Gammellung moor II, Troldebjerg (Langelands Museum).
\& Incomplete skull broken anteriorly $2-3 \mathrm{~cm}$. in front of the tooth row, upper part of the maxillae and nasals is missing. The upper part of the right frontal is broken at middle, the tips of the horn cores are broken off. As the last premolar, p 4, and the last molar, m 3, are only slightly worn, the age of the animal, when killed, may be estimated at well 3 years. Considering this young age, the skull is very heavy.
In shape this skull is similar to the cow skull from Øgaarde II, however, somewhat shorter.
The length from the occipital crest to the nasal base (in the middle line) is 221 mm . as compared with 240 mm . in the Øgaarde cow, and the lengths to the foramen infraorbitale are 334 and 352 mm ., respectively. More important measurements are the lengths from the condylus occipitalis to the anterior border of the tooth row: 305 and 311 mm ., respectively, and the lengths from the foramen magnum to the anterior border of the row of teeth are 278 and 286 mm ., respectively. On basis of this the total length of the Gammellung cow may be calculated at 455 mm ., the condylobasal length at 430 mm ., and the basal length at 400 mm .
The width of the frontal and the height of the occipital part are practically the same in the two specimens. The least frontal width is 151 mm . as compared with 148 mm . in the Øgaarde cow, the postorbital width is 189 mm . and the largest occipital height 148 mm . in both. The zygomatic width, however, is much larger in the Øgaarde cow, 184 mm ., than in the Gammellung specimen, 172 mm ., whereas the smallest supraoccipital width is smaller, 116 mm ., as compared with 128 mm . in the Langeland specimen, these two measurements are fairly variable.
Also in the shape and size of the horn cores, the two skulls are almost identical. Pl. XI, Table III.
No. Vili. Gammellung moor III, Troldebjerg (Langelands Museum).
o A brain-case broken anteriorly on the left side just in front of the eye-socket, on the right side through the eye-socket; the horn cores are broken well over the middle, they are strongly grooved and posteriorly exceptionally flattened, platymer. The interfrontal suture is closed, and the orbits are very protruding, characters indicating a fairly high individual age, well over 8 years.
It was this brain-case, which Winge characterised as almost a typical frontosus form; the frontal surface is swollen and domed, as seen in this "type".

The length of the brain-case from occipital crest to nasal base is equal to that of Gammellung I, but it is broader, the measurements of width come within the range of variation in bulls and outside the size range in cows. The smallest frontal width is 183 mm ., as compared with 177 mm . in the Gammellung bull and 151 mm . in the Gammellung cow. The postorbital widths are 223,226 , and 189 mm ., respectively. As bulls go, the horn cores are fairly small and weak, and the occipital crest is wavy, with a concavity in the middle, the frontal thus not terminating in a boss as ordinarily seen in bulls. This makes the sex determination fairly uncertain, and the question arises whether this skull perhaps may have belonged to a bullock? The problem of castration in prehistoric cattle is an interesting one, but very difficult to clear up (cf. p. 160). - Pl. XI.
VIII. A. Gammellung moor IV. Troldebjerg 1947.
ot Subadult. Fragmentary brain-case; broken through the os lacrymale and in front of the nasal base. Forehead crushed behind and medially of the supraorbital grooves; the basioccipitale missing, loosened along the open sutures; horn cores very porous. The age may be estimated at nearly a year and a half, a little younger than the Snoldelev II Skull and the recent bull skull, from the Study Collection. In shape it is similar to the last-mentioned skull, particularly marked by the comparatively plane frontal, but it is considerably broader, just as broad as the extremely broad Snoldelev II Skull, which, however, is characterized by the much domed frontal (cf. p. 150). In the Gammellung skull the smallest frontal width is 192 mm ., as compared with 187 mm . in the Snoldelev II Skull. and only 166 mm . in the recent skull; the postorbital widths are 212,210 , and 196 mm ., respectively, and the smallest supraoccipital widths are 130,135 , and 110 mm ., respectively (Table III). The Gammellung IV Skull thus represents a young bull; in shape it is similar to a recent bull skull of equal age, but it is considerably larger and more robust in shape. Pl. XI.
IX. Nyrup moor I.
of Sacrifice by the side of a collared vessel (B-landnam). Skull, without mandibles; the posterior part of the frontal is crushed; the horn cores and the occipital crest are missing, no doubt removed by the Stone Age people. Furthermore, some skeletal parts are preserved: the left radius and the lower part of the ulna, left and right femur, left tibia, one vert. cervicalis, the os coxa. The os coxa was placed above the skull, the limb bones about one metre from the skull.
The hindmost molar is only slightly worn, which indicates an age of well over three years. In size, and also in shape, this skull is similar to a recent skull of a cow which for many years has been kept in the Zoological Study Collection (Table III), thus the basal length is practically identical, 428 and 427 mm ., respectively, and the same holds good of the postorbital width, 201 and 200 mm ., respectively. The teeth, however, are somewhat larger, 139, as compared with 130 mm . in the recent cow.Nyrup Skull I thus is also somewhat larger than Øgaarde Skull II. The distance from the condylus to the maxillo-intermaxillare suture, medial (cf. Ogaarde II) is 405 mm ., as compared with 395 mm . in the Øgaarde cow. This is in good agreement with the fact that the condylobasal length in Nyrup Skull I is 455 mm ., as compared with an estimated condylobasal length of 440 mm . in Øgaarde Skull II. - Pl. XI, Tab. III.
X. Nyrup moor II.
of adult. As was the case in Nyrup Skull I, this skull, too, is a very light yellowbrownish colour, corresponding to the fact that it was found deep in the gytja.

The skull is incomplete, broken in front of the tooth rows, nasals are missing, horn cores broken above middle. On the occipital parts several holes lead into the frontal sinuses, and on the right frontal bone a deep depression indicated a severe blow, dealt when the animal was alive. Interior column of m 3 just worn.
Nyrup Skull II is a little larger than the corresponding part of Skull I. The distance from the occipital condyles to the foramen infraorbitale is 315 mm ., as compared with 300 mm . in Nyrup I, and from the condyle to the anterior border of the 1st premolar, p 2, the distance is 325 and 317 mm ., respectively. From the foramen magnum to p 2 the distance is 298 and 290 mm ., respectively. On the basis of this the condylobasal length may be estimated at 465 mm ., the basal length at 435 mm . Nyrup Skull II is also broader than Skull I, and thus much broader than Ggaarde Skull II. The frontal widths are $164 \mathrm{~mm} ., 158 \mathrm{~mm}$., and 148 mm ., respectively. The posterior part of the frontal is fairly dome-shaped, giving the specimen a slightly frontosus-like aspect; however, the occipital crest is not shaped as a boss, but is wavy as in Øgaarde Cow II. The eye-sockets protrude more than in the two skulls mentioned, the postorbital widths are 206, 201, and 189 mm ., respectively. However, the widths across the first molars ( $\mathrm{ml}-\mathrm{ml}$ ) are fairly equal, $134 \mathrm{~mm} ., 130 \mathrm{~mm}$., and 128 mm. , respectively, and the zygomatic widths are identical in the three specimens, 184 mm . In size Nyrup Skull II is comparable to the Holmene cow (p.146). The horn cores are larger than in Øgaarde Cow II, the circumferences at the base are 175 mm . and 157 mm ., respectively, and the lengths of outer curvature of the reconstructed horn cores are 255 mm . and 220, respectively; however, equal to the horn cores in the recent skull of the Jutland cow, No. 860. Pl. XI, Table III.
X. A. Nyrup moor III.
\& Almost complete skull. Nasals, about 10 mm . of the anterior rim of premaxilla, 2 anterior premolars, the right m 2 and the tip of the horn cores are missing. The interfrontal suture posteriorly fused and the tip of the interior column of m 3 worn, indicating the age of about 5 years. The occipital crest is convex, forming a boss between the horn cores. Peculiar to this skull is a well marked longitudinal elevation on each side of the frontal, from the supraorbital groove stretching almost to the occipital crest.
This skull is the smallest of the Nyrup skulls; the basal length is 403 mm ., as compared with 427 mm . in Nyrup I Skull, and the smallest frontal width is 153 mm ., as compared with 158 mm . in Nyrup I Skull, and 164 mm . in Nyrup II Skull, but all in all, it emphasizes the existence of a fairly uniform breed in the Nyrup area. Pl. XI.

## XI. Snoldelev. Aamosen.

$\hat{\sigma}$ An almost complete skull; only the outer half of the right horn core and the tip of left horn core are missing. The worn teeth and partly closed supraorbital sulcus indicate a fairly old animal. In the configuration of the forehead and the horn cores this skull is Urus-like. The occipital crest is fairly straight, only with a concavity at the base of the horn cores, which just from the base are directed immediately upwards and outwards as in B. primigenius, whereas in most prehistoric domestic cattle the base of the horn cores are directed a little downwards, and thus placed below the frontal plane. A line connecting the most posterior part of the horn cores runs behind the occipital crest. The frontal part between the orbits, it is true, forms a single large concavity, without the two longitudinal ridges generally seen in B. primigenius. However, as found in the Danish Urus skulls, this character is fairly variable. In several skulls of Urus cows (Store Taastrup, Bjeverskov, Mørkøv,

Grænge) the frontal bone between the orbits is concave, too, and the same holds good of some male skulls (Mors, Knabstrup, No.9), in which the roofs of the orbits are more elevated than the frontal parts between the orbits.
The Snoldelev skull thus is a representative of the type which has been called the B. t. primigenius.

But how is the occurrence of this fairly isolated form to be explained?
The relatively small size, basal length 435 mm . and short upper row of teeth, 125 mm . indicates that the Snoldelev animal is not the result of interbreeding with the Urus. Furthermore, at that time the Urus was extinct on Zealand. Probably the Snoldelev skull only represents an extreme form of a variable population.
This slightly built and fairly small skull with the well raised horn cores might give one an impression of a female skull. However, i.a. the broad frontal - the smallest frontal width is 184 mm . - indicates a bull. - Pl. XII.

From Vedbæk three skulls of bulls are present.
XII. Vedbæk I.
of A fairly complete skull with mandibles, several vertebrae and ribs. Nasals, a single premolar and the tip of the left horn core are missing. The last molar, m 3, is still concealed in the jaw; of the second molar, $m$ 2, only the very tips are slightly worn, the last two premolars are milk premolars, dp 3 and dp 4 . On the basis of this the age may be estimated at about a year and a half, thus about one year younger than the prehistoric bull skull from St. Lyng (Holger Jørgensens moor) No. II. Considering this age-difference the Vedbæk skull is in shape similar to the Aamose skull. The Vedbæk skull may be compared with a recent bull skull of equal age, for many years kept in the Zoological Study Collection. It is longer than this specimen and comparatively much slenderer. Particularly the total length is longer, 484 mm ., as compared with 440 mm . in the recent skull. When full-grown the Vedbæk skull probably would have attained the same size as the Verupgaard skull. The smallest frontal width is 161 mm ., as compared with 166 mm . in the recent bull skull, postorbital widths are 190 and 196 mm ., respectively. The teeth are much longer in the prehistoric skull. Although the degree of eruption is equal in the two specimens, the lengths of the rows of teeth are 145 and 132 mm ., respectively, however, the teeth are broader in the recent skull. In the skull from St. Lyng the tooth row is 149 mm . long. - Pl. XII.
XIII. Maglemosegaard, Vedbæk II.
ô This almost complete skull belonged to an adult, but fairly young animal about 4 years old; in the hindmost upper molar the interior column is still unworn. With a condylobasal length of 480 mm . it is of the same dimensions as the skull from Verupgaard. It is a well-shaped skull, in shape very Urus-like, almost an Urus skull in miniature. The occipital crest is only a little more convex and the relief of the frontal region is not so sharply indicated as in the Urus, but looks a little swollen. The posterior part of the frontal is broader than in most Urus cows, the shortest width between horn cores on the occipital crest is 210 mm ., as compared with 190 mm . in the Pindstrup skull and 156 mm . in the Grænge skull, and the shortest frontal widths are 188,178 , and 180 mm ., respectively. The width across the posterior rim of the orbits (postorbital width), however, is, as previously emphasized, comparatively large in the Urus, the respective measurements being 237,230 , and 244 mm . In most other width measurements the Vedbæk skull is also comparable to the smaller Urus cows, the mastoid width, e.g., is 232 mm ., as compared with 225 mm . and
about 236 mm . in the Pindstrup and Grænge skulls, and the zygomatic widths are 205, 207 and 201 mm respectively
Quite different from the Urus, however, is the very short row of teeth, the lengths are 138,162 , and 161 mm ., respectively, and the shorter horn cores, the outer curvatures of which measure about 310,365 , and 390 mm ., respectively. Furthermore, the horn cores are not so much upwards directed as in the Urus cows, which in connection with the larger frontal width in the Maglemosegaard specimen gives the astonishing result that the greatest span of the horn cores nevertheless is larger in the domestic Vedbæk skull, 590 mm ., than in the two Urus skulls, 500 and 577 mm ., respectively. A clear domestic feature is the small metapodials (cf. p. 156). - Pl. XII.

On the basis of this skull it might perhaps be tempting to speak about interbreeding with $B$. primigenius. However, here, too, the geological age of the specimen, the Bronze Age or possibly the Iron Age, clearly indicates that such interbreeding could not have occurred on Zealand, nor probably in Denmark.
XIII. A. Vedbæk III.
${ }^{\star}$ A large, typical "frontosus" skull; frontal strongly dome-shaped and occipital ridge posteriorly forming a large projecting boss between the stalked horn cores. A fracture in the frontal indicates that the animal was felled. The dorsal part of the facial region in front of the os lacrymale is fragmentary, nasals and the anterior part of premaxillare are missing, which also applies to the os exoccipitale, which has come loose along the open suture. P4 and m 3 slightly worn, indicating an age of 3-4 years, nevertheless all sutures are unfused.
In size this skull is equal to the above-mentioned skull from Maglemosegaard, Vedbæk II, thus from the same locality and time, but in shape it is quite different. As the premaxillare has broken through the maxillar suture and the os occipitale is missing, no overall length can be stated. The largest length that may be measured is from the occipital crest to the said suture on the palatal plate, 508 mm ., as compared with 504 on the Maglemosegaard skull; and also most other measurements are identical (cf. Table III). Accordingly, the total length, or profile length, is about 550 mm . As also from a judgment of the wear of the teeth, the individual age of the two specimens is almost the same, the basal length and the condylobasal length may be identical, 455 and 480 mm ., respectively.
As appears from the description of the two skulls, the Vedbæk III specimen is in the shape of the forehead quite different from the Maglemosegaard specimen. In Vedbæk III the posterior half of the frontal bone is very convex, almost formed as a roof ridge, and medially to the supraorbital grooves, in the region of the posterior part of the orbits, there are well marked swellings, which give the skull a fairly convex profile, almost as seen in the Verupgaard skull and in the recent bullock skull kept in the Study Collection. The horn cores are outwards and downwards directed; 80 mm . from the horn base the broken horns are 15 mm . below a horizontal plane through the interfrontal suture, whereas the horn cores in the Maglemosegaard skull are upwards and more backwards directed (cf. bullocks p. 157). Pl. XII.

XV-XVI. Holmene, Hillerod.
From a bog near Hillerød two large and in fact complete skulls are known, one of which, however, has a large hole in the frontal ( 114 mm . long and 95 mm . broad); no doubt the animal was felled. The size and shape of these skulls at once indicate that a bull and a cow are represented. It is the bull that has been killed by a severe blow on the frontal. The skulls must have belonged to fairly old animals. In the
cow the teeth are so much worn that the roots of m 2 is just visible. In the bull skull three molars are present, very much worn, height of crown, interiorly, of m 1 is only 5 mm . The horn cores are strongly grooved.
A comparison of the two skulls will demonstrate the typical sex dimorphism in prehistoric cattle. In the form of the skull the bull is, with its dome-shaped frontal, typically frontosus-like, while the cow with an almost plane frontal is a "longifrons type" of large size. The bull skull is much larger and broader than the cow skull. The basal lengths are 497 and 426 mm ., respectively, the smallest frontal widths are 208 and 159 mm . respectively, and the postorbital widths 257 and 220 mm ., respectively. The length of the tooth row, however, is the same in the two skulls, 137 and 139 mm ., respectively. Considering that the bull skull is the largest in the Danish dated material, the horn cores are small and compressed at the base (platymer). The greatest span is 556 mm . (cf. bullocks, p. 156).
Also the cow skull is large, together with the Nyrup skulls belonging to the largest of the dated cow skulls. Exceptionally large, however, are the widths across the orbits, the post- and interorbital widths, 220 and 162 mm ., respectively, as compared with 206 and 146 mm ., respectively, in the Nyrup Skull II, whereas the smallest frontal widths are practically equal, 159 and 162 mm ., in the two specimens.

Pl. XII.
XVII. (Borremose, long limb bones.)

Also from Jordlose, Sandhuse moor, two skulls, of females, are present, one narrowly built, the other fairly broad.
XVIII. Sandhuse moor I, Jordlose, Lille Aamose (Harald Andersen 489/46, K XXXIX 19). \& Skull. A large, irregular hole, about $65 \times 65 \mathrm{~mm}$. in diameter, and with crushed sides, indicates that this animal was felled. The individual age is similar to that of the Nyrup Skull I. Thus a little younger than the Øgaarde Cow II. In shape and length it is similar to the last-mentioned skull, though narrower. The condylobasal length of the two skulls is the same 440 mm ., and the same holds good of the smallest frontal width 148 mm ., but all other measurements of widths are much smaller in the Jordløse cow. The distance between horn cores at the occipital crest is 132 and 148 mm ., respectively, and the horn cores are much shorter; the greatest span is 316 and 395 mm ., respectively. Also the facial part of the skull is narrower; the greatest widths of the maxillae, at the zygomatic suture, are 136 and 145 mm , respectively, and on the outer side of m 2124 and 130 mm ., respectively. The zygomatic widths are 172 and 184 mm ., respectively. In time this lightly formed skull originates from the transition between Zones VIII and IX. - PI. XIII.
XIX. Sandhuse moor II, Jordlose.
\& This incomplete skull was felled and no doubt was a sacrifice. The hole in the frontal is almost circular, $40 \times 40 \mathrm{~mm}$. in diameters. The left mandible is present, the processus angularis is split open, probably for taking out the marrow. This skull is broken through the anterior part of the tooth row. On the left side the posterior margin of the foramen infraorbitale is visible. Of premolars only the posterior one, p 4, is present, just erupting from the palatal plate; laterally to this tooth the alveoles of dp 4 are found, indicating that this milk premolar still was functioning. Of the hindmost molar, m 3 , only the first column is laterally slightly worn. - Of the lower premolars only p 3 has almost erupted, but is not worn, and the same holds good of the posterior column of the lower, hindmost molar, indicating an age of about two years and a half.

As the anterior part of the facial region is missing, the measurements of total length, condylobasal length and basal length cannot be taken, but may be replaced by measurements to the anterior border of the mandible, placed on the skull. The difference between these sets of measurements is not great, in this skull the condylobasal length and the basal length may be about 10 mm . longer than the respective measurements to the anterior point of the mandibles. - After this the condylobasal length and the basal length are about 415 and 390 mm ., respectively, i.e., about 25 mm . shorter than those of the Jordløse Skull I. The correctness of these dimensions is emphasized by the fact that the same proportion exists in the respective distance to the foramen infraorbitale - the longest measurement that can be taken in Skull II - in the two skulls, 300 and 278 mm ., respectively. When full-grown, however, the length of the subadult skull II may have increased by about 6 per cent., or about 25 mm ., and thus attained the same length as skull I. Although it is broader than this skull and the frontal is fairly dome-shaped, it no doubt belonged to a cow, too. The horn cores are directed fairly upwards, proportionally long and thin. The largest length of outer curvature is now 275 mm ., but as the tip is broken off, the original length may be estimated at 305 mm ., the largest horn cores of the females dated. The circumference at the base, however, is only 160 mm . - Pl. XIII.
XXI. Ero.
o The Aro skull is broken anteriorly, about 50 mm . in front of the tooth row or 65 mm . in front of the foramen infraorbitale. The outer parts of the horn cores are missing. It belonged to an adult animal, in which the teeth have been worn to such an extent that the medial column of the last molar, m 3, has become worn down. However, the interfrontal suture is conspicuous in its total length, and even the sinuated inter-parietal suture is visible on the frontal region. In the middle the occipital crest is concave.
As the anterior part of the premaxilla has been broken off, the overall length cannot be immediately measured, but in length this skull may be estimated to be a little longer than the Verup skull. - The distance from the occipital condyles to the said fracture in front of the tooth row is 410 mm ., which is 10 mm . longer than the corresponding distance in the Verup skull, the condylobasal length of which is 495 mm . From the anterior border of the foramen magnum to the said fracture the length is 382 mm ., as compared with 370 mm . to the corresponding point in the Verup skull, which has a basal length of 465 mm . Accordingly, the condylobasal length of the Ærø skull may be estimated at about 505 mm ., the basal length at 475 mm . similarly the total length may be calculated at 555 mm . It should be noted that other length measurements are equal in the two specimens. The length from the occipital ridge to the foramen infraorbitale is 400 mm . in both and the lengths from the occipital condyle to the same foramen are 341 and 342 mm ., respectively. This means that the muzzle proper was longer in the Ærø skull than in the Verup skull. A characteristic feature of the Ærø skull is the very broad frontal region, which is fairly domed with a marked hump or protuberance posterior and medial to the raised roof of the orbits, separated from these by the supraorbital sulcus.
The smallest width of the frontal is 204 mm ., which in the Danish material is only surpassed a little by the large Holmene skull, ô, and the Sønderso skull, in which the corresponding measurement is 208 mm .
The distances between the horn cores, at the occipital crest, are 192, 220, and 189 mm ., respectively, surpassing even the corresponding measurements in the Urus cows. However, as mentioned above under Vedbæk II, the orbits are much more protruding in the Urus as seen in the larger post- and interorbital widths. - This
in connection with the exceptionally long and twisted horn cores, which are outward directed, and in relation to age fairly open suture may probably indicate that the Æro skull belonged to a bullock. - Pl. XIII.

## XXII. Logtved Enge.

ô Brain-case. Adult specimen with grooved horn cores and posterior part of interfrontal suture closed. Broken in front of the os lacrymale, nasal base visible; outer part of horn cores and lower part of skull missing. Posterior part of frontal almost plane and entirely without any swelling between the bases of the horn cores. Occipital crest with a pronounced concavity in the middle. - Pl. XIII.
XXIII. Vikso. Remains of two females from Zone Vili.
\& Fragmentary skull of subadult animal. Upper part severely damaged, felled. The posterior part of the right frontal bone and the upper part of the facial region are missing. Left horn core cut off at base. The posterior molar (m3) is just cutting the maxillary bone; m 2 is very faintly worn and the milk premolars are present; dp 2 and right dp 3 have dropped out.
Age at death almost two years.
When full-grown probably in size dimensions as the Sandhuse Cow II.
XXIV. if Parts of skull, but so severely broken that it cannot be assembled; left mandible; some vertebrae (atlas, epistropheus, vert. thoracalis, vert. lumbalis, vert. sacralis, vert. coccygis), several ribs, 2 scapulae, 2 humeri, 2 antebrachia, part of tibia, 2 metacarpi, 2 metatarsi, 1 phalanx. - Adult but young animal with $m 3$ slightly worn. In the lower jaw the posterior column of $m 3$ is not worn, and the third premolar ( p 4 ) is but very slightly worn. The age at death about three years.
These bones represent a very small cow. In size dimensions the skull is comparable to the small cow skull from Mors, Zone IX. The distance from the hind border of the fossa glenoidalis to the anterior point of the maxilla is the same, 305 mm ., and the lengths of the upper tooth rows are 122 mm . and 120 mm ., respectively. The limb bones are dwarfish. The metacarpus length, e.g., is 187 mm . and the diaphyseal width is 22 mm . (Cf. Tables 11-12).
XXVII. Veddinge, Faarevejle.
$\hat{\sigma}$ As was the case with the Ero skull, the Veddinge skull, too, is broken through the premaxilla, 37 mm . in front of the tooth row and 45 mm . in front of the foramen infraorbitale. This skull is a very fine example of the "frontosus" form. The frontal is dome-shaped, and the uniformly rounded sides slope gently outwardly, the frontal part between the horn cores are uniformly rounded, and the occipital crest is strongly convex. Interior column of m 3 worn.
In shape the Veddinge skull, so to say, is a refined edition of the Verup skull, and also in size it is equal to this skull.
The distance from the occipital condyle to the fracture mentioned is the same in the two specimens, 380 mm ., as also the lengths to the foramen infraorbitale and to the anterior end of the tooth rows are similar. Thus also the condylobasal lengths may be estimated to be equal, 495 mm .
The distances from the foramen magnum to the said fracture, however, are some mm.s longer in the Veddinge skull; thus the basal length must have been about 470 mm ., as compared with 465 mm . in the Verup skull. - Calculated in the same manner also the total length is equal in the two specimens, 545 mm .
Width measurements also agree. The postorbital widths are 234 and 235 mm . respectively, and the interorbital widths 171 and 175 mm ., respectively. However,
the smallest frontal width is narrower in the Veddinge skull, 184 mm ., a compared with 193 mm . in the Verup skull; whereas the maxillary widths (across the molars) are larger in the Veddinge skull, 145 and 135 mm ., respectively, and particularly the mastoid widths and the supraoccipital widths are larger, 249 and 171 mm ., as compared with 230 and 154 mm . in the Verup skull. - Pl. XIII.

## XXVIII. Snoldelev II.

$\delta^{1}$ Almost complete skull, only the nasals and the outer half of the left horn core are missing. It represents a subadult animal. The last molar has not erupted, only the anterior half of m 2 is very slightly worn and all milk premolars are present. Thus it is almost at the same age, one year and a half, as Vedbæk Skull I and a recent bull skull kept in the Study Collection. However, it is shorter, and much more strongly built than these skulls. The frontal is domed, extremely broad, and the horn cores are much thicker. In shape it is thus quite unlike the slenderly built Vedbæk Skull I, but conforms better to the shorter and broader recent skull. The condylobasal lengths in the three skulls are 409,432 and 419 mm ., respectively, however, regarding basal length this Snoldelev skull is only 6 mm . shorter than the recent skull, 381 and 387 mm ., respectively. Due to the heavy and convex occipital crest in the Snoldelev skull the total length of this specimen is much larger, 458 mm ., than is the case in the recent skull, 440 mm .
The smallest frontal width in the Snoldelev skull is 187 mm ., as compared with only 166 mm . in the recent skull and 161 mm . in Vedbæk Skull I; and the postorbital widths are 210 mm ., 196 mm ., and 190 mm ., respectively. The large width of the Snoldelev brain-case is also demonstrated in the large supraoccipital width (distance between the posterior openings of the temporal fossae), 135, as compared with 110 mm . in the recent skull; as also the height of the occipital part is considerable, from the upper border of the foramen magnum, 124 mm ., as compared with 110 mm . in the recent skull. However, the mastoid width, the zygomatic width and the condylus occipital width are equal in the two skulls, and the palatal width, across the first molar, is even larger in the recent animal, 124, as against 118 mm . in the Snoldelev skull.
The very broad and dome-shaped frontal in the Snoldelev skull may suggest a skull of a bullock. However, the horn cores are conical and fairly short as seen in bulls, the outer curvature is 228 mm ., circumference at base 214, as compared with 200 mm . and 170 mm ., respectively, in the recent bull skull. - Pl. XIII.
XXIX. Bodal, Ondlose, Aamosen.
of Complete skull, only the premolars have dropped out, and the tips of the horn cores are missing. The frontal is only faintly convex. The occipital crest is somewhat raised between the horn cores, but does not form a pronounced domed convexity as in the "frontosus" variety, and the outline of the occipital crest is wavy.
The Bodal skull belonged to an adult animal. The teeth are worn, the posterior part of the interfrontal suture is closed and the horn cores are strongly grooved. The basallength is 480 mm ., only surpassed by the very large skull from Holmene I. Regarding several measurements, a skull this size is within the range of variation in Urus cows. A comparison, e.g., with the relatively large skull of the Urus cow from Bjeverskov (No. 21) is illustrative of the similarities and differences between domestic cattle and the Urus. - In size of the frontal the two specimens are almost equal. The smallest frontal width is 3 mm . broader in the Bodal skull, 191 mm ., than in the Bjeverskov skull, 188 mm ., whereas, in accordance with the general rule, the postorbital width in domestic cattle is relatively smaller than in Urus,

244 mm . in the Bodal skull, as compared with 250 mm . in the Bjeverskov skull. Also the zygomatic widths are equal, 213 and 214 mm ., respectively. As an Urus the Bjeverskov skull has fairly small horn cores, in fact it is almost equal to the Bodal skull. The length of the outer curvatures of the restored horn cores are 400 and 385 mm ., respectively, the circumference at the base is a little smaller, 230 mm ., as compared with 240 mm . in the Bodal skull; the diameters are $77 \times 67 \mathrm{~mm}$. and $81 \times 67 \mathrm{~mm}$., respectively.
From these measurements it appears that in this case it is not possible on the basis of size alone to distinguish between even the horn cores of the two specimens, the Urus and the domestic ox. In shape, however, the forehead of the two skulls are quite dissimilar. The posterior part of the frontal region in the Bjeverskov skull is concave and of a typical Urus contouring (cf. p. 55), in the Bodal skull convex as in domestic cattle. The longitudinal grooves of the horn cores, even in the very old female Urus from Bjeverskov, are fine and very narrow, but in the Bodal bull they are very broad, up to 10 mm . deep and with almost perpendicular sides, in fact more pronounced than even in old Urus bulls, where these grooves generally have more rounded walls.
In length, however, the Bjeverskov skull is larger than the Bodal skull. The distance from the foramen magnum to the anterior border of the row of teeth is 355 mm . as compared with 336 mm . in the Bodal skull, which gives a difference of 19 mm . From the occipital condyle to the same point the lengths are 388 mm . and 362 mm ., respectively. The greater difference in these measurements, 26 mm ., is partly explained by the larger condyles and the narrower anterior border of the foramen magnum in the Urus skull. Still greater are the differences in length from the occipital crest to the said anterior border of the tooth row, 465 mm . and 420 mm ., respectively. The height of the occipital region is considerable larger in the Bjeverskov skull. The heights from the upper and lower border of foramen magnum are in the Bjeverskov skull 154 mm . and 192 mm ., respectively, in the Bodal skull 126 and 173 mm ., respectively. - Pl. XIII.
XXXI. ot Gundsomagle. A very thick, compressed horn core, the tip missing. The deep longitudinal grooves and obliterated sutures beneath the horn core indicate an old animal. Circumference at base 280 mm ., diametres $98 \times 67 \mathrm{~mm}$.
XXXIII. Sonderso.
ô A fragmentary skull, mandibles and some posteranial skeletal parts.
Also this skull is broken through the premaxilla, 52 mm . in front of tooth row and 70 mm . in front of the foramen infraorbitale. The left maxilla containing teeth is broken off, but at hand. In the right maxilla all teeth have dropped out. The outer part of the horn cores are missing.
Just as in similar broken skulls the overall length must be calculated by measuring the greatest length possible and by comparing these measurements with corresponding distances in complete skulls of similar dimensions. In this case the Søndersø skull is compared with the Bodal skull and the Holmene male skull.
In the Søndersø skull the distance from the occipital crest to the fracture mentioned is 480 mm ., as compared with the corresponding lengths in the Bodal skull and in the Holmene skull, 455 and 490 mm ., respectively. The total lengths of these two skulls are 546 and 585 mm ., respectively. Accordingly the total length in the Sondersø skull may be calculated at 575 mm . - The distances from the condylus occipitalis to the said fracture on the three skulls are 405,405 , and 423 mm ., respectively, and the condylobasal length in the Sønderso skull may be estimated at same length
as found in the Bodal skull, 505 mm . The length from the anterior border of the foramen magnum to the same fracture is in the Sønderso skull 380 mm ., and the corresponding length in the two other skulls are 385 and 400 mm ., respectively. The basal length in the Sønderso skull is calculated at 480 mm ., as in the Bodal skull.
In the Søndersø skull the teeth are worn, p 2 relatively much worn, the interfrontal suture is closed in the posterior third and the horn cores are grooved. It is of about the same individual age as the Bodal skull.
A faint swelling of the frontal sinuses has caused an almost plane frontal bone, completely missing the typical relief of this bone in the Urus. The occipital crest is wavy, with a deep concavity at the base of the horn cores and a faint concavity in the middle. The frontal is very broad; the smallest frontal width is, as in the Holmene bull, 208 mm ., (the largest measurements in the Danish domestic oxen). In the large female Urus skull from Ullerslev the corresponding width is only 203 mm .
In the Søndersø specimen the horn cores are remarkably thick, the thickest in all Danish domestic oxen, and heavier than in most Urus cows. The circumference at the base is 265 mm .; diameters at the base $93 \times 71 \mathrm{~mm}$.; only in the large Urus cows from Ullerslev, Toftum, and Flintinge the horn cores are just as thick, circumferences 270,264 and 270 mm ., respectively, and diameters $94 \times 74,90 \times 74$, and $89 \times 84 \mathrm{~mm}$., respectively. - The length of the tooth row in the Søndersø skull, however, is typical of the domestic ox, 142 mm ., as compared with 162 mm . in the Ullerslev cow (Pl. XIII).
As a pollen analytical dating of the Sønderso skull was highly uncertain, but might indicate a comparatively late period, Bronze Age or Iron Age, I asked the C14laboratory to try to carry out a C14-dating. The result was that the find belonged to a fairly early period, 2120 years B.C. ( $4070 \pm 120$ before 1950). - Cf. limb bones p. 159.

## Were bullocks represented in the Neolithic Period in Denmark

The possibility of proving the presence of remains of castrated bulls, bullocks, or steers, from prehistoric times has been much discussed. It is of course an important problem, but available evidence for castration is often self-contradictory and unconvincing (Wertnik 1926, Nobis 1954, Bohlken 1962, Jewell 1962, Howard 1962, Bachmann 1962, Imhof 1964).

The castration involves a retarded development of the animal, the sutures fuse later or not at all (Figdor, 1927). Bullocks therefore have longer, but comparatively narrower, limb bones than sex animals.

It is generally claimed that the bulls have the shortest and most conical shaped horn cores; the bullocks the longest horns, which are gradually decreasing in thickness towards the tip, whereas the cows occupy an intermediate shape. The circumference of the base of horn cores should be greatest in bulls, smallest in cows. The forehead in bullocks is stated to be narrow (Nobis, 1954, p. 160) or broad. This may generally be so in some modern breeds, however, the shape and size of horn cores are very variable in different breeds. In the Spanish fighting bulls the horn cores thus are not short and conically shaped, and this no doubt also holds good of prehistoric domestic cattle.

In fact, a certain sex determination, particularly regarding the existence of bul-
locks, is only possible, when the bones compared belong to the same breed or animal population. Regarding prehistoric remains this means that a fairly comprehensive amount of skeletal parts from a comparatively limited area and space of time must be at hand.

My experience from living bullocks in Denmark is that the variation of the horn cores, in shape as well as in size is very large. The horn cores may even be short and compressed at the base, platymer, and directed more or less downwards, but generally the horn cores are long and robust and directed outward-upwards. This, however, may also be different in different breeds.

In the Institute für Züchtungsbiologie, Wien, I have had an opportunity to study some skulls of bullocks. They are very different in shape. In one, from Austria, the forehead is flat and narrow, the horn cores are raised and the span is fairly small, but in a couple of bullocks of the Hungarian steppe cattle the forehead is very broad, flat, or dome-shaped (Bohlken, 1962, p. 396, fig. 30). - The great variation in the skulls of bullocks partly depends on the question in what period of the animal's life the castration took place.

As already mentioned, three Bos skulls are kept in the Zoological Study Collection in Copenhagen, labelled as cow, bullock, and bull (cf. p. 143). - The cow skull must have belonged to an adult and fairly old animal with worn teeth.

In the bullock skull the tips of m 3 are just slightly worn, indicating an age of about three years.

The age of the bull skull may be estimated at about two years. In spite of this young age the frontal is very broad, the smallest frontal width is 185 mm . and the horn cores are turned outwards.

As compared with the bull, the bullock skull is conspicuous by its small width between the horn cores, 120 mm . ; the frontal is swollen and faintly spongy, giving a convex profile.

This corresponds fairly well with the descriptions given by Wertnik (1926).This author has compared 9 skulls of recent bullocks, castrated at an early age, with skulls of cows and bulls. He states that a characteristic feature in the skulls of bullocks is a conspicuous bending or convexity of the frontal and nasal region, particularly the nasal base is arched, as in a ram's head, as also may be seen in living bullocks. Besides the occurrence of the longer but relatively narrower horn cores he emphasizes that the zygomatic width, the palatal width, and the width across the premaxillaries are smaller than in both cows and bulls, giving the impression of a more conical skull. Furthermore the basal length of the premaxillary is shorter in bullocks.

Evidence of a possible existence of bullocks in a prehistoric material thus no doubt must be based on general observations and considerations in connection with numerical calculations.

As horn cores, fragmentary frontal parts, and metapodials are fairly numerous in Neolithic settlements from different parts of Europe, a considerable material of these remains for comparison is present.

Nobis, in examining prehistoric remains (1954) distinguishes between horn cores of cows, bulls, and bullocks. He states that in 11 cows the circumferences of the horn cores vary between 150 and 176 mm ., in 5 bulls between 199 and 210 mm .; but in 4 bullocks the circumferences are $218,220,223$, and 268 mm . (No. 6 , subadult).

In a scatter diagram, in which the circumference at base of horn cores is plotted against the horn core indices (smallest diameter $\times 100 /$ greatest diameter), Nobis demonstrated that the bullocks with their lower indices are placed outside, below, the range of the bulls. If the Danish males are inserted in this diagram it appears that most of them are placed with the bullocks, only one, from Maglemosegaard, is placed with the bulls, and a second skull, from Bodal, lies on the border line between bulls and bullocks.

Survey of the variation of the circumference of horn cores in Neolithic cattle, 106 specimens in all, have furthermore been given by Bachmann (1962) and Imhof (1964) on the basis of the literature. Bachmann (p.19) states that the size range in cows is between 122 and 190 mm . The greatest measurements, from 245 to 268 mm ., come from bullocks only, whereas measurements below that boundary may be due to bulls as well as bullocks. According to this the Danish skulls from Bodal ( 245 mm .), Gammellung I ( 257 mm .) and Sondersø ( 265 mm .) unquestionable should belong to bullocks.

Imhof has re-investigated the cattle remains from early Swiss settlements, from Bielersee and Neuenburger See, which originally, at the latter half of the 19 th century, were studied particularly by Rütimeyer, Studer, and David. He obtained the result that the great variation stated in this material in fact is not based on the existence of different races (brachyceros, frontosus) but is explained by sex only, and he furthermore is of the opinion that besides remains of cows, bulls, and bullocks of domestic cattle also horn cores of Urus are at hand. Imhof claims that some of the large horn cores stated by Nobis and Bachmann (loc. cit.) as belonging to bullocks in fact originate from the Urus. This applies, e.g., to the bullock of Nobis (No. 6) with a circumference of 268 mm . and a length of outer curvature of 440 mm .

Considering that this skull fragment belonged to a subadult animal, this interpretation may be right. It is true that in the two large Danish domestic skulls from Søndersø and Ærø, the corresponding measurements are 265 and 415 mm ., respectively (Søndersø), and 235 and 445 mm . (Ærø), but a better accordance is seen in the measurements of the large Urus cow from Ullerslev: 270 mm . and 450 mm ., respectively. These examples clearly show that a certain identification on the basis of the said two measurements alone is not possible.

Like Nobis also Imhof has a scatter diagram, in which the circumference at the base of the horn cores is plotted against the said index. In this case, too, the range of the bullocks is stated generally to be outside the range of bulls, but not below, as in the diagram of Nobis, but above the range of bulls. Corresponding to the more rounded horn cores in bullocks, the indices are higher than in the more flattened horn cores of bulls. In the bullocks the index is above 79, in bulls below (IMmof).

Entered in this diagram, however, the Bodal- and Maglemosegaard-skulls (index
82) are not, as in the diagram by Nobis, plotted together with bulls but on the border line to female Urus.

According to Imhof horn cores which along the outer curvature are longer than 300 mm ., and the circumference of which at the base is more than 210 mm ., belong to bullocks.

Hence, most of the large Danish skulls should belong to bullocks: Aro 430 (235), Sondersø 415 (265), Bodal 385 (245), Snoldelev I 380 (232), Verupgaard 375 (230), Maglemosegaard or Vedbæk II 340 (220), Gammellung I 335 (257), Holmene I 305 (240); and probably also Veddinge 295 (214).

Also Jewell (1962), in dealing with some large skulls from the Neolithic site at Maiden Castle which originally were considered by Jackson (1943) to represent a $B$. t. primigenius type of domestic ox, doubts this identification, and he is of the opinion that these skulls in fact belong to the Urus. The circumferences of the bases of three horn cores are stated to be 245 (II), 217 (III) and 228 mm . (IV). The last two measures, however, are not very large even in domestic animals, and a circumference of 245 mm . is found in the Danish Bodal skull; and in the skull from Langeland, in time belonging to the B-landnam, the circumference is 257 mm . Thus these measurements are not decisive; they emphasize that a reliable determination is not possible on the said basisJEWELL, however, furthermore states that the length of the outer curvature of the thick horn core (II) is 615 mm ., and so large a measure, in the middle of the size range in primigenius bulls, clearly indicates a Urus. The same probably applies to the other two specimens, No. III with a length of outer curvature of 445 mm ., and No. IV, in which the greatest width of the occipital condyles is 127 mm . (cf. fig. 13, p. 77).Also from the Neolithic site Wind Mill Hill the circumferences of three horn cores are stated: 145,168 , and 220 mm . A comparison of these measurements with the Danish graphs, based on complete skulls, however, clearly indicates domestic animals. As the result of this revision JEWELL claims that evidence for very large, long-horned domestic Neolithic oxen in Britain has not been substantiated.

On the basis of skull indices (occipital height/frontal breadth and occipital breadth/occipital height) Miss Howard (1962) tries to give an easy means of sexdetermination. In males the O.H./F.B. index is lower than the O.B./O.H. index, in females reversely. An exception from this rule, however, makes the immature bulls, which in the highest results of O.H./F.B. index agree with the results obtained from the female skulls. Unfortunately, the indices of the bullocks are now on one side, now on the other. The identification of bullocks, however, may be shown in a scatter-diagram, in which the frontal breadth is plotted against the O.B./O.H. index Here the bulls are separated by their greater frontal breadth, while the large bullocks are grouped with the cows.

In the Danish skulls of domestic males two specimens have the O.H./F.B. index higher than the O.B./O.H. index: Maglemosegaard (Vedbrek II), with the indices 96 and 89 respectively and Langeland I, 97 and 77 respectively, as ordinarily seen in cows. - The Maglemosegaard skull belonged to an adult but fairly young animal,
about four years old, an age which perhaps might explain the departure in the indices. The Langeland skull (I), however, originates from a completely adult animal, in which the horn cores are strongly grooved and the teeth worn.

If you compute the said indices of the Danish Urus skulls you will find that even in fully mature or fairly old bulls the O.H./F.B. index may be higher than the O.B./ O.H. index. In the subadult bull skulls from Hallenslev, Viesø, and Gøderupgaard, e.g., the indices are: 96-87, 100-78, and 94-84, respectively; in the young adult animals from Ugilt and Stokholt Huse (Sorø), in which the teeth are very slightly or slightly worn, the indices are $92-89$ and $100-83$ respectively; but even in the old bull skull from Olholm with much worn teeth and strongly grooved horn cores and at the basis granulated the indices are: 102 and 97 . The divergent indices in subadult animals may be explained by the comparatively narrow frontal in these specimens, a feature also seen in bullocks (Wertnik) and which also exists in narrow skulls of adult bulls.

On the basis of this it is apparent that these indices do not always form a distinct decision of sex-determination.

If the measurements of the Danish domestic male skulls, however, are inserted in the above-mentioned scatter diagram (Howard, loc. cit.), it appears that with one exception, the Gammellung skull I (indices $97-77$ ), all adult skulls are grouped with bulls, though most of them are placed in the periphery of the group.

The sex dimorphism, however, is also, as mentioned, manifested in the limb bones and particularly in the metapodials. But only a few of the Danish skulls have been found in connection with postcranial skeletal parts. Metapodials are only known from four adult specimens, the Holmene cow and three males, from Maglemosegaard (Vedbæk II), Holmene I and Vedbæk III, and in addition from the subadult male from Store Lyng and the heifer from Aamosen.

The length of the metapodials is almost equal in females and males, but the width particularly of the diaphysis and the distal end, is larger in bulls. Bullocks have particularly long metapodials, the width of which, however, is intermediate between those of cows and bulls. (Figs. 24-26).

The metacarpals of the Holmene cow are long, 205 mm ., but comparatively narrow, the diaphysis width is 33 mm ., which gives an index (in relation to length) of 16.1 . The broadest metacarpals belong to the Maglemosegaard specimen (Vedbæk); they are fairly short, 199 mm . in length, but the width in the middle is 39 mm ., giving an index of 19.6 mm ., no doubt indicating a bull.

Regarding the metacarpal length the presumed border line between Neolithic bulls and bullocks is stated at well over 205 mm ., as seen in the scatter diagrams of Dürr (1961, No. V) and Imhof (loc. cit.). In length the metacarpals of the Holmene male passes this boundary. Strange to say, the length of the two metacarpals is different, 210 (left) and 216 mm ., whereas the metatarsal lengths are equal, 250 mm . Similar length of metacarpals ( 217 mm .) also occur in the postcranial skeleton from Borremose, characterized by very long limb bones. Probably both the Holmene and the


Fig. 24. Metacarpus. - Ordinate axis: diaphysis index (diaphysis width/maximum length, Table 11). Abscissa: maximum length.
The Urus bull on the extreme right is from Grejs Molle, the specimen at the bottom from Tinglev. The Urus cow connected by a dotted line is from St. Taastrup.
B. t. dom. Sex symbols indicate estimated sex. A stroke through the male symbol indicates presumed bullocks. Recent animals the sex of which is known, are encircled or placed in a square (Price bull). II and III: Vedbæk II and III. Aa. Aamosen, B. Bundsø, B.M. Borremose, H. Holmene, T. Troldebjerg, Bj. Bjerget.

Borremose specimens represent bullocks, as also stressed by the comparative slenderness of the bones, in which the diaphysis indices are 17.9 and 17.1 , respectively. Regarding the Holmene male this view is furthermose confirmed by the unfused sutures in a very old skull (p. 160).

Also the metacarpals from Vedbæk III are comparatively narrow with a diaphysis index of 17.6 , probably indicating a bullock.

For the sake of comparison I have in Table 11 stated the measure of some further metacarpals.

Two of the largest metacarpi from Troldebjerg are 210 and 212 mm . long and the diaphysis indices are 19 and 17,9 , thus, according to what has been mentioned above, representing a bull and a bullock. A still smaller diaphysis index, 17.1, occurs in a specimen from Aamosen (Holbæk), length 210 mm ., indicating a bullock. Of similar length, 210 mm ., is the metacarpal bone of the often mentioned animal from Bjerget, the diaphysis width is 39.5 mm ., which, although the bone belonged to a very old individual, might indicate a male, diaphysis index 18.8. In three metacarpi from Bundsø (Degerbøl, 1939) the diaphysis indices are 14.9, 17.2, and 17.3 , probably representing cows. As a sort of proof of the validity of the said indices it should


Fig. 25. Metacarpus. Distal index plotted against maximum length. Legend as in Figure 24.


Fig. 26. Metatarsus. Diaphysis index plotted against maximum length. Legend cf. Figure 24. (•) from Hescheler og Rüeger.
The three longest metatarsi (Grejs Molle, Holbæk (Aamosen), Soro) have the smallest diaphysis indices
be noted that in a prize bull ("stamtyr") from the year 1870 the diaphysis index is 19.8, and a similar high index, 20.5, is also seen in the recent bull No. A. 740 . In some recent females (Table 11, Nos. 74 and 71 ) the metacarpals are comparatively large, 214 and 228 mm . in length, but the diaphysis indices is small, 16.8 and $17.5 .-\mathrm{A}$ similar figure appears when the distal index of metacarpus is plotted against maximum length (Fig. 25).

Also the metatarsals of the said prehistoric Danish animals indicate the same relations as seen in the metacarpals (fig. 26).

A sexdetermination on the basis of metacarpals of subadult specimens is difficult to carry out. In the metacarpus of the subadult animal from St. Lyng, the distal epiphysis is completely free, but nevertheless the length of the bone is 201 mm ., thus a little longer than the metacarpus from Maglemosegaard, and when fully developed it would no doubt pass the length of the metacarpals from Vedbæk III and Holmene $q$.

As mentioned under the heading of the skulls, the age of the St. Lyng animal, on the basis of the stage of eruption of teeth, may be estimated at $2^{1} / 2^{-3}$ years. At that age, however, the epiphysis is generally more or less fused with the shaft, as also the sutures in the skull normally are more closed than seen in this specimen. As the ossification in bullocks is retarded, this might indicate that this animal might have been a bullock.

One more skull is excavated together with limb bones. To the skull form Sonderso belong a scapula, a humerus, and a femur. This skull is one of the largest in the Danish material and the horn cores are remarkable thick. The teeth are much worn, the height of the medial column of m 3 is only 26 mm .; indicating an age of about ten year. However, most sutures of the skull are open. In the brain-case the frontoparietal suture beneath the horn core is unfused, and this also applies to the sutures visible in the temporal fossa, even in the occipital region the parieto-occipital suture is laterally visible. Almost closed, however, is the posterior half of the interfrontal suture. For the sake of comparison it may be mentioned that in three four-year old Spanish fighting bulls the hindmost molar, as also the last premolar (p. 4), are only slightly worn, whereas the posterior half of the interfrontal suture and the frontolacrymal suture are obliterated, and no suture is visible in the occipital area. In three five-year old bulls the teeth are still slightly worn.

In the humerus the suture of the proximal epiphysis, which in sex-animals normally is closed at the age of $3^{1} / 2^{-4}$ years, is wide open, and the same holds good of the femur, with the exception of trochanter major, that posteriorly is completely fused with the diaphysis; the proximal as well as the distal suture are open, also normally closed at $3^{1} / 2^{-4}$ years of age. - As already mentioned - this late fusion of the epiphysis with the shaft might indicate a bullock. Of course, the time of fusion of the sutures and the stage of wear of the teeth may vary a good deal, but in this case the difference in age indication is very large, perhaps so large that it may be a question whether the limb bones and skull belong to the same individual, excavated as they are by workers during peat-digging.

However, the explanation may be that the late closed sutures in bullocks have less firmly coalesced with the bones as in sex-animals, and therefore in the dry air of the museum are more easily broken up. At least the muscular attachments are in these bones strongly marked, as in adult animals.

The limb bones from Søndersø must be characterized as long and slender, al-
though smaller than the corresponding bones from Borremose, and almost not so broad as the bones from Bjerget. Vide: limb bones Tables 11-23.

From this examination of the limb bones present it appears that bullocks probably are represented already in the Danish Neolithicum. Particularly the placing in the diagrams (figs. 24-26) of a group of metapodials between those of bulls and cows is indicative. On the other hand, it should be noted that in Urus bulls an almost similar figure in the diagrams turns up, just comprising the largest specimens.

Attached to metapodials of presumed bullocks are the skulls from Vedbæk III, Holmene I, and St. Lyng.

Furthermore, it is of particular interest that also the metapodials emphasize that the Maglemosegaard (Vedbæk II) animal was a bull. A distinct, complete skull of a bull thus is as conclusively established in the Danish material.

After this I shall offer a general view of the rest of the large domestic skulls.
Two skulls, Holmene $I$ and Gammellung $I I I$, are divergent on account of the strongly compressed bases of horn cores (platymer). On basis of the long limb bones and open sutures in a very old skull the Holmene $I$ skull is included among bullocks. This probably also applies to the second platymer skull Gammellung III. This peculiar flattening of the horn core base is known from other Neolithic skulls, as mentioned by Duerst and Imhof. Duerst (1904) was of opinion that it is caused by the use of a frontal yoke. However, in Danish bullocks I have observed this feature in individuals which never had been used as draught animals.

A third divergent skull is the Ero skull, in which the horn cores are extraordinarily long, wide-spread and strongly twisted. Although this skull belonged to a fairly old individual most sutures are not fused. It no doubt represents a bullock.

A particular type is characterized by the distinctly dome-shaped, laterally broadly rounded forehead, with the occipital crest raised as a bony boss between the stalky horn cores; the frontal between horn cores and eysockets is narrow-the very ideal of the frontosus type, so to say; a shape quite unknown in the Urus. The skull from Vedbæk III, which according to the metapodials belongs to a bullock, may be taken as a paradigm of this group which furthermore comprises the skulls from Veddinge and Verupgaard.

The Gammellung $I$ skull is astonishingly narrow, the smallest frontal and maxillary width (at the zygomatic suture) thus are smaller than in any of the adult Danish skulls, 177 and 154 mm ., respectively, as compared e.g. with 188 mm . and 162 mm ., respectively, in the male skull from Maglemosegaard, which has the same basal length, 455 mm . - The narrow frontal, between horn cores and orbits, as mentioned above, indicates bullocks, which are castrated at a young age (Wertnik), perhaps the only real feature characterizing bullocks of this stamp. If this should be correct, the type specimen of B. $t$. frontosus Nilsson represents a bullock.

The above-mentioned platymer skull Gammellung III may also be placed in this group; the smallest frontal width is only a little larger than in Gammellung I, 183 mm ., as compared with 184 mm . in the Veddinge skull, 190 mm . in the

Vedbæk III skull, 193 mm . in the Verupgaard skull, and 191 mm . in Nilsson's frontosus type.

In the brain-case from Logtved Enge the occipital crest is strongly concave, which may indicate a bullock, however, a similar feature occurs in the skull of the Urus cow from Bjerregrav (p. 56).

The remaining four skulls, from Bodal, Snoldelev I and II, and Gammellung IV probably represent bulls, just as also the Maglemosegaard skull must have belonged to a bull.

Against this sex-determination it may be objected that it is unlikely that so many of these skulls should have belonged to bullocks. It should be noted, however, that this material only comprises dated skulls, which in a way is a selected material, as some of the largest specimens no doubt have been sent to the Zoological Museum, just on account of their large size. Furthermore, comparatively many of these skulls are felled, representing sacrifices, which also may indicate a selection.

Killed by a blow on the forehead are the four known specimens from Gammellung moor (two bullocks, a bull and a cow) two cows from Nyrup moor (posterior part of frontal crushed), Maglemosegaard (bull), Holmene I (bullock), and two cows from Jordløse; that is 10 out of 24 . Probably also some of the other skulls have been placed as sacrifices.

Some of the skulls mentioned, from Holmene and Nyrup, have been found in moors, where particularly shaped places of sacrifice have been excavated together with Neolithic pottery and axes and now and then human bones. At the bank of the Holmene moor, or Salpeter moor, as it was named by the investigator (C.J.Becker, 1948, p. II), about 6 m . from the firm ground, a stage consisting of a thick layer of branches and twigs, supported by vertical piles and posts was found. This platform was strong enough to carry people and was no doubt built to facilitate the deposition of offerings in vessels from Early Neolithic Period B and Period I of the Middle Neolithic, which indicates that the spot was visited several times during a long period.

As regards bones, only a few marrow-split bones of cow and lamb were found, but there was neither flint waste nor other settlement-refuse present.

Besides the finds of oxen here described, ox bones of a sacral character are known from other places in bogs or from springs (cf. Becker, loc. cit.). They no doubt indicate that the old Danes in prehistoric times were so pronounced stock-breeders that it influenced their religious life.

In connection with the Funnel-Beaker culture and later similar finds at burials of animals along with men are known from several places in Central and Eastern Europe (Behrends, 1964).

Summary. (Domestic oxen). From these investigations of domestic cattle it appears that no less than 30 complete or almost complete skulls and brain-cases are present. From a numerical point of view this number is not, perhaps, particularly large, but it should be borne in mind that the occurrence of skulls of domestic cattle from the

Neolithic period have only recently been established in Denmark (Degerbøl, 1963) and are on the whole either very rare, or information supported by measurements is not at hand. Jewell (1963) and Nobis (1954) give no overall length, although the latter figured three fragmentary skulls, broken through the premaxilla. However, Вӧкönyı (1962) states that skulls are missing from the Hungarian material. The size range of Neolithic cattle has mostly been based on more or less fragmentary skeletal parts.

The variation in size of the Danish prehistoric cattle is comprehensive, inasmuch as fairly small cow skulls as well as large bull skulls are present; subadult animals are also represented. The Danish material is of special interest because measurements published are based on unambiguous domestic animals. In other cases it may often be a problem whether singly found skull-parts, particularly of large animals, originate from small Urus or large domestic animals.

As mentioned above, a considerable sex dimorphism has been established in the Danish Neolithic cattle. It is a characteristic feature that most width measurements of the bull skulls overlap the corresponding measurements in the female Urus.

The basal length is shown in fig. 8. From this it will be seen that the range of variation in the female skulls is outside the variation limits of the males. The basal length of the two largest cow skulls, from Holmene II and Nyrup I, is 422 mm ., as compared with 435 mm . in the shortest male skull, from Snoldelev I.

The earliest bull skull known, from the beginning of Zone VIII, at the very Elm decline, is fairly large (St. Lyng), and the same is true of the Verup skull from the beginning of the B -landnam. However, it is worth noting that the largest bull skulls (Bodal, Holmene), belong to the close of the period. - According to Böкӧnyı a similar state of things has been established in Hungary, and this author is of the opinion that it was caused by interbreeding with the Urus. However, this cannot be the case regarding the Danish material. At the time the Urus had long been extinct in Zealand, and at the end of the period the Urus was a rare animal even in Jutland. The existence of such large-sized cattle in Zealand must either be explained by a change within the domestic stock on this island, or importation must have occurred.

Even if these skulls belonged to bullocks, they must be characterized as very large (cf. p. 66), just as large as large recent animals. For the sake of comparison it may be mentioned that the basal length of 17 recent bull skulls, belonging to different breeds, varies between 355 mm . and 510 mm .; the largest measure originating from a very large shorthorn bull (Bohlken, 1962, p. 616).

However, only the large Holmene skull falls within the size range of Danish Urus cows.

The occurrence of these large domestic oxen from Maglemosegaard (Vedbæk II), Bodal, Holmene I and II from the Bronze Age or Iron Age is particularly remarkable because at that time a decrease in size of domestic cattle already had taken place in western and northern Europe (Winge 1900, Degerbøl 1928, 1962, Boessneck 1958, and Jewell 1964). These data are, however, based on fragmentary remains from settlements (teeth, horn cores, limb bones) whereas the present material comprises
complete, or almost complete, skulls. There is a possibility, however, that skeletal parts of such large and more aged animals did not end up in the refuse heaps of the settlements, probably these animals were used as draught animals, and at last as sacrifices. On the other hand, it may be mentioned that there is evidence of larger animals from the Pre-Roman and Roman Iton Age in Central and Western Europe (Boessneck, 1958, p. 73 and Jewell 1962, p. 164), either originating from importation or based on better feeding of the original stock, perhaps under the influence of the Romans.

Possibly, however, the large size of the said Danish domestic oxen may have a certain bearing on the use of new tools, e.g., larger and heavier ploughs, particularly the very heavy wheel ploughs known from the early Iron Age, but probably having been in use earlier, in working up greater parts of land for cultivation.

Regarding further measurements of skulls reference may be made to Tables $2-10$ and figs. 8-17. It should be noted that also in the length of tooth rows, upper and lower, only a very small overlap between Urus and domestic oxen exists, but ordinarily the teeth are much smaller in domestic oxen and the same holds good of the width of the hindmost molar. However, on account of the great overlapping of several other measurements it may often be impossible on the basis of size alone to distinguish the two bovine categories, also the shape must be taken into consideration; eventually the total impression of the complete skull.

The Urus skull is characterized by a concavity on each side of the original interfrontal suture, between the orbit and the horn core, giving the posterior part of the frontal a concave profile; in domestic cattle this part is more or less swollen, involving a more or less convex profile of the said frontal part. Also the position and shape of the horn cores distinguish the domestic oxen from the Urus. In most of the Danish prehistoric domestic oxen the base of the horn cores is directed a little downwards, thus placed below the frontal plane; only in the Snoldelev skull the horn cores are directed immediately upwards, as in the Urus.

## Concluding Remarks

The problem of the origin of domestic cattle in a particular area, whether introduced or of autochtonous origin in the area involved, must be solved on the basis of a sufficient large skeletal material of Urus, or wild Aurochs, as well as of domestic oxen, zoologically examined and reliably dated. The lack of concrete data on the size range and appearance of the Urus, bulls and cows, and particularly of the earliest Neolithic domestic cattle, has created great difficulties and confusion. It is an old problem how to distinguish between remains of small Urus cows and large domestic bulls. In case of doubt the judgment must be based on complete, or almost complete, skulls or skeletons.

In the present inquiry about 200 finds of Urus, about one half of which is dated, have been treated, comprising, amongst other items several almost complete skeletons,
and about 50 skulls and brain-cases, well over 20 of which must have belonged to cows. Considering that skulls of Urus cows are stated to be rare, this number is comparatively high, about two fifths of the totality, indicating that skulls of cows, when recognized and taken care of, probably would be just as common as bull skulls.

Two female skulls are of particular interest because they are almost complete and well dated, belonging to the Boreal period, Zone V. This early dating clearly excludes any possibility of incipient domestication or interbreeding with domestic cattle. They represent pure Urus cows. The one, from Ullerslev, is attached to a complete skeleton, the limb bones of which also evidently indicate a female, the only extant skeleton of an adult Urus female. The second skull, from Grænge, is a typical representative of the so-called "small Urus", but in fact specimens of this size are fairly common, and do not represent rare exceptions. The renowned size of the Urus is based on the large bulls. In general males especially benefit from particularly good ecological environments, which give them a surplus of strength, whereas females, which must provide for the offspring, unborn and born, remain on a more modest size. An exceptionally large bull skull originates from Zone III, at the close of the Late Dryas period; the earliest known find of Urus from Denmark.

The range of sex dimorphism in Urus and domestic cattle as well as the difference in size between these two categories of oxen is demonstrated in Tables $1-23$, and the figs. 8-25.

As compared with the bull skulls the female skulls in Urus are shorter (fig. 8) and particularly narrower (fig. 9), the orbits are less protruding (fig. 10), the horn cores in particular are reduced in length (fig. 15) and thickness (fig. 14), and are directed more upwards, and the occipital crest is weaker, characters that also are correlated to age. The females are, so to say, retarded in their development; they are more juvenile-like.

With the exception of the length of teeth, the sex dimorphism in skulls of adult Urus is so considerable that no or only a slight overlapping occurs, if so, it is mainly caused by comparing animals from different geological ages, e.g., large cows from the earlier periods, Preboreal and Boreal (Zone IV and V) with small bulls from the Subboreal period (Zone VIII), cf. p. 66.

Regarding the basal length there is in the Danish material a very slight overlapping between Urus bulls and cows (Table 1, fig. 8). - Only one skull of the Neolithic domestic males (from Holmene) is within the size range of Urus cows, but the shape is different.

The narrow frontal of the Urus females is demonstrated in smallest frontal width (between orbits and horn cores) and in the postorbital width (width across the posterior rims of orbits) Tables 2 and 3, and graphs, figs. 9 and 10. In full-grown skulls these measures are in females just outside the range of variation in male skulls. Even in subadult and not quite full-grown animals (e.g. animals in which not all teeth are in place) the postorbital width particularly depends on the individual age, fairly small even in almost adult animals.

In domestic males the range of variation of "smallest frontal width" is coextensive with the size range in Urus cows; and also the size range of postorbital width of domestic oxen and Urus cows is largely overlapping.

In most other width measurements too, the size range of Urus bulls is outside the range of Urus cows, as seen in the mastoid width (Table 4 and fig. 11), and in the supraoccipital width (smallest width between temporal fossae, posteriorly), fig. 12; here, too, the absolute measurements in domestic males are co-extensive with the measurements of Urus cows.

In the width across the occipital condyles great variation exists (Table 6, fig. 13); an exceptionally small measure, quite outside the range of other Urus males, occurs in a robust bull skull from Mors.

Measurements of horn cores are stated in Tables 7-8 and figs. 14-15. In Urus males, even in subadult and young adults, the horn cores are comparatively thick, being outside the size range in Urus females. Domestic males may have just as thick horn cores as seen in Urus cows.

The length of horn cores, measured along the outer curvature, are in full-grown bulls, with one ecception, outside the range in Urus cows measured here; however, fragmentary horn cores from large female skulls, e.g., in the Flintinge and Svebolle specimens, may indicate an overlapping. Between Urus cows and domestic oxen overlapping occurs.

The teeth of Urus cows are comparatively large. The length of the row of upper teeth is within the range of Urus bulls. In large domestic males the said length is just reaching the size range in small, old Urus. The width of the teeth in domestic cattle, however, is outside the range of Urus (Table 10).

From prehistoric settlements a comparatively large number of single, or solitarily found, mandibular hindmost molars (m3) of Urus as well as of domestic oxen are at hand, the sex of which is unknown (graph fig. 17, filled circles). Teeth from mandibles attached to skulls, or otherwise determined as to sex, are marked as sex symbols.

From this figure it appears that the range of m 3 length in Urus cows falls within the range of Urus bulls. - The smallest m 3, placed in the jaw, was till now known from the Pindstrup cow, from the Subboreal (Degerbøl, 1962), the only m 3 length below 46 mm . ( $45,5 \times 18.7 \mathrm{~mm}$.). In the present material furthermore three cows, also from the Subboreal period, have similar or still smaller m 3: 45.9 mm ., 45.8 mm ., and 44.3 mm . (Toftum). A most remarkable deviation, however, is constituted by the subboreal Ugilt bull with an m 3 length of only 42.5 mm . (width 18.5 mm .).

If this tooth had been found isolated it would no doubt have been referred to domestic animals. However, it now definitely proves that so small an m 3 may occur in Urus, and even in a large bull. A fact which must give rise to a new estimation of the small questionable solitary m 3 from several Ertebølle kitchen middens, and which has involved so great difficulties. These teeth naturally fill in the place between the Ugilt and the Toftum specimens: Dyrholmen 42.7 mm ., Norslund 43.5 mm .
( 44.5 mm ., and 45.2 mm .), Hjerk Nor 43.8 mm ., Krabbesholm 43.5 mm . (and 47 mm .), Aamolle 44.5 mm . They no doubt represent the Urus.

It is a well-known fact that teeth of many subfossil mammal species on an average are larger than the corresponding recent ones, as e.g., pointed out regarding several Danish carnivores from the Boreal period (Degerbøl, 1933).

It is likely that a similar fast, short-term rate of evolution has occurred regarding the Urus, and particularly at the close of its existence (p. 42).

The large dimorphism is also demonstrated in the size of the limb bones (Tables 11-23), which in Urus bulls are considerably larger, particularly broader, than in Urus cows.

Complete metatarsal bones of Urus cows have been rare. In 1942 I had none at my disposal, but in the present work measures of seven cows are given. In metapodial length a considerable overlap occurs, but in most width measurements the range of variations does not meet (figs. 18-20). Regarding length the metapodials of domestic oxen are widely separated from those of Urus, in fact the most distinctive mark between these animals. - The transversal width measurements of domestic cattle merge with those in Urus cows; the anterior-posterior width of the trochlea, however, is comparatively larger in the Urus. (figs. 6, and 20) thus indicating that the small metatarsals from Dyrholmen represent the Urus.

In other limb bones the size range of width in females is outside the range in Urus bulls, or only a slight overlap exists, cf. e.g., astragalus fig. 23.- From this figure it also appears that the "small" astragali from Ertebølle kitchen middens, e.g., Brabrand and Dyrholmen I and II unambiguously belong to the Urus.

Most measurements of limb bones of Neolithic domestic cattle here examined are outside the corresponding range in Urus.

For the first time a fairly comprehensive material of skulls or brain-cases of Neolithic domestic cattle is provided, 30 specimens in all. - Here, too, the sex dimorphism is considerable. From the same time and from the same narrow localities smaller and larger skulls exist, originally supposed to represent two different breeds or races; $B t$. longifrons and $B$. $t$. frontosus, but no doubt in fact representing cows and bulls respectively. - Already at the earliest Neolithicum, at the Elm decline, about 2800 B.C., these two "types" occur: the males with a domeshaped or swollen frontal and the occipital crest formed as a posteriorly projecting boss between the horn cores, a new cranial shape in the Bos-evolution, quite different from the concave frontal profile and fairly straight occipital crest in the Urus. The cow skulls represent small animals, e.g., similar to a cow skull from Jutland, from the middle of the nineteenth century. During about 5000 years this phenotype thus has existed in Denmark.

The occurrence of these early Neolithic skulls, which in shape and size are so divergent from Bos primigenius clearly indicate that the domestication of the Urus must have taken place long before the period mentioned. This cattle must have been imported into Zealand, or the domestication of the Urus in Denmark must be sought for at a still earlier period.

In this connection particularly the small bovine bones in the kitchen middens from the Ertebolle culture were a controversial problem, much discussed. However', these bones generally were included among domestic cattle. With the material for comparison now at hand, with the demonstration of the large sex dimorphism in the Urus and the common appearence of this species in the Subboreal period in Jutland, a basis of a real judging of these bones was established.

The age of many kitchen middens is questionable. In some kitschen middens, particularly the classical finds (Ertebolle, Aamølle, Mejlgaard, Krabbesholm) only a few bones of Urus were present, whereas in an other group of settlements (Brabrand, Dyrholmen I and II, Hjerk Nor, Kolding Fjord, Norslund) comparatively many Urus bones occur.

Only one of these settlements, from Norslund, is not only relatively dated, - the layer with bones chiefly belonging to the High Atlantic transgression, Zone VII, as Dyrholm I, -but also C14-dated, about 3780 B.C. (cf. p. 40). Also the bones from the Brabrand settlement belong to Zone VII, and the same probably applies to the remains from Hjerk Nor and Kolding Fjord.

As mentioned above even the small bovine bones from these kitchen middens, belong to Urus cows.

Lack of knowledge of the range of variation, in size and shape of modern bullocks, makes a statement of these animals in prehistoric time problematic. - The castration involves a retarded development of the animals, the sutures fuse later or not at all (Figdor, 1927). Bullocks therefore have longer, but comparatively narrower limb bones than sex animals.

Only a few Neolithic skulls of domestic oxen, however, are found in connection with limb bones.

Belonging to the skull of the Holmene cow is a typical female metacarpus, and long and comparatively narrow metapodials are attached to the male skull from Holmene, indicating a bullock, which is in accordance with the unfused sutures in the very old skull.

Also the metacarpals from Vedbæk III are comparatively narrow, with a diaphysis index of 17.6 , probably indicating a bullock. This is of particular interest, as these metapodials are attached to a typical frontosus skull, similar to Nilsson's frontosus type specimen.

The broadest metacarpals belong to the skull from Maglemosegaard (Vedbæk II). They are fairly short, 199 mm . in length, but broad; the width in the middle is 39 mm ., giving an index of 19.6 , and thus confirming the supposition that this skull represents a bull.

A group of comparatively long metapodials, in width between bulls and cows, as seen in the diagrams, figs. 24-26, furthermore indicates that bullocks probably were represented in Denmark in prehistoric times.

## Summary

About 200 finds of Urus, almost one half of which is dated, and 30 finds of Neolithic domestic oxen have been examined.
In Urus as well as in domestic oxen a great sex dimorphism exists. Measures of Danish Urus cows are outside the range in Urus bulls (basal length, smallest frontal width, mastoid width, cicumference at base of horn cores) or a small overlap occurs (postorbital width, supraoccipital width, condylus width, length of outer curvature of horn cores). In Urus cows the teeth are comparatively large; the length of upper tooth row falls within the range of Urus bulls.
The domestic oxen are in general considerably smaller than the Urus. The lengths of metapodials are widely outside the corresponding range in Urus, and only in one skull of domestic cattle is the basal length within the range of Urus cows; almost the same applies to the length of rows of teeth, where only a slight overlap occurs. In most other skeletal parts, however, a large overlapping has been established, the measures in domestic males are co-extensive with those of Urus cows (figs. 8-25). A characteristic feature in Urus is a concave frontal profile, behind the orbits.
The earliest discoveries of Urus in Denmark originate from the close of the Late Dryas, Zone III. In Zealand the Urus disappeared at the close of the Boreal period, Zone VI, and, with one exception from Zone VIII, the same applies to Funen. In Jutland the Urus was still living during the Subboreal, and probably also at the beginning of the Subatlantic period, Zone IX. From the Atlantic period only one find from peat bogs is known, from the isle of Langeland, S.E. of Funen. - However, remains of Urus have been found in several Jutland kitchen middens from the Ertebølle culture, probably Zone VII (Brabrand, Dyrholmen I and II, Hjerk Nor, Norslund). Several Bos remains from these settlements are comparatively small, even for cows, but they no doubt represent the Urus (figs. 4-6 and 23-26). Thus the hindmost lower molar (m 3) in Urus from the Ertebolle kitchen middens and from the Subboreal period no doubt indicate a trend towards reduction in size of these teeth in the phylogenetical latest Urus (p. 91, fig. 17). - The skulls of domestic cattle treated are all from Zealand. From the Elm decline two skulls, of a female and a male (bullock), are at hand, indicating that already at that early period an advanced cattle breeding existed, which might imply a long preceding domestication. These animals must have been imported into this island, perhaps from the southeast.

From the close of the Subboreal period, late Bronze Age and early Iron Age comparatively large skulls of domestic oxen are at hand, mostly characterized by a domeshaped frontal and the occipital crest formed as a projecting boss between the stalked horn cores ("frontosus" form), a shape quite unknown in the Urus. The corresponding metapodials are long and slender, in width intermediate between bulls and cows (fig. 24-26). The occurrence of these large animals probably indicates the use of new, heavier, but more effective tools (e.g. wheel ploughs.)

Table

| Zone |
| :--- |
|  |
|  |


|  |  | V |  |  |  |  | V I |  |  |  |  | V II | V III |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{aligned} & \sim \\ & \text { ~ } \\ & \text { © } \\ & \text { © } \\ & \text { H } \end{aligned}$ | J 0. 0 0 0 0 0 |  |  | 7 7 7 | $\begin{aligned} & \dot{H} \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \end{aligned}$ |  | $\begin{aligned} & \text { O} \\ & \\ & 0 \\ & 0 \end{aligned}$ |  | $\begin{gathered} 0.0 \\ \stackrel{50}{3} \\ \stackrel{5}{0} \\ \hline \end{gathered}$ |  |  | - | \% |  | $$ | - | $\begin{aligned} & 0 \\ & 0 \\ & \frac{0}{1} \\ & 0 \\ & \vdots \\ & 0 \\ & Z \end{aligned}$ | U $\stackrel{0}{n}$ $\pm$ $=0$ |
| 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| - | (690) | - | - | - | - | - | 716 | -- | - | 680 | 690 | 650 | 685 | 630 | 660 | 700 | 670 | - | - |
| - | 600 | - | - | - | - | - | 635 |  | - | 592 | 615 | 580 | 581 | 555 | 577 |  | 602 | - | (570) |
| - | 565 | - |  | - | - |  | 597 |  | - | 564 | 581 | 543 | 551 | 525 | 542 | (580) | 570 | - | (540) |
| - | 360 | - | (310) | (317) | - | - | 345 | - | 340 | 338 | 317 | 311 | 314 | 308 | 318 | 342 | 310 | - | 305 |
| - | 350 | - | - | (317) | - |  | 375 |  | - | 357 | 375 | 341 | 365 | 330 | 358 | 366 | 370 | - | - |
| - | 295 | - | - | 270 |  |  | 305 |  |  | 292 | 280 | 283 | 278 | 285 | 278 | - | 285 | - | - |
| - | - | - | - | - |  |  | 520 | - | - |  | 590 | 530 | - | 520 | 566 | 595 | 575 | - | - |
| - | 510 | - | - | 462 |  |  |  |  |  | 495 | 494 | 468 | 492 | 467 | 475 | 502 | 475 | - | 460 |
| - | - | - | - |  |  |  | -- | -- |  |  | 542 | 483 | - | 475 | 505 | - | 530 | - | - |
| - | 240 | - | - | 195 |  |  |  |  | - | (244) | 250 | 225 | 250 | 228 | 214 | - | 245 | - | - |
| - | 415 | - | - | 366 | - | - | 424 |  | - | 400 | 412 | 382 | 402 | 390 | 386 | - | 405 | - | 385 |
| - | 186 | - | - | 169 |  |  | 190 | -- | - | 175 | 185 | 170 | 183 | 170 | 178 | 181 | 170 | - | - |
| - | 370 | -- | - | - | - | - | 400 | - | - | 365 | 390 | 356 | 360 | 343 | 374 | 385 | 370 | - | - |
| - | - | - |  |  | - | - | - | - |  | - | 270 | 220 | - | 215 | 264 | 256 | 270 | - | - |
| - | -- | - | - | - |  | - | - | -- | - | - | 96 | 83 | - | - | - | 93 | - | - | - |
| - | 205 | - | - | - |  | - | 193 | - | -- | - | 192 | 170 | 177 | 185 | 202 | 197 | 190 | - | - |
| - | 215 | - | - | 180 |  | - | 240 | - | - | 222 | 210 | 221 | - | 200 | 210 | - | 220 | - | 206 |
| - | 350 |  | - | - | - |  | 378 | - | - | 365 | 355 | - | 322 | - | 330 | - | 346 | - | - |
| - | 83 | - | - | 75 | - | - | 76 | - | - | 86 | 68 | 75 | 79 | 70 | 82 | 72 | 77 | - | 80 |
| - | 70 | - | - | 63 | - | - | 67 | - | - | 72 | 69 | 67 | 59 | 64 | 67 | 68 | 63 | - | 70 |
| 215 | 193 | 250 | 187 | 254 | 205 | 230 | 146 | 232 | 160 | 200 | 206 | 212 | 200 | 167 | 215 | 235 | 173 | 190 | 200 |
| 260 | 220 | 305 | 250 | 306 | 230 | 300 | (200) | 295 | 205 | (285) | 215 | 245 | 240 | 194 | 265 | 287 | 200 | 210 | 265 |
| 234 | 240 | 237 | 247 | 220 | 240 | 254 | 255 | 270 | 242 | 234 | 230 | 242 | 245 | 242 | 222 | 237 | 238 | 230 | 220 |
| 300 | 302 | 287 | - | 254 | - | - | 328 | - | 286 | 295 | 320 | 290 | 314 | (310) | 262 | 303 | 298 | 286 | 268 |
| - | 225 | - | - | 186 | - | - | - | - | - | 225 | 255 | 220 | 268 | 262 | 195 | 256 | 258 | - | 193 |
| - | 230 | - | - | - | - | - | 270 | - | - | 232 | 255 | 235 | 255 | 244 | 204 | 256 | 235 | - | 206 |
| - | 170 | - | - | 146 | - | - | 170 | - | - | 163 | 165 | 158 | 173 | 168 | 153 | - | 160 | - | 153 |
| - | 185 | - | - | 185 | - | - | 200 | - | - | 180 | 200 | 185 | 205 | 191 | 194 | - | 180 | - | 175 |
| - | 120 | - | - | - | - | - | 123 | - | - | - | 118 | 107 | - | 119 | 106 | - | 112 | - | - |
| - | - | - | - | - | - | - | 130 | - | - | - | 128 | 113 | - | 118 | 101 | - | 118 | - | - |
| 243 | 250 | 245 | - | 220 | - | 246 | 255 | 270 | - | 240 | 246 | 245 | 263 | - | 238 | 252 | 246 | 248 | 231 |
| 305 | 320 | 281 | - | 244 | - | 315 | 326 | (315) | - | 303 | 305 | 310 | 320 | 320 | 280 | - | 310 | 300 | (270) |
| 210 | 215 | 198 | - | 184 | 245 | 212 | 216 | 231 | - | 210 | 192 | 203 | 240 | 222 | 185 | 235 | 260 | 233 | - |
| 130 | 125 | 136 | - | 125 | - | 135 | 129 | 147 | - | 128 | 127 | 132 | 142 | 132 | 137 | - | 136 | 127 | 134 |
| - | 40 | 41 | - | 39 | - | 35 | 37 | 40 | - | 50 | 38 | 39 | 38 | 38 | 52 | -- | 38 | - | 47 |
| 220 | 215 | 226 | - | (212) | - | 229 | 225 | 230 | - | 224 | 216 | - | - | 208 | 205 | - | 205 | 206 | 212 |
| 180 | 170 | 169 | - | (162) | - | 183 | 180 | 178 | - | 177 | 160 | 187 | 171 | 165 | 160 | - | 155 | 160 | 165 |
| 785 | 818 | 797 | 815 | (770) | 792 | -- | 750 | - | 876 | 770 | 855 | 825 | 884 | 790 | 774 | 900 | 845 | 750 | 790 |
| - | 705 | 600 | 705 | - | 640 | -- | - | - | 695 | (700) | 660 | 720 | - | 600 | 705 | 688 | 700 | - | (765) |
| 345 | 315 | 295 | 345 | 285 | 335 | 322 | 375 | 397 | 345 | 315 | 341 | 337 | 340 | 325 | 283 | 335 | 365 | 300 | 290 |
| 122 | 113 | 100 | 122 | 100 | 123 | 107 | 123 | 138 | 112 | 115 | 110 | 115 | 110 | 111 | 97 | 115 | 132 | 101 | 102 |
| 97 | 87 | 85 | 95 | 78 | 86 | 87 | 103 | 113 | 79 | 85 | 100 | 92 | 89 | 83 | 82 | 95 | 100 | 99 | 78 |
| 580 | 570 | 570 | 515 | 320 | - | $370+$ | 490 + | -- | 655 | (515) | 686 | 590 | (680) | 625 | 490 | 675 | 650 | $410+$ | 550 |
| - | 175 | - | - | 171 | - | - | 174 | - | - | 182 | 161 | 163 | 155 | 143 | 157 | - | 156 | - | 158 |
| - | 70 | 70 | - | 69 | - | - | 62 | - | - | 80 | 65 | 65 | 62 | 57 | 64 | - | 65 | - | 60 |
| - | 110 | - | - | 108 |  | - | 107 | - | - | 114 | 100 | 103 | 93 | 89 | 95 | - | 95 |  | 100 |

Table I

| Zone | V III |  |  |  |  |  |  | IX | Uncertain Age |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Bos primigenius ơơ |  | 气 |  | \# ¢ ¢ |  | $\frac{\vdots}{80}$ | $\begin{aligned} & \text { E } \\ & \frac{0}{0} \\ & \frac{\pi}{n} \\ & =1 \end{aligned}$ |  |  |  | N |  |
|  | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 |
| 1. Total length | - | (630) | - | 651 | 640 | (630) | (710) | - | - | 700 | 706 | 675 |
| 2. Condylobasal length | - | (585) | - | 592 | 580 | (555) | (610) | - | - | 617 | 616 | 587 |
| 3. Basal length... | - | ( | - | 554 | 548 | 532 | (566) | - | - | 583 | 571 | 549 |
| 4. Occipital ridge - nasal base | - | - | 316 | 290 | 295 | 300 | - | 315 | - | 322 | (340) | 320 |
| 5. Nasal base - tip of premaxilla. | - | - | - | 372 | 348 | - | - | - | - | 380 | (380) | 367 |
| 6. For. magnum upper border - nasal length | - | - | - | 268 | 270 | 277 | - | - | - | 290 | 305 | 280 |
| 7. Occipital ridge - nasal tip . . . . . . . . . . . | - | - | - | 545 | 555 | 532 | - | - | - | 585 | - | 574 |
| 8. Occipital ridge - for. infraorbitale. | - | - | - | 457 | 462 | 460 | - | - | - | 502 | 510 | 488 |
| 9. Cond. occipitalis - nasal tip | - | - | - | 505 | 520 | 495 | - | - | - | 533 | - | 510 |
| 10. Cond. occipitalis - orbita. . . . . . . . . . . . . | - | - | - | 235 | 230 | 226 | - | - | - | 246 | 227 | 230 |
| 11. Cond. occipitalis - for. infraorbitale | - | - | - | 390 | - | 395 | - | - | - | 415 | 408 | 395 |
| 12. Orbita - for. infraorbitale | - | - | 180 | 164 | 175 | 166 | - | - | - | 180 | 192 | 183 |
| 13. Orbita - tip of premaxilla | - | - | - | 368 | 360 | - | - | - | - | 382 | 400 | 380 |
| 14. Nasal length, largest | - | - | 240 | 270 | 262 | 235 | - | - | - | 258 | - | 260 |
| 15. Nasal width, largest of both. | - | - | - | 90 | - | 82 | - | - | - | 83 | - | 92 |
| 16. Length of premaxilla (outer side, chord) | - | - | - | 183 | 165 | - | - | - | - | 200 | 205 | 184 |
| 17.) Palatal length $\{$ palatinum, middle.. | - | - | - | 225 | (190) | - | - | - | - | 230 | 215 | 200 |
| 18.) ( to tip of premaxilla | - | - | - | 340 | - | -7 | - | - | - | 362 | 355 | 340 |
| 19. Diametres of orbits $\{$ | - | - | - | 97 | 75 | 77 | - | - | - | 71 | 74 | 74 |
| 20.) Diametres of orbits | - | - | - | 70 | 64 | 64 | - | - | - | 66 | 74 | 69 |
| Least width between horn cores: <br> 21. a. at occipital ridge . | 175 | 200 | 204 | 215 | 160 | 235 | - | - | 187 | 177 | - | 215 |
| 22. b. at frontal, middle | 235 | 235 | 262 | 265 | 245 | 260 | (240) | - | 218 | 235 | - | 255 |
| 23. Frontal width, least | 246 | 212 | 216 | 228 | 210 | 214 | (238) | 230 | 231 | 242 | 240 | 247 |
| 24. Postorbital width . | - | - | 274 | 280 | 266 | 280 | (300) | 293 | 305 | 295 | 301 | 307 |
| 25. Interorbital width \{ least, incisur | - | - | - | 217 | (238) | 224 | - | - | 226 | 256 | (195) | 245 |
| 26. finterorbital wide anterior... | - | - | - | 217 | (238) | 218 | - | - | - | 245 | 245 | 255 |
| 27. Maxillary width $\{$ m 1-m 1 , outer border | - | - | - | 158 | - | 156 | - | - | - | 162 | 160 | 165 |
| 28. f ${ }^{\text {zyg. sut... }}$ | - | - | - | 186 | 173 | 177 | - | - | - | 200 | 203 | 190 |
| 29. Premaxillary width \{ largest. | - | - | - | 110 | (105) | (119) | - | - | - | 117 | 119 | 118 |
| 30.) Premaxiliary width a anterior | - | - | - | 110 | (105) | - | - | - | - | 115 | 117 | 123 |
| 31. Zygomatic width | - | - | - | 245 | - | 240 | - | 250 | - | 250 | 252 | 250 |
| 32. Mastoid width | - | 300 | 293 | 301 | 285 | 294 | (325) | - | - | 322 | 305 | 320 |
| 33. Width, post. border of fossae temporalis | - | 220 | - | 218 | 210 | 213 | - | - | 211 | 244 | 244 | 230 |
| 34. Condylus occipitalis, width | 140 | 132 | - | 134 | 131 | 124 | - | 133 | 128 | 128 | 132 | 128 |
| 35. Height of fossa temporalis, least. . . . . . . . . | - | - | - | 38 | - | 49 | - | - |  | 37 | 36 | 39 |
| 36. Occipital height $\{$ for. magn., lower border. | - | 228 | - | 202 | 218 | 215 | - | 210 | 225 | (220) | 244 | 218 |
| 37.) ( for. magn., upper border | - | 180 | 158 | 154 | 175 | 166 | - | 163 | 172 | 177 | 194 | 165 |
| 38. Greatest span of horn cores. | 915 | - | 770 | 822 | 730 | 774 | - | - | - | 762 | 890 | 925 |
| 39. Tip to tip of horn cores. . . . . . . . . . . . . . . | - | - | - | 712 | 605 | 560 | - | - | - | 627 | 810 | 760 |
| 40. Circumference of horn cores, base | 340 | 323 | 310 | 283 | 285 | 295 | (340) | - | 385 | 350 | 358 | 345 |
| 41. Diametres of horn cores, | 122 | 109 | 105 | 98 | 100 | 99 | - | - | - | 125 | 123 | 116 |
| 2. | 97 | 92 | 90 | 77 | 80 | 86 | - | - | - | 95 | 95 | 103 |
| 42. Length of horn cores, outer curvature | $505+$ | (620) | 630 | 575 | 540 | 610 | (680) | - | 595 | 525 | 615 | 695 |
| 43. Length of upper tooth row | - | - | - | 145 | 143 | 155 | (145) | - | - | 171 | 168 | 153 |
| 44. Length of premolars (p 2-p 4) | - | - | - | 61 | - | 60 | - | - | - | 68 | 68 | 59 |
| 45. Length of molars (m 1-m 3). | - | - | - | 88 | 92 | 103 | (94) | - | - | 105 | 104 | 98 |

${ }^{1}$ ) Measured by a folding rule.
(continued)

| Uncertain Age |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| - | E | $\stackrel{n}{0}$ | $\begin{aligned} & \text { E } \\ & \text { O } \\ & \text { \# } \end{aligned}$ | $\begin{aligned} & \underline{~} \\ & 0 \\ & 0 \\ & \vdots \\ & 0 \\ & 0 \\ & 0 \end{aligned}$ |  |  | 苋 |  |  |  |  |  |  | Iु 0 0 $=$ $=$ |  | $\stackrel{\text { ¢ }}{\substack{\text { ¢ }}}$ | $\frac{ \pm}{0}$ |  |
| 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 |
| 669 | - | - | 687 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 586 | - | - | 610 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 555 | - | - | 572 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 328 | - | 327 | 323 | - | - | - | - | 305 | - | - | - | 320 | - | - | - | - | - | - |
| 347 | -- | - | 380 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 290 | - | 285 | 295 | - | - | - | - | - | - | - | - | 275 | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 485 | - | - | 492 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - | - | - | - | - | 235 | - | - | - | - | - | - |
| 235 | - | 228 | (230) | - | - | - | - | - | - | - | - | 235 | - | - | - | - | - | - |
| 395 | - | - | 405 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 175 | - | - | 195 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 360 | - | - | 395 | - | - | - | $\square$ | - | - | - | - | - | - | - | - | - | - | - |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | -- | - | - |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 179 | - | - | 240 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 215 | - | - | 235 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 340 | - | - | 365 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 80 | - | 72 | 74 | - | - | - | - | 69 | - | - | - | 68 | - | - | - | - | - | - |
| 69 | - | 65 | 62 | - | - | - | - | 66 | - | - | - | 65 | - | - | - | - | - | - |
| 225 | 143 | 175 | 205 | 210 | 180 | 240 | 220 | 193 | 145 | 220 | 141 | 155 | - | - | - | 210 | 230 | - |
| 255 | 230 | 230 | 200 | 270 | 225 | 252 | 250 | 220 | 230 | 260 | (273) | 188 | - | - | - | 250 | - | - |
| 236 | - | 217 | 207 | - | - | (250) | - | 225 | 232 | 275 | (235) | 220 | - | - | - | 237 | - | - |
| 291 | - | 292 | 275 | - | - | - | - | 298 | - | - | - | 289 | - | - | - | - | - | - |
| 220 | - | 246 | 235 | - | - | - | - | 249 | - | - | - | 233 | - | - | - | - | - | - |
| 210 | - | 224 | 220 | - | - | - | - | 251 | - | - | - | 225 | - | - | - | - | - | - |
| 150 | - | 160 | 164 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 175 | - | 180 | 190 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 112 | - | - | 118 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 117 | - | - | 129 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 236 | - | 245 | 236 | - | - | - | - | 246 | - | 260 | - | 235 | - | - | - | - | - | - |
| 295 | (275) | 300 | 295 | - | - | - | - | 300 | 290 | - | - | (310) | - | - | - | - | - | - |
| 219 | 222 | 215 | 205 | - | 232 | - | - | 238 | 245 | 247 | - | 226 | - | $\bar{\square}$ | - | - | - | - |
| 123 | 136 | 110 | 129 | - | - | - | - | - | 122 | 137 | - | (130) | 134 | 134 | 146 | - | - | - |
| 42 | - | 44 | 45 | - | - | - | - | - | - | 40 | - | 36 | - | - | - | - | - | - |
| 223 | 230 | - | 212 | - | - | - | - | - | 216 | 230 | - | 238 | - | - | - | - | - | - |
| 170 | 185 | 170 | 166 | - | - | - | - | 165 | 172 | 182 | - | 171 | - | - | - | - | - | - |
| 700 | 780 | 825 | 730 | 890 | 770 | 915 | (870) | 900 | 950 | (880) | 815 | 720 | - | - | - | 826 | 932 | - |
| 500 | 560 | 690 | 620 | 745 | 645 | (810) | 780 | 720 | 805 | (700) | 575 | 555 | - | - | - | (710) | 740 | - |
| 318 | 375 | 355 | 295 | 338 | 340 | 340 | 305 | $\left\{\begin{array}{l}345 \mathrm{r} \\ 3271\end{array}\right.$ | $\begin{aligned} & 445 \mathrm{r} \\ & 4201 \end{aligned}$ | \} 385 | 370 | 355 | - | - | 365 | 335 | 342 | 398 |
| 107 | 135 | 127 | 102 | 113 | 120 | 120 | 104 | $\left\{\begin{array}{l}127 \\ 114\end{array}\right.$ | 160 | 135 | 130 | $122)$ | - | - |  | $\left\{\begin{array}{r}116 \\ 95\end{array}\right.$ | 118 | - |
| 89 | 97 | 100 | 78 |  | 94 | 95 |  | -114 | 146 | 106 | 116 | 88) |  |  |  | ( 95 | 951 |  |
| 525 | 645 | 595 | 540 | 645 | 580 | (620) | 580 | 96 635 | 685 r | $\overline{710}$ | 665 | 548 | - | - | - | 595 | $\overline{710}$ | - |
|  |  |  |  |  |  |  |  |  | $6701$ |  |  |  |  |  |  |  |  | - |
| 172 | - | - | 147 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 66 | - | - | 59 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 108 | - | - | 89 | - | - | - | - | - 1 | - | - | - | - | - | - | - | - | - | - |

Table

| Zone | IV |  |  |  | V |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Bos primigenius $\uparrow \uparrow$ | $\begin{aligned} & = \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & i \end{aligned}$ |  | $\begin{aligned} & \frac{0}{6} \\ & \frac{0}{2} \\ & \vdots \end{aligned}$ |  | U \% ¢ | \% | - |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1. Total length. | - | - | - | - | 635 | 585 | - |
| 2. Condylobasal length | - | $\ldots$ | - | - | 556 | 527 | 540 |
| 3. Basal length. . . . . . | - | $\ldots$ | - | - | 525 | 496 | (515) |
| 4. Occipital ridge - nasal base. | - |  | - | 264 | 315 | 288 | 274 |
| 5. Nasal base - tip of premaxilla. | - | - | - | - | 327 | 300 | - |
| 6. For. magnum - nasal base. . . | - | - | - | - | 257 | 263 | 260 |
| 7. Occipital ridge - nasal tip . | $\cdots$ | - | - | - | 530 |  | 2 |
| 8. Occipital ridge - for. infraorbitale . | - | - | - | - | 466 | 422 | - |
| 9. Cond. occipitalis - nasal tip . . . . . |  | -- | - | - | 470 | , |  |
| 10. Cond. occipitalis - orbita. . | - | 210 | -- | - | 210 | 205 | 205 |
| 11. Cond. occipitalis - for. infraorbitale. | - | - | - | - | 380 | 357 | - |
| 12. Orbita - for. infraorbitale. | - | - | - | - | 182 | 156 | - |
| 13. Orbita - tip of premaxilla | - | - | - | - | 358 | 327 | - |
| 14. Nasal length, largest. | - | - | - | - | 230 | - | - |
| 15. Nasal width, largest of both. | - | - | - | - | 62 | - | - |
| 16. Length of premaxilla | - | - | - | - | - | 157 | - |
| 17.) Palatal length \{ palatinum, middle. | - | - | - | - | 198 | 189 | - |
| 18.) ( to tip of premaxilla | - | - | - | - | - | - | - |
| 19. 20.$\}$ Diametres of orbita $\left\{\begin{array}{l}\text {. . . . } \\ \ldots\end{array}\right.$ | - | - | - | - | 66 | 70 | 71 |
| 20.) | - | - | - | - | 66 | 67 | 67 |
| Least width between horn cores: <br> 21. a. at occipital ridge. | 157 | 200 | - | 165 | 184 | 156 | 156 |
| 22. b. at frontal, middle | 190 | 210 | - | 207 | 240 | 200 | 200 |
| 23. Frontal width, least | 183 | 192 | - | 192 | 203 | 180 | 188 |
| 24. Postorbital width | (230) | 260 | - | 248 | 268 | 244 | 250 |
| 25. Interorbital width $\{$ least, incisur | - | - | - | - | 193 | 173 | 181 |
| 26.) | - | -- | - | - | 206 | 185 | 202 |
| 27. Maxillary width $\{$ molars, outer border | - | - | - | - | 157 | 150 | 162 |
| 28. ${ }^{\text {a }}$ ( zyg. sut.. | - | - | -- | - | 185 | 165 | 175 |
| 29. 30.$\}$ Premaxillary width $\left\{\begin{array}{l}\text { largest } \\ \text { anterior }\end{array}\right.$ | - | - | - | - | 99 | 95 | - |
| 30. 3 . Zygomatic width ( anterior | - | - | - | - | 100 | 105 | - |
| 31. Zygomatic width. | - | - | - | - | 220 | 201 | 214 |
| 32. Mastoid width. | 240 | 242 | - | - | 267 | 236 | 234 |
| 33. Width, post. border of fossa temporalis | 153 | 169 | - | 168 | 171 | 157 | 160 |
| 34. Condylus occipitalis, width | 117 | 117 | 121 | - | 125 | 122 | 116 |
| 35. Height of fossa temporalis, least. | - | 42 | - | - | 44 | 38 | 41 |
| 36.) Occipital height f for. magnum, lower border | 190 | 192 | - | - | 189 | 183 | 192 |
| 37.) 1 for. magnum, upper border | 148 | 149 | -15 | 586 | 142 | 140 | 154 |
| 38. Greatest span of horn cores | 666 | 640 | 715 | 586 | 640 | 557 | $580+$ |
| 39. Tip to tip of horn cores... | 580 | , | - | 460 | 515 | 488 | - |
| 40. Circumference of horn cores (base) | 240 | 240 | 245 | 240 | 270 | 225 | 235 |
| 41. Diametres of horn cores, base $\{$ | 79 | 80 | 82 | 87 | 94 | 80 | 77 |
| 42. | 68 | 67 | 71 | 65 | 74 | 60 | 70 |
| 42. Length of horn core, outer curvature | 495 | $(330+)$ | $(360+)$ | 430 | 450 | 395 | $300+$ |
| 43. Length of upper tooth row . | - | + | + | - | 162 | 161 | 158 |
| 44. Length of premolars (p $2-\mathrm{p} 4$ ) | - | -- | - | -- | 65 | 67 | 64 |
| 45. Length of molars (m 1-m 3). | - | - | - | - | 101 | 103 | 97 |

II．

|  | II／V | VIII |  |  |  | Uncertain Age |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | 曹 | 会 | 言 |  |  |  | $\begin{aligned} & \text { E } \\ & \text { E } \\ & \text { 首 } \end{aligned}$ |  | $\begin{aligned} & \frac{7}{y} \\ & \frac{3}{0} \\ & \frac{0}{3} \end{aligned}$ | 㧞 |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| － | － | （570） |  | － | － | － | － | － | － |  | － | － |
| － |  | （520） | （555） | － | － | － | － | － | － | （525） | － | － |
| － | ${ }_{285}^{(510)}$ | ${ }_{255}^{490}$ | （520） 290 | 二 | － | － | － | － | 275 | 500 270 | － | － |
| － |  |  |  | － | － | － |  |  | 27 | ， | 二 | － |
| － | － | 245 | 273 | － | － | － | － | － | － | 241 | － | － |
| － | － | 412 | － | － | － | － | － | － | － | － | － | － |
| － | － | 190 | 216 | － | － | － | 208 | － | － | 198 | － | － |
| － | － | 355 |  |  | － | － |  | － | － |  | － | － |
| － | － | 158 | － | － | － | ＝ |  | － | － | － | － | － |
| 二 | 二 | － | － | － | － | － | － | － | － | － | － | 二 |
| － | － | － | － | － | － | － | － | － |  | － | － | － |
| － | － | － | － | － | － | － |  | － | － | － | － | － |
| － | － |  | － | － | － | － | － | － | － | － | － | － |
| － | － | 71 68 | － | － | － |  |  | － | － | $\begin{aligned} & 72 \\ & 65 \end{aligned}$ | － | － |
| 215 | 200 | 190 | 186 | 190 | 162 | － | 168 | （220） | － | 168 | 192 | 174 |
| 250 | 210 | 220 | 220 | 220 | 178 |  | 215 | （240） |  | 210 | 202 | 200 |
| 205 | 180 233 | 178 230 | 200 253 | 182 | 175 | 186 | 195 | （ | 178 | 177 | 188 | 195 |
| － |  | ${ }_{168}$ | 190 | － |  |  |  | － | 188 180 | ${ }_{163}^{235}$ | $\stackrel{240}{-}$ | － |
| － | 173 | 172 | 硣 | － | － | － | － | － |  | － | － | － |
| － | － | 140 | － | － | － | － | － | － | 183 | － | － | － |
| 二 | － | － | － | － | － | － | － | － | － | － | － | － |
| － | － |  | － | － |  | － | － | － | － | － | － | － |
| － | 23 | ${ }^{207}$ | － | － | 204 | － |  | － |  |  |  | － |
|  | ${ }_{145} 23$ | ${ }_{148}^{\text {ab．} 225}$ |  |  | （210） | － | 234 | － | 240 | 227 | 240 | － |
| 127 | 120 | 111 | 107 | 155 119 | 114 | 107 | 165 | － | 159 118 | 163 116 | 167 118 | － |
|  |  | 38 |  |  | 42 |  | 33 | － |  | 43 |  | － |
| 196 | 212 | 178 | 206 | － | 178 | － | 180 | － | 175 | 185 | 188 | － |
| 150 770 | 165 | 135 500 | 166 680 | 143 600 | 137 630 | － | 142 600 | － | 131 580 | 142 585 | 144 |  |
| ＋ |  | ${ }_{360}$ |  |  | 630 520 | － | 600 |  | 580 | 585 | 535 | 685 |
| 275 | 240 | 181 | 270 | 195 | 220 | 206 | 227 | 233 | 195 | 227 | 235 | 235 |
| 89 84 | 84 67 | 60 50 | 90 | 65 | 78 | 73 | 76 | 76 | 65 | 79 | 86 | 82 |
| 380 |  | 365 | ab． 480 | 410 | 465 | $\stackrel{5}{-}$ | 59 385 | ${ }_{65}^{65}+$ | 58 | 58 412 | 61 380 | －${ }^{70} 00$ |
|  | 160 | 162 | － | － | － | 148 |  |  | － |  |  | － |
| － |  | 67 | － | － | － | 54 | － | － | － | － |  | － |
| － | 99 | 97 | － | － | － | 97 | － | － | － | － | － | － |


| Bos taurus domesticus <br> （Zone VIII） |  |  |  |  |  |  | 品 シ シ シ |  |  |  | $\begin{aligned} & \text { च } \\ & \vdots \\ & \text { そ. } \\ & \text { Z. } \end{aligned}$ |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 1．Total length | 475 | （362） | － | 510 | 545 | 513 | （455） | － | － | － | 485 | （480） | 510 | 484 |
| 2．Condylobasal lengt | 440 | － | － | 460 | 495 | 478 | （430） | － | － | 455 | 465 | （430） | 465 | 432 |
| 3．Basal length．．． | 411 | － | － | 433 | 465 | 455 | （400） | － | － | 427 | 435 | （403） | 435 | 405 |
| 4．Occipital ridge－nasal base | 235 | 187 | 225 | 265 | 270 | 254 | 221 | － | 215 | － | 235 | 242 | 240 | 250 |
| 5．Nasal base－tip of premaxilla | － | 180 | － | 245 | 282 | 257 | 215 | － | － | 280 | 222 | 208 | 271 | 238 |
| 6．For．magnum－nasal base ．． | 215 | － | 207 | 240 | 250 | 240 | 215 | － | － | 210 | 222 | － | 210 | 229 |
| 7．Occipital ridge－nasal tip | － | － | － | － | － | 411 | － | － | － | － | － | － | 410 | － |
| 8．Occipital ridge－for．infraorbitale | 352 | 260 | － | 372 | 400 | 381 | 334 | － | － | － | 360 | 355 | 376 | 358 |
| 9．Cond．occipitalis－nasal tip ．．．． |  |  | －8 | － | － | 395 | － | － | － | 105 | － | 16 | 380 | － |
| 10．Cond．occipitalis－orbita．． | 165 | － | 158 | 175 | 195 | 194 | 170 | － | － | 165 | 170 | 165 | 170 | 163 |
| 11．Cond．occipitalis－for．infraorbitale | 305 | － | － | 317 | 242 | 335 | 296 | － | － | 300 | 315 | 290 | 320 | 306 |
| 12．Orbita－for．infraorbitale ．．．．．．． | 135 | 97 | － | 131 | 142 | 135 | 125 | － | － | 129 | 135 | 121 | 142 | 125 |
| 13．Orbita－tip of premaxilla | － | 206 | － | 280 | 295 | 279 | － | － | － | 282 | － | － | 282 | 258 |
| 14．Nasal length． | － |  | － | － | － | $\begin{gathered} 139 \\ (168) \end{gathered}$ | － | － | － | － | － | － | 169 |  |
| 15．Nasal breadth | － | － | － | － | － | － | － | － | － | － | － | － |  |  |
| 16．Length of premaxilla（laterally） | － | 102 | － | － | 143 | 134 | － | － | － | 170 | － | － | 141 | 122 |
| 17．）Palatal length $\{$ Os pal．，middle | 162 | 123 | － | 149 | 183 | 165 | － | － | － | 172 | － | 155 | 169 | 165 |
| 18．）Palatal length to tip of premaxilla | － | 197 | － | 260 | － | 271 | － | － | － | 272 |  | 6 |  | 251 |
| 19．Diametres of orbita | 66 | 56 | 61 | 73 | 73 | 72 | 61 | － | － | 66 | 65 | 66 | 69 | 63 |
| 20．）Diametres of orbita | 61 | 52 |  | 63 | 71 | 65 | 58 | － | － | 65 | 60 | 62 | 61 | 56 |
| Least width between horn cores： <br> 21. <br> a．at occipital ridge ． | 148 | 124 | 139 | 200 | 203 | （180） | 145 | 175 | 210 | － | 150 | 136 | 174 | 165 |
| 22．b．frontal，middle | 160 | 145 | 150 | 235 | 240 | （195） | 154 | 192 | － | － | 178 | 165 | 200 | 190 |
| 23．Frontal width，least | 148 | 133 | 145 | 180 | 193 | 177 | 151 | 183 | 192 | 158 | 164 | 153 | 185 | 161 |
| 24．Postorbital width | 189 | 158 | 179 | 211 | 235 | 226 | 189 | 223 | 212 | 201 | 206 | 210 | 218 | 190 |
| 25．Interorbital width $\{$ least | 135 | 112 | 128 | 143 | 175 | 165 | 132 | － | 147 | 137 | 146 | 150 | 165 | 145 |
| 26．）Interorbital width $\{$ anterior． | 146 | 118 | － | 160 | 178 | 177 | 143 | － | － | 151 | 160 | 160 | 167 | 142 |
| 27．）Maxillary width $\{\mathrm{m} \mathrm{1-m} 1$ ，outer bord | 130 | 101 | － | 130 | 135 | 141 | 125 | － | － | 130 | 134 | 135 | 133 | 119 |
| 28．）Maxillary widt $\{$ sut．zygomat．． | 145 | 118 | － | 147 | 164 | 154 | 144 | － | － | 150 | 145 | 143 | 91 | 142 |
| 29． Premaxillary width \｛ largest．．． | － | 53 | － | 78 | 96 | 91 | － | － | － | 77 | － | 78 | 91 | 69 |
| 30．fremaxinary （ anterior | 184 | （52） | － | 74 | － | 89 | $\overline{172}$ | － | － 180 | 72 184 | 184 | 185 | $\begin{array}{r}87 \\ \hline 206\end{array}$ | 69 |
| 31．Zygomatic width | 184 | 150 | 170 | 190 | 206 | 195 | 172 | 215 | 180 | 184 | 184 | 185 | 206 | 167 |
| 32．Mastoid width． | 194 | 146 | 173 | （215） | 230 | 216 | － | 215 | 189 | 202 | 207 | （190） | 227 | 188 |
| 33．Width，post．bord．fossae temp． | 116 | 88 | 107 | 151 | 154 | 134 | 128 | 158 | 130 | 133 | 129 | 126 | 134 | 130 |
| 34．Condylus occipitalis，width | 95 | － | 87 | 100 | 106 | 102 | 95 | 110 | － | 92 | 97 | 98 | 106 | 94 |
| 35．Height of fossa temp．，least | 38 | 30 | － | 36 | 44 | 33 | 36 | 34 | － | 31 | 35 | 32 | 41 | 33 |
| 36．）Occipital height $\{$ lower bord．for．magn． | 148 | － | － | 172 | 160 | 171 | 148 | 158 | － | － | 150 | 149 | 154 | 156 |
| 37．S ${ }^{\text {a }}$（ upper bord．for．magn． | 108 | － | － | 130 | 120 | 134 | 108 | 121 | － 60 | － | 111 | 110 | 115 | 116 |
| 38．Greatest span of horn cores | 396 | 283 | $355+$ | $515+$ | 610 | $560+$ | 395 | $470+$ | 600 | － | $400+$ | 405 | 560 | 466 |
| 39．Tip to tip of horn cores．． | － | 283 | $355+$ | － | 230 | 257 | 157 | 215 | 215 | － | 175 | 170 | 232 | 455 |
| 40．Circumference of horn cores，base． | 157 | 130 | 45 | 205 | 230 | 257 | 157 | 215 | 215 | － | 175 | 170 | 232 | 190 |
|  | ¢ 54 | 40 | 45 | 68 | 80 | 88 | 57 | 75 | 71 | － | 60 | 58 | 78 | 66 |
| res of horn cores， | ¢ 40 | 35 | 35 | 62 | 60 | 68 | 40 | 50 | 66 | － | 46 | 45 | 60 | 49 |
| 42．Length of horn cores，outer curvature | 210 | 125 | 153 | $240+$ $(250)$ | $275$ <br> （365） | 227 | $180+$ | － | 250 | － | $\begin{aligned} & 185+ \\ & (255) \end{aligned}$ | $185+$ | （380） | 233 |
| 43．Length of upper tooth row | 133 | （110） | － | 149 | 134 | 139 | 136 | － | － | 139 | 140 | 133 | 125 | （152） |
| 44．Length of premolars（p $2-\mathrm{p} 4)$ | 52 | （61） | － | 63 | 51 | 58 | 53 | － | － | 56 | 61 | 56 | － | （62） |
| 45．Length of molars（m 1－m 3）．．． | 82 | （35） |  | 92 | 82 | 84 | 85 | － | － | 86 | 85 | 82 | 75 |  |

＊Probably bullock．
III.

|  |  | $\begin{aligned} & \stackrel{\otimes}{\Xi} \\ & \stackrel{1}{\Xi} \\ & ={ }_{*}^{*} \end{aligned}$ | $\begin{aligned} & \stackrel{0}{む} \\ & \stackrel{\text { g }}{0} \\ & {\underset{\Xi}{0}}_{0+} \end{aligned}$ |  |  | 宽* |  |  | $\begin{aligned} & \approx \\ & 0 \\ & = \\ & = \end{aligned}$ |  |  |  |  |  |  | B. t. domesticus. - Recente |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | $\begin{aligned} & 8_{0}^{0} \\ & y_{6}^{1} \end{aligned}$ |  |  |  |  |  |
| 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
| 550 | (550) | 585 | 500 | 465 | (445) | (555) | - | 447 | - | (545) | 458 | 546 | (575) | - | 400 | 460 | 475 | 485 | 440 | 470 | 497 |
| 480 | (480) | 525 | 450 | 440 | (415) | (505) |  | 411 | - | (495) | 409 | 505 | (505) | - | 380 | 440 | 445 | 465 | 419 | 442 | 465 |
| 455 | (455) | 497 | 426 | 413 | (390) | (475) | - | 382 | - | (470) | 381 | 480 | (480) | - | 355 | 410 | 415 | 428 | 387 | 414 | 442 |
| 270 | 275 | 296 | 246 | 215 | 238 | 262 | 238 | - | - | 258 | 250 | 278 | 275 | - | 186 | 200 | 224 | 215 | 215 | 228 | 248 |
| 290 | - | 304 | 250 | 260 | - | - |  |  | - | - | 218 | 275 | - | - | 215 | 262 | 253 | 275 | 229 | 248 | 252 |
| 235 | - | (262) | 220 | 205 | 225 | (252) | 225 | - | - | 239 | 228 | 245 | 235 | - | 192 | 212 | 215 | 215 | 226 | 226 | 232 |
| 465 | - | 475 | 416 | 380 |  | - |  |  |  |  |  | 442 | - | - | - | 367 | 405 | 418 | 355 | 380 | 411 |
| 405 | 411 | 426 | 360 | 320 | 312 | 400 | - | 327 | - | 392 | 340 | 393 | 415 | - | 297 | 326 | 355 | 345 | 325 | 344 | 356 |
| 413 | - | 432 | 385 | 365 |  |  | - |  |  |  | - | 420 | - | - |  | 360 | 395 | 415 | 346 | 365 | 397 |
| 180 | - | 198 | 168 | 165 | - | 208 |  | 147 | (150) | - | 158 | 200 | 183 | - | 140 | 162 | 185 | 174 | 166 | 180 | 190 |
| 330 | - | 356 | 310 | 300 | 278 | 341 | - | 280 | (150) | 340 | 284 | 345 | 340 | - | 266 | 298 | 320 | 320 | 298 | 305 | 312 |
| 142 | 150 | 152 | $\begin{gathered} 130- \\ 140 \end{gathered}$ | 125 | 106 | 143 | - | 117 | 105 | 139 | 114 | 145 | 141 | - | 114 | 125 | 128 | 133 | 115 | 122 | 117 |
| 300 | - | 322 | 276 | 270 | - | - | - | 246 | - | - | 244 | 308 | - | - | - | 267 | 258 | 280 | 240 | 262 | 267 |
| 197 | - | 187 | 178 | 166 | - | - | - | - | - | - | - | 176 | - |  | - | 167 | 178 | 205 | 140 | 150 | 164 |
| 166 |  | 172 | 152 | 112 | - | - | - | 110 | - | - | 118 | 1 | - | - | - | - | - | - | - | - | 65 |
| 166 | - | 172 | 152 | 142 | - | 170 |  | 110 | - | - | 118 | 148 | - | - | - | 146 | 138 | 165 | 120 | 129 | 137 |
| - | - | 180 | 168 | 174 | - | 176 | - | 156 | - | - | 142 | 178 | (190) | - | 141 | 174 | 155 | 178 | 144 | 155 | 158 |
| - |  | 300 | 273 | 270 | - | - | - | 241 | - | - | 230 | - | (190) | - | 222 | 265 | 256 | 273 | 241 | 280 | 270 |
| 72 |  | 75 | 56 | 64 | 62 | 76 |  | 57 | - | 66 | 71 | 72 | 78 | - | 58 | 66 | 62 | 68 | 65 | 62 | 66 |
| 64 | - | 67 | 58 | 60 | 56 | 72 | - | 58 | - | 62 | 63 | 66 | 67 | - | 56 | 57 | 55 | 61 | 55 | 57 | 62 |
| 210 | 183 | 220 | 162 | 132 | 185 | 192 | 197 | - | - | 196 | 193 | 180 | 189 | - | 113 | 125 | 148 | 155 | 187 | 120 | 211 |
| 232 | 229 | 235 | 172 | 150 | 198 | 237 | 220 | - | - | 226 | 218 | 210 | 238 | - | 136 | 158 | 163 | 164 | 200 | 157 | 252 |
| 188 | 190 | 208 | 159 | 148 | 170 | 204 | 184 | 158 | - | 184 | 187 | 192 | 208 | - | 135 | 161 | 159 | 155 | 165 | 163 | 197 |
| 237 | 233 | 257 | 220 | 188 | 201 | 239 | 225 | 178 | - | 234 | 210 | 244 | 260 | - | 167 | 200 | 200 | 200 | 196 | 212 | 233 |
|  | 180 | 192 | 162 | 130 | (145) | 171 | 163 | 128 | - | 171 | 156 | 184 | - | - | 108 | 131 | 139 | 130 | 134 | 152 | 169 |
| - |  | 202 | 171 | 144 | - | 188 |  |  |  | 183 | 158 | 195 | 190 | - | 119 | 146 | 143 | 148 | 147 | 159 |  |
| 138 | 142 | 155 | 142 | 124 | 120 | 140 | - | 120 | (115) | 145 | 118 | 147 | 154 | - | 116 | 130 | 125 | 132 | 124 | 125 | 137 |
| 162 | 164 | 171 | 161 | 136 | 145 | 160 | - | 134 | (115) | 160 | 145 | 170 | - | - | 121 | 146 | 143 | 147 | 144 | 144 | 150 |
| 89 |  | 95 | 82 | 75 | - | - | - | 65 | - | - | 75 | 101 | - | - | 70 | 79 | 81 | 80 | 70 | 79 | 94 |
| - | - | 95 | 81 | 76 | - | - | - | 68 | - | - | 70 | 102 | - | - | 66 | 75 | 78 | 78 | 70 | 70 | 90 |
| 205 | 208 | 226 | 192 | 172 | 186 | 212 | 194 | 174 | - | 212 | 184 | 213 | 224 | - | 159 | 185 | 191 | 196 | 188 | 188 | 207 |
| 232 | 230 | 263 | 205 | 184 | 186 | 245 | 5 | 178 | - | 249 | 191 | 256 | 256 | - | 165 | 200 | 200 | 202 | 191 | 210 | 234 |
| 160 | 154 | 179 | 137 | 108 | 127 | 168 | 145 | 116 | - | 171 | 135 | 158 | 167 | - | 89 | 131 | 109 | 129 | 110 | 142 | 156 |
| 112 | - | 108 | 104 | 92 | 96 | 118 | 112 | 98 | - | 108 | 103 | 107 | 114 | - | 76 | 96 | 98 | 104 | 103 | 98 | 103 |
|  | - | 33 | 33 | 34 | - | 40 | - | 30 | - | 34 | 30 | 37 | 39 | - | 34 | 33 | 37 | 41 | 36 | 38 | 35 |
| 180 | - | 171 | 152 | 148 | 154 | 180 | 152 | 147 | - | 164 | 162 | 173 | 184 | - | 132 | 145 | 159 | 140 | 147 | 143 | 125 |
| 136 | - | - | 112 | 110 | 116 | 140 | 107 | 113 | - | 123 | 124 | 126 | 138 | - | 105 | 113 | 118 | 110 | 110 | 105 | 166 |
| 590 | - | 556 | 398 | 316 | 480 | 801 | - | - | - | 532 | 532 | 620 | 600 | - | 347 | 480 | 397 | 372 | 515 | 400 | 667 |
| - | - | 510 | 346 | - | 460 | - | - | - | - | - | 532 | - | - | - | 342 | 470 | 395 | 367 | 515 | 400 | 633 |
| 220 | 215 | 240 | 164 | 145 | 160 | 235 | 220 | - | - | 214 | 214 | 245 | 265 | 280 | 142 | 175 | 155 | 125 | 170 | 155 | 222 |
| 76 | 73 | 81 | 59 | 50 | 52 | 84 | 75 | - | - | 74 | 71 | 80 | 93 | 98 | 48 | 59 | 52 | 43 | 58 | 56 | - 78 |
| 62 | 58 | 56 | 43 | 40 | 46 | 60 | 57 | - | - | 56 | 60 | 67 | 71 | 67 | 35 | 47 | 42 | 35 | 46 | 42 | 58 |
| 340 | - | 305 | 209 | $155+$ | 305 | 445 | - | - | - | (295) | 228 | (385) | (415) | , | 165 | 255 | 200 | 162 | 200 | 175 | 395 |
| 138 | 145 | $135+$ | 139 | 138 | - | 143 | - | $\left\{\begin{array}{l} \mathrm{dp} 4 \\ (142) \end{array}\right.$ | 122 | 134 | $\left\{\begin{array}{l} \operatorname{dp} 4 \\ (145) \end{array}\right.$ | 138 | 142 | - | 120 | 132 | 120 | 130 | $\left\{\begin{array}{l} \mathrm{dp} 4 \\ (131) \end{array}\right.$ | 132 | 143 |
| $58+$ | 58 | $\overline{82}$ | $60+$ | 58 | 85 | 57 | - | 66 | 51 | 50 | (62) | 55 | 62 | - | 49 | 53 | 56 | 53 | (55) | 54 | 59 |
| 85 | 90 | 82 | 83 | 85 | 85 | 88 | - | 82 | 76 | 87 | 92 | 89 | (84) | - | 73 | 80 | 73 | 78 | 85 | 79 | 86 |

## PLATES I-XIV

I-VII: Skulls of Bos primigenius, ổ̉.
VIII-IX: Skulls of Bos primigenius, + ¢
X-XIII: Skulls of Neolithic Bos taurus domesticus.
Arranged according to geological age.
XIV: Skeletons of Bos primigenius, $\circ$ and ${ }^{1}$.













$$
\begin{aligned}
& \text { 留 } \\
& \text { Fir } \\
& 7 \pi \\
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& \text { \% }
\end{aligned}
$$





* Probably bullock.

 * Probably bullock.



## $Y T Y$ $\frac{Y}{2} \frac{E}{6}$





Plate XIV: Bos primigenius. o, from Ulierslev. Boreal period. (Zone $\downarrow$ ) Mounted and photographed by U. MoHL.
(Complementary bones: left calcaneus (black) of Bos primigenius, Sværdborg XXX E2 atlas, epistropheus from Bos taurus domesticus of similar size).
Bos primigenius. ${ }^{\text {on }}$, from St. Damme. Boreal period (H. Winge, 1904).


Bos primigenius. ㅇ. - Ullerslev.


# II. PALYNOLOGICAL PART 

By Bent Fredskild

## Introduction

Up to 1955 most of the work of dating bones found in bogs was carried out at the Geological Survey of Denmark in collaboration with the Zoological Museum of the University of Copenhagen, a collaboration resulting, amongst other things, in the publication of various monographs - on the occurrence of bison in Danish Pleistocene deposits (Degerbøl \& Iversen 1945), on the pond tortoise (Degerbøl \& Krog 1951), and on the reindeer (Degerbøl \& Krog 1959).

In 1955 the dating was taken over by the Department of Natural Sciences of the National Museum, where Dr. Svend Jørgensen and the author since then have carried out a long series of datings of various animals, of recent years mainly Urus and domestic ox.

My colleagues at the Geological Survey of Denmark and at the National Museum, first of all Alfred Andersen, Harald Krog, and Svend Jørgensen, have been kind enough to place their material at my disposal so that all the datings can be coordinated in the present publication. My thanks also due to the head of the Department of Natural Sciences of the National Museum, Dr. J. Troels-Smith, for good advice.

As some of the analyses were made up to 30 years ago, the material presented is bound to be highly heterogeneous. In general only about 100 pollen grains were counted in the oldest samples, and beyond the usual forest tree pollen (sub-fossil pollen of Populus and Juniperus were unknown) only Ericales, Cyperaceae, Gramineae and Chenopodiaceae, and a few others were normally determined. Since then pollen analysis has undergone a remarkable development, and in contrast to the primitive analyses of the early days we find today's samples, where the total in each sample may be $2-3000$ pollen grains, covering more than 100 species or higher taxa. (In Table B 153 taxa of pollen and spores have been listed, and in the appendix p. 21113 further taxa are mentioned). Many of the old samples are nevertheless fully adequate for accurate dating. A handsome example of this is Professor Knud Jessen's dating in 1926 of the Urus from Vig (No. 2). On the basis of a pollen spectrum containing $68 \%$ Betula and $32 \%$ Pinus, besides the find of epidermis of pine needles, hair of

[^1]Nymphaea, and fern spores, he dated the bull at Zone IV. Three samples from the skull were analyzed by the present author in 1965 , and the 4554 pollen grains counted confirmed the dating, only with the addition that the middle of the zone would seem most likely.

Cases in which old datings have had to be substantially corrected do, of course, occur, e.g. the revision of the datings of the Swedish bisons (Fredskild 1966).

The treatment of the samples is as described in Jørgensen (1963, vol. II). This is, in short, boiling with KOH , acetolyzing, treatment with KOH , staining with fuchsine, and embedding in glycerine. At different stages in the process treatment with HF , decanting of sand, or treatment with HCl may, if needed, be introduced. All slides are sealed before being analyzed and afterwards stored.

## Sources of Error

The dating of an animal the size of an Urus based on a single pollen sample taken somewhere in the skeleton is hazardous, but often this was the only choice: either no dating at all of a beautiful skull, or analysing an only sample which might date the animal.

Isberg (1949) mentions a very interesting case which deserves translation (from the Swedish): "The animal, found at the depth of one metre, lay with the skullheavily corroded by humic acid-in dark-brown fen dy, while the rest of the body was embedded in chalk gyttja. The right ribs were in an almost vertical position, while the left ribs lay almost horizontally. The proximal segments of the limbs were vertical, while the distal segments were bent under the body. The skull lay on its left side with the left horn partly stuck down into the grey-white gyttja, and with the condyle of the left mandible in situ, while the right one had slipped. The hand-sized stones, kicked up from the moraine and found a bit higher up in the gyttja, were proofs of the animal's violent struggle to survive. The distinct borderline between the gyttja and the fen dy was deranged at the spot, and at a distance of approximately one metre from the skull three lumps of chalk gyttja were found in the dy, 12 cm . above the borderline. Thanks to these bits of chalk a dating was made possible by analyzing the place of contact between the lumps and the dy, as these, with the kicks of the animal, had been thrown up, and had fallen down on to the bottom of the lake at that time."

One conclusion to be drawn from this is that, as a rule, the dating of samples from the skull will get nearer to the truth than dating of samples from the limbs.

Excavations of more or less complete skeletons carried out in the bog Aamosen, Western Zealand, however, have also shown examples where all the bones were embedded horizontally in the same thin layer, and in cases like these only a surface sample from the distal end of a vertical horn may be slightly younger. The analyses of 14 samples from different places in the skeleton of an Ox gave almost the same dating (cf. Ogaarde I, p. 205).

When possible, more than one sample from the same animal have been analyzed,
and several examples of highly different pollen spectra can be found in the text. An example of this is the dating of the bison from Bjärsjöholm, Scania (Fredskild 1966), where five samples from the skull were almost identical, with a spectrum from the transition between Zones III and IV, while a sample from the big nerve foramen on the left metatarsus was so severely contaminated with recent or sub-recent material that the dating of this sample, if anything, would be at Zone IX.

This example leads from the question of the contemporaneousness of a sample and the death of the animal concerned to the question of the reliability of the sample. Krog (1951) has written a survey of this, dividing the samples into four groups, A-D, ranging from fresh material in situ without any possibility of contamination to a sample which in all probability is contaminated.

## Comments on Table A

In Table A are listed the frequencies of pollen of a number of species (or genera, or families) important for the dating, expressed in percentages of AP, including Alnus, Betula, Carpinus, Corylus, Fagus, Fraxinus, Juniperus, Picea, Pinus, Populus, Quercus, Salix, Tilia, and Ulmus.

In the case of some of the first analyses a "??" had been put against the number of the species in question at the time because of uncertainty concerning the determination. This has been retained in the table. An "x" under Calluna instead of a number denotes that some Ericaceae were found in the sample in question, but that no separation between Calluna, Empetrum, and others has been made. In the great majority of the cases, apart from early Preboreal samples, all the ericaceous pollen undoubtedly originates from Calluna.

At the bottom of the table the sum of AP is listed, and finally the degree of destruction (D.b.). This is the percentage of the most common pollen with a fairly smooth exine (Alnus, Betula, Corylus, Carpinus, Gramineae, and Tilia) in which destruction could be observed. When discussing the reliability of a dating, D.b. must be kept in mind, as the differential destruction of different pollen may influence the dating.

## Comments on Table B

The results of the pollen analyses are presented in Table B, giving the numerical values of the occurrence of the various types of pollen and spores. Included are all analyses carried out in 1948 and later. Before that year Juniperus and Populus were not determined, and only rarely other plants than those listed in Table A.

The first and major part of the table is taken up by the phanerogams (Spermatophyta), arranged alphabetically according to family, by means of the terminology suggested by Hylander (1941). The families are followed by what is termed "a.i.d.", i. e. pollen which it has not been possible to determine because of a too high degree of destruction, "a.i.p.", indeterminable because of the pollen being too much folded,
and finally "a.i.l.", indeterminable because of the pollen being partly concealed under remains of another plant, being filled up with microscopical pyrite crystals, etc.

Next in the table we have the vascular cryptogams (Pteridophyta), followed by mosses (Bryophyta), represented only by Sphagnum and Thallophyta-a somewhat heterogeneous section. Finally the easily recognizable hairs of Ceratophyllum and Nymphaea, recent pollen contamination, rebedded pollen and spores, microscopical charcoal, and three spore-types: "Hystrix", "Pentagon", and "Paraplya". The category "recent pollen contamination" only includes pollen so highly deviating in colour in the freshly stained slides that there was no doubt at all about the recent origin. Pollen judged to be recent (e.g. Cerealea in Pollen Zones IV or V), but not deviating in colour, is listed in the first part of the table. Rebedded pollen and spores include Platycaria, Engelhardtia, Pinus haploxylon type, Sciadopitys, and other types, as well as the trilete spores. "Hystrix" includes the common types of Hystricosphaeridae. "Pentagon", which looks like a picture of Cymatiosphaera canadensis (DEunfF 1956, p. 80) is often met with in Danish clayey marine sediments. "Paraplya" is supposed to be a rhizopod. It is very common in Danish alder-swamp peat.

An "x" under Empetrum denotes that in the sample in question the Empetrum has not been separated from the other ericaceous pollen. A " + " in the table denotes a pollen which was not found during the counting, but during the preparation or later during the revision of the rarer pollen, the position of which is always noted. (All slides analyzed by Sv. J. and B. F. are permanent mounts, sealed before analysis).

Fern spores of the Dryopteris type, and colonies of Botryococcus and Pediastrum are often met with in so large quantities that a counting of the number in all the slides of the sample is too time-consuming. In such cases the number is counted on the first slide only. In the table the extrapolated number as well as the number actually counted is listed.

By means of Table B a good deal of information can be obtained about the occurrence of different species in the pollen zones. Before evaluating these records, however, it must be remembered that most of the samples from Zones IV-VI are lacustrine sediments (gyttja, fine gyttja, gyttja with a touch of swamp peat, with fine drift, etc.), where pollen of amphiphytes are to be expected, whereas, with few exceptions, swamp peat, usually a highly destructed alder-swamp peat, is the main component in the samples from Zones VIII-IX. On pp. 197, 207 and 211-215 pollen lists for 24 further analyses are given in the text. They include 13 taxa, not mentioned in Table B: Scleranthus sp. and Euphrasia type (incl. Euphrasia and Rhinanthus) from Tinglev, Juglans from Gundsømagle, Hordeum and Rumex acetosa from Læsten, Centaurea cyanus from Nyrup III and Elymus, Oxyria digyna, Polygonum viviparum, Primula sp., Pyrola type, Selaginella selaginoides and Trollius europaeus from Terp.

Araliaceae. One pollen of Hedera in sample 17 b and another in No. 19, both from the same locality (Grænge) on Lolland are unexpected, as the spectra are clearly Zone V, cf. the diagram in Andersen and Møleer (1946, Plate I). But two grains would hardly be there by accident, and as long-distance transport of Hedera pollen
is unlikely, this may be a case of local immigration of Hedera into southern Denmark prior to the QM. Another example may be the sample from Hallenslev in western Zealand (No. 26). One pollen grain of Hedera was found in No. 26 a, another in 26 b, but while 26 b is obviously contaminated, 26 a , originating from the middle of Zone V , or even more likely from Va, was clean. In this latter sample Ulmus, the only QMconstituent, represented only $0.3 \%$, and Alnus was lacking.

Cannabaceae. All pollen from this family is listed under Humulus lupulus, even though the possibility can not be excluded that some pollen from the youngest samples may be Cannabis.

Caprifoliaceae. One find of Lonicera periclymenum was made in Rislev (No. XXXII, Iron Age). Sambucus nigra was found together with this, and also in one sample from Zone VIII (No. 71), and in one from Zone V, the latter from the same locality (Grænge) as that in which the early Hedera was found. Viburnum opulus flourished in Zones V-VI, being found in one sample from Zone IV, 13 from V-VI, 4 from VIII, and one from IX.

Cistaceae. Helianthemum was found in the only skull from Zone III (No. 1), in the one from the transition III-IV (No. 1 A ) and, presumably rebedded, in VIII (No. XX).

Compositae. One pollen of Centaurea cyanus was found, cf. No. NA. Liguliflorae has been favoured by forest clearance, but it was also found in 14 samples out of 53 prior to that time. Pollen of the Cirsium type was met with only once (No. 16) before the landnam, but in 7 finds (in 10 samples) later.

Cyperaceae. Like Viburnum, Cladium flourished in Zones V-VI, but an odd pollen grain may be found now and then up to the very latest sample.

Empetraceae. Empetrum is frequent in Zones III-IV, rare in V-VI, and, with two exceptions (Nos. XXXII and 71 D) absent later. In earlier analyses Empetrum has been included in Ericaceae; cf. p. 181.

Ericaceae. In some analyses no distinction was made between Calluna and Ericaceae sp.

Gramineae. It has often been impossible to determine as to genera the pollen of the Cerealea type.

Guttiferae. Hypericum was found only in Zones VIII-IX, occurring in 18 samples.
Haloragaceae. Pollen of Myriophyllum alterniflorum was found three times (No. 71 D, No. 1 A , and No. V). M. spicatum is very frequent in Zone IV, but from later samples we have only one uncertain find (No. 53). This agrees with many lake diagrams from Denmark and Greenland, which show that the species flourished in the alkaline facies of the early Post-glacial lakes. M. verticillatum occurs more scattered, yet with a preference for Zone IV.

Juncaceae. Fegri and Iversen (1964, p. 194) describe the pollen of Luzula and Juncus as follows: Psilate pollen grains united in tetrads. "Inaperturate, exine extremely thin. Normally not preserved in fossil state, or at any rate not recognized". WODEHOUSE (1935, fig. 88 and Plate $V, 7$ ) shows drawings of Juncoides campestris
(=Luzula campestris), and writes (p.321): "The germinal furrow is not sharply defined but is represented by a thin area of the exine on the outer face of each grain. . . Though these thin elastic areas are generally overlooked, they are undoubtedly true furrows." Erdtman (1952, p. 217), like Wodehouse, describes the pollen grains as, as a rule, united in tetrahedral tetrads, monaperturate, but adds that the dissepiments (i.e. the partition walls) are thinner than the outer walls. Hyde and Adams (1958, pp. 50-51) have photographs of Luzula campestris and Juncus acutiflorus in a defatted, but not acetolyzed state, clearly showing the tetrad with the big thin areas.

If, however, pollen grains of Juncaceae are acetolyzed, they will not appear as tetrads, as the partition walls disappear and only the outer exine is left, and they will thus only show as 4 -aperturate, psilate pollen with extremely big apertures (cf. fig. 1). In some, but far from all, grains the position of the partition walls are seen as a very low, thin crest on the inner side of the exine. A total of more than 25 sub-fossil pollen grains of Juncaceae has been recorded in the past 10 years from localities in Switzerland, Greenland, and Denmark by Sv. J. and B. F. One pollen grain from Nyrup (No. IX), three from Rislev (No. XXXII). No doubt the usually very crumpled pollen of sub-fossil Juncaceae is often mistaken for thin-walled Cyperaceae. Nine preparations of Juncus (seven species) and seven preparations of Luzula (three species) have been used for reference.

Liliaceae. 11 pollen grain of Allium have been found, all of them in Zones VIIIIX. Judged from length of the colpe, the sculpture and structure, and the size, seven of them have been determined as A. ursinum (cf. p. 205), while four of them were too badly preserved for a closer determination to be made.

Lythraceae. In the present material pollen from the ubiquitous Lythrum salicaria was rare prior to Zone VIII. One pollen grain only was found (No. 26c), originating from Zone V, whereas it has been recorded from 21 samples in Zones VIII-IX. Even considering the differences in the sediments, this points to late immigration, and, not least, to a flourishing state from late Zone VII (unpublished diagrams from Aamosen) and up through Zones VIII and IX. Godwin (1956) mentions one record from Zone VIa, three from VIIb and two from VIII in England. Late flourishing is also emphasized by the material from Aamosen, comprising more than half a million pollen grains (Jørgensen 1963), and covering late Zone IV up to the beginning of Zone VII. A total of 8 pollen grains of Lythrum was found, all of them in the latter part of Zone VI.

Menyanthaceae. Menyanthes trifoliata is frequent throughout the whole period, especially in Zone IV.

Orchidaceae. 5 tetrads of Orchidaceae sp. were found in a sample from Zone VIII (No. XXVII). This is, to the best of the author's knowledge, the first finds of subfossil pollen in Denmark. Godwin (1956) has no records either. Within only some genera of Orchidaceae the pollen is united in tetrads (ByUG 1961). The 5 tetrads (fig. 1) were very similar to those in Epipactis palustris, but too little reference material (Epipactis palustris and Listera ovata) was at hand to make a safe determination as to genus or even species.


Fig. 1 a-b Recent Juncus trifidus L. boiled in KOH, stained (a: High level, b: Optical section).
c Recent Juncus compressus Jacq., high level, boiled in KOH, stained.
d Recent Juncus articulatus L.; Lagerst. og Krok, boiled in KOH, acetolysed, stained.
e Fossil Juncaceae, boiled in KOH, acetolysed, stained (Andbjerg, Jutland, Pollen Zone IX).
$\mathrm{f}-\mathrm{g}$ Fossil Epipactis type, boiled in KOH , acetolysed, stained (Veddinge, Zealand, Pollen Zone VIII). Magnification a, b, e ca. $775 \times$ : c, d, f, g ca. $700 \times$.

Polygonaceae. Two pollen grains of Polygonum viviparum type and one of Oxyria digyna were found in two samples from the same locality (No. 1 A) dating from the transition III-IV.

Potamogetonaceae. In some older samples no distinction has been made between the two easily distinguished pollen types: Coleogeton (including in our area only Potamogeton pectinatus and P. filiformis) and Eupotamogeton, but most probably all the pollen in the table under Potamogeton sp. are Eupotamogeton. Coleogeton was found twice: one pollen grain in No. XII in a marine gyttja (probably P. pectinatus) and another in a limnic gyttja together with 15 Eupotamogeton.

Primulaceae. Subfossil pollen of Hottonia is rarely found, and in the present material only in the very localcoloured spectras from Rislev (No. XXXII), where 8 pollen grains were recorded in 3 samples.

Ranunculaceae. Most, if not all, the pollen listed as Ranunculaceae sp. and Ranunculus sp. is presumably of the Ranunculus repens type, including most of the genus Ranunculus, apart from Batrachium. One pollen grain of Trollius europaeus was found in Terp (No. 1 A, transition Zone III-IV).

Rosaceae. Prunus padus was met with thrice: Terp (No. 1 A, one pollen grain) from Zones III-IV, Vig (No. 2, four pollen grains in three samples) from Zone IV, and Ullerslev (No. 15, two pollen grains in two samples) from Zone V. One pollen grain of Sanguisorba minor from late Iron Age was found in Rislev (No. XXXII).

Saxifragaceae. Saxifraga oppositifolia type includes $S$. aizoides, S. aizoon, $S$. cotyledon and $S$. oppositifolia. Three pollen grains were found from Zones III-IV (Nos. 1, 3, and 9).

Scheuchzeriaceae. One dyad of Scheuchzeria palustris was found in Brændholt (No. 23) from Zone V.

Sparganiaceae. Pollen of the Sparganium type comprises Sparganium as well as Typha augustifolia, i. e. all single pollen grains, whereas tetrads are referred to T. latifolia.

Tiliaceae. In earlier analyses Tilia pollen is listed as Tilia sp. In later analyses, after the morphological distinction between $T$. cordata and $T$. platyphylla had been realized, only pollen grain of $T$. cordata has been found.

Equisetaceae. The table reflects ample occurrence in the early Post-glacial Period in contrast to the very sparse occurrence in the later part.

Ophioglossaceae. Botrychium was found in two localities only: Faaborg (No. 1) from Zone III, and Knabstrup (No. 9) from Zone IV, whereas Ophioglossum vulgatum was found in 7 localities ( 19 pollen grains in 10 samples), covering the whole of Zones III to IX.

Polypodiaceae. As usual Thelypteris dryopteris is commonest in early Postglacial samples, yet single spores occur right up to the latest samples. Pteridium aquilinum was found throughout the whole period, yet a little more frequently in Zones VIII-IX, favoured by human activity. The distribution of Polypodium vulgatum is very marked: one spore in Zone III (and one in Allerød, cf. Iversen 1954), none
at all in Zones IV-VII, and 56 spores in 27 samples (from 19 localities) in Zones VIIIIX. In the material from Aamosen (Jørgensen 1963) single spores were found throughout IV-VII, but the particular distribution of this acidiphilous species in the present material may reflect the retrogressive vegetational succession (sensu Iversen 1964) more than the influence of human activity.

Selaginellaceae. One microspore of Selaginella selaginoides was found in Terp (No. 1 A , transition III-IV).

## Dating of the Individual Finds

## Comments.

With every find the following information, if available, is given: (1) The geological and archaeological circumstances in connection with the find, with quotations from former references to the find, if of interest, (2) the place where the sample was taken, (3) when and by whom, (4) when the sample was analyzed and by whom, (5) the kind of sediment, generally with use of the terms defined by Troels-Smith (1955). The nature of the sediment is mainly based on observations made during the preparation, and finds of macrofossils are mentioned; cf. XXVII, Veddinge Mose, p. 210, where 12 seeds of 8 species besides 12 oospores of a characeous plant were found in a pollen sample of normal size. Finally (6), a short discussion of the pollen spectrum (-spectra). All percentages mentioned in the text are with AP (cf. Comments on Table A, p. 181) as the basic sum.

For reasons of simplification the following abbreviations of names have been used in the text: A.A. = Alfred Andersen, geologist, M.Sc., The Geological Survey of Denmark, Sv.J. = Svend Jørgensen, assistant keeper, Ph.D., The National Museum, Department of Natural Sciences, Copenhagen, H.K. = Harald Krog, geologist, M.Sc., The Geological Survey of Danmark, U.M. = Ulrik Mohl, taxidermist, The Zoological Museum, University of Copenhagen, T-S = Jorgen Troels-Smith, Keeper, Ph.D., Head of the Department of Natural Sciences, The National Museum, Copenhagen, and B.F. = Bent Fredskild, the present writer, assistant keeper, The National Museum, Department of Natural Sciences, Copenhagen.

The pollen zones used are those shown in the schematic diagram suggested by Iversen (1960, fig. 7), apart from the borderlines V-VI, where the definition (the rational limit of QM), suggested by Jørgensen (1954, p. 176) was preferred.

The numbering of the finds is in chronological order, though with a few exceptions.

One skull only can be dated at Zone III, and one skull dates from the transition III-IV.

Within Zone IV even a single sample can often be dated more accurately than at the zone in general by reference to absence or presence of Juniperus, the amount of Populus, Salix, Empetrum, and Corylus, besides the ratio Pinus/Betula. If an insufficient number only of pollen grains has been counted and determined, the theoretical
possibility exists that the sample may originate in Zone II, but as hair and pollen of Nymphaea alba (a plant which has not been found in Zone II (Iversen 1954, p. 115)) were noted even in the first pollen analyses from the 1930 es , the possibility can mostly be excluded. In the more recent investigations there has been no problems as far as the question: Zone II or Zone IV is concerned.

Within Zone $V$ it may be difficult to date a sample more precisely, only the amount of Corylus may give a hint.

Most of the samples dated at Zone VI originate from the beginning of the zone, still with high frequencies of Corylus and with few QM, of which Ulmus is the most frequent. Three samples were dated at the middle of the zone.

From Zone VII only two samples can be said with reasonable certainty to originate, while a few insufficiently analyzed samples may be dated at either Zone VII or Zone VIII.

Within Zone VIII samples from the "A-landnam" has a characteristic spectrum (cf. p. 205), but as regards most samples from the zone a closer dating than : contemporaneous with, or later than the "B-landnam" (sometimes also termed the "Iversenlandnam'') is not possible without a standard pollen diagram from the basin proper. Towards the end of the zone a small number of Fagus occurs, and it may be difficult to decide the dating unless Secale is found. Secale was introduced into Denmark during the Iron Age at the beginning of Zone IX, presumably about the beginning of our era. The great number of Calluna and Sphagnum and the sparser occurrence of Carpinus is also characteristic of Zone IX.

## Bos primigenius

## 1. Faaborg.

This find was made in "blue clay underlaying peaty soil" in Gule Mose, Millinge. It was given to the Zoological Museum some time in the 19 th century by a Mr. Deichmann. H. Krog (1959, p. 147 and $152-53$ ) has published two pollen analyses in connection with the skull: (a) from a big gyttja clod in the brain case, and (b) from a cavity at the occipital condyle. Both samples originate from the end of Zone III. A new sample-egg-sized-was taken (U.M. 1961) from the brain-case, and from the centre of this a pollen sample, (c) was analysed (Sv. J. 1961). The sediment was a slightly sandy clay gyttja with some lime. Both the sediment, the ratio of Betula/Pinus and of NAP/AP, and the high frequency of Empetrum (incl. in Ericaceae in the table) date this sample, which much resembles sample (a) at the very end of Zone III.

1 A. Terp moor. vide p. 211.
2. Vig.

As mentioned by Nordmann (1936, p. 75 and 210), this find (made famous by the flint arrow heads found in two of the ribs) originates from Zone IV, based on analyses made by KNud Jessen in 1926, and further indicated by the profile from the finding place, described by N. Hartz (Hartz and Winge 1906). Jessen found $68 \%$ Betula and $32 \%$ Pinus, besides epidermis of pine needles, hair of Nymphaea alba, and spores of a fern (Dryopteris thelypteris?).

New samples were taken from the skeleton on exhibition in the National Museum, Copenhagen (B.F. 1965). 4 samples were analyzed (B.F. 1965): (a) from a groove in the left orbit, (b) alveole in right mandible, (c) nerve foramen on frontalis, and (d) cavities and nerve foramina in the occipital region. The sediments as well as the pollen spectra were much alike, and may be mentioned together. The sediment was gyttja with very little macroscopial plant remains. The spectrum is typical of the Preboreal; noteworthy is Juniperus, of which only one pollen grain was found out of a total of 4,554 pollen grains counted. Accordingly the dating cannot be the beginning of the Preboreal, and with very sparse Corylus, the middle of the zone is most likely.

## 3. Stokholt Huse.

A sample from a cavity in the occipital region (U. M. 1961) was analyzed (Sv. J. 1961). The sediment was a gyttja with a bit of rootfelt, moss-leaves, fine sand, and clay. The sample originates from the beginning or the middle of Zone IV.

## 4. Grænge moor $A$.

This find was dated by A.A. in 1943-44, and published two years later (A. Andersen and K. Møller, 1946). A profile from the finding place was as follows (translated from Danish):
$0-36 \mathrm{~cm}$.: Surface layer of humified peat.
$36-231 \mathrm{~cm} .:$ Blackish brown, highly humified fen peat, in the upper part a few rhizomes of Equisetum, farther down many Alnus roots.
231-304 cm.: Transitional layer with the dark fen peat intermingling with the brown-yellow Phragmites peat.
304-436 cm.: Phragmites peat. Many seeds of Nuphar luteum. Besides, shells of freshwater molluses.
436- cm.: Slightly clayey and sandy chalk gyttja, in the upper part with shells of freshwater molluscs (Anodonta, Sphaerium, Planorbis, etc.).

The bones were found in the uppermost part of the chalk-gyttja. A sample from the skull, consisting of calcareous gyttja, originates from the beginning of Zone IV.

## 5. Goderupgaard A.

A sample (a) from a cavity in the occipital region (U.M. 1961), analyzed by Sv. J. in 1961, and another (b) (B.F. 1961) from a nerve foramen on the upper side of the left half of the atlas, analyzed by B.F. in 1964, are almost identical. The sediment was gyttja with a little rootfelt, and, besides, in (b) some remains of characeous plants. They originate from Zone IV, and the percentages of Populus ( 1.5 respectively $7.0 \%$ ), Juniperus ( 0.2 respectively $0.3 \%$ ) and of Corylus ( 1.2 respectively $0.4 \%$ ) indicate the middle of the zone.
6. Vieso.

A sample from the skull, analyzed by A.A. in 1942, originates from Zone IV. The ratio Betula/Pinus indicates the first part of the zone, in spite of the frequency of Corylus $\left(3.1^{0} / 0\right)$, as some of the pollen of this may have been confused with Betula. The pollen of Myriophyllum spicatum and Nymphaea indicate a gyttja.

## 7. Vigersted.

A sample from the skull was analyzed by H.K. in 1945. The sediment is gyttja with mollusc shells and swamp peat. The sample is from Zone IV. Another sample, taken from the brain-case (U.M. 1961), was analyzed by B.F. 1964. The sediment is a swamp peat with fine
drift-gyttja and shells. During the preparation one seed of Menyanthes, two fragments of Nymphaea alba seeds, and a fruit of Ranunculus sp. (not Batrachium) were found. The pollen spectrum clearly indicates the middle of Zone IV.

## 8. Munke-Bjergby.

A peat sample from this metacarpus was analyzed by A.A. in 1942. He found 9 Corylus pollen grains out of a total of 159 pollen grains counted, and this refers it to the transition IV-V. Another sample was taken from the marrow cavity (B.F. 1964) and analyzed by B. F. 1964. A wingless nut of Betula and some fruits of Cyperaceae sp. were found. The sediment is a rather highly humified swamp peat. One Corylus pollen grain was found in a total pollengrain sum of 795 , and this, together with other indices, refers the sample to the middle or the later part of Zone IV.

## 9. Knabstrup 1.

A sample taken in a foramen at the posterior wall of the orbit (U.M. 1961) was analyzed by Sv. J. in 1961. The sediment was a clayey calcareous gyttja with a little swamp peat and a touch of sand. The frequencies of Juniperus $(3.9 \%)$, Salix $(4.8 \%)$, and Empetrum $(0.9 \%)$ indicate the beginning of Zone IV.

## 10. Knabstrup 2.

The sender (Johan Frost) states that the skull was found at a depth of approximately 3 m . in a bog in Knabstrup Enge, about 800 m . ENE of Dyrehavegåd. A sample, (a) from the skull was analyzed by A.A. in 1942. The spectrum (Pinus $22 \%$, Betula $58 \%$, Corylus $13 \%$, and Alnus $6.5 \%$ ) seems very strange and must be due to contamination of the material, and another sample, (b) from the brain-case (U.M. 1961) therefore was analyzed by B.F. 1962. The sediment consists of gyttja and swamp peat; during the preparation some undetermined Carex nuts were found. The sample originates from the first part of Zone IV.

## 11. Rode Molle Aa.

A sample was taken from a nerve foramen in the posterior wall of the orbit (U.M. 1961), and analyzed by Sv. J. in 1961. The sediment was a gyttja with a little fine root felt. The sample originates from Zone IV. Corylus constitutes $1.1 \%$, but there is still twice as much Betula as Pinus, and the middle of the zone therefore is most probable.

## 12. Fyn.

Nothing is known about this find except that it was given to the Zoological Museum about the middle of the 19th century by a clergyman, Mr. Appeldorn. A sample was taken from the frontal cavity (U. M. 1961) and analyzed by Sv. J. in 1961. The sediment was a gyttja, originating from late Zone IV.

## 13. Svebolle.

Two samples, (a) from a cavity in the horn core and (b) from between pars petrosa and basi occipitale, were taken (U.M. 1962). They were analyzed by B.F. in 1963. Sample (a) was very small, possibly a gyttja with a little fine drift and a great content of microscopical pyrite crystals. No pollen of water plants was found. It was very poor in pollen, one slide containing only 73 AP besides two unmistakably recent pollen grains of Tilia. Due to destruction Pinus is heavily over-represented, and it is most likely that the sample dates from Zone IV. Sample (b) is a rather destructed swamp peat with no traces of gyttja, and this is also poor in pollen. 6 slides were counted in order to obtain an AP-sum of 500 . Pinus must be over-represented
$(82 \%)$, but as the sum contains only one pollen grain of QM and 11 of Corylus, late Zone IV is the most likely. 5 pollen grains of Alnus may be a more recent contamination.

## 13 A. Tepstrup Lake.

The find was made at the edge of the lake. A sample consisting of lake marl was analyzed by Johs. Iversen in 1934. A total of 134 pollen was counted, giving the following spectrum: Salix $2 \%$, Betula $34 \%$, Pinus $57 \%$, and Corylus $7 \%$. Late Zone IV or the beginning of Zone V seems to be the most likely dating.

13 B. Bjerregravs moor.
Vide p. 212.

## 14. Ronnebæksholm.

No information is available about the finding place except that the find was made in a bog. A sample from the nasal cavity was analyzed by H.K. in 1948. The sediment is a somewhat humified gyttja with swamp peat (or vice versa). Corylus constitutes $32 \%$, and no QM was found. The sample originates from Zone Va.

## 15. Ullerslev.

The find - made during peat-digging - has been mentioned by V. Madsen (1902, p. 121). About the finding place, a bog situated 700 m . east of Ullerslev railway station, he gives the following information:

A profile at the finding place showed:
Approximately 2.5 m . peat.
1.6 m . yellow warp with many snail shells, the lowermost bluish and clay-like.

Below this at least 1.6 m . of grey-blue, gravelly, calcareous sand with a few bryozoa. Late-glacial?
The Urus skeleton, according to the finders, was found on the border between the peat and the layer of warp. In the peat bricks they found birch-twigs, hazelnuts, and pine cones, a fact which showed that the lowermost part of the peat must originate from the pine period, if not even from a period before this time. In a sample of the warp N. Hartz found Nymphaea alba L. and Potamogeton sp. (natans L.?). In the same sample A. C. Johansen determined a number of molluscs. (A list of 17 species is given).

Two samples were taken (U.M. 1960), (A) an egg-sized lump from the brain-case, and (B) a smaller one from a nasal cacity. They were analysed by Sv. J. in 1960-61. In both samples there was a kind of fine stratification, one half of which consisting mainly of chalk-gyttja with a few shells, the other half of layers rich in shells. Four samples were taken from fresh surfaces, viz. from (A):
(a) from the shell-fraction:

The following shells were determined:
Valvata piscinalis, Bithynia tentaculata, Sphaerium corneum, Pisidium, Planorbis planorbis, and Planorbis sp. (det. Sv. J.) Oospores of characeous plants, one seed of Nymphaea alba and one seed of Pedicularis palustris (!) (det. B.F.) A little fine sand and some swamp peat was found.
(b) from the gyttja-fraction:

Three fruit stones of Potamogeton sp. and a fruit of a grass were found.
And from (B):
(c) from the shell-fraction:

The same as at (a), with oospores, fine sand, and some swamp peat.
(d) from the gyttja-fraction:

Oospores and some swamp peat.
All samples were very rich in pyrite.
The four pollen spectra are very similar. Corylus varies between 41 and $53 \%$, QM between 0.4 and $0.6 \%$. The samples originate from Zone V, and, as most published diagrams from Fyn, have a Corylus-maximum of about $80 \%$. V a is most likely.

## 16. Knabstrup 3.

Two samples were taken (U.M. 1962): (a) from sulcus supraorbitalis and (b) from the brain-case. They were analyzed by B.F. in 1963-64. The sediments were highly humified swamp peat with a great content of pyrite. Due to the destruction - about every fourth pollen was indeterminable because of this - a safe dating cannot be made, but it seems likely to be close to the zone-border V-VI. The high frequency of Corylus and the absence of Tilia, Fraxinus, Viscum, and Hedera points to Vb, whereas the high frequency of Ulmus points to the beginning of VI.

## 17. Grænge $B$.

A sample from the brain-case (a) has been analyzed and published by A. Andersen (1946). Another sample, (b) was taken (U. M. 1962) from a frontal cavity behind the lacrymale, and analyzed by B.F. 1962. The sediment was a slightly humified gyttja with some fine drift and a little fine sand. Seeds of, amongst others Menyanthes were observed. Corylus constitutes $35 \%$, QM $0.1 \%$ and Alnus $0.1 \%$. The sample must originate from Zone Va, as is the case with the sample dated by A. A. A single grain of Hedera may be a hint of an early immigration into southern Denmark (cf. p. 182-183).

## 18. Grænge C.

A sample (a), has been dated and published by A. Andersen (1946). Another sample, (b), was taken from the foramen supraorbitale (U.M. 1962) and analyzed by B.F. 1962. The sediment was a slightly humified swamp peat with gyttja (or vice versa) and a little fine sand. Corylus constitutes $42 \%$, QM $0.5 \%$, Alnus $0.4 \%$. The sample seems a little younger than the one from Grænge $B$, but still - as sample (a) -from Zone Va.

## 19. Grænge $D$.

Two samples: (a) from the mandible and (b) from the pelvis, were analyzed and published by A.A. (loc.cit.). The sediment is unknown. The spectra are very similar, and are presumably intermediate between Grænge B and C. In (a) a pollen grain of Hedera was found (cf. Grænge B, Sample b).

## 21. Bjeverskov.

A sample was analyzed by A. A. in 1942. No information is available about the sediment. Corylus constitutes $86 \%$, and the sample must originate from the Corylus maximum in the middle of Zone V. In the table Corylus ( 710 pollen grains) is extrapolated from 500 Corylus pollen grains, corresponding to 82 AP excl. Corylus.

## 22. Tranemosegaard.

A sample taken from a cavity between the meatus acusticus and the basi occipitale (U.M. 1961) was analyzed by Sv. J. in 1961. The sediment was slightly humified swamp peat with gyttja (or vice versa). The percentage of Corylus is 37 , and both QM and Alnus constitutes less than $1 \%$. The sample thus originates from Zone V, most likely Va.

## 23. Brændholt.

The finding-place was examined shortly after the find was made by S. Th. Andersen, B. Brorson Christensen, and Sv. J. from the National Museum. Beside a pollen series close to the skeleton two pollen samples were taken: (a) from the impression of the scapula, and (b) from between two ribs. These two samples were counted by B.F. 1964. The sediment was a fine detritus gyttja. The two spectra are almost identical, except for local plants, thus Lemna ( 0.1 resp. $1.5 \%$ ). The high frequency of Corylus ( 58 resp. $63 \%$ ), and the very low frequency of QM point towards the middle of Zone V, presumably the very end of Zone Va.

## 24. Flintinge.

A sample from a frontal cavity (U. M. 1962) was analyzed by B.F. in 1963. The sediment was a somewhat humified swamp peat with a few scraps of moss. The spectrum is from the very beginning of Zone Va (Corylus $14 \%$, QM $0.2 \%$, Alnus 0 ).

## 25. Saxkobing.

A sample from a frontal cavity was taken and analyzed by H. K. in 1949. The sediment was a Dryopteris-Cyperaceae swamp-peat. Corylus constitutes $45 \%$ QM $1.2 \%$, and Alnus $0.8 \%$, and the sample presumably originates from Zone Va. H. K. calls attention to the fact that the sun-bleached appearance of the skull indicates that it must have been exposed during a prolonged period.

## 26. Hallenslev.

The find was made in the lower-most peat layer on the border of a sand layer in a bog belonging to the farm "Sandhøjgaard" in the village of Hallenslev. Two samples were taken (U.M. 1962): (a) from the central part of a big peat-lump in the brain-case and (b) from the frontal sinus. They were analyzed by B.F. in 1963. The sediment in (a) was a finely stratified gyttja with a little fine sand and much microscopical charcoal and pyrite, and in (b) a highly humified swamp-peat with gyttja, pyrite, charcoal, and a little fine sand. As the two pollen spectra differed greatly new samples were taken, two of which were analyzed by B.F. in 1964, viz. (c) from the right foramen costotransversarium in a vertebra cervicalis, and (d) from the $\mathrm{P}^{4}$. Both sediments were like (a). The three spectra (a), (c) and (d) are very similar. QM and Alnus are missing or constitute less than $0.5 \%$, and Corylus varies from 33 to $40 \%$. A pollen grain of Hedera was found in (a). These three samples date the animal at Zone Va. Sample (b) is obviously contaminated, as also indicated by the crushed frontal region.

## 27. Lerbjerggaard, Niverod.

A sample was taken from a frontal cavity by Valdemar Mikkelsen in 1945. It was analyzed by B.F. in 1964. The sediment was a highly humified forest peat, but the spectrum is so characteristic (Corylus $58 \%$, QM $1,0 \%$ ) that the middle of Zone V is the only possible dating.

## 27 A. Kratholm.

The find was made at a depth of approximately 5 m . below a marl pit on a slope towards the river Odense å. A sample consisting of travertine was analyzed by Johs. Iversen in 1935. The spectrum: Betula $5.6 \%$, Pinus $62 \%$, Ulmus $2.8 \%$, Corylus $26 \%$, Varia $3.5 \%$ indicates the latter half of Zone V.
28. Alsonderup.

Two samples were taken (B.F. 1964): (a) the innermost part of a sample from the distal end of the cavity in the horn core, and (b) from the central part of a big lump in the horn core
at the base. The sediment was a highly humified swamp peat with a little gyttja and a few grains of sand, and in (b) many seeds of Menyanthes. The samples were analyzed by B. F. in 1964. The spectra are very similar, and the samples seem to originate from Zone V. The small frequencies of Corylus ( 27 respectively $25 \%$ ) indicate V a, whereas the frequencies of QM (1.0 respectively $1.7 \%$ ), and not least of Alnus ( 2.2 respectively $6.4 \%$ ) indicate late Zone Vb.

## 29. Jonstrup Vang.

A sample was taken from the deepest part of a peat-plug in the cavity of a complete horn core (B.F. 1964). It was analyzed by B.F. in 1964. The sediment was a highly destroyed swamp peat, and a normal pollen counting was abandoned, but a slide, rich in pollen (5001000), was carefully examined. Neither QM nor Alnus pollen was observed, whereas Corylus was very common. This seems to point to Zone V as the most likely.
30. Falster.

A sample taken from a cavity in a horn core (U. M. 1962) was analyzed by B.F. in 1963. The sediment was highly humified swamp peat with a great content of pyrite. The sample was clearly contaminated with recent material-thus three pollen grains of Gramineae sp. and one of Tubuliflorae sp. were recent, and one pollen grain of Plantago major or P. media was probably recent as well. Apart from this the spectrum is characterized by the high frequency of Pinus $(55 \%$ ) (due to the destruction). A dating of the sample can only be uncertainthe transition between Zones V and VI is the most likely.

## 31. Bedsmose.

The finder took two samples from the skull. They were analyzed by A. A. in 1945-46. The one, (a) was a peat with a spectrum from Zone V $(32 \%$ Corylus, $1.6 \%$ Alnus, $1.6 \%$ QM). One Hystrix, 1.5 Picea pollen grain, and possibly the two Tilia pollen grains indicate some contamination with secondary pollen. The other sample, (b) was a clay gyttja with an apparently uncontaminated spectrum from the beginning of Zone V (Corylus $4.3 \%$, QM totally missing). The possibility exists that the skull was lying with its deepest part in a gyttja from the beginning of Zone V, and the upper part embedded in swamp peat - later contaminated - from a slightly later stage of the zone, but this cannot be confirmed.

## 32. Risby.

From a peat pillar sent to the Geological Survey of Denmark by the finder, J. Ferdinand, 3 pollen samples were taken by A.A., one, (a), from the very layer with the horn cores, another, (b) from 5 cm . above this layer, and a third from 5 cm . below the layer. The two former were analyzed by A. A. in 1944. The sediments were: (a) a Dryopteris peat, and (b) a Cyperaceae-peat. The spectra are very similar, and originate from the beginning of Zone Va, with a Corylus percentage of 7.4 and 11 , respectively.

32 A. Ryemarksgaard. (Vide p. 212.)

## 33. Bregninge.

A sample was taken from the concha nasalis superior (H.K. 1953), and was analyzed by A.A. in 1953. The sediment was a somewhat humified gyttja. Corylus constitutes $60 \%$, and of the $3.5 \%$ QM, Ulmus constitutes $2.5 \%$ and Quercus $1.0 \%$. Two grains of Hedera were found. The sample must therefore originate from the very beginning of Zone VI.
34. Lorup Hede.

Two samples were taken (U.M. 1961) from the skull: (b) from the frontal cavity and (c) from a cavity in the horn core--this latter immediately after a fracture had occurred, the
sample thus certain to be without recent contamination. Both were analyzed by Sv. J. in 1961. The sediment in both samples was a humified chalk gyttja with fragments of shells and a great content of pyrite. A slide from sample (b) contained a total of 19.5 pollen grains and further counting was abandoned. (c) was also poor in pollen, but 6 slides gave 316.5 AP with a spectrum from the beginning of Zone VI.

A sample (a) which had been taken in 1938 was analysed by H. K. in 1945. The spectrum is from the middle of Zone V (Corylus $68 \%$ ).

## 35. Kulemile.

A sample taken from a cavity in the supraoccipitale (U.M. 1961) consisted of a big lump of gyttja, hard as a stone. From the central part of this a sample was analyzed by Sv. J. in 1961. It originates from Zone VI, and as Corylus constitutes $60 \%$, QM $7.6 \%$, with Ulmus $(4.4 \%)$ as the dominant species, and Alnus $1.5 \%$, the very beginning of the zone is most likely.

## 36. Grevinge, Gundestrup.

This find was made in a bog 600 m . east of Sylebjerg and 125 m . north-north-east of the farm Annexgåden, and belonging to the farm. Of the samples taken from the skull (B.F. 1963) two were analysed by B.F. in 1963: (a) from a nasal cavity on the right side, and (b) from the right foramen infraorbitale. The sediment in both cases was a drift gyttja with swamp peat, (a) containing a fruit of a Carex. The pollen spectra are very similar, and to some extent characterized by the local vegetation: Viburnum ( 2.2 respectively $0.2 \%$ ), Populus ( 5.4 respectively $2.5 \%$ ), and Tilia as frequent as Ulmus, 5 to 10 times as common as Quercus. Corylus is very frequent ( 56 respectively $67 \%$ ), Alnus and Quercus absent or rare, and the sample must be dated at the beginning of Zone VI.

## 37. Taageby.

H. Winge (1904, p. 290) offered the information that the find was made at a depth of 8 alen (app. 16 feet) in a bog beneath big trunks of oak. A sample was taken from the interior cavity of the horn core (U.M. 1962). The sediment is a highly humified swamp peat. It was analyzed by B.F. in 1962. The sample originates from the beginning of Zone VI (QM being $3.1 \%$, out of which Ulmus constitutes $2.4 \%$, no Alnus found, and because of the extremely high frequency of Corylus $(79 \%)$ ).

## 38. Bisserup.

A sample taken (U.M. 1962) from the foramen mentale mandibulae was analyzed by B. F. in 1963. The sediment was a slightly humified gyttja with a little fine sand. The spectrum seems to be very local, with $31 \%$ Salix. As Ulmus constitutes more than half the QM and the Corylus percentage is very high $(48 \%)$ it is most likely that the sample originates from the beginning of Zone VI. It should be mentioned that the skull was very much sun-bleached and covered on the underside with green, dried-out algae, which indicates an extended exposure out-of-doors.

## 39. Goderupgaard.

A plug-like sample was pulled out from the interior of the metacarpus, and from its deepest part a pollen sample was taken (B.F. 1956). It was analyzed by B.F. in 1956. The sediment was a gyttja with some swamp peat and a little sand. The spectrum is from the beginning of Zone VI, with a high frequency of Corylus ( $51 \%$ ), small amounts of QM $(2.8 \%)$, and very few Alnus $(0.3 \% / 0)$.

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40. Gøjs moor.

A sample, probably from a vertebra (U.M.) was analyzed by Inger Brandt 1945. The sediment was a swamp peat. Few pollen grains were counted, but as QM constitutes $6.0^{0} / 0$ the sample must be assumed to originate from the very beginning of Zone VI.

## 41. Kettinge.

A sample from the brain-case, taken by O. Nielsen, Nykobing F., was analyzed by A. A. in 1950. The sediment seems to be a gyttja ( $18 \%$ Nymphaea). QM constitutes $7.3^{0} /$, Corylus $46^{\circ} / 0$, and the dating is the beginning of Zone VI.

## 42. St. Damme.

Steenstrup, who excavated a part of the almost complete skeleton in 1865 , has given a very detailed description of the excavation, the position of the bones in the peat, etc. $(1870$, p. 106-110. With a summary in French). Large numbers of pine needles were found between the bones and in the supposed stomach, but as no other macrofossils were found, it cannot be decided whether the find originates from Zone IV or Zone V.

## 43. Maglemose, Mullerup.

This site has been pollen-analytically dated by K. Jessen (1935, p. 5-13). According to the diagram of Maglemose finds published by Sv. J. (Jørgensen, 1954, p. 183) Mullerup is dated at Zone Vb.

## 44. Lundby.

K. Jessen (1935, p. 23-31) has made a pollen-analytical investigation of this site. From his diagrams it can be seen that this dwelling place, found in the same bog as No. 45 , Sværdborg, can be dated at Zone V, apparently having come into existence at the end of Zone Va and lasting into Zone VI.

## 45. Sværdborg.

This site, dated by K. Jessen (1935, p. 16-23), seems to be slightly later than Lundby, dating at the first half and the middle of Zone VI. But it should be kept in mind that many of the great finds from Danish bogs excavated in the first decades of the 20 th century are difficult to date pollen-analytically, mainly because the sites were used again and again during long periods of time.

## 46. Holmegaard

This site has been pollen-analytical dated by K. Jessen (1935) and by T. Nilsson (1947). Sv. Jørgensen has discussed the divergency between the two datings of the Holmegaard West settlement (Jørgensen, 1954, p. 175), finding himself a dating at the very beginning of Zone VI most probable. This is confirmed by the dating of two skulls of dog (Canis familiaris), found in the settlement Holmegaard IV, made in 1964 by B.F. The analyses are included in the list as No. 43 a (skull marked 58 E -a sample taken (B.F. 1964) above the palatinum consisting of gyttja with a little swamp peat and drift, i.a. a seed of Nymphaea) and 43 b (skull marked 46-48. X. E-F.-a sample taken (B. F. 1964) from the left bulla tympani, consisting of a chalk-gyttja with few shells and a little swamp peat). Both spectra clearly belong to the very beginning of Zone VI.

## 47. Vinde Helsinge.

Troels-Smith (unpuslished) investigated the bog in 1935 and worked out a pollen diagram. The dwelling-place was situated directly on dried-out lake marl, i.e. in a period when
the water-level was low. The diagram is from just outside the small "island" where the people settled, and the culture layer covers the transition V-VI.

## 48. Øgaarde II.

This site has been dated at the middle of Zone VI by Troels-Smith (1943, p. 148-53).
49. Hesselbjerggaard.

This site has been dated at the middle of Zone VI by Troels-Smith (1943, p. 161).
50. Magleo $I$.

This site has been dated by Troels-Smith (1943, p. 153-58). The settlement can be dated at the middle of Zone VI, though the upper and lower limits are a bit uncertain, cf. Jorgensen (1954, p. 183).
51. Kongemose.

A preliminary pollen-analysis by the excavator, Sv. Jorgensen (1956, p. 37), has shown that the site can be dated at the transition between Zones V and VI, or the very beginning of Zone VI.
52. Ulkestrup.

Sv. Jorgensen (1963, p. $25-26$ ) has published a diagram from the site. Due to the occurrence of floating islands the dating cannot be more accurate than Zone VI in general.

## 53. St. Taastrup.

A sample taken in 1938 was analyzed by H. K. 1945. The sediment was a slightly sandy gyttja with a very strange spectrum. In Japetus Steenstrup's correspondence in the Royal Library a letter tells us that many years earlier a skull of a Urus was found in the same bog, but that it was thrown into the bog again. It seems very likely that it is the same skull which was found in 1880, and this may be the explanation of the very mixed pollen spectrum dominated by Betula and Pinus. The occurrence of a few pollen grains of Corylus and Alnus, and a single one of Ulmus may be contamination, and if this is the case, the dating may be Zone IV, this supposition being reinforced by the plentiful occurrence of Empetrum. Theoretically Zone II is a possibility, too. In any case, the animal seems to be older than Zone VI.

## 54. Bonnelykkegaard.

A sample, (a) was taken from cranial cavities (H.K. 1948) and analyzed by H.K. in 1948. The sediment was peat, and the sample originates from Zone VII. Another sample, (b) was taken (U. M. 1961) between the orbita and $\mathrm{M}^{3}$, and was analyzed by Sv. J. in 1961. This sediment was a slightly humified swamp peat with some gyttja. A seed of Menyanthes was found. The spectrum is very similar to that of sample (a).

As this seemed to be only Atlantic find of the Urus made in a bog, two further samples were taken to be analyzed after the completion of the tables (B. F. 1965): (c) from the humerus dextra below the proximal trochanter minor, and (d) from the lacrymale dextra. The sediments were coarse detritus gyttja with some slightly humified swamp peat. The spectra are from Zone VII, as were (a) and (b). The following pollen grains were found: Hedera (3-6), Alnus (348-471), Betula (99-86), Humulus (2-0), Chenopodiaceae (1-0), Artemisia (0-2), Tubuliflorae (1-1), Corylus (196-139), Cruciferae (0-1), Cyperaceae (48-53), Quercus (147-183), Gramineae (24-14), Secale (1-0), Lemnaceae (1-1), Viscum (1-1), Menyanthes (1-4), Nuphar (1-0), Nymphaea (4-2), Fraxinus (2-3), Abies (1-0), Pinus (94 ${ }^{1} /{ }_{2}-100$ ), Eupotamogeton (3-5),

Ranunculus repens type (0-1), Galium (0-1), Populus (1-9), Salix (2-4), Sparganium type (7-9), Tilia (91-61), Typha latifolia (1-0), Ulmus (74-79), Umbelliferae (3-1), Urtica (3-0), a.i.d. (4-1), a.i.p. (0-1), E (1164 $1 / 2-1239)$, Dryopteris type (111-113), Pteridum (1-1), Botryococcus (4-1), Pediastrum (11-9), Ceratophyllum hair (3-5), charcoal (4-5), "Paraplya" (4-1), recent Corylus (1-0), D.b. (14-17).

## 55. Ørting.

A big sample was taken from the brain-case (U.M. 1960), and later a sample (a) taken from the centre of this lump was analyzed by Sv. J. 1960-61. Another sample from a nerve foramen in the orbit was analyzed by B.F. in 1964. The sediments were very similar, namely a somewhat humified alder-swamp peat with a few grains of sand. The spectra are also very similar, with a few pollen grains of Plantago lanceolata and of other plants favoured by human activity. There is no doubt that the samples originate from Zone VIII, and the Ulmus decline in the very beginning of the zone is most likely, as the sum of pollen of Tilia and Ulmus is almost the same as the number of Quercus pollen. The different land occupation phases (the "A-landnam", the "B-landnam" and the "passage grave landnam") are mentioned in connection with the cattle on p. 205 ff ., and a survey is also given in S. Hansen (1965).

## 56. Østbirk.

From the centre of a big sample from the brain-case (U.M. 1960) a pollen sample was taken out and analysed by Sv. J. in 1960. The sediment was a slightly humified gyttja with swamp peat (or vice versa) with a little sand. The find of a pollen grain of Plantago lanceolata, together with the scanty amount of Tilia, and not least of Ulmus in relation to Quercus (2.4, 1.1 , and $19 \%$ respectively) date the sample at Zone VIII.

## 57. Pindstrup

4 samples were taken (H. K. 1951): (a) from the nasal cavity, (b) from the bulla tympani, (c) from a cavity in the maxilla just behind $\mathrm{M}_{3}$, and (d) from a big protected lump in the distal inter-condylar notch of a femur. The sediments were alder-swamp peat with some gyttja. The spectra are very similar, originating from Zone VIII. The very sparse Ulmus (max. $0.5 \%$ ) shows that the very beginning of the zone is out of the question; on the other hand there is the fact that neither Fagus nor Carpinus were found (the total sum of AP is 1574).

## 58. Ugilt.

A big sample was taken from a skull cavity under the orbita (U. M. 1962). From the centre of this a small sample was analyzed by B.F. in 1963. The sediment was a highly humified swamp peat, originating from Zone VIII, indicated amongst other things by one pollen grain of Viscum, one of Hedera, two of Plantago lanceolata, and none of Fagus. Of special interest is $18 \%$ Rumex acetosella and/or R. acetosa, and this, together with $14 \%$ Gramineae, indicate extended forest-less areas, but without a diagram from the very basin, a closer dating cannot be given, as it can be related to any local forest clearance.

## 59. Klarup.

A sample, (a), was taken from a cavity between the radius sinistra and the ulna, and another, (b) between the lower epiphyses of the metatarsus sinistra (U.M. 1963). These were analyzed by B.F. in 1963. The sediments were rather humified swamp peat. The spectra are very similar, and characteristic of Zone VIII. As in the sample from Ugilt, Rumex acetosellal acetosa was very common ( 9.4 and $4.6 \%$, respectively). Tilia and Ulmus constitute approximately half of the QM, and may thus possibly indicate the beginning of the zone.
60. Auning, Lykkegaards moor.

Valdemar Mikkelsen analyzed three samples in the 1940 e , dating the animal at Zone VIII. The three spectra are very similar, and they have been averaged in Table A as No. 60 a. A sample, (b), from a calcaneus was analyzed by B.F. in 1964. The spectrum confirms the dating. Another sample from the centre of a big peat-lump from the brain-case gave the same result; this sample was prepared, but not counted.

## 61. Toftum.

A sample was taken (a) from a cavity near the meatus acusticus and (b) from a nasal cavity (T-S 1960). Both were analyzed by Sv.J. in 1960. The sediments were highly humified alder-swamp peat $\left(10-20^{\%} \%\right.$ of all the pollen counted could not be determined because of destruction), and as a consequence but few pollen were counted. In spite of this pollen grains from culture-plants and culture-favoured plants were met with (Plantago lanceolata, Liguliflorae, Polygonum cf. aviculare), and the AP-spectum also indicates Zone VIII.

## 62. Aarhus.

A sample was taken in a cavity near the meatus acusticus (T-S 1960). It was analyzed by B.F. in 1960. The sediment was a slightly sandy-clayey, rather humified swamp peat with gyttja. The occurrence of 27 pollen grains of Ruppia (of a total of 380.5 ) showed that it must be a marine sediment. The spectrum is from Zone VIII. (Tilia, and especially Ulmus rare, a single pollen of Plantago lanceolata). From Brabrand sø (lake), a few km. west of Aarhus, a pollen diagram covering Zones VII-VIII has been published by Troels-Smith (1937). Lake Brabrand was an inlet during a long period until the end of the Subboreal transgression. It is not possible to fit the spectrum from the Urus into the diagram, but at the end of the transgression Quercus and Fraxinus reach high percentages, as is the case with the present spectrum. The sediment as well would indicate the time just before the regression.

## 63. Korinth.

From the centre of the very big lump of stone-hard mud in the brain-case a sample was taken to be analyzed by B.F. (1964). The sediment was a very highly humified alder-swamp peat. The spectrum is from Zone VIII, and the relatively high frequencies of Tilia and Ulmus (4.1, respectively $2.7 \%$ ) might indicate the beginning of the zone.

## 64. Bonnerup.

H. K. has analyzed samples from the smaller animal: (a) from the metacarpus, (b) from the metatarsus, (c) from a nerve foramen in the metatarsus, and one sample from the larger animal: (d) from the metacarpus. The spectra are very similar, originating from Zone VIII.

## 65. Holme moor.

A sample was taken from a frontal sinus (U. M. 1962). It was analyzed by B. F. in 1963. The sediment was a highly humified swamp peat originating from Zone VIII-indicated by three pollen of Plantago lanceolata, etc. Several features point to the regeneration phase after a forest clearance in the beginning of the zone (the "B-landnam"): Tilia $5.1^{0} /{ }_{0}$, Ulmus $1.1^{0} /{ }_{0}$, Betula $21^{\%} \%$, and Corylus $43 \%$, and relatively few herb-pollen grains, apart from Cyperaceae.

## 66. Hornslet.

A sample was taken from the centre of a big lump of gyttja found in the brain-case (B. F. 1964). It was analyzed by B.F. in 1964. The sediment was but slightly humified coarse detritus-gyttja with a touch of clay. Two seeds of Betula, small fragments of Nymphaea seeds,
besides two oospores of a characeous plant were found. The AP-spectrum shows that the sample originates from Zone VIII, as indicated also by Plantago lanceolata. The find of one pollen of the marine Ruppia, one "Hystrix", besides a Tertiary (?) spore ("Pentagon"), often met with in Danish marine sediments, are in sharp contrast to the freshwater sediment (pollen and seeds of Nymphaea). No explanation can be given, as nothing is known about the findingplace.

## 67. Horning.

A sample was taken from a sinus in the occipital crest (U. M. 1961). It was analyzed by Sv. J. in 1961. The sediment was a highly humified swamp peat. The sample originates from Zone VIII, as indicated by 3 pollen grains of Plantago lanceolata, etc. The high percentage of Tilia $(7.0 \%$ ) in contrast to the low one of Ulmus $(1.8 \%)$ and the high Betula percentage $(19 \%)$, and six pollen grains of Hedera $(0.5 \%)$, tend to date the sample to the stage just after the Ulmus decline and before the Tilia decline and the Corylus incline.

## 68. Olgod.

A sample was analyzed by A.A. in 1942. According to the spectrum the sediment was an Alnus-fen peat. A.A. notes that it was somewhat humified and that treatment with hydrofluoric acid was necessary, indicating the presence of either sand or clay. The AP-spectrum might be either Zone VII or Zone VIII, but two pollen grains of Plantago lanccolata were found, indicating VIII. As nothing is known about the taking of the sample, the dating of the animal on the basis of this analysis is rather uncertain.

## 69. Tranekær, Staus Hede.

Two samples were taken (U.M.), (a) from the nasal cavity and (b) from the meatus acusticus. They were analyzed by H. K. in 1945. (a) is a slightly sandy peat, too poor in pollen to justify a counting. (b) according to H.K. was a light sandy gyttja, but the very high percentages of Alnus and Cyperaceae ( 66 and 18, respectively) and enormous quantities of spores of ferns seem to indicate a high content of Alnus-swamp peat. The sample originates from Zones VII-VIII. Too few pollen grains have been counted to make a safe dating; the lack of pollen of cultivated plants, and the fact that Tilia and Ulmus are rare in diagrams from the heath plains of West Jutland point to Zone VII, whereas the high frequency of Fraxinus points to Zone VIII.
70. Skovlund.

The atlas was found during ploughing in a small cultivated bog 200 m . south of the farm Skovlund, one km. northeast of the village of Dybvad. Two samples from nerve formina were taken a few months after the finding (Sv.J. 1962), and analyzed in 1963 by Sv. J. The samples were very similar according to sediment as well as spectrum, and will be regarded as one in the following. The sediment was a somewhat humified swamp peat with some gyttja and a little sand. Finding of pollen of Cerealea, Plantago lanceolata, P. major, a Polygonum aviculare type, and high frequencies of a Rumex acetosella type and, in contrast to these, only two pollen of Fagus and one of Carpinus (out of a total of 2238 AP) date the samples at Zone VIII. Ulmus is still rather frequent and a little more so than Tilia and Populus is frequent; this and others features seem to narrow the dating down to the "A-landnam", or to the beginning of the "B-landnam". The latter is most likely.

## 71. Kjærsholm.

Three samples were taken by T-S in 1960: (a) in the cavity behind the right $M_{3}$, (b) behind the left condyle of the mandible, and (c) in the nerve foramen in the right orbit. All
samples were analyzed by B.F. in 1965. (a) was a highly humified alder-swamp peat with a few grains of sand, (b) was like (a), but in addition had a piece of Menyanthes seed and small pieces of twigs; (c) was a less humified swamp peat with a touch of gyttja beside some few grain of sand.

The pollen spectra are somewhat different, mainly because of being to a great extent characterized by local vegetation, demonstrated by $25 \%$ of Urtica and $57 \%$ of Alnus etc., in (a). This local over-representation may be the cause of the very high frequencies of Betula and Pinus ( 20 , respectively $41 \%$ ) in (c), or it may have been caused by contamination with Boreal material. It should be mentioned that the find was made in the course of regulation of the river Tange Aa, and the possibility of a rebedding of the skull cannot be excluded. (a) and (b) are very similar as far as the AP-spectrum and also the NAP-spectrum are concerned, which dates the samples at Zone VIII (Plantago lanceolata 1.0 , respectively $1.5 \%$, Rumex acetosella type 2.6 , respectively $3.5 \%$, Fagus 0.2 , respectively $0 \%$, and no Carpinus). In (c) Plantago lanceolata was not found, but one P. major.

71 A. Læsten. (Vide p. 212).

71 B. Grejs Molle. (Vide p. 212).
71 C. Fæsted. (Vide p. 213).

71 D. Tinglev. (Vide p. 213).
72. Rise.

Two samples from the skull, (a) and (b), were analyzed by A. A. in 1942-43. The frequencies of Fagus ( 10 , respectively $2.1 \%$ ) together with other indices point to Zone IX. But it should be kept in mind (1) that the find was made in the bank of a brook running through a meadow or bog, (2) that the samples were sandy, and (3) that the skull was water-worn, and that the dating - the only dating of a Danish Urus at Zone IX - therefore is slightly uncertain.

## 73. Jelling.

Two samples were taken (B.F. 1964): (a) from a nerve canal in a vertebra and (b) from the interior of the distal end of the horn core. They were analyzed by B.F. in 1964. The sediment was a chalk-gyttja with swamp peat, in (a) with chalk-gyttja as the dominating fraction (Potamogeton $11 \%$ and Polypodiaceae $21 \%$ ) and in (b) with the swamp peat dominating (1.7, respectively $667 \%$ ). The pollen was highly destructed in both samples (D.b. 86, respectively $90 \%$ ). The AP-spectra are very similar, and both are characterized by over-representation of Pinus, Tilia and other easily recognizable pollen. A dating of the samples can only be very uncertain, but no culture pollen was found, although a very dense slide was examined (but not counted) to look for Plantago, etc. Ulmus constitutes a great part of the QM, partly due to over-representation, and Fraxinus was not found. The Rumex acetosella type on the other hand, is, in general very scarce in Zone VII. The samples must be dated at Zone VII, or the very beginning of Zone VIII.

## 74. Skaarup, Skanderborg.

The finder brought a sample, still with the impressions of the teeth, which was analyzed by A.A. in 1941. Too few pollen grains were counted for a safe dating, but the sample originates from Zone VII or Zone VIII.

## 75. Mariager.

A sample from the interior of the horn core was taken (U.M. 1949) and was analyzed by H. K. in 1949. The sediment was a chalky clay gyttja with fragments of shells and a great content of fine sand. The spectrum is Atlantic, but as it contains many secondary pollen grains (Pinus haploxylon type, Sequoia, etc.) besides Hystrix, the dating at Zone VII is somewhat uncertain, even though no culture pollen was found. The risk of the horn core being re-bedded may be added.

## 76. Mjesing.

A sample was analyzed by A.A. 1940. The sediment seems to be a Dryopteris swamp peat. The spectrum is somewhat strange ( $23 \%$ Tilia, $53 \%$ Ulmus ) and is most likely to be Atlantic but only 131 AP were counted. The dating at Zone VII is also uncertain, as nothing is known about the taking-out of the sample.
77. Asaa.

A sample from grooves on the outer surface of the horn core was analyzed by H.K. in 1946. As the find was made during dredging of a brooklet, and the spectrum was clearly mixed, the result is too uncertain and will not be given in the table.

## 78. Understed.

The find of the horn core was made during dredging of a brooklet. The finding-place was visited on Sept. 29th, 1960 by T-S and U.M., who further found some teeth and other parts of the skull. From the sediment, in which the impression of one of these was made, a sample was taken (B.F.). A profile was dug near the finding-place, showing:
$0-108 \mathrm{~cm}$. : heterogeneous, loamy fine sand with more peaty or sandy parts.
$108-$ ? cm.: sandy moraine clay.
The parts of the skull were found at a depth of $80-90 \mathrm{~cm}$. The sediment of the pollen sample was sand with coarse drift. The spectrum was from Zone VIII ( $1.1 \%$ of Ulmus, 1 pollen grain of Plantago lanceolata). But as parts of the skull are likely to be re-bedded, the dating is, to put it mildly, very uncertain.

## 79. Julianelyst.

A sample taken in a frontal sinus (U. M. 1961) was analyzed by Sv. J. 1961. The sediment was a rather humified, sandy swamp peat, possibly originating from the beginning of Zone VI, but possibly being a mixture of a sediment from Zones IV-V ( $37 \%$ Pinus, relatively high frequencies of Populus, Salix, Filipendula, Thelypteris dryopteris) and a sediment from VII or VIII (2 uncertain Cerealea pollen grains, but no Plantago).
90. Brabrand. (Vide p. 214).
94. Norslund. (Vide p. 214).

## Summary of the Datings of the Urus

In the diagram, fig. 2, a survey is given of the results of the pollen-analytical datings. It should, however, again be pointed out that the reliability of the datings will be very fluctuating. No attempt has been made at classifying the samples according to reliability, for example by means of different signatures in the diagram. The reader


Fig. 2. Pollen-analytical dated finds of Urus (Bos primigenius) in Denmark. The finds No. 32 A (Pollen Zones V-VI) and No. 90 (Zone VII) have not been included.
therefore, is referred to the text dealing with the individual samples to learn under what circumstances the sample was taken. The datings should be within the space of time marked with a continuous line; only if there is some uncertainty concerning the limits, a dotted line is used, frequently, though, with an unbroken line to suggest the most likely period.

One animal has been dated at Zone III, one at the transition III-IV, 12-16 at Zone IV (12 are from the zone proper, while 4 may be from another zone), 17-29 date from Zone V, 15-22 from Zone VI, 2-3 from Zone VII, 21-23 from Zone VIII, and one or two from Zone IX. In other words: From Zones IV-VI, covering a period of about 2.5 millenia 54 finds are known, from Zone VII, covering another 2.5 millenia only 2 or 3 are known. From the following 2.5 millenia, Zone VIII, we have 21 finds, while from the last 2 millenia and up to the present time only two uncertain finds are known. To this it may be added that some of the Uruses found in "kitchen-middens" from the so-called "Ertebolle culture" may originate from Zone VII, e.g. Brabrand (cf. p. 214), but as the problems concerning the dating of the Ertebolle culture have not yet been solved-besides the fact that they are usually mixed up with material covering several millenia - they have not been included in this summary.

The Urus seems to have invaded Denmark at the end of the Late-glacial Period, but the possibility of a temporary immigration as early as the Allerød Period does exist. During the Preboreal and the Boreal it was very common all over the country as it was in southern Sweden, especially in Scania (cf. Isberg, 1962). From the transition to the Atlantic period and during the following 2.5 millenia up to the forest clearances at the beginning of the Subboreal it must have been very rare as were also other big mammals, including man. This fact is usually interpreted as being a consequence of the dense growth of the climax-forest.

20 of the 21 finds from the Subboreal are from Jutland, one from Funen and none from Zealand, nor from the other isles east of the Great Belt, which were formed during the period from late Zone V to early Zone VII (Krog 1960, p. 127). This seems to indicate that the Urus died out in the eastern part of Denmark during the Atlantic, and if this holds good, the cattle on Zealand cannot be locally domesticated Urus oxen.

The diagram, fig. 2, very much resembles the corresponding one from Sweden (Isberg 1962, fig. 13), where only one find dates from the Atlantic as against 68 from the Preboreal and the Boreal, and 19 finds scattered through the Subboreal and Subatlantic. In Denmark the Urus seems to have died out at the end of the Subboreal (the two uncertain Subatlantic finds are very close to the German frontier and may be accidental guests). For a discussion of the possible late extinction of the Urus in Sweden (1100-1200 A.D.) see Degerbøl (1945 p. 31-32) and Isberg (1962 p. 514).

## Bos taurus domesticus

## I. Øgaarde I.

The find of a skull was made during peat cutting close to an Ertebolle settlement with thin-walled ceramics, and the same day the place was investigated by T-S and B. Brorson Christensen. A section could not be obtained, but 36 bones were found in addition to the skull, all of them rebedded. A number of pollen samples were taken from the skull and from the inside or outside of various bones in order to discover possible discrepancies between pollen-analytical datings of various samples from the same animal. 14 samples were analyzed by Sv. J. in 1955-56.

The result will be published later by Sv. J., but it can briefly be stated that the variations in the spectra are very slight. Several published and unpublished pollen diagrams from within a distance of a few hundred metres of this settlement, and covering the same period, are available at the National Museum, and the 14 samples analyzed originate from the period of the Ulmus decline at the very beginning of Zone VIII. The well-known settlement Mul I, situated approximately 1 km . from Ogaarde in the same basin, Aamosen, originated from the same period. Mul I is the "type locality" of the "semi-farmer culture", responsible for the "Alandnam" (cf. Troels-Smith 1954 and 1960). In the pollen diagrams this period is characterized, amongst other things, by few, but on the other hand constantly occurring pollen grains of Allium ursinum and Plantago major, and a but slight increase in grasses, possibly indicating that the cattle was stable-fed, in contrast to the later "B-landnam", as described by Iversen (1941), when herds of cattle were untethered and left to graze on extensive pastures of grass, Plantago lanceolata, Trifolium repens, etc., but with no Allium ursinum, and rarely Plantago major.

In the Mul I excavation as well, bones of domesticated cattle were found. The site, dated by radiocarbon (Tauber 1960) was used only during a short period about 2.800 B.C., and pollen-analytically it is placed in the very Ulmus-decline.

## II. Store Lyng.

The third animal from the period of the "A-landnam" is from Store Lyng, a couple of hundred metres from Øgaarde. Less than a month after the find the place was investigated by T-S, who took a series of samples. In the profile he found a phalanx in situ and took a sample, (c). In 1960 and 1962 he obtained some further samples from the Zoological Museum, two of which: (a) from the nasal cavity and (b) from the brain-case, were analyzed by B. F. in $1962-$ 64 , together with (c). The sediments were gyttja with a little drift, some swamp peat, and a few grains of sand, besides, in (a) and (c) some snail shells. In (c) was found a seed of Nuphar luteum, and in (b) a seed of Urtica.

## III. Verupgaard.

This find as well is from Aamosen. A sample, (a), from the brain-case was analyzed by H. K. in 1949, and later, in 1964, B. F. analyzed another sample, (b), which is assumed to have come from the same glass tube as (a). The sediment in (b) was a drift gyttja with a little swamp peat. Three fragments of fruits of Najas marina (fairly common in Danish Post-glacial freshwater sediments), three oospores of characeous plants, one seed of Lythrum salicaria, and two Carex nuts were found. Apart from minor deviations in the frequencies of Fraxinus and Gramineae the spectra are very similar. The percentages of Tilia (3.9, respectively $3.2 \%$ ) and especially of Ulmus ( 4.5 , respectively $4.6 \%$ ) are relatively high, indicating the beginning of Zone VIII, but with $2.1 \%$ Fraxinus and $0.9 \%$ Plantago lanceolata in (b), a dating slightly later than the "A-landnam" is most likely.
IV. Ogaarde II.

The skull was presumably found by peat workers who had placed it on the surface near the peat pitch, where it was discovered by T-S. Three samples were also taken by B. Brorson Christensen shortly afterwards, in 1943, (a) from the brain-case, (b) from the nasal cavity, and (c) from the right glenoid fossa. They were analyzed by Sv. J. in 1955. The sediment was the same in all samples: a fine detritus gyttja with a little swamp peat. The spectra are also very similar, and with sparse Tilia $(1.1-1.5 \%)$ and Ulmus $(0.9-1.0 \%)$, more frequent Fraxinus (1.3-2.2 $\%$ ), plenty of Corylus $(38-40 \%$ ) and a relatively high frequency of Plantago lanceolata $\left(0.7-0.9 \%_{0}\right)$ a dating at the "B-landnam" in the middle of the 3rd millenium B.C. is most likely.

## V. Øgaarde III.

The skull was found together with the preceding find. B. Brorson Christensen took the following samples in 1943: (a) from the brain-case, (b) from the left meatus acusticus, and (c) from the interior cavity of the left horn core. They were analyzed by Sv. J. in 1955. The sediment was the same in the three samples: a fine detritus gyttja with a little swamp peat, and the pollen spectra are almost identical with the three from Øgaarde II as well.

## VI, VII, VIII. Troldebjerg, Gammellung moor.

Four skulls of bulls were found during the excavation, and pollen-analytical dating of three of them was published by Iversen (1941, p. 58). In Table A the three analyses are included as VIa, VIb, and VIc, as it is not known which sample belongs to what skull. The pollen spectra are very similar, characterized by high frequencies of Corylus and Alnus, and very low frequencies of Tilia and Ulmus. In the diagram from the same bog, published by Jessen (1938, p. 127), no corresponding pollen spectrum can be found, and Iversen (loc.cit.) takes these three samples as a proof that "at Troldebjerg, too, there is a pronounced occupational phase" - in the present paper called the "B-landnam".

## IX. Nyrup I.

The skull was found together with a collared flask of Early Neolithic age and five handsized stones, indicating an offering. At a distance of approximately 1 m . bones (the skull and sacrum, etc.) of another ox, and further away, but still at the same depth below the surface, two further skulls were found (Becker 1947, p. 40).

Two samples were taken (B.F. 1964): (a) from cavities in the left occipital region and (b) from a nerve foramen in a vertebra. They were examined by B.F. in 1964. (a) was a drift gyttja with swamp peat and a little sand; one seed of Nymphaea alba, one fruit of Carex sp., one seed of Fragaria sp., and one oospore were found. (b) was a highly humified alder-swamp) peat, mainly consisting of alder roots.

The pollen spectrum in (a) is characteristic of the "B-landnam", in accordance with the archaeological dating. (b) was very poor in pollen and was not counted.

## X. Nyrup 11 .

Another of the skulls from Nyrup (vide above) has been dated. Three samples were taken: (a) from sinus occipitalis dextra, (b) between the nasals (B.F. 1964), and (c) from a nasal cavity (T-S 1962). They were analysed by B.F. in 1964. The sediments in (a) and (b) were fine detritus gyttja with a little drift, in (a) thus one fruit of Betula sp. and six oospores and in (b) small fragments of stems of water mosses. (c) was a drift gyttja with swamp peat containing one fruit of Betula sp. and one badly preserved fruit of a Cyperaceae, presumably a Carex. The pollen spectra are very similar to IX.

X A. Nyrup III.
Only lately, during the writing of the present paper, another skull from Nyrup bog has been pollen-analytically dated. The sample was taken from a cavity in a horn core (U. M. 1965) and analyzed by B.F. in 1965. The sediment was a fine detritus gyttja with a few grains of sand. The spectrum is very similar to the four spectra from IX and X.

As the analyses were made after the closing of Table B, but before the closing of Table A, the figures of the species not mentioned in Table A will be given: Centaurea cyanus 1, Chenopodiaceae 1, Cruciferae 1, Hypericum 2, Lemnaceae 18, Mentha type 1, Menyanthes 1, Plantago major 1, P. major/P. media 1, Sparganium type 1, Thalictrum 1, Typha latifolia 23, Tubuliflorae 3, Umbelliferae 3, a.i.d. 2, a.i.p. 2. Summa spermatophyta 1017. Dryopteris type 312, Pteridium 4, Botryococcus 1, Pediastrum 34, Ceratophyllum hair c, charcoal c, "Paraplya" 3, fragment of Characea oospore 1.

A remarkable find is that of Centaurea cyanus, which has not otherwise been recorded between the Late Glacial and the 14 th century A. D., when it becomes common with the introduction of cultivation of winter crops. Contamination cannot, of course, be excluded, and this find is not very suitable for demonstrating an Early Neolithic occurrence, though a rare occurrence of this weed cannot be ruled out.

## XI. Snoldelev $I$.

The sample was taken in 1938. It was analyzed by H. K. in 1946. The sediment was a sandy gyttja. The spectrum is very similar to the five spectra from Nyrup, thus indicating a dating at the "B-landnam".
XII. Vedbæk I (1942).

Two samples were taken (B.F. 1964): (a) from cavities in the occipital region and (b) from the centre of a big lump of sediment between the nasals. Both were analyzed by B.F. in 1964. (a) was a marine, clayey-sandy peat with a little swamp peat and many pieces of wood besides three fruits of Alnus. (b) was a marine, slightly sandy, clayey gyttja with fragments of molluse shells, of Mytilus edulis and others.

The spectra are almost identical, with Alnus the dominating species (62, respectively $60 \%$ ). Of special interest is the find of one pollen grain of Allium ursinum in (b). As mentioned above, this species occurs in freshwater diagrams in the period of the "A-landnam", but disappears during the "B-landnam", presumably having been eaten by the grazing cattle (TroelsSmith 1954, p. 55). The analysis of a diagram from the former inlet at Dyrholmen (B.F. unpublished; part of the diagram published in Troels-Smith 1960) gave eight pollen grain of Allium ursinum throughout the "A-landnam" and during the "B-landnam".

Concerning the dating of the samples the frequencies of Plantago lanceolata and the occurrence of pollen of the Trifolium pratense type, the T. repens type, and the Polygonum aviculare type, together with the sparse Tilia and Ulmus and the relatively high frequencies of Fraxinus indicate that the oldest possible dating is the "B-landnam". A total of five Carpinus, some of which may have been rebedded, together with Engelhardtia and others, but no Fagus (AP total: 2780.5) point to the middle of Zone VIII. During the Subboreal transgression the valley was an inlet, but the exact time of the regression is not known.

## XIII. Maglemosegaard, Vedbæk II.

Another skull from the same inlet as in XII has been dated. Two samples were taken (B.F. 1964): (a) from the middle of a big lump from the interior cavity of the right horn core, and (b) from a frontal cavity. They were analyzed by B.F. in 1964. The lump from which (a) was taken was heterogeneous, mainly consisting of gyttja, hard as stone, but in places with many fragments of molluscs. During the preparation of the pollen sample the sediment proved
to be marine, sandy clay-gyttja with small pieces of wood, a little swamp peat, five fruits of Ruppia maritima, one fruit of Najas marina, one fruit of Betula sp., besides some oospores. (b) was a marine, sandy-clayey peat with some gyttja. Two fruits of Alnus and one fruit of a Chenopodiaceae sp. were found. Nine pollen grains of Lemnaceae sp. indicate outflow of fresh water. In both samples pollen of Eupotamogeton was found.

The sediments must originate from shallow, brackish- or salt water. Ruppia maritima can be met with in brackish water with a NaCl-concentration of less than $0.3 \%$. (Mathiesen and Nielsen 1956, p. 19). High frequencies of Alnus and Cyperaceae may indicate that the sedimentation took place immediately before the regression.

Like the preceding find (XII) the earliest possible dating is the "B-landnam", but XIII seems to be later, presumably from just below the zone border VIII-IX, as six pollen grains of Carpinus and nineteen of Fagus (AP total: 3.122.5) were found. In the case of both animals the possibility of some rebedding of material in the shallow water near the beach should be kept in mind.

XIII A. Vedbæk ((vide p. 214).
XIV. Ordrup moor.

The dating of the bone as well as a diagram from the bog proper have been published by Iversen (1941 p. 61). The sample originates from the beginning of Zone VIII, just above the layer with the many pieces of charcoal (the result of the burning of part of the forest during the "B-landnam").

XV-XVI. Holmene, Hillerod.
A sample from one of the animals was analyzed by A.A. in 1942. The spectrum is characterized by Corylus $(36 \%$ ) and Alnus $(52 \%) .1 .3 \%$ Plantago lanceolata suggests the "Blandnam', to be the oldest possible dating.

## XVII. Borremose.

The find was made during peat cutting "at the bottom of the peat layer". A sample from the os sacrum (H.K. 1949) was analyzed by the same worker in 1949. The sediment was an alder-swamp peat with a little gyttja, owing to the fact that the bottom of a peat ditch usually borders on an underlying gyttja. Neither Fagus nor Carpinus was found; the frequency of Plantago lanceolata, on the other hand, indicates that the sample cannot be older than the "B-landnam".
XVIII. Sandhuse moor $I$.

A sample from a cavity in the left occipital area was taken and analyzed by B.F. in 1964. The sediment was a humified alder-swamp peat with coarse and fine drift gyttja (thus one seed of Nymphaea alba and one of Scirpus sp.), a little fine-sand and pyrite.

The frequency of Fraxinus in relation to Tilia and Ulmus and the relatively few Corylus pollen grains ( $16 \%$ ) point to a time after the "B-landnam". Neither Fagus nor Carpinus was found (AP total: 1331.5).
XIX. Sandhuse moor II.

Two samples were taken during the excavation of some sites in the bog by Harald Andersen in 1945-46: (a) from a frontal cavity and (b) from the foramen magnum. They were analyzed by B.F. in 1964. (a) as well as (b) was a highly humified, slightly sandy, coarse detritus gyttja with fine and coarse drift. In (b) small fragments of seeds of Nuphar luteum, Nymphaea alba, and Najas marina were found.

Both skulls from Sandhuse Mose had a crushed frontal area and must have been laid out in the lake at that time as offerings. If the pollen samples really date the skulls, they are not of the same age, the second being considerably later, indicated amongst other things by the Fagus pollen grains and one Carpinus (AP total: 1448), and a much higher frequency of NAP. The large number of archaeological finds in the bog cover a long period and thus cannot give any hint as to the dating.
XX. Vejlby.

Two big gyttja cubes with marrow-split ox bones in situ were brought to the Zoological Museum by Sv. Th. Andersen. B. F. took five samples a few days later, in 1964. Three of the samples were analyzed by B.F. in 1964: (a) from the deepest part of a plug at the proximal end of the marrow cavity of the humerus dextra, (b) from the impression of the proximal end of a radius, and (c) from the impression of the os sacrum. The sediment in the samples was a slightly sandy clay-gyttja with a little swamp peat. High frequencies of Ruppia testified to the marine origin of the sediment, and so did the amount of rebedded Tertiary or early Quaternary pollen from Engelhardtia, Juglandaceae, Platycaria, Sciadopitys, etc. The single pollen grain of Ilex in (c) may well have been rebedded (cp. Troels-Smith 1960 p. 20: a total of eight Ilex pollen grains found in the Atlantic period in Danish diagrams, and eleven in the Subboreal), as may the two Helianthemum pollen grains in (c).
XXI. Ero.

A sample, taken in 1938, was analyzed by H. K. in 1945. The sediment was a sandy, slightly clayey gyttja. The spectrum is characterized by high frequencies of Chenopodiaceae $(10 \%)$, but apart from the absence of Fagus and Carpinus (AP total: 239) it gives no hint as to the time from which in Zone VIII the sample originates.
XXII. Logtved Enge.

A sample taken in 1938 was analyzed by H. K. in 1945. The sediment was described as a gyttja, but with $76 \%$ of Alnus and no aquatic plants, a dy (in this case a highly humified alder-swamp peat) is mot likely. Apart from Alnus, the species Corylus and Fraxinus are commonest within AP; Plantago lanceolata and the other NAP are frequent, pointing to the middle or later part of Zone VIII. No Fagus or Carpinus was found.
XXIII. Vikso $I$.

This skull and the following one were found together with nine vertebrae and a fragment of a mandible at a depth of 2.5 m . in a bog in a tunnel valley. A sample, from "the interior of the skull', taken by the finder, was analyzed by B. Brorson Christensen in 1944. Very few pollen grains were counted, and a closer dating than at Zone VIII cannot be given on the basis of the spectrum.

## XXIV. Viksø $I I$.

A sample, from "the interior of the skull", taken by the finder in 1944, was analyzed by H. K. in 1950. The sediment was a slightly sandy, highly humified peat. The spectrum dates the sample at Zone VIII, but like the preceding one, a closer dating cannot be given.

## XXV. Holt.

The find was made in peat at a depth of 3 m . A sample, taken by T-S in 1942, was analyzed by A. A. the same year and published in 1943 (Andersen 1943, p. 64-65). The sediment must be an alder-fen peat $(90 \%$ Alnus $)$. Due to this the sum of AP exclusive of Alnus is very
small (41.5), and a dating is difficult. Three pollen grains of Plantago lanceolata, but none of Fagus or Carpinus, point to Zone VIII, and a period not earlier than the "B-landnam".
XXVI. Odense $A$ a.

The find was made between Seden and Skibhuse, approximately 2 m . above the bottom of a bog which fills a depression in the ground close to the inlet, being itself a former marine or brackish inlet. A sample was taken by the finder in cavities outside as well as inside the horn core. It was analyzed by H. K. in 1950. The sediment was a marine or brackish, sandy gyttja with many Ruppia pollen grains.

The spectrum is characterized by high frequencies of NAP. Neither Fagus nor Carpinus was found, and the sample must originate from Zone VIII, a period not earlier than the "Blandnam".

## XXVII. Veddinge moor.

Two samples were taken and analyzed by B. F. in 1964: (a) from a cavity in the occipital area and (b) from the interior cavity in the left horn core. (a) was a slightly sandy gyttja with some fine drift, thus a fruit of a Potamogeton, and four oospores. (b) resembles (a), but has a higher content of drift, fine as well as coarse. Of macrofossils were found half a seed of Ranunculus sp., one seed of Batrachium sp., two seeds of Menyanthes trifoliata, three fruits of Carex sp., two fruits of Potamogeton sp., one of Ceratophyllum demersum, one of Potentilla sp. (incl. Comarum), one undetermined seed, twelve oospores and fragments of mosses, all in one pollen sample!

The NAP frequencies in the two spectra are very high, and this, together with the frequencies of Fagus ( 1.6 , respectively $1.0 \%$ ) and Carpinus $(0.4 \%$ in both) date the samples at the border VIII-IX. In the vicinity of the bog Bronze Age as well as Iron Age settlements are common.

In (a) a pollen grain of Allium ursinum was found, and in (b) five tetrads of an Orchidaceae sp. of the Epipactis type, the first published fossil record of an orchid in Denmark (fig. 1, f-g).

## XXVIII. Snoldelev II.

Two samples: (a) from the nasal aperture and (b) from a thoracic vertebra, both taken by U.M., were analyzed by H.K. in 1946. The sediments were peat with gyttja, slightly sandy, and in (a) with some snail shells. Plantago lancolata was found in both samples; in (a) four Fagus pollen grains (AP total: 350), but in (b) none (AP 326) were seen. Zone VIII, not earlier than the "B-landnam", and possibly as late as the late Zone VIII, is the resulting dating.
(XXIX. Bodal. Vide zoological part.)
XXX. Mors.

A sample from "nerve foramen in the skull" was taken and analyzed by H. K. in 1948. The sediment was a sandy peat. NAP constituted approximately $3 / 4$ of the pollen counted (NAP + AP: 272), and as one pollen of Secale was found, a dating at the beginning of Zone IX is most convincing, in spite of the fact that no Fagus was found (AP: 54).
XXXI. Gundsomagle (vide p. 215).
XXXII. Rislev.

The Rislev offering find has been dated archaeologically to about 300-400 A.D. Four of the samples from a pollen series taken during the excavation by T-S were analyzed by B.F. in 1961, and later published by Troels-Smith (1962 p. 93-96). No pollen list or diagram was published, and as it may be of some interest to publish four thoroughly worked-out pollen spectra from this period (a total of 13.677 .5 pollen grains was counted) they are included in

Table B. (a) in Troels-Smith (loc. cit.) mentioned as M 17, was a fine detritus gyttja with a few grains of sand, $(b)=M 14,(c)=$ M 2 , and $(d)=$ M 12 were drift gyttja with some swamppeat. (a) was found beneath the culture layer, (b) and (c) within, and (d) above the culture layer.

Several rare pollen types occur, thus one Lonicera periclymenum in (a) (cp. TroelsSmith 1960 p. 21), two Juncus or Luzula in (a) and one in (c), one Sanguisorba minor in (c), besides Hottonia palustris, Hypericum sp., Jasione montana, Sambucus nigra, Succisa pratensis and others.
XXXIII. Sonderso.

A sample was analyzed by A.A. in 1942. The sediment was an alder-fen peat, which gave a spectrum so uncharacteristic that the dating of the sample may be any time between the "B-landnam" and the Middle Ages. In 1964 B. F. took another big lump from a cavity in the interior of the brain-case at the base of the left horn. From the middle of the lump a pollen sample was taken. The sediment was an alder-fen peat so much humified that about every second pollen grain was indeterminable, and counting was given up, but a much concentrated slide was examined. No Fagus pollen was seen, a fact which indicates Zone Viri, but several Picea pollen grains were found, pointing to a very late dating, as Picea was only introduced into Denmark about 1730 A. D. The Picea pollen on the other hand was of a slightly deviating colour, indicating recent contamination, but as the sample was taken from the middle of a lump, it should not have been recently contaminated. The conclusion to be drawn must be that the animal cannot be dated by means of pollen analysis.

In 1966 a radiocarbon dating was made at the Copenhagen Radiocarbon Laboratory. The material used was a fragment of the pelvis. The age was $2120 \pm 120$ B.C. (K 1116).

## Appendix

Having finished the manuscript in the autumn of 1965 the author has carried out some additional investigations, and would like also to add some already published pollen-analytical data.

## Bos primigenius

## 1 A. Terp moor.

Three samples, (a) from a cavity in the supraoccipitale sinister, (b) from the lower part of the sutur between the left and right part of pubis, and (c) from foramen nutricium in a femur (U. M. 1968) were analyzed by B. F. in 1968. The sediments were sandy, slightly clayey gyttja, in (a) and (b) with one fruit of Potamogeton sp. The spectra are very similar with Juniperus ranging between 34 and $44 \%$ and Betula between 31 and $33 \%$. Empetrum, Salix and Filipendula are common, Polygonum viviparum type, Oxyria, Helianthemum, Trollius and Selaginella noteworthy. The spectra are characteristic of the transition between Zone III and Zone IV.

The following pollen grains were found: Alnus 3-2-1, Betula 172-157-166, Caryophyllaceae 0-1-0, Chenopodiaceae 1-0-2, Helianthemum 0-1-0, Artemisia 4-8-9, Liguliflorae 7-3-5, Tubuliflorae 3-2-2, Cruciferae 1-1-0, Juniperus 228-190-171, Cyperaceae 154-133-165, Empetrum 18-714, Pyrola type 1-0-0, Quercus 0-1-0, Gramineae 322-254-320, Elymus 1-0-0, Myriophyllum alterniflorum 28-29-33, Myriophyllum spicatum 35-11-32, Hippuris 0-0-1, Labiatae 0-1-0, Leguminosae 0-0-2, Picea 0.5-0-0, Pinus 85-84-88, Plantago maritima 0-1-0, Oxyria 1-0-0, Polygonum viviparum type 1-0-1, Rumex acetosella type 6-2-7, Eupotamogeton 31-5-22, Primula 1-0-0, Caltha 0-0-1, Ranunculus repens type 13-12-12, Thalictrum 5-20-4, Trollius $0-+-0$, Filipendula 10-31-33, Potentilla 13-12-13, Prunus padus 1-0-0, Galium 1-7-3, Populus 2-2-2, Salix 25-70-73, Sparganium/Typha angustifolia type 1-0-1, Ulmus 0-0-1, Umbelliferae 3-5-2, Urtica 0-0-2, a.i.d. 2-0-1, a.i.p. 3-1.4, a.i.1. 2-1-1, $\Sigma 1184.5-1054-1194$, Equisetum 11-8-9, Botrychium 2-2-3, Dryopteris

Biol.Skr. Dan. Vid.Selsk. 17, no. 1.
type 0-1-0, Selaginella 0-0-1, Sphagnum 2-3-1, Botryococcus 177-300-281, Pediastrum 1442-514511, Rebedded 1-0-0, Charcoal c-r-c, D.b. 6.6-4.9-4.1.

## 13 B. Bjerregravs moor.

A sample from a frontal cavity (U.M. 1967) was analyzed by B.F. 1967. The sediment was a slightly humified Carex-Dryopteris peat with a touch of gyttja. Achenes from a distigmate and a tristigmate Carex were found. The spectrum is typically Preboreal, with the latter part of Zone IV as the more likely dating.

The following pollen grains were found: Betula 199, Cerastium type 2, Corylus 4, Cruciferae 1, Juniperus 1, Cyperaceae 374, Cladium 1, Ericaceae 1, Calluna 2, Gramineae 42, Menyanthes 1, Pinus 302, Rumex acetosella type 2, Eupotamogeton 6, Ranunculus 1, Salix 4, Populus 15, Melampyrum 2, Sparganium/Typha angustifolia type 4, Typha latifolia 17, a.i.d. 7, a.i.p. 4, इ 992. Equisetum 5, Dryopteris type 382, Thelypteris dryopteris 10, Pediastrum 4, Sphagnum 5, D.b. 25 .

## 32 A. Ryemarksgaard.

Th. Mathiassen (1941) mentions and depicts a find of an ornamented metatarsus of a Urus from Ryemarksgaard near Osted, Zealand. In an appendix Troels-Smith gives the results of the analyses of two very small samples of peat from the bones: Salix 0.5 , respectively $1 \%$, Betula $29-33 \%$, Pinus $43-57 \%$, Alnus $15-0 \%$, Ulmus $4-6 \%$, Tilia $3-0 \%$, Quercus $5-3 \%$, AP exclusive of Corylus 173 - 101, Corylus 116 , respectively $200 \%$, Cyperaceae 7 $3 \%$, Gramineae $0-1 \%$, Chenopodiaceae $0-2 \%$, Rosaceae $0.5-0 \%$, Calluna $0-1 \%$, hair of Nymphaea few - single, Dryopteris thelypteris many in both samples. Pollen zone ex Knud Jessen VI, respectively V.

In most early analyses Rosaceae are identical with pollen of Filipendula, and Dryopteris thelypteris must be spores of the Dryopteris type. The later samples must be dated at the transition V-VI or the very beginning of VI.

## 71 A. Læsten moor.

A sample from the centre of a big, solid clod in the brain case (U. M. 1967) was analyzed by B. F. in 1967. The sediment was a dy-like forest peat. The spectrum is clearly Zone VIII, and the high frequencies of NAP may indicate a time after the immigration of the Passagegrave people between 2500 and 2000 B.C.

The following pollen grains were found: Hedera 1, Alnus 95, Betula 52, Campanula 1, Caryophyllaceae 1, Cerastium type 1, Chenopodiaceae 1, Liguliflorae 3, Tubuliflorae 2, Corylus 128, Sedum 1, Cruciferae 2, Juniperus 2, Cyperaceae 23, Cladium 1, Calluna 13, Quercus 135, Gramineae 46, Hordeum 1, Labiatae 1, Fraxinus 28, Pinus 28, Plantago lanceolata 4, Rumex acetosella type 88 (quite a number were definitely Rumex acetosa), Ranunculaceae 1, Caltha 1, Filipendula 1, Populus 1, Salix 1, Tilia 31, Ulmus 5, Umbelliferae 1, Urtica 2, a.i.d. 30, 5722. Dryopteris type 39, Thelypteris dryopteris 1, Polypodium 1, Pteridium 2, Sphagnum 40, Tilletia 11, charcoal c, D.b. 51.

71 B. Grejs Molle.
Six samples were taken (U.M. 1966-67) from (a) between the distal condyles of the metatarsus sinistra, (b) between the distal condyles of the metacarpus sinistra, (c) the left part of the pelvis in the incisura acetabulum, (d) cavity beneath the orbita sinistra at the lacrymale, (e) nasal cavity underneath the proximal suture of the nasale, and (f) cavity in occipital region behind the left horn core. They were analyzed by B.F. (1966-67).

The sediments were: (a) clayey-sandy, highly humified forest peat, (b) clayey sand with humified forest peat, (c) slightly clayey sand with a touch of highly humified forest peat, (d) slightly sandy clay with some highly humified forest peat, (e) sandy clay, rich in microscopical pyrite, with some highly humified forest peat, and (f) clay with sand, gravel, and a touch of
humic substance, probably humified forest peat. Five samples were counted, while the counting of (f) was omitted as the very sparse pollen turned out to be mainly rebedded pollen (Sciadopitys, Castanea, Engelhardtia type, Hystrix, etc.). The five spectra are very similar, although stamped by the local vegetation. Notable are the extremely high frequencies of Tilia (23, 14, 24,21 , and $18 \%$, respectively) and the abundance of Acer $1.0,4.6,2.7,11$, and $4.9 \%$ ). The samples originate from Zone VIII. The very low frequencies of NAP may possibly indicate the period between the B-landnam and the immigration of the Passage-grave people.

The following pollen grains were found: Acer 5-23-6-41-30, Ilex 0-0-0-1-0-, Hedera 0-0-0-3-0, Alnus 143-214-66-65-257, Betula 6-17-5-14-14, Campanula 0-1-0-0-0, Cerastium type $0-0-0-0-1$, Melandrium type 0-0-0-1-0, Chenopodiaceae 0-1-0-1-0, Tubuliflorae 1-0-1-0-0, Artemisia 1-0-1-1-1, Cirsium type 0-1-0-0-0, Corylus 124-91-41-60-116, Cruciferae 0-3-13-1-1, Juniperus 2-0-0-1-1, Cyperaceae 7-3-2-0-1, Calluna 0-2-0-4-3, Quercus 64-66-36-73-68, Gramineae 24-32-14-30-29, Cerealea 0-1-0-0-0, Hypericum 0-0-0-2-1, Fraxinus 26-23-11-28-13, Pinus 22.5-12-5.5-34-15, Plantago lanceolata 3-6-0-3-3, Rumex acetosella type 2-2-1-2-1, Rumex hydrolapathum 0-0-0-1-0, Ranunculaceae 0-1-0-0-0, Anemone 9-1-0-0-3, Caltha 0-0-0-0-1, Ranunculus 1-1-1-0-1, Rosaceae 1-1-0-0-0, Filipendula 2-2-1-6-5, Galium 1-2-0-1-0, Salix 0-1-0-0-1, Euphrasia type 4-0-0-0-0, Tilia 121-68-54-77-111, Ulmus 13-9-5-8-17, Umbelliferae 8-5-4-4-7, Urtica 4-4-0-1-0, a.i.d. 9-10-18-20-14, a.i.p. 1-0-1-6-2, a.i.1. 0-1-0-3-0, $\sum 604.5-604-286.5-492-717$. Dryopteris type 2-1-4-8-8, Thelypteris dryopteris 7-3-3-0-1, Polypodium 2-6-0-1-2, Pteridium 1-2-1-2-2, Sphagnum 2-0-0-1-0, Pediastrum 1-0-0-1-0, Botryococcus 0-0-0-1-0, rebedded pollen 0-0-0-9-1, Hystrix 0-0-0-3-0, charcoal cc-c-c-c-c, D.b. 59-43-61-43-36.

## 71 C. Fæsted.

Two samples were taken from the skull (M. Degerbøl 1966): (a) was shaken out from the interior of the skull, while (b) was exposed in the glenoid fossa. The sediment in (a) was a highly humified, sandy alder-fen peat without traces of gyttja (neither algae (Pediastrum and Botryococcus) nor pollen grains of limnophytes were found), while in (b) it was sand with a bit of highly humified alder-fen peat with fragments of wood and a single sclerotie of Cenococcum geophilum. The samples were analyzed by B.F. in 1966.

With a few exceptions the spectra are identical, characteristic of Zone VIII, but a closer dating cannot be made. The following pollen grains were found: Alnus 406 - 380, Betula $25-25$, Humulus $0-2$, Viburnum 1-1, Liguliflorae $0-2$, Tubuliflorae 4-1, Corylus $54-27$, Cyperaceae $11-8$, Succisa $1-0$, Calluna $7-4$, Quercus $56-27$, Gramineae $36-29$, Cerealea $0-1$, Hypericum 1-1, Fraxinus 6-3, Pinus 16 - 11, Plantago lanceolata $2-0$, Rumex acetosella type $1-3$, Ranunculus acris type $0-4$, Filipendula $8-7$, Potentilla $0-2$, Galium $2-0$, Salix $2-2$, Melampyrum $1-0$, Solanum dulcamara $0-3$, Sparganium/Typha angustifolia type $0-1$, Tilia $34-26$, Ulmus $3-1$, Umbelliferae $2-1$, Urtica $9-18$, a.i.d. 19 - 6, a.i.p. $0-2$, a.i.l. $1-0, \Sigma 708-598$. Dryopteris type $16-10$, Polypodium $1-2$, Pteridium $0-6$, Thelypteris dryopteris 5-0, Sphagnum 4-0, Charcoal cc - c, D.b. 60-46.

## 71 D. Tinglev Lake.

Two samples were taken from the skull (U.M. 1966): (a) from the middle of a big clod in the brain case, and (b) from foramen infraorbitale. Both were analyzed by B. F. in 1966. (a) was a heterogenous sediment consisting mainly of microscopical pyrite, with fragments of shells, macroscopical plant remains (e.g. a Carex-achene), a touch of swamp peat and gyttja. (b) was a gyttja with a few fragments of shells and sand grains. Sample (a) originates from the very end of Zone VIII, while (b) is from the beginning of Zone IX (Fagus 0.2, respectively $4.1 \%$, Calluna $2.9-15$, Rumex acetosella type $3.4-16$, Plantago lanceolata $0.2-2.0$, Secale $0-3.7$, Gramineae $13-61$, Sphagnum 0.9 - 11).

Andersen (1954) has published two pollen diagrams from the former lake Tinglev Sø. (a) matches the diagram from Tinglev Søndersø at a depth of $1.30-1.35 \mathrm{~m}$. and the diagram
from Tinglev Nørresø at a depth of 1.55 m ., while for (b) the corresponding depths are 1.20 , respectively 1.05 m .

The following pollen grains were found: Hedera 1 - 0, Alnus 215 - 166, Betula $53-99$, Caryophyllaceae 2-5, Cerastium type $0-1$, Scleranthus $0-1$, Chenopodiaceae 2-4, Liguliflorae $0-8$, Tubuliflorae $2-4$, Artemisia $5-1$, Carpinus $0-3$, Corylus $121-55$, Cruciferae $3-4$, Juniperus $0-5$, Cyperaceae 22 - 172, Succisa $0-1$, Empetrum $0-4$, Calluna 16 - 74, Fagus 1 - 21, Quercus 92 - 87, Gramineae 71 - 291, Cerealea 1 - 0, Secale $0-19$, Myriophyllum alterniflorum $0-2$, Leguminosae $0-1$, Menyanthes $0-4$, Myrica $0-5$, Nymphaea $0-1$, Fraxinus 8 - 5, Picea 0 - 1, Pinus 39.5-51.5, Plantago lanceolata 1 - 10, Polygonum aviculare type $0-1$, Rumex sp. 1-0, Rumex acetosella type 19-82, Eupotamogeton 0-1, Caltha $1-5$, Ranunculus acris type $0-3$, Filipendula $1-1$, Potentilla $0-5$, Galium $0-3$, Salix $0-3$, Euphrasia type 0-1, Melampyrum 1-1, Sparganium/Typha angustifolia type 13-8, Tilia 22-6, Typha latifolia $0-4$, Ulmus $8-6$, Umbelliferae $2-6$, a.i.d. $9-14$, a.i.p. $8-4$, a.i.l. $2-2$, इ 742.5-1261.5, Equisetum 1-4, Dryopteris type 152-358, Polypodium 1-0, Pteridium 8-8, Thelypteris dryopteris 1-0, Sphagnum 5-55, Botryococcus 1-1, Pediastrum 41-719, Tilletia $0-2$, Charcoal c - c, D.b. $17-28$.

## 90. Brabrand.

In Troels-Smith (1937) an analysis is given of a sample consisting of marine, sandy clay-gyttja from the marrow-cavity in a metacarpus of a Bos from the kitchen midden at Brabrand, Jutland, presumed to be from a B. domesticus. He found the following spectrum: Betula $4 \%$, Pinus $10 \%$, Alnus $21 \%$, Ulmus $21 \%$, Tilia $13 \%$, Quercus $29 \%$, AP exclusive of Corylus 183 , Corylus $27 \%$. The determination of the bone as belonging to B . domesticus cannot be maintained with the much greater reference material now at hand, and this analysis, therefore, cannot be used as a proof of cattle in Denmark prior to the Ulmus decline-apart from the fact that the problem of dating kitchen middens is far from having been solved.

A sample from a horn core of Urus from the kitchen midden of Brabrand was taken out and analyzed by B. F. in 1965. The sediment was a very sandy clay-gyttja with fragments of shells, thus of Mytilus, as well as charcoal, besides a seed of a Chenopodium sp. and the chitin of an oribatid. The spectrum is clearly Zone VII, and compared with the diagram (TroelsSmith loc.cit.) the sample should originate from the Corylus minimum at a depth of $3.40-$ 3.50 m ., i.e. half a metre deeper than the border VII-VIII. The following figures were found: Hedera 6, Alnus 203, Betula 87, Chenopodiaceae 10, Artemisia 12, Liguliflorae 1, Corylus 155, Cruciferae 1, Cyperaceae 4, Juniperus 10, Calluna 2, Quercus 397, Gramineae 19, Viscum 1, Fraxinus 14, Pinus 56, Filipendula 1, Ruppia 3, Populus 2, Salix 4, Tilia 96, Ulmus 127, Urtica 3, a.i.d. 5, a.i.p. 11, a.i.l. 1, $\Sigma 1231$, Dryopteris type 10, Polypodium 5, Pteridium 9, Thelypteris 2, Botryococcus 3, Hystrix 45, "Pentagon" 30, rebedded pollen grains 3, D.b. $2.0 \%$.

## 94. Norslund.

At the mesolithic coastal settlement Norslund, 15 km . south of Aarhus, Jutland, 182 fragments of bones of Bos primigenius have been determined (U. Møhl in: Andersen and Malmbos 1966). They were found in layers 3 and 4, and both layers were radiocarbon dated (Layer 3, charcoal samples: 3780 and $3730 \pm 120$ B. C., Layer 4, shell fragments: $4470 \pm 130$ B. C.).

## Bos taurus domesticus

XIII A. Vedbæk.
A third animal originating from the same former inlet as Nos. XII and XIII has been dated. Three samples were taken (T-S 1966): (a) from a cavity in the sixth vertebra, (b) from the sinus frontalis, and (c) from the lacrymale dextra. They were analyzed by B.F. in 1966.
(a) was a highly humified gyttja with swamp peat, while (b) and (c), very alike, were but slightly humified gyttjas with a little swamp peat, a touch of sand and clay, and with numerous fragments of small snails.

The spectrum in (a) is characterized by the swamp. Within AP Quercus, Alnus, and Corylus each constitute a quarter of the $\Sigma$ AP. Tilia and Ulmus are rare, and this, connected with the frequent occurrence of Plantago lanceolata, dates this sample to after the A-landnam. Pollen of Ruppia, besides the presence of Hystrix, etc., indicate a slight contamination with marine sediments. The spectra in (b) and (c) are almost identical, dominated by Alnus and Corylus and with but relatively few herbs. Tilia and Ulmus as well as Fagus and Carpinus are sparse, but in spite of the discrepancy with (a) they may be of about the same age. Ruppia pollen also occurs in (b) and (c) side by side with Eupotamogeton. A likely explanation of the three strange spectra might be the following: Soon after the isolation of the inlet from the sea a swamp of reeds, sedges, bulrushes, etc., spreads into the shallow lake. Caused by waveaction some of the underlying marine sediment may from to time have been stirred up and embedded in the lake-gyttja. If this holds good, the samples originate from the regression period after the Subboreal transgression in the middle of Subboreal.

The following pollen grains, spores, etc., were found: Hedera 0-0-1, Alnus 96-322-215, Betula 30-66-53, Jasione 1-0-0, Humulus 1-2-1, Caryophyllaceae 1-0-0, Cerastium type 1-0-0, Spergularia 4-1-0, Chenopodiaceae 8-6-4, Artemisia 1-5-3, Tubuliflorae 22-2-7, Carpinus 1-1-0, Corylus 92-264-200, Cruciferae 1-0-1, Cyperaceae 138-24-30, Calluna 0-4-0, Fagus 0-1-2, Quercus 97-115-78, Gramineae 70-39-38, Cerealea 1-0-0, cf. Triglochin 0-0-1, Mentha/Lycopus type 1-0-0, Trifolium repens type 0-1-0, Allium sp. 1-0-0, Allium ursinum 0-1-0, Lythrum 1-0-1, Fraxinus 2-23-12, Picea 0.5-0.5-0, Pinus 32-29-37, Plantago lanceolata 11-4-9, Polygonum persicaria 0-1-0, Rumex acetosella type 1-3-2, Eupotamogeton 52-2-0, Lysimachia 0-1-0, Caltha 1-4-1, Galium 3-0-0, Ruppia 1-9-1, Populus 0-2-1, Salix 6-0-2, Odontites 5-0-0, Solanum dulcamara 0-1-1, Sparganium/Typha angustifolia type 0-3-1, Tilia 1-6-3, Typha latifolia 0-16-35, Ulmus 1-5-7, Umbelliferae 4-2-3, Urtica 2-3-6, a.i.d. 50-8-4, a.i.p. 2-1-5, a.i.1. 1-0-0, $\Sigma$ 743.5-977.5-765. Dryopteris type 13-55-51, Pteridium 1-10-7, Sphagnum 0-1-0, Botryococcus 0-2-1, Pediastrum 0-11-7, Ceratophyllum hairs 0-1-1, "Paraplya" 0-2-0, "Pentagon" 1-0-1, Hystrix 1-0-0, charcoal c-c-c, D.b. 51-8.7-10.

## XXXI. Gundsomagle moor.

A sample was taken from a cavity at the distal end of the horn core (U.M. 1966) and analyzed by B.F. shortly afterwards. The sediment was a drift-gyttja with swamp peat. 6 oospores, one seed of Urtica dioica, one fragment of a seed of Nymphaea alba and two fragments of fruits of Najas marina were found. The spectrum is Subboreal, but a closer dating within the zone is difficult, yet the sample must be later than the B-landnam.

The following pollen grains were found: Acer 1, Alnus 285, Betula 42, Humulus 4, Viburnum 1, Chenopodiaceae 1, Liguliflorae 6, Tubuliflorae 2, Arlemisia 17, Cirsium type 1, Corylus 361, Cruciferae 4, Juniperus 2, Cyperaceae 62, Cladium 5, Quercus 78, Gramineae 114, Cerealea 3, Hypericum 2, Juglans 1, Menyanthes 4, Nymphaea 20, Fraxinus 18, Pinus 19.5, Plantago lanceolata 30, P. major/media 1, Rumex acetosella type 5, Eupotamogeton 1, Ranunculus repens type 2, Crataegus type 1, Filipendula 3, Potentilla 2, Rubus type 1, Salix 6, Solanum dulcamara 1, Sparganium/Typha angustifolia type 1, Taxus 1, Tilia 2, Typha latifolia 2, Ulmus 9, Umbelliferae 3, Urtica 12, a.i.d. 2, $\Sigma 1138.5$. Dryopteris type 105, Pteridium 3, Botryococcus 21, Pediastrum 26, Ceratophyllum hairs 2, "Paraplya" 1, charcoal c, D.b. 7.3.

TABLES

Table A.


Table A (continued).

|  | 12 | 13a | 13b | 14 | 15a | 15 b | 15 c | 15 d | 16a | 16b |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Betula | 37 | 8.2 | 13 | 41 | 26 | 23 | 25 | 27 | 8.3 | 3.5 |
| Pinus | 57 | 86 | 82 | 23 | 20 | 21 | 23 | 27 | 23 | 23 |
| Salix | 0.7 | 2.7 | 1.0 | 1.8 | 0.8 | 0.5 | 0.5 | 0.8 | 3.4 | 1.2 |
| Juniperus... | 0.5 | - | - | - | - | - | - | - | - | - |
| Populus | 2.0 | 1.4 | 0.8 | 1.8 | 2.9 | 2.2 | 1.5 | 3.6 | 0.6 | - |
| Viburnum | - | - | - | ? 0.4 | - | - | 0.1 | 0.1 | 0.2 | - |
| Corylus. | 1.9 | - | 2.1 | 32 | 49 | 53 | 50 | 41 | 57 | 69 |
| Quercus | 0.5 | - | 0.2 | - | 0.1 | 0.1 | 0.1 | 0.1 | 1.1 | - |
| Fraxinus | - | - | - | - | - | - | - | - | - | - |
| Tilia | 0.2 | - | - | - | - | - | - | - | - | - |
| Ulmus | 0.3 | 1.4 | - | - | 0.5 | 0.5 | 0.3 | 0.4 | 5.9 | 2.3 |
| Alnus | 0.8 | - | 1.0 | -- | - | - | - | 0.1 | 0.6 | 1.2 |
| Hedera | - | - | - | - | - | - | - | - | - | - |
| Viscum | - | - | - | - | - | - | - | - | - | - |
| Fagus. | - | - | - | - | - | - | - | - | - | - |
| Calluna. . . . . . . | - | - | - | -- | 0.2 | 0.4 | 0.3 | 0.1 | 0.2 | 1.2 |
| Gramineae . . . . | 5.7 | 15 | 6.0 | 6.2 | 1.7 | 1.3 | 0.5 | 1.9 | 18 | 16 |
| Cyperaceae | 13 | 49 | 29 | 15 | 3.6 | 3.8 | 2.4 | 3.7 | 9.1 | 7.0 |
| Artemisia. | 0.3 | 1.4 | 0.4 | - | 0.1 | 0.1 | 0.1 | 0.1 | - | - |
| Rumex acet. | - | - | - | 0.4 | - | 0.1 | - | - | - | - |
| Plantago lanc. . | 0.1 | - | - | - | - | - | - | - | - | - |
| Cerelea. . . . . | - | - | - | - | - | - | - | - | - | - |
| $\Sigma \mathrm{A} . \mathrm{P}$. | 1052 | 73 | 512.5 | 242 | 2173 | 2551 | 2148.5 | 2135 | 472 | 85.5 |
| Destruction D.b. | 0.0 | 24 | 37 | - | 0.5 | 0.4 | 0.1 | 0.7 | 42 | 57 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 17a | 17b | 18a | 18 b | 19a | 19b | 21 | 22 | 23a | 23b |
| Betula | 27 | 23 | 16 | 18 | 19 | 20 | 8.8 | 37 | 14 | 12 |
| Pinus | 43 | 38 | 32 | 36 | 39 | 38 | 4.9 | 21 | 23 | 20 |
| Salix. | - | 1.1 | - | 0.3 | 0.3 | 0.3 | 0.1 | 1.7 | 0.7 | 1.0 |
| Juniperus. | - | 0.3 | - | 0.1 | - | - | - | 0.1 | - | - |
| Populus | — | 2.2 | - | 1.9 | - | - | - | 2.3 | 3.7 | 2.2 |
| Viburnum | - | 0.1 | - | - | -- | - | - | 0.1 | 0.2 | 0.1 |
| Corylus. | 29 | 35 | 51 | 42 | 41 | 41 | 86 | 37 | 58 | 63 |
| Quercus | - | - | - | 0.3 | 0.5 | 0.9 | - | 0.2 | 0.1 | 0.3 |
| Fraxinus . | - | - | - | - | - | - | - | - | - | - |
| Tilia | - | - | - | - | - | - | - | 0.2 | - | - |
| Ulmus | - | 0.1 | 0.3 | 0.2 | 0.8 | 0.9 | 0.1 | 0.1 | 0.4 | 1.2 |
| Alnus | - | 0.1 | 0.3 | 0.4 | - | - | 0.1 | 0.4 | - | - |
| Hedera. | - | 0.1 | - | - | 0.3 | - | - | - | - | - |
| Viscum | - | - | - | - | - | - | - | - | - | - |
| Fagus . . . . . | - | - | - | - | - | - | - | - | - | - |
| Calluna. . | - | 0.2 | - | 0.1 | - | - | x | 0.1 | 0.1 | 0.1 |
| Gramineea | 8.1 | 1.6 | 4.2 | 15 | 11 | 14 | 0.4 | 5.5 | 1.4 | 0.9 |
| Cyperaceae | 0.9 | 4.9 | - | 12 | 4.0 | 1.2 | 0.1 | 7.8 | 1.6 | 1.3 |
| Artemisia. | - | 0.2 | - | 0.2 | - | - | 0.1 | 0.1 | 0.1 | - |
| Rumex acet... | - | - | - | 0.1 | - | - | - | 0.2 | 0.1 | 0.1 |
| Plantago lanc. . | - | - | - | - | - | - | - | - | - | - |
| Cerealea...... | - | - | - | - | - | - | - | - | - | - |
| $\Sigma \mathrm{A} . \mathrm{P}$. | 234 | 939 | 309 | 916 | 397 | 343 | 826.5 | 1679.5 | 2421 | 2769 |
| Destruction D.b. | - | 24 | - | 32 | - | - | - | 11 | 2.2 | 1.3 |

Table A (continued)


Table A (continued).


Table A (continued)

|  | 60a | 60 b | 61a | 61b | 62 | 63 | 64a | 64b | 64 c | 64 d |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Betula | 42 | 36 | 9.0 | 8.5 | 3.8 | 7.9 | 3.8 | 2.1 | 1.2 | 5.5 |
| Pinus | 4.4 | 4.1 | 4.0 | 12 | 5.0 | 3.9 | 10 | 10 | 12 | 17 |
| Salix | - | 0.4 | - | - | 1.0 | 0.9 | 5.3 | ?0.7 | 1.9 | 0.6 |
| Juniperus. . | - |  | - | - | 1.0 | - | - | - | - | - |
| Populus | - | 0.2 | - | - | - | 0.2 | - | - | - | - |
| Viburnum | - |  | - | - | - | - | - | - | - | - |
| Corylus. | 9.7 | 7.8 | 20 | 21 | 14 | 20 | 19 | 16 | 20 | 18 |
| Quercus | 8.3 | 14 | 6.0 | 13 | 36 | 19 | 7.6 | 11 | 18 | 12 |
| Fraxinus | -. | 0.9 | 3.0 | 2.8 | 9.1 | 5.8 | 2.3 | 2.1 | 3.7 | 0.6 |
| Tilia | 3.4 | 2.3 | 1.0 | 2.8 | 4.3 | 4.1 | 5.3 | 7.1 | 5.6 | 9.7 |
| Ulmus | 1.4 | 0.5 | 2.0 | 1.4 | 1.9 | 2.7 | 1.5 | 4.3 | 1.9 | 1.8 |
| Alnus | 31 | 34 | 55 | 38 | 24 | 36 | 45 | 46 | 36 | 35 |
| Hedera | - | - | - | - | - | - | - | - | 0.6 | - |
| Viscum. | - | 0.2 | - | - | - | - | - | - | - | - |
| Fagus | - | - | - | - | - | - | - | - | - | ?0.6 |
| Calluna | x | 0.4 | - | - | - | - | - | - | 0.6 | - |
| Gramineae | 2.6 | 9.0 | 12 | 8.5 | 15 | 5.3 | 16 | 14 | 19 | 19 |
| Cyperaceae | 7.4 | 9.2 | 59 | 55 | 27 | 27 | 9.9 | 16 | 20 | 27 |
| Artemisia | - | 0.2 | - | - | - | 0.5 | 0.8 | - | - | - |
| Rumex acet. | - | 2.0 | 4.0 | - | - | 0.2 | 3.0 | - | 2.5 | 0.6 |
| Plantago lanc. . . . . | $? 0.3$ | 0.4 | 1.0 | - | 0.5 | 0.2 | - | 0.7 | 0.6 | 0.6 |
| Cerealea. | - | 0.2 | - |  | - | - | - | - | - | - |
| $\Sigma \mathrm{A} . \mathrm{P}$. | 351.5 | 554 | 100 | 70.5 | 209.5 | 660.5 | 131.5 | 140 | 162 | 165 |
| Destruction D.b.. |  | 49 | 46 | 65 | 46 | 71 |  |  |  | - |


|  | 65 | 66 | 67 | 68 | 69 | 70a | 70b | 71a | 71b | 71c |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Betula | 21 | 9.5 | 19 | 6.1 | 9.2 | 11 | 11 | 8.5 | 15 | 20 |
| Pinus | 2.6 | 2.6 | 4.9 | 5.2 | 4.4 | 9.7 | 12 | 7.8 | 12 | 41 |
| Salix . . . . . . . . . | 0.3 | 0.1 | 0.1 | - | 0.4 | 0.2 | 0.2 | 0.7 | 1.0 | 1.3 |
| Juniperus. . . . . . . . | 0.1 | 0.1 | - | - | - | - | 0.1 | 0.2 | - | - |
| Populus . . . . . . . . | - | 0.1 | 0.1 | - | - | 0.8 | 0.2 | - | - | 0.4 |
| Viburnum . . . . | - | - | - | - | - | - | - | - | - | - |
| Corylus. | 43 | 14 | 19 | 25 | 8.5 | 25 | 20 | 15 | 15 | 14 |
| Quercus | 10 | 19 | 27 | 2.8 | 5.9 | 18 | 19 | 7.1 | 6.1 | 2.1 |
| Fraxinus | 2.7 | 3.1 | 3.7 | - | 2.9 | 1.1 | 0.8 | 0.2 | 1.0 | -- |
| Tilia | 5.1 | 4.6 | 7.0 | 4.7 | 2.2 | 2.9 | 3.4 | 0.9 | 2.0 | - |
| Ulmus . . . . . . . . . | 1.1 | 1.2 | 1.8 | 2.3 | 0.7 | 4.2 | 4.3 | 1.7 | 0.5 | 1.0 |
| Alnus . . . . . . . . . . . | 14 | 45 | 18 | 54 | 66 | 28 | 30 | 57 | 47 | 21 |
| Hedera . . . . . . . . . . | 0.2 | 0.1 | 0.5 | - | - | - | 0.2 | - | - | - |
| Viscum. . . . . . . . . . | - | - | - | - | - | - | - | - | - | - |
| Fagus . . . . . . . . . . . | - | - | - | - | - |  | 0.2 | 0.2 | - | - |
| Calluna. . . . . . . . . . | 0.1 | 0.2 | 0.2 | x | 0.4 | 0.4 | 0.5 | 0.7 | 2.8 | 0.8 |
| Gramineae . . . . . . . . | 1.4 | 1.3 | 0.7 | 6.1 | 5.9 | 2.7 | 2.2 | 19 | 29 | 4.4 |
| Cyperaceae . . . . . . | 6.7 | 2.9 | 7.5 | 0.5 | 18 | 50 | 55 | 16 | 22 | 21 |
| Artemisia . . . . . . . . | - | - | 0.2 | 0.5 | 0.4 | 0.1 | 0.1 | 0.5 | 0.8 | 0.4 |
| Rumex acet. . . . . . | 0.2 | 0.1 | 5.4 | - | - | 4.6 | 7.8 | 2.6 | 3.5 | 0.4 |
| Plantago lanc. . . . . | 0.3 | 0.2 | 0.2 | 0.9 | - | - | 0.2 | 1.0 | 1.5 | - |
| Cerealea | - | - | - |  | - |  | 0.3 | - | 0.3 | - |
| इ A.P. . . . . . . . . . . . . | 898.5 | 1172 | 1232 | 213 | 272 | 1123 | 1115 | 574 | 395.5 | 480 |
| Destruction D.b.... | 65 | 8.6 | 73 | - | - | 45 | 46 | 48 | 54 | 33 |

Table A (continued).

|  | 72a | 72b | 73a | 73b | 74 | 75 | 76 | 79 | IIa | IIb |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Betula | 10 | 3.5 | 11 | 3.9 | 4.6 | 18 | 3.8 | 21 | 4.1 | 5.9 |
| Pinus | 4.3 | 9.2 | 20 | 14 | 3.2 | 25 | 11 | 37 | 7.1 | 7.8 |
| Salix . | 1.7 | 0.7 | - | - | - | - | - | 1.0 | 1.2 | 0.5 |
| Juniperus. | - | - | - | - | - | - | - | - | - | 0.1 |
| Populus | - | - | - | - | - | - | - | 0.7 | 0.3 | 0.4 |
| Viburnum | - | - | - | - | - | - | - | - | -- | - |
| Corylus. | 5.1 | 12 | 15 | 17 | 37 | 18 | 21 | 23 | 19 | 17 |
| Quercus | 1.7 | 8.4 | 7.4 | 8.8 | 5.5 | 17 | 4.6 | 1.8 | 15 | 16 |
| Fraxinus | 1.7 | 0.7 | - | - | - | 0.7 |  | 0.1 | 3.3 | 4.3 |
| Tilia | 3.4 | 7.0 | 25 | 31 | 14 | 6.3 | 23 | 5.0 | 4.7 | 4.4 |
| Ulmus | - | 0.7 | 8.2 | 11 | 5.5 | 4.3 | 5.3 | 4.2 | 6.7 | 5.9 |
| Alnus | 58 | 55 | 14 | 14 | 30 | 11 | 32 | 5.4 | 39 | 38 |
| Hedera | - | - | 0.8 | + | - | 0.2 | - | - | 0.1 | 0.3 |
| Viscum. | - | - | - | -- | - | - |  | - | - | 0.1 |
| Fagus. | 10 | 2.1 | - | - | - | - | - | - | - |  |
| Calluna | x | 0.7 | 0.8 | - | - | 0.2 | - | 0.3 | 0.2 | 0.2 |
| Gramineae | 22 | 53 | 5.8 | 7.7 | 5.5 | 2.2 | - | 5.3 | 5.2 | 6.6 |
| Cyperaceae | 21 | 20 | 21 | 22 | 15 | 2.9 | 26 | 10 | 10 | 9.2 |
| Artemisia. . | - | - | - | - | -- | 0.2 |  | - | - | 0.2 |
| Rumex acet. | - | 4.2 | 2.5 | 2.7 | - | - |  | - | - | 0.1 |
| Plantago lanc. . | 1.7 | 8.4 | - | - | - |  | - | - | -- | 0.1 |
| Cerealea. | 5.1 | 6.3 |  |  | - | - | - | 0.2 | 0.1 | 0.3 |
| $\Sigma \mathrm{A} . \mathrm{P}$. | 58.5 | 142 | 121.5 | 182 | 108.5 | 445 | 131 | 955 | 2518 | 2525 |
| Destruction D.b. | - | - | 86 | 90 | - |  |  | 47 | 7.8 | 7.9 |


|  | IIc | IIIa | IIIb | IVa | IVb | IVc | Va | Vb | Ve | V Ia |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Betula | 5.5 | 6.5 | 7.6 | 7.2 | 6.3 | 6.7 | 6.6 | 7.2 | 5.6 | 9.8 |
| Pinus | 7.5 | 3.8 | 4.4 | 4.3 | 3.6 | 4.3 | 4.0 | 3.8 | 3.1 | 4.8 |
| Salix . | 0.2 | 0.1 | 0.2 | 0.7 | 0.6 | 0.6 | 0.2 | 0.5 | 0.7 | - |
| Juniperus. | - | -- | - | - | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | - |
| Populus.. | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | - |
| Viburnum | - |  | - | - |  | - |  | 0.1 | - | - |
| Corylus. | 19 | 32 | 33 | 38 | 40 | 38 | 41 | 38 | 42 | 32 |
| Quercus | 15 | 12 | 14 | 13 | 13 | 15 | 12 | 13 | 12 | 10 |
| Fraxinus | 3.0 | 0.4 | 2.1 | 1.3 | 2.2 | 1.9 | 1.2 | 2.4 | 2.3 | 0.6 |
| Tilia | 4.7 | 3.9 | 3.2 | 1.5 | 1.2 | 1.1 | 0.8 | 1.2 | 0.7 | 0.6 |
| Ulmus | 6.5 | 4.5 | 4.6 | 1.0 | 0.9 | 0.9 | 0.9 | 1.1 | 0.9 | 0.6 |
| Alnus | 38 | 37 | 30 | 33 | 32 | 31 | 34 | 33 | 33 | 42 |
| Hedera. | 0.3 | - | 0.1 | 0.1 | 0.1 | - | - | - | 0.1 |  |
| Viscum. | 0.1 | - |  |  | 0.1 |  | - | - | - | - |
| Fagus. | - | - | - | 0.1 | - | 0.2 | 0.2 | 0.1 | 0.1 | 0.2 |
| Calluna. | 0.1 | 0.1 | 0.1 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 | 0.1 | - |
| Gramineae . | 8.6 | 2.3 | 6.1 | 2.7 | 3.7 | 3.5 | 2.2 | 3.9 | 3.6 | 0.6 |
| Cyperaceae | 9.2 | 3.8 | 4.7 | 5.3 | 5.2 | 6.1 | 4.4 | 5.7 | 5.2 | 3.7 |
| Artemisia. | 0.1 | 0.1 | 0.1 | 0.3 | 0.3 | 0.2 | 0.1 | 0.4 | 0.2 | 0.4 |
| Rumex acet. ....... | - |  | 0.1 | 0.1 | 0.2 | 0.2 | 0.1 | 0.1 | 0,1 | 1.2 |
| Plantago lanc. . . . . . | - | 0.3 | 0.9 | 0.8 | 0.7 | 0.9 | 0.8 | 0.5 | 0.9 | 0.2 |
| Cerealea. . . . . . . . . | 0.1 | 0.1 | 0.1 | 0.1 | - | 0.1 | 0.1 | 0.1 | - | - |
| इA.P. . . . . . . . . . | 2498.5 | 709 | 1541.5 | 3506 | 3334 | 3293.5 | 3375 | 3321.5 | 3472 | 482 |
| Destruction D.b..... | 6.7 | - | 7.1 | 1.2 | 2.3 | 1.7 | 1.1 | 1.7 | 4.2 | - |

Table A (continued).

|  | V Ia | $V$ Ic | IX | Xa | Xb | Xc | XA | X I | XIIa | XIIb |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Betula | 4.9 | 4.1 | 6.9 | 13 | 6.9 | 8.4 | 8.7 | 8.0 | 4.3 | 4.6 |
| Pinus | 4.9 | 2.6 | 2.3 | 1.7 | 1.7 | 1.6 | 2.2 | 3.4 | 3.2 | 3.6 |
| Salix . | - | - | 0.9 | 0.8 | 0.6 | 0.5 | 0.8 | - | 0.3 | 0.2 |
| Juniperus. | - | - | - | - | - | - | - | - | - | 0.2 |
| Populus | - | - | 0.5 | 1.0 | 0.4 | 1.0 | 0.6 | - | 0.1 | - |
| Viburnum | - | - | - | - | - | - | - | - | - | - |
| Corylus. | 38 | 43 | 31 | 29 | 30 | 27 | 34 | 29 | 18 | 16 |
| Quercus | 6.6 | 3.5 | 8.9 | 10 | 11 | 12 | 9.2 | 9.2 | 9.2 | 11 |
| Fraxinus | 0.9 | 0.3 | 1.7 | 2.2 | 3.0 | 2.0 | 2.4 | 2.7 | 1.5 | 2.3 |
| Tilia | 0.9 | 1.0 | 2.3 | 1.9 | 3.2 | 3.5 | 2.6 | 1.1 | 0.8 | 1.1 |
| Ulmus | 1.8 | 0.6 | 2.5 | 1.2 | 3.1 | 2.0 | 1.1 | 1.5 | 0.6 | 1.1 |
| Alnus | 42 | 42 | 43 | 39 | 40 | 42 | 38 | 45 | 62 | 60 |
| Hedera | - | - | 0.1 | - | 0.1 | 0.2 | 0.1 | - | 0.1 | - |
| Viscum | - | - | - | - | - | - | - | - | - | - |
| Fagus . | - | - | - | 0.1 | - | - | - | 0.4 | - | - |
| Calluna. | - | - | 0.1 | - | 0.1 | - | - | 0.4 | - | - |
| Gramineae | 1.3 | 1.1 | 3.1 | 1.4 | 1.5 | 1.4 | 4.5 | 2.7 | 3.9 | 4.0 |
| Cyperaceae | 2.6 | 0.6 | 3.7 | 3.0 | 2.8 | 4.3 | 3.2 | 1.9 | 3.8 | 4.1 |
| Artemisia | - | - | 0.8 | 0.4 | 0.4 | 0.4 | 0.8 | 0.4 | 0.3 | 0.2 |
| Rumex acet. | 0.4 | - | 0.2 | - | - | 0.1 | 0.1 | - | 0.1 | 0.2 |
| Plantago lanc. | 0.4 | - | 1.6 | 0.2 | 0.2 | 0.6 | 1.3 | 1.1 | 0.3 | 0.4 |
| Cerealea | -- | - | 0.1 | - | - | - | 0.1 | - | - | - |
| $\Sigma$ A.P. | 227 | 315 | 1466 | 1696.5 | 1633.5 | 1530 | 869 | 263 | 1577 | 1203.5 |
| Destruction D.b.... |  | - | 10 | 2.4 | 2.0 | 7.7 | 3.9 | - | 19 | 41 |
|  |  |  |  |  |  |  |  |  |  |  |
|  | XIIIa | XIIIb | XIV | XV/XVI | XVII | XVIII | XIXa | XIXb | XXa | XXb |
| Betula | 9.4 | 8.5 | 6.7 | 4.7 | 3.8 | 5.0 | 3.2 | 5.0 | 6.8 | 6.5 |
| Pinus | 5.8 | 6.3 | 10 | 2.0 | 2.0 | 2.8 | 6.5 | 7.2 | 6.6 | 5.3 |
| Salix . | 0.1 | 0.1 | 0.5 | - | - | 0.7 | 2.0 | 0.7 | - | 0.3 |
| Juniperus. | 0.1 | - | - | - |  | 0.1 | - |  | - | - |
| Populus | 0.1 | 0.1 | - | - | - | 0.2 | 0.2 | 0.4 | 0.1 | 0.6 |
| Viburnum | - | - | - | - | - | - | - |  | - |  |
| Corylus. . | 32 | 32 | 26 | 36 | 45 | 16 | 17 | 15 | 21 | 20 |
| Quercus | 17 | 14 | 19 | 4.3 | 8.1 | 10 | 11 | 9.8 | 19 | 17 |
| Fraxinus | 2.9 | 2.6 | 1.6 | 0.2 | 0.7 | 2.3 | 2.5 | 1.7 | 5.5 | 6.7 |
| Tilia | 1.3 | 0.8 | 1.6 | 0.9 | 0.7 | 1.0 | 2.7 | 2.0 | 2.2 | 2.6 |
| Ulmus | 1.1 | 0.8 | 2.3 | 0.2 | 0.5 | 0.6 | 1.2 | 1.4 | 0.4 | 1.3 |
| Alnus | 30 | 33 | 33 | 52 | 39 | 61 | 53 | 56 | 39 | 39 |
| Hedera. | - | 0.1 | - | - | - | - | - | 0.1 | - | 0.2 |
| Viscum | - | - | - | - | - | - | - | 0.1 | 0.2 | - |
| Fagus . | 0.2 | 1.0 | - | - | - | - | 0.3 | 0.9 | 0.3 | - |
| Calluna | 0.1 | - | - | - | 0.2 | 0.1 | - | - | 0.6 | 0.2 |
| Gramineae . | 5.4 | 9.8 | 2.3 | 1.9 | 0.7 | 3.0 | 6.1 | 5.1 | 15 | 14 |
| Cyperaceae . . . . . . | 4.7 | 12 | 7.3 | 2.8 | 0.9 | 2.0 | 12 | 7.6 | 1.3 | 0.6 |
| Artemisia | 0.7 | 0.3 | - | 0.2 | 0.5 | 0.2 | 1.8 | 0.6 | 0.9 | 1.3 |
| Rumex acet. . . . . . | 0.2 | 0.7 | - | - | 0.2 | 0.5 | 0.3 | 0.1 | 0.1 | 0.6 |
| Plantago lanc. . . . . . | 1.5 | 1.1 | 1.6 | 1.3 | 0.9 | 0.4 | 0.7 | 0.8 | 0.6 | 1.0 |
| Cerealea. | 0.2 | 0.3 | - | - | - | 0.1 | - | - | 0.4 | 0.2 |
| £ A.P. . . . . . . . . . | 1635 | 1487.5 | 218 | 467.5 | 443 | 1331.5 | 602 | 846 | 786 | 628 |
| Destruction D.b.... | 10 | 11 | - | - | - | 19 | 65 | 41 | 14 | 12 |

Table A (continued).

|  | XXc | XXI | XXII | XXIII | XXIV | XXV | XXVI | $\begin{gathered} \text { XXVII } \\ a \end{gathered}$ | XXVII <br> b | $\begin{gathered} \mathrm{XXVIII} \\ \mathrm{a} \\ \hline \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Betula | 8.4 | 2.5 | 1.9 | 6.0 | 5.7 | 1.7 | 6.8 | 6.9 | 6.5 | 9.1 |
| Pinus . . . . . . . . | 7.4 | 7.7 | 4.4 | 12 | 13 | 1.1 | 7.0 | 5.4 | 3.7 | 2.9 |
| Salix . . . . . . . . | - | - | - | - | 1.3 | - | -- | 0.2 | 0.3 | - |
| Juniperus. . . . . . . . | 0.3 | -- | - | - | -- | $\cdots$ | - | -- | -- | - |
| Populus . . . . . . . . | 0.4 | - | - | - | - | - | 0.6 | 0.1 | 0.1 | - |
| Viburnum . . . . . . | - | - | - | - | - | -- | - | - | -- | - |
| Corylus. . . . . . . | 19 | 37 | 7.5 | 29 | 38 | 4.9 | 29 | 30 | 24 | 37 |
| Quercus | 19 | 22 | 3.1 | 27 | 11 | 1.0 | 21 | 10 | 7.3 | 7.1 |
| Fraxinus . . . . . . . | 8.2 | 3.3 | 3.8 | 0.9 | 1.3 | 0.2 | 2.0 | 1.6 | 2.5 | 0.3 |
| Tilia | 2.7 |  | 2.5 | - | 3.2 | 0.7 | 1.1 | 1.2 | 1.1 | 2.9 |
| Ulmus | 0.4 | 2.1 | 0.9 | 1.7 | 1.3 | 0.2 | 0.8 | 1.6 | 1.5 | 2.0 |
| Alnus . . . . . . . . . . . | 34 | 25 | 76 | 23 | 25 | 90 | 32 | 41 | 52 | 38 |
| Hedera. . . . . . . . . . | - | - | - | - | - | - | - | - | 0.1 | 0.3 |
| Viscum. . . . . . . . . . | - | - | - | - | - | - | - | - | - | - |
| Fagus . . . . . . . . . . . | - | - | - | - | - | - | - | 1.6 | 1.0 | 1.1 |
| Calluna. . . . . . . . . . | 0.9 | - | - | - | - | - | - | 0.6 | 0.4 | - |
| Gramineae . . . . . . . | 10 | 4.2 | 6.3 | 2.6 | 6.9 | 2.2 | 9.8 | 26 | 25 | 0.3 |
| Cyperaceae . . . . . . | 0.8 | 1.7 | 6.3 | 17 | 28 | - | 3.4 | 6.7 | 11 | 0.6 |
| Artemisia . . . . . . . . | 0.5 | 0.8 | 0.9 | 0.9 | - | - | 1.1 | 2.7 | 2.5 | - |
| Rumex acet. . . . . . . | 0.7 | - | - | - | 0.6 | - | 0.3 | 1.6 | 1.3 | - |
| Plantago lanc. . . . . . | 0.3 | 0.4 | 1.6 | - | - | 0.7 | 2.0 | 12 | 8.8 | 1.1 |
| Cerealea. . . . . . . . . | - | - | - | - | - | - | 0.3 | 1.6 | 1.0 | - |
| £ A.P. . . . . . . . . . | 742.5 | 239 | 320 | 116 | 158.5 | 410.5 | 356.5 | 1456 | 1343.5 | 350 |
| Destruction D.b.... | 14 | - | - | - | - | - | - | 5.0 | 7.2 | - |






## LITERATURE

## Abbreviations

Aarb. $\quad$ Aarbøger for nordisk Oldkyndighed og Historie. København.
D.G.U. $\quad$ Danmarks Geologiske Undersogelse (Bulletin of the Geological Survey of Denmark). Kobenhavn.
O.V.S.F. $=$ Oversigt Kongelige Videnskabernes Selskabs Forhandlinger. Kobenhavn.
Z. Tierzücht $=$ Zeitschrift für Tierzüchtung und Züchtungsbiologie. Hamburg.
V.M. $\quad$ Videnskabelige Meddelelser fra Dansk naturhistorisk Forening. København.

Adametz, L., 1930: Der sexuelle Dimorphismus am Schädel des Urs und seine Beziehungen zum Rassen- und Abstammungsproblem des Hausrindes. Biologia Generalis. Bd. VI. Wien und Leipzig.
Ambros, C., 1961: Neolithic Animal Bones from Lužianky and Mlynarce (District Nitra). (Engl. summary) Musaica, Ročnik XII. Bratislava.
Andersen, A., 1943: Pollenanalytisk Datering af nogle mosefundne Dyreknogler fra Søborgsoomraadet. "Det gamle Gilleleje".

- 1954: Two Standard Pollen Diagrams from South Jutland. D.G.U. II R. Nr. 80.

Andersen, A., \& K. Møller, 1946: Fund af Urokse (Bos taurus urus L.) i Grænge Mose paa Lolland. D.G.U. IV R., Bd. 3, Nr. 1.
Andersen, S. H. \& C. Malmros, 1966: Norslund. A Coastal Settlement from the Old Stone Age. Kuml 1965. Århus.
Antonius, O., 1922: Grundzüge einer Stammesgeschichte der Haustiere. Jena.
Bachmann, M., 1962: Schädelreste des Rindes aus dem keltischen Oppidum von Manching. Studien an vor- und frühgeschichtlichen Tierresten Bayerns XIV. München.
Banks, C. Grigson, 1962: Report on the Recently Discovered Remains of the Wild Ox (Bos primigenius Bojanus) from East Ham. London Naturalist. No. 41.
Becker, C. J., 1948: Mosefundne Lerkar fra yngre Stenalder. (Engl. Summary.) Aarb. 1947.

- 1955: Stenalderbebyggelsen ved Store Valby i Vestsjælland. (Engl. Summary.) Aarb. 1954.

Behrens, H., 1964: Die neolitisch-frühmetallzeitlichen Tierskelettfunde der Alten Welt. Veröffentlichungen des Landesmuseums für Vorgeschichte in Halle. H. 19. Berlin.
Berlin, H., 1932: De svenska nötboskapsrasernas härstamning. Lund.
Beug, H.-J., 1961: Leitfaden der Pollenbestimmung für Mitteleuropa und angrenzende Gebiete. Stuttgart.
Вöкönyı, S., 1958: Zur Urgeschichte der Haustiere und der Fauna der archäologischen Urzeit in Ungarn. Z. Tierzücht, Bd. 72, H. 3.

- 1959: Die frühalluviale Wirbeltierfauna Ungarns. Acta Arch. Acad. Scient. Hung. 11. Budapest.
- 1962: Zur Naturgeschichte des Ures in Ungarn und das Problem der Domestikation des Hausrindes. Acta. Arch. Acad. Scient. Hung. 14. Budapest.
Bökönyi, S., L. Kállai, J. Matolcsi und R. Tarján, 1965: Vergleichende Untersuchungen am Metacarpus des Urs- und des Hausrindes. Z. Tierzücht. Bd. 81, H. 4.
Biol.Skr. Dan.Vid.Selsk. 17, no. 1.

Boessneck, J., 1956: Tierknochen aus spätneolithischen Siedlungen Bayerns. Studien an vorund frühgeschichtlichen Tierresten Bayerns I.

- 1956 a: Ein Beitrag zur Errechnung der Widerristhöhe nach Metapodienmaszen bei Rindern. Z. Tierzücht. Bd. 68.
1957: Funde des Ures, Bos primigenius Bojanus, 1827, aus alluvialen Schichten Bayerns. Säugetierkundliche Mitt. Bd. 5, H. 2.
- 1958: Zur Entwicklung vor- und frühgeschichtlicher Haus- und Wildtiere Bayerns im Rahmen der gleichzeitigen Tierwelt Mitteleuropas. Stud. an vor- und frühgeschichtlichen Tierresten Bayerns II. München.
Boessneck, J., J.-P. Jéquier und H. R. Stampfli, 1963: Die Tierreste, Seeberg BurgäschiseeSüd. Acta Bernensia. Il, Teil 3. Bern.
Bohlken, H., 1958: Vergleichende Untersuchungen an Wildrindern (Tribus Bovini Simpson 1945). Zool. Jahrb. Bd. 68.
- 1961: Haustiere und Zoologische Systematik. Z. Tierzücht. Bd. 76. H. 1.
- 1961: Der Kouprey, Bos (Bibos) sauveli Urbain 1937. Zeitschr. f. Säugetierkunde. Bd. 26. Berlin u. Hamburg.
- 1962: Probleme der Merkmalsbewertung am Säugetierschädel, dargestellt am Beispiel des Bos primigenius Bojanus 1827. Morphologisches Jahrbuch. Bd. 103. H. 4. Leipzig.
- 1964: Vergleichende Untersuchungen an den Schädeln wilder und domestizierter Rinder. Zeitschr. f. wissenschaftliche Zoologie. Bd. 170. Leipzig.
Broholm, H. C. 1924 : Nye Fund fra den ældste Stenalder, Holmegaard- og Sværdborgfundene. Aarb.
- 1928: Langøfundet. En Boplads fra den ældre Stenalder paa Fyn. Med Bidrag af Magnus Degerbøl og Knud Jessen. Aarb. III. R. Bd. 18.
Brøndsted, J., 1957: Danmarks Oldtid I. Stenalderen. København.
Clark, J. G. D., 1954: Excavations at Star Carr, an Early Mesolithic Site at Seamer, near Scarborough, Yorkshire. Cambridge.
Clason, A. T., 1964: De oeros in Groningen en Noord-Drente Groningse Volksalmanak.
- 1967: Animal and Man in Holland's Past. Palaeohistoria. Vol. XIII. Groningen.

Degerbol, M., 1928: Langofundet. Vide Broholm 1928.

- 1933: Danmarks Pattedyr i Fortiden i Sammenligning med recente Former (Engl. Summary: The Prehistoric Mammals of Denmark Compared with Recent Forms p. 616-41). Vidensk. Medd. Dansk naturh. Foren. Bd. 96,2.
- 1939: Bundsø (Res.: Os d’animaux). Vide Mathiassen 1939.
- 1940: Dyreknogler i Havnelev - Strandegaard. Vide Mathiassen 1940.
- 1942: Et Knoglemateriale fra Dyrholm-Bopladsen, en ældre Stenalder-køkkenmødding, med særligt Henblik på Uroksens-kønsdimorphisme og paa Kannibalisme i Danmark. (Zusammenfassung: Knochenmaterial aus dem steinzeitlichen Wohnplatz Dyrholmen. Mit besonderer Berücksichtigung des Geschlechts-Dimorphismus des Auerochsen und des Kannibalismus in Dänemark). - Vide Mathiassen 1942.
- 1943: Om Dyrelivet i Aamosen i Stenalderen. Vide Mathiassen 1943.
- 1948: Dyreknogler fra Vikingeborgen "Trelleborg". (Engl. Summary). Nord. Fortidsminder. IV. Bd., 1. H. København.
- 1952: Recent Discoveries of Remains of Mammals from Glacial Deposits in Denmark. Dicerorhinus kirchbergensis (Jäger) new to the Fauna of Denmark; Megaloceros giganteus (Blumenbach) and Bison priscus (H. v. Meyer). Biol. Skr. Dan. Vid. Selsk. Bd. 6, No. 8. København.
- 1962: Ur und Hausrind. Z. Tierzücht. Bd. 76, H. 2/3.
- 1963: Prehistoric Cattle in Denmark and Adjacent Areas. Royal Anthr. Inst. Occasional Paper. No. 18. London.

Degerbøl, M., 1964: Some Remarks on Late- and Post-Glacial Vertebrate Fauna and Its Ecological Relations in Northern Europe. Brit. Ecol. Soc. Jub. Symp. J. Anim. Ecol. 33 (Suppl.) Oxford.
Degerbøl, M., \& J. Iversen, 1945: The Bison in Denmark. D. G. U., II. R., Nr. 73.
Degerbol, M., \& H. Krog, 1951: Den europæiske Sumpskildpadde (Emys orbicularis L.) i Danmark. En zoologisk og geologisk undersogelse af danske postglaciale fund og deres betydning for bedømmelsen af temperaturforholdene i forhistorisk tid. (Engl. Summary: The European Pond Tortoise (Emys orbicularis L.) in Denmark. A Zoological and Geological Investigation of Danish Post-Glacial Finds, and their Importance in the Estimation of the Temperatures of Pre-Historic Times). D. G. U., II. R., Nr. 78.
Degerbol, M., \& H. Krog, 1959: The Reindeer (Rangifer tarandus L.) in Denmark. Biol. Skr. Dan. Vid. Selsk. 10, No. 4. København.
Deunff, J., 1956: Progrès récents de nos connaissances sur les micro-planctons fossiles à Hystrichosphères des mers primaires. Grana Palynologica, Vol. 1:2.
Ducos, P., 1961: Application de quelques données de la biologie des bœufs domestiques actuels à l'étude historique de leur domestication. Z. Tierzücht. Bd. 76, H. 1.
Dottrens, E., 1947: Les ossements de Bos taurus brachyceros Rütim. et de Bos primigenius Boj. In: Revilliod, R. et Dottrens, E.: La faune nèolithique de la couche profonde de Saint-Aubin. Rev. Suisse Zool., T. 54. Genève.
Dürr, G., 1961: Neue Funde des Rindes aus dem keltischen Oppidum von Manching. Studien an vor- und frühgeschichtlichen Tierresten Bayerns. XII. München.
Duerst, J. U., 1904: Die Tierwelt der Ansiedelungen am Schlossberge zur Burg an der Spree. Arch. f. Anthr. Bd. II. H. I. N. F. Braunschweig.
Erdtman, G., 1952: Pollen Morphology and Plant Taxonomy. Angiosperms. Uppsala.
Ferdinand, J. \& K., 1962: Jernalderofferfund i Valmose ved Rislev. Kuml 1961. Aarhus.
Figdor, H., 1927: Über den Einfluss der Kastration auf das Knochenwachstum des Hausrindes. Z. Tierzücht. Bd. 9.

Foск, J., 1966: Metriche Untersuchungen an Metapodien einiger europäischer Rinderrassen. München.
Fraser, F. C., and J. E. King, 1954: Faunal Remains. Vide Clark, 1954.
Fredskild, B., 1966: Pollenanalytisk datering af nogle svenske bisonfund. Geol. Fören. Stockholm Förh. vol. 88.
Faggri, Knut, \& Johs. Iversen, 1964: Textbook of Pollen Analysis. 2nd. rev. ed. København. Gesner, C., 1551: Historia animalium, Lib. II. Zürich.
Godwin, H., 1956: The History of the British Flora. Cambridge.
Grigson, C., 1962: Vide Banks, C.

- 1965: Windmill Hill. Measurements of bones, horncores, antlers, and teeth. Vide Keiller 1965.

Gromova, V., 1932: Contribution à la connaissance de l'ure (Bos primigenius Boj.) de l'Europe orientale et de l'Asie septentrionale. (Russian.) Annuaire d. Mus. Zool. l'Acad. Sciences de l'URSS. XXXII, 1931, Leningrad.
Hankó, B., 1950: Ursprung und Geschichte des altungarischen, silbergrauen langhörnigen Steppenrindes. Z. Tierzücht. Bd. 58. H. 3.
Hansen, S., 1965: The Quaternary in Denmark. The Quaternary, Vol. 1. Kalervo Rankama (Ed.)
Hartmann-Frick, H. 1960: Die Tierwelt des prähistorischen Siedlungsplatzes auf dem Eschner Lutzengüetle Fürstentum Liechtenstein (Neolithikum bis La Tène). Jahrb. Hist. Vereins Fürstentum Liechtenstein. Bd. 59. Vaduz.

- 1965: Die Fauna der befestigten Höhensiedlung auf dem Borscht Fürstentum Liechtenstein (Neolithikum bis La Tène). Ibid. Bd. 63. Vaduz.

Hartz, N., og H. Winge 1906: Om Uroxen fra Vig, saaret og dræbt med Flintvaaben. Aarb. II. R., 21. Bd.

Heck, L., 1952: Über den Auerochsen und seine Rückzüchtungen. Jb. d. Nass. Ver. f. Naturk., Bd. 90.
Herre, W., 1948: Zur Abstammung und Entwicklung der Haustiere I. Über das bisher älteste primigene Hausrind Nordeuropa. Verh. Dtsch. Zool. Kiel.
1961: Vide Rörms.
Hescheler, K., u. E. Kuhn, 1949: Die Tierwelt. In: Tschumi, O.: Urgeschichte der Schweiz. Frauenfeld.
Hescheler, K., u. J. Rüeger, 1942: Die Reste der Haustiere aus den neolithischen Pfahlbaudörfern. Egolzwil 2 (Wauwilersee, Kt. Luzern) und Seematte-Gelfingen (Baldeggersee, Kt. Luzern). Vierteljahrschr. naturf. Ges. Zürich. Zürich.
Higgs, E. S., 1961: The excavation of a Bos primigenius at Lowe's Farm. Littleport. Proc. Camb. Ant. Soc. vol. LIV.
Higham, C. F. W., 1967: The Economy of Iron Age Veileby (Denmark). Acta Archaeologica. Vol. XXXVIII. København.
Hilzheimer, M., 1909: Wisent und Ur im Kgl. Naturalienkabinett zu Stuttgart. Jh. d. Ver. f. vaterl. Naturk. in Württemberg.
Howard, M., 1962: The Early Domestication of Cattle and the Determination of Their Remains. Z. Tierzücht. Bd. 76. H. 4.

- 1963: The Metrical Determination of the Metapodials and Skulls of Cattle (Man and Cattle. Proc. Symp. on Domestication. Edit. A. E. Mourant and F. E. Zeuner) Royal Anthropological Institute Occasional Paper No. 18. London.
Hyde, H. A., \& K. F. Adams, 1958: An Atlas of Airborne Pollen Grains. London.
Hylander, N., 1941: Kärlväxter. Förteckning över Skandinaviens växter, 1. Lunds Botaniska Förening (Ed.).
Imhof, U., 1964: Osteometrische Untersuchungen an Rinderknochen aus Pfahlbauten des Bielersees. Mitt. Naturf. Gesellsch. Bern N.F. Bd. 21. Bern.
Isberg, O., 1950: Visenten (Bison bonasus arbustotundrarum Magn. Degerbøl) i Sverige jämte ett bidrag till dennes indvandringshistoria. Lunds Universitets Arsskrift. N.F. Avd. 2, Bd. 45. Nr. 11.
- 1962: Uroxen (Bos primigenius L.) i Sverige. Geol. Fören. Stockholm Förh., Bd. 84. H. 4. (Posthumed edited by E. Mohrén.)
Iversen, J., 1937: Undersøgelser over Litorinatransgressioner i Danmark. Medd. Dansk Geol. Foren. Bd. 9.
1941: Landnam i Danmarks Stenalder. Land Occupation in Denmark's Stone Age. A Pollen-Analytical Study of the Influence of Farmer Culture on the Vegetational Development. D. G. U. II. R. Nr. 66.
- 1945: The Bison in Denmark, Vide Degerbol \& Iversen.
- 1960: Problems of the Early Post-glacial Forest Development in Denmark. D. G. U. IV. Række. Vol. 4. No. 3.
- 1964: Retrogressive Vegetational succession in the Postglacial. J. Ecol. 52 (Suppl.). March 1964.
Jequier, J. P., 1963: Die Tierreste, Seeberg. Vide Boessneck 1963.
Jessen, A., 1906: Brabrand-Fundet fra den ældre Stenalder. Vide Thomsen 1906.
Jessen, K., 1927: Et Kulturlag fra den ældre Stenalder ved Horsø. Medd. Dansk Geol. Foren. Bd. 7. København.
- 1935: The Composition of the Forests in Northern Europe in Epipalæolithic Time. Biol. Medd. Dan. Vid. Selsk. XII. 1.
1937: Litorinasænkningen ved Klintesø i pollenfloristisk Belysning. Medd. Dansk Geol. Foren. Bd. 9. København.

Jessen, K., 1938: Some west baltic pollen diagrams. Quartär. Bd. 1. Berlin.
Jewell, P. A., 1962: Changes in Size and Type of Cattle from Prehistoric to Mediaeval Times in Britain. Z. Tierzücht. Bd. 77. H. 2.

- 1963: Cattle from British Archaeological Sites. Royal Anthropological Institute Occasional Paper. No. 18.
Johansen, Friis K., 1919: En Boplads fra den ældre Stenalder i Sværdborg Mose. Aarb. III R. 9. Bd.

Jonassen, H., 1950: Recent Pollen Sedimentation and Jutland Heath Diagrams. Dansk Botanisk Arkiv. Bd. 13. Nr. 7.
Jørgensen, S., 1954: A Pollen Analytical Dating of Maglemose Finds from the Bog Aamosen, Zealand. D. G. U. II. R. Nr. 80.

- 1956: Kongemosen. Kuml 1956.
- 1963: Early Postglacial in Aamosen. Vol. 1-2. D. G. U. II. R. Nr. 87.

Klafs, G., 1965: Zur Formenkenntnis von Bos primigenius Boj. nach Hornzapfenfunden im Mittelelbe-Gebiet. Z. Tierzücht. Bd. 81. H. 4.
Klarer, M., 1953: Wachstumsbeobachtungen beim Allgäuer Braunvieh. München.
Koch, W., 1927: Über angebliche Anzeichen von Domestikation am Skelett von Rindern. Zeitschr. f. Morph. u. Ökol. d. Tiere. Bd. 7. H. 3.
Keiller, A., 1965: Windmill Hill and Avebury. Oxford.
Krog, H., 1951: Den europæiske sumpskildpadde (Emys orbicularis L.) i Danmark. Vide Degerbøl \& Krog 1951.

- 1959: The Reindeer (Rangifer tarandus L.) in Denmark. Vide Degerbøl \& Krog 1959.
- 1960: Post-glacial Submergence of the Great Belt Dated by Pollen-Analysis and Radiocarbon. Report of the Intern. Geol. Congr. XXI Session. Norden. 1960. Part IV.
Kuhn, E., 1949: Die Tierwelt. Vide Hescheler 1949.
Kurtén, B., 1959: Rates of Evolution in Fossil Mammals. Cold Spring Harbor Sym. Quant. Biol. Vol. XXIV.
Madsen, A. P., and others, 1900: Affaldsdynger fra Stenalderen i Danmark undersøgte for Nationalmuseet. (Res. en français). Kjøbenhavn.
Madsen, V., 1902: Kortbladet Nyborg. D. G. U. I. R. Nr. 9. København.
Mathiassen, Th., K. Jessen, and M. Degerbøl, 1939: Bundsø, en yngre Stenalders Boplads på Als. Aarb.
Mathiassen, Th., 1940: Havnelev-Strandegaard. Et Bidrag til Diskussionen om den yngre Stenalders Begyndelse i Danmark. Aarb.
- 1941: Vore ældste Menneskefremstillinger. Fra Nationalmuseets Arbejdsmark. 1941.

Mathiassen, Th., M. Degerbøl, and J. Troels-Smith, 1942: Dyrholmen. En Stenalderboplads paa Djursland. Kgl. Dansk Vid. Selsk. Arkæol.-kunsthist. Skr. Bd. 1. Nr. 1. København.
Mathiassen, Th., 1943: Stenalderbopladser i Aamosen. - Med Bidrag af J. Troels-Smith og Magnus Degerbøl. Nordiske Fortidsminder. III. Bd. H. 3. København.
Mathiesen, H., \& J. Nielsen, 1956: Botaniske undersøgelser i Randers Fjord og Grund Fjord. (Engl. Summary). Botanisk Tidsskrift Bd. 53. København.
Matolcsi, J., 1967: Massverhältnisse der Extremitätenknochen des Rindes. (Deutsche Zusammenfassung, Magyar.) Budapest.

- 1968: Die Veränderung der Körpergrösse des Rindes in den geschichtlichen Epochen auf dem Gebiete Ungarns. - Ibid.
Melnyk, O., 1927: Das Wildrind Osteuropas und seine Domestication. Z. Tierzücht. Bd. 9.
La Baume, W., 1947: Diluviale Schädel vom Ur (Bos primigenius Bojanus) aus Toscana. Ber. Schweiz. Paläont. Gesellsch. Eclogae geol. Helvetiae Vol. 40. Nr. 2. Basel.
- 1958: Drei Schädel vom Ur (Bos primigenius Bojanus) aus Niedersachsen. Die Kunde (N. F.) 9.

La Tour, G. D. De, 1968: Zur Frage der Haustier-Nomenklatur. Säugetierkundliche Mitteilungen. Bd. XVI.
Leithner, O., 1927: Der Ur. Ber. intern. Gesellsch. z. Erhaltung des Wisents. Bd. 2. Berlin.
Lehmann, U., 1949: Der Ur im Diluvium Deutschlands und seine Verbreitung. N. Jahrb. für Mineralogie etc. Bd. 90. Abt. B.

- 1954: Die Fauna des "Vogelherds" bei Stetten ob Lontal (Württemberg) Neues Jb. Geol. u. Paläontol. Abh. Bd. 99. Stuttgart.

Lengerken, H. v., 1955: Ur, Hausrind und Mensch. Berlin.
Lilljeborg, W., 1874: Sveriges och Norges Däggdjur. Uppsala.
Lorenzen, P., 1854: Meddelelse om Fundet af et Uroxeskelet. V. M. 1853. København.
Lukaszewicz, K., 1952: Tur (Engl. Summary) "Ochrony Przyrody". R. XX.
Mohrén, E., 1962: Vide Isberg.
Müller, H.-H., 1959 : Die Tierreste von Alt-Hannover. Hannoverische Geschichtsblätter. N. F. Bd. 12. H. 3/4.

- 1965: Tierreste aus mittelalterlichen Siedlungen bei Dabrun, Kreis Wittenberg. Jschr. mitteldt. Vorgesch. Bd. 49. Halle (S).
Møнц, U., 1957: Knoglematerialet fra Jernalderbopladserne Dalshøj og Sorte Muld. Bornholm. Nationalmuseets Skr. 2. København.
- 1962: Rislevfundets Dyreknogler. Kuml. Aarhus. Vide Ferdinand. 1962.

Nehring, A., 1888: Über das Skelett eines weiblichen Bos primigenius aus einem Torfmoore der Provinz Brandenburg. Sitz. Ber. naturf. Freunde, Berlin.
Nielsen, J., 1956: Vide H. Mathiesen.
Nilsson, S., 1847: Skandinavisk Fauna. Däggdjuren. Lund.
Nilsson, T., 1947: A Pollen-Analytical Investigation of Holmegaards Mose. Medd. f. Dansk Geol. Foren. Bd. 11. H. 2.

- 1964: Standardpollendiagramme und $\mathrm{C}^{14}$-Datierungen aus dem Ageröds Mosse im mittleren Schonen. Lunds Universitets Årsskr. N. F. Avd. 2. Bd. 59. Nr. 7.
Nobis, G., 1954: Zur Kenntnis der ur- und frühgeschichtlichen Rinder Nord- und Mitteldeutschlands. Z. Tierzücht. Bd. 63.
- 1962: Die Tierreste prähistorischer Siedlungen aus dem Satrupholmer Moor (SchleswigHolstein). Z. Tierzücht.
- 1968: Das "Rind" aus dem Warnsdorfer Moor bei Ratekau, Kr. Eutin. Studien zur europäischen Vor- und Frühgeschichte. Neumünster.
Nordmann, V., 1936: Menneskets Indvandring til Norden. D. G. U. III. R. Nr. 27.
PaAver, K., 1965: Die Entstehung der Säugetierfauna und die Variabilität der Säugetiere des Ostbaltikums im Holozän (Russian, Deutsche Zusammenfassung). Tartu.
Peterson, R. L., 1955: North American Moose. Toronto.
Pontoppidan, E., 1767: Danske Atlas. Bd. 3. København.
Prell, H., 1939: Skandinavische Wildrinder in historischer Zeit. Zool. Anz. Bd. 125. Leipzig.
Reed, C. A., 1961: Osteological Evidence for Prehistoric Domestication in Southwestern Asia. Z. Tierzücht. Bd. 76. H. 1.

Reinhardt, J. H., 1834: Om Fund af Uroxer fra Danmark. O. V. S. F. for Aaret 1833-34. København.
Requate, H., 1957: Zur Naturgeschichte des Ures (Bos primigenius Bojanus 1827) nach Schädel- und Skelettfunden in Schleswig-Holstein. Z. Tierzücht. Bd. 70. H. 4.

- 1957: Zur nacheiszeitlichen Geschichte der Säugetiere Schleswig-Holsteins. Bonner zoologische Beiträge. Bd. 8. H. 3-4.
Reynolds, S. R., 1939: The Bovidae. A Monograph on the British Pleistocene Mammalia. Vol. III. Part VI. London.
Rüeger, J., 1942: Egolzwil. Vide Hescheler 1942.

Rydbeck, O., 1928: Stenålderhavets nivåförändringar och Nordens äldsta bebyggelse (Engl. Summ.: The Changes of Level of the Stone Age Sea and the Earliest Settling of Man in Scandinavia). Kungl. Human. Vetenskapssamfundets Åsberättelse.
Röhrs, M., und W. Herre, 1961: Zur Frühentwicklung der Haustiere. Z. Tierzücht. Bd. 75. H. 2 .

Sarauw, G. F. L., 1903: En Stenalders Boplads i Maglemose ved Mullerup, sammenholdt med beslægtede Fund. Aarb. II. R. Bd. 18.
Schneider, F., 1958: Die Rinder des Latène-Oppidums Manching. Studien an vor- und frühgeschichtlichen Tierresten Bayerns. München 1958.
Schwabedissen, H., 1962: Die Anfảnge der Haustierhaltung in Schleswig-Holstein im Lichte der Archäologie. Z. Tierzücht. Bd. 77. H. 2.
Stampfli, H. R., 1963: Vide Boessneck 1963.

- 1964: Vergleichende Betrachtungen an Tierresten aus zwei neolithischen Siedlungen am Burgäschisee. Mitt. naturf. Gesellsch. Bern. N. F. Bd. 21. Bern.
Steenstrup, J., 1849: Om Bos longifrons Owen funden i Danmark. Forh. Skand. Naturf. 5. Møde. Kjøbenhavn 1847.
- 1852: Kjæmpeoxens (Bos Urus Linn.) og Bæverens (Castor fiber Linn.) Samtidighed med Urindvaanerne her i Landet. V. M. 1851. København.
Steenstrup, J., 1870: Om Samtidigheden mellem Kjæmpe-Oxen (Bos primigenius Boj.) og Landets ældre Fyrreskove og om Flintskjærver, indvoxne i Dyreknokler, som Minder om Stenalderens Forfølgelser af de vilde Dyr. O. V. S. F.
Tauber, H., 1961: Danske kulstof- ${ }^{14}$ dateringsresultater I. Medd. Dansk Geol. Foren. Bd. 14. H. 4. København.

Teichert, M., 1964: Die Tierreste von den jungbronzezeitlichen Burgwällen Kratzeburg und Gühlen-Glienicke. Praehistorische Zeitschr. Bd. 42. Berlin.

- 1964 a: Die Tierreste aus der spätlatènezeitlichen Siedlung von Schönburg, Kreis Naumburg. Wiss. Z. Univ. Halle. XIII Jg.
Thomsen, Th., og A. Jessen, 1906: Brabrand-Fundet fra den ældre Stenalder. Aarb. II. R. Bd. 21.
Troels-Smith, J., 1937: Pollenanalytisk Datering af Brabrand-fundet. D. G. U. IV. R. Bd. 2. Nr. 16.
- 1942: Geologisk Datering af Dyrholmen-Fundet. Vide Mathiassen 1942.
- 1943: Geologiske Dateringer af Bopladser i Aamosen. Vide Mathiassen 1943.
- 1954: Ertebøllekultur-Bondekultur. Resultater af de sidste 10 Aars Undersøgelser i Aamosen, Vestsjælland. Aarb. 1953.
- 1955: Karakterisering af løse jordarter. D. G. U. IV. R. Bd. 3. Nr. 10.
- 1960: Ivy, Mistletoe and Elm Climate Indicators-Fodder Plants D.G.U. IV. R. Bd. 4. Nr. 4.
- 1962: De geologisk-botaniske Forhold i Forbindelse med Rislev-Fundet. (Engl. Summary) Kuml. Aarhus. Vide Ferdinand 1962.
- 1967: The Ertebølle Culture and Its Background. Palaeohistoria. Vol. 12 (1966).

Van der Vlerk, J. M., 1942: Kwartaire Bovidae van Nederland. De schedels en hoornpitten, welke zich bevinden in het Rijksmuseum van Geologie te Leiden. Leid. Geol. Medd. Deel XIII.

Vogel, R., 1933: Tierreste aus vor- und frühgeschichtlichen Siedlungen Schwabens. I. Die Tierreste aus den Pfahlbauten des Bodensees. Zoologica. H. 82, Lief. 1. Stuttgart.
Wertnik, R., 1926: Über die Wirkung der frühzeitigen Kastration auf das Schädelskelett des Rindes. Z. Tierzücht. Bd. 5.
Wettstein, E., 1924: Die Tierreste aus dem Pfahlbau am Alpenquai in Zürich. Viert. Jahrsch. d. Naturf. Ges. Zürich 69.

Winge, H., 1900: Dyreknogler i Affaldsdynger fra Stenalderen i Danmark. Vide Madsen 1900.

- 1903: Dyreknogler fra Maglemose ved Mullerup. Vide Sarauw 1903.
- 1904: Om jordfundne Pattedyr fra Danmark. V. M. Aarg. 56. København.
- 1906: Om Uroxen fra Vig. Vide Hartz 1906.
- 1906: Dyreknogler i Brabrand-Fundet. Vide Th. Thomsen 1906.
- 1919: Dyreknogler i Sværdborg-Fundet. Vide Frirs Johansen 1919.
- 1924: Dyreknogler i Holmegaards-Fundet. Vide Broholm 1924.

Winther, J., 1935: Troldebjerg. En bymæssig Bebyggelse fra Danmarks yngre Stenalder. Rudkøbing.

- 1926, 1928: Lindø. En Boplads fra Danmarks yngre Stenalder. I. og II. Rudkøbing.
- 1943: Blandebjerg. Rudkøbing.

Wodehouse, R. P., 1935: Pollen grains. New York 1935.
Würgler, F., 1958: Die Knochenfunde aus dem spätrömischen Kastell Schaan (4. Jahrhundert n. Chr.). Jd. d. Hist. Vereins f. d. Fürstentum Liechtenstein.
Zeuner, F. E., 1963: A History of Domesticated Animals. London.

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# ELECTRON-MICROSCOPICAL STUDIES ON THE ULTRASTRUCTURES OF SOME PERFORATE CALCITIC RADIATE AND GRANULATE FORAMINIFERA 

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# ELECTRON-MICROSCOPICAL STUDIES ON THE ULTRASTRUCTURES OF SOME PERFORATE CALCITIC RADIATE AND GRANULATE FORAMINIFERA 

Det Kongelige Danske Videnskabernes Selskab<br>Biologiske Skrifter 17, 2



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## Synopsis

The ultrastructures of the shells of six species of forminifera are described. Within the group of optically radiate/ultrastructurally radiate species (viz. Nodosaria latejugata Gümbel; Polymorphina sp.; Bulimina midwayensis Cushman \& Parker; Bulimina marginata d'Orbigny) the crystal units of the wall are composed of single crystals each of which is enveloped by an organic membrane. In the boundaries between secondary lamels are concentrations of spongy organic material which is intimately connected with the organic pore-tubes. Locally the secondary lamels were found to be constructed of primary lamels. The calcite crystals of the wall are generally elongated in direction of the optical c-axis which is orientated perpendicular to the shell surface.

In the granulate Melonis scaphum (Fichtel \& Moll) the crystal units are constructed of single crystals which are deliminated by organic membranes. The crystal units in Heterolepa cf. subhaidingeri (Parr) are composite but united by an organic membrane. The crystal units are build of tiny plates of calcite each of which is surrounded by an organic membrane which is much more delicate than the one surrounding the whole crystal unit.

## INTRODUCTION

TThe present study is a continuation of a previous work by the present author (Hansen, 1968a) in which the crystallographic orientation of the calcite crystals in a radiate and a granulate foraminifer was investigated by X-ray diffraction.

It was concluded that in the radiate form the calcite crystals are orientated with their basal pinacoid parallel to the shell surface. This corroborates the observations by Wood (1949) who arrived at the same conclusion using a polarizing microscope.

In the granulate form the crystallographic face parallel to the shell surface was shown to be the cleavage rombohedron as suggested in a hypothesis by Towe \& Cifellei (1967).

The question as to the morphology of the calcite elements in these two types of wall structure naturally rises. This study is an attempt to clarify the ultrastructures of the shells of some radiate and granulate foraminifera.

The choice of species for electron-microscopical studies was largely determined by the forms used in the X-ray diffraction work.

When describing radiate wall structures it would appear necessary to distinguish between, on one hand, optically radiate/ultrastructurally radiate, and on the other hand optically radiate/ultrastructurally non-radiate walls in view of the investigations by Pessagno \& Miyano (1968), Reiss \& Schneidermann (1969), and by Hansen, Reiss \& Schneidermann (1969).

The radiate Polymorphina sp. has a thick shell. This also applies to the species Nodosaria latejugata. The former was earlier used for X-ray diffraction studies while the surface ultrastructures of the latter were briefly described by Hay, Towe \& Wright (1963).

In contrast to Polymorphina sp., Nodosaria latejugata possesses ornamental costae of the inflational type and shows a very distinct secondary lamination. The Paleocene Bulimina midwayensis has a relatively thin wall and is ornamented with spines in the older part of the test. The closely related recent species Bulimina marginata (the type species of the genus) was studied with respect to concentration of organic matrices as these were not prominent in the fossil Bulimina midwayensis.

In the granulate Melonis scaphum the wall is extremely thin and is therefore well suited for combined studies in light microscope and electron microscope, especially so, as the distal face of the final chamber is constructed of only one layer of crystal units. By contrast, the species Heterolepa cf. subhaidingeri was chosen to represent thick shelled granulate forms. This species was investigated earlier by Hansen, Reiss \& Schneidermann (1969) in their study of the nature of the bilamellar septa.

Both types of wall structures represented in the present study are illustrated by forms which beyond any doubt can be referred to either the radiate or the granulate structural type by aid of a polarizing microscope.

The aragonitic species have been omitted from consideration as a thorough investigation of a representative of the Robertinacea, viz. Hoeglundina elegans, was published recently by Reiss \& Schneidermann (1969).

In the following the abbreviations SEM and TEM are used for scanning electron microscope and transmission electron microscope respectively.

## Acknowledgements

Professor Z. Reiss, The Hebrew University, Israel, kindly placed specimens of Heterolepa cf. subhaidingeri at the author's disposal.

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## TECHNIQUE

## Preparation of Specimens for the Scanning Electron Microscope

The specimens studied in the SEM were mounted, plated and if necessary cleaned again according to the technique described by Hansen (1968b). The SEM micrographs shown in the present work were made in a Stereoscan Mk. II a scanning electron microscope housed in the Geological Institutes of the University of Copenhagen.

## Preparation of Specimens for the Transmission Electron Microscope

All sections of specimens studied in the TEM were prepared according to the technique described by Hansen $(1967,1969)$ involving embedding in araldit, sectioning by frosted glass plates, polishing with MgO -powder prior to etching.

The author also applied the method described by Krinsley \& Bé (1965) but found a replication with collodium dissolved in pentylacetate more convenient.

Replicas of etched and un-etched outer and inner surfaces were made of specimens embedded in araldit. In order to obtain replicas of inner surfaces the chosen specimen was embedded with the chambers air-filled. The aperture was sealed with gum tragantum prior to embedding to prevent the embedding medium from flowing into the empty chambers. After hardening of the araldit the specimen was ground half way down with a frosted glass-plate leaving the specimen like a series of hemispheres. Before etching the specimen was replicated one or several times to remove the inner organic membrane and grinding dust. The specimen was then etched with an EDTA-solution (EDTA $=$ ethylene-diamine-tetra-acetate) and washed in distilled water. After etching the specimen was cleaned by being replicated one or several times to remove the free-etched organic matrices.

The specimen does not necessarily have to be perfectly clean when this technique is used.

As fossil specimens often have sediment particles adhering to the surface even after careful washing it was necessary to find a technique by which it was possible to replicate the surface several times without loosing the specimen.

The specimens were laid on a glass plate, which had been covered in the centre with a small drop of araldit. The drop was spread to a very thin film using a needle and a dry test was placed in the araldit in the desired position. If a lenticular specimen was to be orientated vertically (i.e. standing on the periphery) it was first mounted on a clean glass plate with a very small amount of gum tragantum and afterwards the araldit was placed around it with a needle. Specimens with heavy ornamentation, reticulate surface or larger pores may cause some difficulty as the embedding medium creeps along the uneven structures and covers the specimen. This can be avoided by using only very little embedding material. By this method the surface of a specimen can be studied in an un-etched and later in an etched state.

The replicas were shadowed in an Hitachi vacuum evaporator. The author found it most convenient to use only carbon shadowing. Shadow casting with gold or platinum veiled the very faint differences in electron density between the organic membranes and the pure carbon film. The combination of a carbon replica with adhering organic material is in the following called replica-pseudoreplica.

In replicas of some specimens shadowed with carbon-platinum, striation with a spacing of $30-40 \AA$ was found (pl. 2, fig. 1). The striation is orientated in two directions cutting each other at an angle of about $30^{\circ}$.

According to Reimer (1967) the resolution power of a collodium replica should at its best be about $60 \AA$. The striae are thus probably an artefact representing the structure of the replication material and do not refer to any structure in the replicated specimen.

Two-stage replicas have mainly been used. All micrographs made in the TEM show inverted relief.

The transfer of the shadowed replicas to cut-out grids has previously been described by the author (Hansen, 1967).

The technique used by Hansen (1969) was applied for preparation of specimens for combined light microscope and electron microscope studies.

In this work three different transmission electron microscopes have been used, viz. Hitachi HU-11-C, Akashi transcope and Philips EM-75. The former two are housed in the Geological Institutes of the University of Copenhagen, while the latter is now housed in the Department of Metallurgy, the Royal Danish Technical University.

## Species with Radiate Wall Structure

> Nodosaria latejugata Gümbel, 1868.
> Pls. 1-8.

The material of this species originates from the Lower Selandian sediments in the Copenhagen area.

Thin section studies under light microscope between crossed nicols showed a very distinct radiate extinction. The extinction of the ornamental costae gave the
impression of a fan-shaped orientation of the crystals while the adjacent part of the shell showed the normal radiate extinction.

The test is distinctly lamellar (pl. 1, figs. 1-2). One specimen consisting of 11 chambers was cut, and a thin section of each chamber was prepared. The sections illustrated here represent chambers 7 and 8 of this series. When the nicols of the microscope were orientated parallel a faint lamination of the costae in some sections could be observed.

In the wall itself the youngest secondary lamels are considerably thinner than the older ones. The glassy appearance of the costae is due to the lack of pores which are abundant in the adjacent chamber wall. The abundant slender pores led early workers to introduce the term fibrous when describing this kind of wall structure. It later caused some difficulty as the term was considered synonymous with the term optically radiate and should accordingly be avoided (for discussion see Towe \& Cifelli, 1967).

The boundaries between the secondary lamels are clearly seen on replicas of etched sections studied in the TEM. At the boundaries organic matrices were found. The boundaries are found on both strongly and slightly etched sections (pl. 1, fig. 3; pl. 2, fig. 2).

In deeply etched sections the secondary lamels were locally found to be constructed of primary lamels (pl. 3, figs. 1-2; pl. 4, fig. 1). The primary lamels are not as pronounced and distinct as the secondary ones. This is possibly due to the thicker organic matrices found between the secondary lamels.

The calcite crystals of the wall are elongated in the direction of the optical c-axis (pl. 3, figs. $1-2$; pl. 5, fig. 2 ; pl. 7, fig. 2). The reason why there is a primary lamination in certain areas of the shell, while this structure seems untraceable in other areas is problematic. In most cases a distinct columnar structure indicative of continuous growth within each secondary lamel was found (pl. 5, figs. 1-2).

On replicas of etched inner surfaces the boundaries between the crystal units are distinct (pl. 6, figs. 1-2). Pores are found distributed both along the boundaries and inside the crystal units. The pores are circular to slightly elliptical in cross section and have a diameter of about $0.2 \mu$. Their diameter is thus smaller than the resolution power of a normal light microscope.

In the boundaries of the crystal units are organic matrices enveloping each of the units (pl. 6, fig. 1). The replica-pseudoreplica shadowed at right angles to the surface showed the delicate nature of the membranes.

Hay, Towe \& Wright (1963) studied the ultrastructures of the surface of specimens of Nodosaria affinis from the basal part of the Kincaid Formation, Texas, U.S.A. combining electron microscope investigations of one-stage surface replicas and light microscope studies of thin sections. They wrote, concerning the ornamental costae: "Where the test is thickened by the ornamental ribs, the pores are discontinuous ... The pores appear to have originally been continuous, but have later been filled in with calcite. . . . the ribs behave like a few large crystals of calcite which
extinguish in different orientations from the adjacent perforate wall. It is not certain whether this is due to recrystallization or whether it is an original feature".

Specimens of Nodosaria latejugata Gümbel (= ? Hay et al.'s Nodosaria affinis) from the basal part of the Kincaid Formation from the collection of the Mineralogical Museum of the University of Copenhagen were studied in TEM by the author. The structures found in these specimens are identical with the ones present in the Danish material but were different from those of Hay et al. It therefore would seem likely that the specimens studied by Hay et al. were recrystallized in view of their remarks on the extinction of the costae compared to the adjacent chamber wall.

Replicas of sectioned specimens cut at righ angles to the long axis of the test clearly demonstrated that the pores are not discontinuous at the ornamental ribs (pl. 4, fig. 1) and that they follow the general direction of the crystal units. The latter show a fan-shaped striation indicative of the optical orientation of the crystals.

If pores had been present in the ornamental ribs they should be traceable on etched surfaces. Replicas of etched surfaces of ornamental ribs did not show any trace of pores (pl. 7, fig. 3; pl. 8, fig. 2) while they were abundant in the areas between i.e. the un-ornamented chamber wall (pl. 7, fig. $1 \& 3 ;$ pl. 8, fig. 1).

## Polymorphina sp. <br> Pls. 9-11.

The material of this recent species originates from a sample collected by the author at a locality situated in the Kattegat east of Læsø at a depth of 56 m . Specimens of the same species were earlier investigated by the author by X-ray diffractometry.

Both sections and crushed specimens showed a distinct radial extinction when studied between crossed nicols under the light microscope.

The specimens used for electron microscopy were embedded air-filled in araldit and sectioned to the median plane. They were replicated to remove the inner membrane, etched for 2 minutes with EDTA and replicated again. After shadowing a replicapseudoreplica was obtained. TEM stereo micrographs (pl. 9, figs. 1-2) showed that the organic membranes adhere for some distance to the free etched pore-tubes. A generalized model of the relation between the pore-tubes and the organic membranes is shown Fig. 1. This model is comparable with the micrograph shown on pl. 10, fig. 1.

To obtain a further proof of the presence of organic material in the wall the following technique was used. Specimens were embedded so that a small area was left free of embedding material. To clean the surface it was replicated several times to remove the organic material. Afterwards it was etched for 45 seconds with EDTA. After washing in distilled water the specimens were shadowed at a low angle. After this, collodium was put on top and left to dry. Instead of pulling off the replica it was only lifted a little at one side in order to expose a small area of the shell. The specimen with adhering replica was then transferred to $5 \% \mathrm{HCl}$. When the specimen was dissolved the replica was pulled off and washed in distilled water.


Fig. 1. Generalized model of the relation between the organic membranes enveloping the crystal units and the organic pore-tubes.

Where organic membranes are present they will cause shadow and they will remain in their original position in the carbon film; when using a two-stage replica technique the organic membranes often flow away from their original position during the dissolution of the collodium.

The organic matrices enveloping the crystal units are clearly exposed by this method (pl. 11, fig. 1).

Bulimina midwayensis Cushman \& Parker, 1936.
Pls. $12-16 ;$ pl. 17, fig. 1.
The material of this species originates from the Lower Selandian deposits exposed in the gorge of the streamlet Lellinge a south of Copenhagen.

Thin sections studied under the light microscope between crossed nicols show a radiate extinction indicative of an optical radiate arrangement of the crystals where the c-axis are perpendicular to the surface of the test. Secondary lamination of the older part of the test could also be observed.

A section of Bulimina midwayensis studied in TEM was published by Hansen (1967). On replicas of etched polished sections the lamination connected with the addition of new chambers is distinct. The secondary lamels found in the older part of the test have an almost constant thickness of about $3 \mu$. There is, however, a slight thickening of the lamels in the inflational spines and especially of the oldest lamels (pl. 12, fig. 1).

At the lamel boundaries are found concentrations of organic material. The organic material is, however, not prominent in Bulimina midwayensis. The systematically closely related recent species Bulimina marginata had more organic material and is described below. Fossilisation may have caused a shrinkage of the organic material in Bulimina midwayensis and accordingly no attention has been paid to the organic material in the test of this species.

The optical radiate arrangement of the calcite crystals is also seen in the crystal morphology. The boundaries between the crystal units are found to run perpendicular
to the test surface (pl. 12, fig. 2; pl. 13, fig. 1). It was found that the crystal units are interrupted at the lamel boundaries (pl. 13, fig. 2).

Areas with more irregular boundaries between crystal units were found as well (pl. 14, fig. 1), mainly where new chambers are added.

On etched inner surfaces of the chambers the crystal unit boundaries are distinct (pl. 15, fig. 1; pl. 16, fig. 1). There would seem to be some difference between the construction of the wall of the proloculus and that of the younger chambers. The two figured chambers (pl. 15, fig. 1; pl. 16, fig. 1) showing the proloculus and the third chamber have been exposed to the same etching for the same period of time. The boundaries in the proloculus are more deeply etched than those of the younger chamber. This is possibly due to thicker organic matrices between the crystal units in the proloculus than in the younger chambers. The boundaries between crystal units in the proloculus seem to be more irregular than in the younger chambers.

The pattern of the boundaries between the crystal units gives the impression of a simple jig-saw puzzle. In end view the crystal units show a lobate configuration. In the calcite small pits are seen where the crystalline matter has been more strongly attacked by the EDTA. This may possibly be explained as areas of dislocation or some other disorder in the crystal structure. That they do not represent planes of twinning or crystal intergrowth is indicated by their irregular distribution. The etch pits are found both in the basal pinacoid (parallel to the surface of the test) and in sections at right angles to the wall surface (pl. 17, fig. 1).

The transition from an etched hollow chamber to the adjacent sectioned chamber wall is shown in pl. 14, fig. 2. The crystal unit boundaries stand out like mountain ranges and it is evident that these boundaries are the ones found running perpendicular to the wall surface when studied in sections. As on pl. 16, fig. 1, the boundaries between crystal units are more regular than the boundaries in the proloculus.

Bulimina marginata d'Orbigny, 1826.
Pl. 17, fig. 2; pl. 18.
Specimens recently collected from the Kattegat were embedded, sectioned, polished, etched and replicated. The first replica after etching was used to study the free etched organic material. The replica-pseudoreplica was shadowed with about $75 \AA$ carbon at a very high angle. The true replica is found as a background on which the organic membranes and pore tubes are lying. There are some difficulties in obtaining resonably well-focused electron micrographs of this kind of specimens as the organic matter gives a very high relief. In the sections was found a high concentration of organic material both on the inner and outer surface of the test as well as in the boundaries between secondary lamels (pl. 18, figs. 1-2).

A replica-pseudoreplica of an etched inner surface showed the crystal unit boundaries as dark irregular bands which are relatively thick and also the free etched organic membranes which lay within the replica while it was shadowed. The mem-
branes have probably floated out of position during the dissolution of the replica and have shrunk in such a way that they are now found as dark bands running concordant with the crystal unit boundaries (pl. 17, fig. 2).

## Species with Granulate Wall Structure

Melonis scaphum (Fichtel \& Moll, 1798). Pls. 19-21.

The material of this species was recently sampled from the Kattegat by the author.
A micrograph of a crushed specimen observed under the light microscope between crossed nicols showing extinction indicative of a granulate wall structure was previously published by Havsex (1968a). When studying flat fragments under the light microscope between crossed nicols the question of the delimitation of crystal units arises. When rotating the microscope stage the jig-saw puzzle pattern of dark lines constituting the boundaries between optical crystal units disappear and reappear.

In thin sections of radiate calcitic forms the lamel boundaries are clearly seen when the boundaries are orientated at right angles to the polarizing direction of the nicols (especially so when both nicols are orientated parallel). It would appear that the same phenomenon to a certain extent applies to the boundaries between the optical crystal units in Melonis scaphum.

As Melonis schaphum has a lamellar test, only the central part of the relatively plane apertural faces of the septa have been used, as this part is non-lamellar, so that a possible optical phenomenon, superimposed from one crystal upon another, could be avoided. The apertural face provided a flat fragment of the shell apparently constructed of only one layer of crystals as in Chilostomella (see Towe \& Cifelli, 1967). The central part of the apertural face of several specimens was broken off and embedded floating on a small drop of half-hardened araldit on a glass slide. The same fragment could in this way be studied under the light microscope and could also be replicated for electron microscope study.

In the TEM a slightly etched apertural face showed the presence of organic material delimiting the crystal units and lying along the boundaries (pl. 19, figs. 1-2.)

Pores are present both inside the crystal units and along the boundaries between them (pl. 20, fig. 1). The organic material is of a spongy nature and is intimately connected with the pore-tubes (pl. 20, fig. 2). On one of the specimens a correlation between the light microscope picture and the electron microscope observations could be achieved. Pl. 21, figs. $1-3$ shows the same area seen in both types of microscope. It is evident from these micrographs that one optical crystal unit consists of only one morphological single crystal. This also corroborates the observation of the crystal units of the optically and morphologically radiate forms. In these a crystal unit consists of only one crystal which is indicated by the lack of any organized etch figures that are to be expected along lines of crystal intergrowth and lines between crystallographic twins.

When studied in thin section between crossed nicols the test was found to be lamellar. The secondary lamels are very thin but can be seen in the older thickened walls. In these the optical crystal units were found to extinguish across the lamel boundaries. As, however, the wall is very thin, even in the older part, observational difficulties made it impossible to correlate light microscope and electron microscope observations of the same specimen.

## Heterolepa cf. subhaidingeri (PARR, 1950). Pls. 22-26.

The specimens of this form originate from off New Zealand. The were kindly placed at the author's disposal by Professor Z. Reiss, Israel.

In thin section this species shows a very pronounced secondary lamination. The extinction between crossed nicols is of the granulate type as described by Wood (1949). Micrographs of the species were published by Hansen, Reiss \& Scineidermann (1969). The extinction demonstrates optical units extinguishing across the boundaries between secondary lamels. The shapes of the extinguishing units may vary somewhat, but are in general elongated in a direction perpendicular to the shell surface. These optical units are of the order of size of $20-30 \mu$ in length while their width is about $3-5 \mu$. The boundaries between them studied in thin sections only are not as well defined as in Melonis scaphum. Crushed specimens studied between crossed nicols showed an indistinct extinction.

On replicas of etched and polished sections studied in TEM was found a pronounced division of the calcite into plates each of which have a thickness of about $0.3 \mu$ (pl. 22, fig. 1). The calcite plates are grouped as morphologically uniformly orientated piles surrounded by a thick organic membrane (pl. 22, fig. 2; pl. 23, fig. 1 ). Also between the plates which lie within the thick organic membrane are found organic matrices (pl. 23, fig. 2) which, however, are much more delicate than those mentioned above.

The boundaries between secondary lamels are marked by a concentration of organic material easily seen on replicas of etched specimens (pl. 24, fig. 2). It is not as thick as that found in the septa (pl. 24, fig. 1).

While each of the crystal units in Melonis scaphum consists of an optical and morphological single crystal of calcite (in the septa) the crystal units in Heterolepa cf. subhaidingeri are composed of a group of plates which all have the same optical and morphological orientation. Analogous to the radiate forms and the granulate Melonis scaphum the delimiting factor of the crystal unit is the thicker organic membrane surrounding the optical unit.

The same orientation of the calcite plates continues across the boundaries between the secondary lamels (pl. 24, fig. 2). In contrast to this the crystal plates are interrupted at the lamel boundaries (pl. 25, figs. 1-2).

The pores have a diameter of about $15 \mu$. Prominent constrictions are found where the pores cross the boundaries between the secondary lamels. Besides the
strong constrictions corresponding to these lamels are found less pronounced constrictions (pl. 26, fig. 1). The lamels corresponding to these latter constrictions could not be traced in the SEM and TEM. The slight constrictions are supposed to represent primary lamination analogous to the one observed in some of the radiate forms. The minor constrictions are not found in all pores (pl. 26, fig. 2).

In the septa (pl. 24, fig. 1) are found the same piles of calcite plates with alternating directions as in the chamber wall and in the secondary lamels. The orientation of the plates is not identical on both sides of the thick organic matrix constituting the dark dividing line in the septum. This may explain the indistinct extinction of the septa when studied in crushed specimens between crossed nicols.

## CONCLUSIONS AND DISCUSSION

In the present work mainly optically radiate/ultrastructurally radiate species have been investigated. These forms show both in their optical properties and in their ultrastructures that the calcite of the wall is columnar and elongated in direction of the c-axis arranged perpendicular to the wall surface. In these forms the crystal units are composed of single crystals which are interrupted at the boundaries between the secondary as well as at the primary lamels. The interruption of crystals at lamel boundaries was mentioned earlier by Hansen (1968c), Reiss \& Schneidermann (1969) and by Hansen, Reiss \& Schneidermann (1969).

Two granulate species have been investigated. The one shows, that an optical crystal unit consists of a morphologically single crystal, while it in the other form is composed of a series of thin plates with identical morphological orientation.

The question of single crystals, aggregates etc. in the description of mineral matter in the test of foraminifera was discussed by Towe \& Cifelli (1967). They concluded that it would be nonsense to measure parameters like crystal diameter. As, however, single crystals or aggregates of crystals are delimited by organic membranes, and, as these are easily traceable on etched specimens studied in the TEM, it is possible to discern crystal units. A crystal unit is thus here defined as one or more crystals with identical optical orientation enveloped by a membrane; the membrane is regarded as the delimiting factor.

In the investigated species the pores are situated both inside and along the boundaries between crystal units. In Heterolepa cf. subhaidingeri the author did not succeed in observing the position of the pores in relation to the crystal unit boundaries.

The presence of pores within the crystal units conflicts with the statement by Loeblich \& Tappan (1964) that the pores pass between crystals in the hyaline radiate forms.

In the sectioned specimens concentrations of organic material are prominent in the boundaries between the secondary lamels. Hansen, Reiss \& Schnembermann (1969) demonstrated the continuity of the organic spongy material in the bilamellar septum with the spongy organic material found at the inner boundary of the corresponding secondary lamel (i.e. lying at the inner surface of the outer lamella).

Towe \& Cifelli proposed a model of calcification in foraminifera. They suggested an epitaxial growth of crystals from an active-passive membrane. The passive membrane, being thick, carries the active compounds responsible for the nucleation of the calcite which, when initiated, grows on outwards.

This model fits to a certain extent to the observation of calcification in Spiroloculina hyalina published by Arnold (1964). The crystallization takes place in the wall close to its inner surface. In the later stages of mineralisation the outer part of the organic wall is calcified. It was found that the wall of Spiroloculina hyalina was formed
as an organic matrix prior to calcification. As, however, the calcification takes place in a series of isolated spots also in the middle and upper part of the primary organic matrix there must be several more points of nucleation than those found close to the passive innermost membrane.

Towe \& Cifelli did not stress the importance of the organic matrices enveloping the crystals or crystal units. Accordingly their model of calcification does not encompass these structures.

All observations point to the presence of an organic three-dimensional framework probably of spongy nature intimately connected with the organic pore-tubes in the wall of foraminifera prior to calcification. Moreover, the crystal interruption at lamel boundaries would imply that renewed nucleation of calcite takes place on the other side of the lamel boundary. The crystal unit boundaries in Heterolepa cf. subhaidingeri were found to be independent of the secondary lamination. In contrast to the crystal units the small plates comprising the crystal units are interrupted at the boundaries, while their direction is un-altered. In spite of the crystal plate interruption at the lamel boundaries the orientation from an older to a younger lamel persists.

The problem of primary lamination needs a thorough study but already with the few available observations (Gerke, 1957; de Civrieux \& Dessauvagie, 1965; Reiss \& Schneidermann, 1969; Hansen, Reiss \& Schneidermann, 1969) it appears that the model of calcification proposed by Towe \& Cifelli needs modification, as pointed out by Lynts \& Pfister (1967).

The solution to this problem lies within the field of study of living specimens rather than in the study of tests of dead foraminifera as clearly demonstrated by the work of Arnold (1964), and Angell (1967).

## PE3ЮME

В данной работе описаны ультраструктуры раковин шести видов фораминифер. В группе оптически радиально-лучистых - ультраструктурно радиально-лучистых видов (Nodosaria latejugata Gümbel; Polymorphina sp.; Bulimina midwayensis Cushman \& Parker; Bulimina marginata d’Orbigny) кристаллические единицы стенок состоят из единичных кристаллов, каждый из которых покрыт органической мембраной. На границах между вторичными пластинками развито губчатое органическое вещество, непосредственно связанное с органическими поровыми трубками. Местами вторичные пластинки оказываются сложенными первичными. Кальцитовые кристаллы, слагающие стенку, обычно удлинены в сторону оптической оси "c", которая направлена перпендикулярно к поверхности раковины.

У гранулированной Melonis scaphum (Fichtel \& Moll) кристаллические единицы состоят из единичных кристаллов, разделенных тонкими органическими мембранами. Кристаллические единицы у Heterolepa cf. subhaidingeri (Parr) являются сложными, но также окруженными органической мембраной. Каждая единица сложена тонкими пластинами кальцита, каждая из которых покрыта органической мембраной, намного тоньше той, которая покрывает всю пачку.

## REFERENCES

Angell, R. W. (1967) The process of chamber formation in the foraminifer Rosalina floridana (Cushman). J. Protozool. 14, 566-574.
Arnold, Z. M. (1964) Biological observations on the foraminifer Spiroloculina hyalina Schulze. Univ. Calif. Publ. Zool. 72, 1-78.
de Civrieux, Sellier, J. M. and Dessauvagie, T. F. J. (1965) Reclassification de quelques Nodosariidae, particuliérement du Permien au Lias. M.A.T. Publ. 124, 1-178. Turkey.
Gerke, A. A. (1957) Sur quelques caractéres importants de la structure interne des Foraminiféres de la famille Lagenidae, d’aprés les représentants du Permien, du Trias et du Lias de l'Arctique soviétique. Nauchno-issl. Inst. geol. Arktiki, Sborn. Stat. Paleontol. Biostratgr. SSSR, 4, 11-26.
Hansen, H. J. (1967) A technique for depiction of grind sections of foraminifera by aid of compiled electromicrographs. Medd. dansk geol. Foren. 17, 128 only.

- (1968a) X-ray diffractometer investigations of a radiate and a granulate foraminifera. Medd. dansk geol. Foren. 18, 3-4, 345-348.
- (1968b) A technique for removing gold from plated calcareous microfossils. Micropaleontology, 14, 4, 499-500.
- (1968c) Shell structures in foraminifera in light of electronmicroscopical investigations. Geol. För. Stockh. Förh. 90, 3, 459 (in Swedish).
- (1969) Combined light- and electron microscope studies of thin-sections. Micropaleontology, 15, 426.
Hansen, H. J., Reiss, Z. and Schneidermann, N. (1969) Ultramicrostructure of bilamellar walls in Foraminiferida. Revista Española Micropal. 1, 293-316.
Hay, W. W., Towe, K. M. and Wright, R. C. (1963) Ultramicrostructure of some selected foraminiferal tests. Micropaleontology, 9, 2, 171-195.
Krinsley, D. and Bé, A. W. H. (1965) Electron microscopy of internal structures of foraminifera. Handbook of paleontological techniques, 335-343, (ed. by Kummel and Raup) Freeman and Co.
Loeblich, A. R. and Tappan, H. (1964) Treatise on invertebrate paleontology. Part C. Protista 2. Sarcodina chiefly "Thecamaebians" and foraminiferida. University of Kansas Press, (ed. Moore), 1-900.
Lynts, G. W. and Pfister, R. M. (1967) Surface ultrastructure of some tests of recent foraminiferida from the Dry Tortugas, Florida, J. Protozool, 14, 387-399.
Pessagno, E. A. and Miyano, K. (1968) Notes on the wall structure of the Globigerinacea. Micropaleontology, 14, 1, 38-50.
Reimer, L. (1967) Elektronenmikroskopische Untersuchungs- und Präparationsmethoden. 1-598. Springer-Verlag, Berlin, Heidelberg.
Reiss, Z. and Schneidermann, N. (1969) Ultrastructure of Hoeglundina. Micropaleontology, 15, 135-144.
Towe, K. M. and Cifelli, R. (1967) Wall ultrastructure in the calcareous foraminifera: crystallographic aspects and a model for calcification. J. Paleont., 41, 3, 742-762.
Wood, A. (1949) The structure of the wall of the test in the foraminifera; its value in classification. Q. Jl. geol. Soc. Lond., 104, 229-252.

PLATES

## Plate 1

Figs. 1-2. Nodosaria latejugata Gümbel.
Transverse thin section of chambers 7 and 8 respectively, showing secondary lamination. 2 nicols parallel.
Fig. 3. Nodosaria latejugata Gümbel.
Carbon shadowed replica of etched transverse section showing the boundary between two secondary lamels with a sheet of organic material. TEM.


## Plate 2

Fig. 1. Nodosaria latejugata Gümbel.
Carbon-platinum shadowed collodium replica of etched transverse section of chamber wall. The micrograph shows in two directions (with an angle of ca. $30^{\circ}$ ) striae with a distance of $30-40 \AA$ representing the structure of the collodium. TEM.
Fig. 2. Nodosaria latejugata Gümbel.
Carbon-platinum shadowed replica of slightly etched transverse section of the chamber wall with a boundary between two secondary lamels at which the pore-tubes show slight constrictions. TEM.

PL. 2


## Plate 3

Fig. 1. Nodosaria latejugata Gümbel.
Carbon shadowed replica of etched transverse section of ornamental costa showing primary lamination. Shell surface in upper right direction. TEM.
Fig. 2. Detail of fig. 1. The primary lamels are seen to be constructed of columnar calcite crystals about $1 \mu$ long and enveloped by delicate organic membranes. TEM.



## Plate 4

Fig. 1. Nodosaria latejugata Gümbel.
Carbon shadowed replica of slightly etched transverse section showing the base of an ornamental costa. In the costa is seen slight striation of a fan-shaped arrangement indicating the morphological orientation of the calcite identical to the optical orientation. The pores are seen to follow the general direction of the calcite crystals and are not present within the costa itself. In the upper part of the micrograph are seen traces of primary lamination. TEM.


## Plate 5

Fig. 1. Nodosaria sp. Hvorslev, Denmark. Middle Oligocene.
Fractured and naturally corroded apertural part, showing the columnar nature of the calcite. SEM.
Fig. 2. Detail of fig. 1. Columnar calcite crystals indicative of continuous growth with slight etch lines indicative of the cleavage rombohedron. Note that the crystals are uninterrupted, suggesting that no primary lamination is present. SEM.

$50 \mu$

1


## Plate 6

Fig. 1. Nodosaria latejugata Gümbel.
First replica of inner etched surface. Carbon shadowing at right angles to the surface showing organic membranes between crystal units as well as organic pore-tubes. TEM.
Fig. 2. Nodosaria latejugata Gümbel.
Third replica of inner etched surface shadowed with carbon at right angles to the surface showing pores along the crystal unit boundaries and within the crystal units. TEM.


## Plate 7

Fig. 1. Nodosaria latejugata Gümbel.
Slightly etched outer surface of chamber wall with pore-tubes etched free. SEM.
Fig. 2. Nodosaria latejugata Gümbel.
Fractured wall showing the columnar nature of the calcite crystals. SEM
Fig. 3. Nodosaria latejugata Gümbel.
Slightly etched outer surface showing transition from a pore-free costa (left) to porous chamber wall (right). SEM.


## Plate 8

Fig. 1. Nodosaria latejugata Gümbel.
Carbon shadowed replica of un-etched surface of porous chamber wall. TEM.
Fig. 2. Same specimen as fig. 1.
Non-porous costa. TEM.



Fig. 1. Polymorphina $s p$,
Carbon shadowed replica of etched inner surface with organic pore-tubes and adhering membranes. Stereopair. TEM.
Fig. 2. Same specimen as fig. 1.
Pores are found both along the boundaries between crystal units and within the crystal units. Stereopair. TEM.



## Plate 10

Fig. 1. Polymorphina sp.
Replica of etched inner surface shadowed with carbon showing pore-tubes and organic membranes. TEM.


Fig. 1. Polymorphina sp.
One-stage carbon replica of etched surface showing organic membranes and crystal units. TEM.

$2 \mu$

1

## Plate 12

Fig. 1. Bulimina midwayensis Cushmann \& Parker.
Carbon shadowed replica of etched section showing lamination of spine of proloculus. TEM.
Fig. 2. Same specimen as fig. 1.
Showing columnar orientation of the crystal units. TEM.


$5 \mu$

## Plate 13

Fig. 1. Bulimina midwayensis Cushman \& Parker.
Carbon shadowed replica of polished, etched section of chamber wall showing columnar orientation of the crystal units. TEM.
Fig. 2. Bulimina midwayensis Cushman \& Parker.
Carbon shadowed replica of etched longitudinal section with hollow chambers. The area shown is transitional between the inner surface with torn-out pore-tubes and boundaries between crystal units and a cross section of the laminated chamber wall. TEM.



## Plate 14

Fig. 1. Bulimina midwayensis Cushman \& Parker.
Carbon shadowed replica of polished, etched longitudinal section showing irregular crystal units at the junction between the walls of two chambers. TEM.
Fig. 2. Same as fig. 1.
In the right side of the micrograph are seen crystal units interrupted at a lamel boundary. TEM.


$3 \mu$

## Plate 15

Fig. 1. Bulimina midwayensis Cushman \& Parker.
Second carbon shadowed replica of etched inner surface of proloculus of megalospheric specimen showing irregular boundaries between crystal units. TEM.


## Plate 16

Fig. 1. Bulimina midwayensis Cushman \& Parker.
Second carbon shadowed replica of etched inner surface of the oldest-but-two chamber of megalospheric specimen showing irregular boundaries between crystal units. In spite of the same duration of etching the boundaries are less deepened than in the proloculus (compare pl. 15, fig. 1). TEM.


## Plate 17

Fig. 1. Bulimina midwayensis Cushman \& Parker.
Carbon shadowed replica of polished, etched section of lamellar chamber wall. Etch pits are found along lamel boundaries and at places with supposed disorder in the crystal structure. TEM.
Fig. 2. Bulimina marginata d'Orbigny.
High angle carbon shadowed replica of inner etched surface showing pore-tubes and boundaries between crystal units. In the right side of the micrograph are seen delicate organic membranes running inside the crystal unit boundaries and roughly following the direction of the boundaries. The shrinkage of the membranes, the original position of which was in the boundaries, is thought to be caused by the dissolution of the collodium replica. TEM.


## Plate 18

Fig. 1. Bulimina marginata d'Orbigny.
Replica-pseudoreplica of etched section of laminated wall of youngest-but-one chamber, showing concentration of organic material in the lamel boundary intimately connected with the pore-tubes. TEM.
Fig. 2. Same as fig. 1.
In left side of the micrograph are seen organic membranes adhering to pore-tubes and high concentrations of organic material in the lamel boundaries. TEM.


$5 \mu$

2

## Plate 19

Fig. 1. Melonis scaphum (Fichtel \& Moll).
Replica-pseudoreplica of outer etched surface of central part of apertural face showing delimitation of a crystal unit by organic spongy material. TEM.
Fig. 2. Melonis scaphum (Fichtel \& Moll).
Replica-pseudoreplica of outer etched surface of central part of apertural face showing free-etched organic limitations of the crystal units. The crystalline matter has been dissolved prior to replication. TEM.


## Plate 20

Fig. 1. Melonis scaphum (Fichtel \& Moll)
Second carbon shadowed replica of inner surface of central part of apertural face showing pores both inside the crystal units and along the boundaries. TEM.
Fig. 2. Melonis scaphum (Fichtel \& Moll).
First carbon shadowed replica of strongly oblique section of wall of the youngest chamber after etching with EDTA for 20 secunds. Note the intimate relationship between the spongy organic material bounding the crystal units and the pores. TEM.


## Plate 21

Fig. 1. Melonis scaphum (Fichtel \& Moll).
Photomicrograph of central part of fractured apertural face. Crossed nicols.
Fig. 2. Same as fig. 1.
Specimen rotated $40^{\circ}$ relative to fig. 1. Crossed nicols.
Fig. 3. Same as fig. 1.
Carbon shadowed replica of the same area (slightly etched). (a) the single crystal unit which in fig. 2 shows extinction. (b) the crystal unit which in fig. 1 has just passed the extinction point. TEM.


1


2


## Plate 22

Fig. 1. Heterolepa cf. subhaidingeri (Parr).
Third two-stage replica of polished, etched section showing platy nature of calcite constituting crystal units in a secondary lamel. The furrow from left center to lower right represents the boundary between two crystal units. TEM.
Fig. 2. Heterolepa cf. subhaidingeri (Parr).
Second replica of slightly etched shell surface (umbilical side) showing calcite plates (upperleft) and organic matrices marking the boundaries of crystal units. TEM.


## Plate 23

Fig. 1. Heterolepa cf. subhaidingeri (Parr).
First two-stage replica of polished, etched section showing delicate organic membranes enveloping the small crystal plates constituting crystal units. A crystal unit boundary is seen running from botlom to top of the micrograph slightly right of center. TEM.
Fig. 2. Heterolepa cf. subhaidingeri (Parr).
Second two-stage replica of polished, etched section showing secondary lamels. The orientation of the calcite plates constituting the crystal units is seen to continue across the lamel boundary. The boundary between two crystal units (upper left to lower right) is slightly irregular. TEM.


1


## Plate 24

Fig. 1. Heterolepa cf. subhaidingeri (Parr).
Second two-stage replica of polished, etched section of septum showing concentration of spongy organic material between outer lamel (lower left) and inner lamel (upper right). The directions of the calcite plates are not identical in the inner and outer lamel. TEM.
Fig. 2. Heterolepa cf. subhaidingeri (Parr).
First two-stage replica of polished, etched section of chamber wall demonstrating identical orientation of calcite plates across boundary between two secondary lamels. In the lamel boundary is seen concentration of organic material of a spongy appearance. TEM.


1


## Plate 25

Fig. 1. Heterolepa cf. subhaidingeri (Parr).
Fractured outer wall (umbilical side) showing secondary lamination with corresponding pore constrictions. Pore-tubes fully or partly filled in with embedding medium. SEM.
Fig. 2. Detail of fig. 1, showing boundary floor between two secondary lamels. The direction of the plates is at right angles to the plane of the picture. On the floor is seen the concentration of organic material. The crystal plates are seen to be interrupted at the lamel boundary. SEM.


Figs. 1-2. Heterolepa cf. subhaidingeri (Parr).
Second two-stage replica of polished, etched section of outer chamber wall showing concentrations of organic material in the boundaries between secondary lamels with corresponding pore constrictions. Remains of the organic inner lining of the pores are seen along the sides of the pores. Between the constrictions of the pore shown in fig. 1 are seen smaller constrictions supposed to represent primary lamination. In fig. 2 such finer constrictions are missing. TEM.


1


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# PALAEOBOTANICAL INVESTIGATIONS INTO SOME CORMOPHYTIC MACROFOSSILS FROM THE NEOGENE TERTIARY LIGNITES OF CENTRAL JUTLAND 

PART II:<br>GYMNOSPERMS

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PART II:

GYMNOSPERMS


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## Synopsis

Remains of gymnosperms, which are copiously present in the Danish lignitic deposits, are referable to the recent families Cephalotaxaceae, Podocarpaceae, Abietaceae, Sciadopityaceae, Taxodiaceae and Cupressaceae. Some of the types are only represented by fossil wood with a more or less well preserved anatomical structure (Taxoxylon amentotaxoides, Saxegothaeoxylon, Cupressinoxylon callitroides, C. thujoides and C. biotoides). In other genera leaves and pollen grains are found in addition to the wood (Pinus and Sciadopitys) and in a few examples (Sequoias, Taxodium and Glyptostrobus) the association of leaves, twigs, cones and seeds are of common occurrence.

Taxoxylon amentotaxoides, Cupressinoxylon callitroides, C. thujoides and Saxegothaeoxylon miocenicum represent types of fossil wood not previously described, and the diagnoses of Taxodioxylon taxodii W. Gothan and Cupressinoxylon biotoides (R. Prill) have undergone some extension.

The age of the flora is regarded as Neogene Tertiary. A marine clay with a molluscan fauna of Middle Miocene age occurs locally in the western parts of the brown coal area where besides pollen and carpolithes only pieces of fossil wood are found, but as most of these are compatible with leaves and other remnants in the eastern localities (Moselund, Silkeborg Vesterskov) the strata could be considered as a continuous series. The character of the pteridophytic flora, described in Part I, does not contradict this.

## II. Gymnospermae

This second part of my memoir on the cormophytic macrofossils from the Neogene of central Jutland, of which the first part, the "Introduction and Pteridophytes", appeared in 1965, deals with the gymnosperms. Remains of gymnosperms are copiously present in the Danish lignites and are referable to the recent families Cephalotaxaceae, Podocarpaceae, Abietaceae, Sciadopityaceae, Taxodiaceae and Cupressaceae. The fossil conifers from the European Neogene, and especially the more common types, are regarded in many cases as being nearly related to, or perhaps identical with, still living species (Taxodium, Glyptostrobus, etc.). Recent analogues are mainly to be sought for in floras of North America and the Far East, but also the floras of Australia, and even of the more remote parts of South America have, as will be shown, claimed consideration.

Some of the types described in the following pages are only represented by samples of fossil wood with a more or less well preserved anatomical structure. The existence of some genera (Pinus, Sciadopitys) were confirmed by leaves and pollen grains, and there are a few examples of leaves, twigs, cones and seeds (Taxodium, Glyptostrobus and Sequoias) found in the strata associated with the wood which give support to the exactitude of the generic determination on the fossil woods recorded.

The general type of the gymnosperm flora described is considered as being of Neogene Tertiary age. Most of the species are already known as being widespread in the lignitic floras of central Europe and of so great a vertical extension that they cannot be used for a closer determination of the geological age of the strata. According to L. Banke Rasmussen (1961) a layer of marine origin (a clayish soil enclosing a molluscan fauna of Middle Miocene age) is locally present in the western parts of the brown coal area. The lignites overlying and underlying this clay agree closely in appearance but have not offered determinable plant material other than fossil wood, pollen grains and some common and widely repanded carpolithes. The most common types of fossil wood from the coal layers is compatible with the remains of leaves and other remnants found in the eastern localities (Moselund, Silkeborg Vesterskov) situated at a somewhat higher topographic level. It is possible that the eastern localities represent a geological age a little older than the exploited lignitic layers to the west. The character of the pteridophytic flora, described in Part I, indeed points in that direction.

As many of the Neogene types dealt with here possess a considerable geological extension in time and space references to descriptions of the more common types are very frequent in the relevant phytopalaeobotanical literature. Reference to older memoirs concerning fossils referred to the genera Sequoia, Glyptostrobus and Taxodium may be found in the very complete lists of P. Friedrich (1883), M. Staub (1887) and P. Menzel (1900).

In the extensive literature dealing with the general morphology, anatomy and geographical distribution of the gymnosperms, extant and fossil, prominance may be given to the memoirs by A. C. Seward (1919), R. Pilger (1926) and R. Florin (1931 and 1963). Details concerning the development and anatomy of the seed are given by K. Schnarf (1937), and the anatomical structure of the secondary wood in relation to systematics has been closely studied by W. Gothan (1905), R. Kräusel (1919 and 1920 ) and P. Greguss (1955), the latter work dealing only with extant species. In a recent paper (1967) P. Greguss offers a review of the fossil gymnospermous woods found in Hungary from the Permian to the Pliocene.

In many cases it will be convenient to study my plates through a reading glass.
My thanks are due to Mr.Chr. Halkier of the Mineralogical and Geological Museum of Copenhagen and to Mr. H. N. Hansen of the Royal Danish School of Pharmacy for their most valuable collaboration in preparing the photographs for the plates. Mrs. E. Nordmann of the staff of the Institute of Historical Geology has been good enough to draw the figures 6 and 15 and has added a finishing touch to some of my drawings.

For comparison I received from R. Kräusel, Frankfurt a.M. in 1920 a valuable collection of slides of fossil wood from the "Senftenberger Braunkohlenrevier", and from the Museum Ziemi, Warszawa, I obtained through Dr. Z. Zalewska the loan of some interesting slides of fossil wood from the Aquitanian material of Turów, Poland.

Samples of Amentotaxus wood were obligingly places at my disposal by the Forestry School of Yale University, U.S.A.

I am highly obliged to the curator af the Royal Botanic Gardens, Kew, Dr. R. Shaw for his efforts in procuring a sample of wood of Saxegothaea conspicua for investigation.

Samples of wood of the recent species of Widdringtonia, together with herbarium vouchers were kindly presented to the Botanical Museum of Copenhagen University by Prof. N. B. Rycroft, Director of the National Botanical Gardens at Kirstembosch Newlands, South Africa.

I am also greatly indebted to Mrs. H. Helbæk and to Mrs. L. Christiansen of the Mineralogical and Geological Museum and the Royal Danish School of Pharmacy respectively, for their careful retyping of the manuscript.

Dr. Stuart Watt of the staff of The Geological Survey of Greenland has been good enough to revise my translation into English and has kindly read a proof.

The publication of this paper has been made possible by grants from the Carlsberg and Rask-Ørsted Foundations.

Taxoxylon amentotaxoides $n . s p$.
A sample of fossil wood from the lignite at Salten exhibits the anatomical characters of a Taxoxylon (Fr. Unger 1847, R. Kräusel 1949). The fragment was about 5 cm long and 2 cm thick, probably derived from a stem. The peripheral parts were decayed but a central portion about 1 cm thick appeared rather well preserved, of an almost wax-like consistence. Cutting on the microtome was facilitated after hardening in alcohol and very smooth and thin sections could be obtained.

Plate I, A and C show parts of transverse sections; the first figure giving a view of a larger area, while the second only shows a single growth ring under higher magnification. The growth rings appear to be of somewhat variable thickness but the early wood has nearly the same volume in the different rings; the borders are well marked as the transition from late to early wood of the sequent ring is distinct. The more thin-walled elements of the early wood are higly compressed and deformed thus making it difficult to ascertain their original size and shape in the photographs. The tracheids of the late wood are also somewhat radially compressed, but are not so highly deformed. The microstructure of the tracheidal walls is evidently dissolved as the usual double refraction of the wall substance is completely missing and the details of the wall structure (tracheidal pits etc.) are consequently hardly discernable.

Resiniferous elements, conspicuous by their dark brown content, are predominant in the outer part of the early wood and locally form an almost regular tangential zone. They are exceedingly thin walled but, probably due to their compact resinous content, only slightly compressed and deformed thus appearing almost unaltered with an elliptical outline. The tracheids surrounding the resin cells have a considerably smaller diameter than the tracheids of the inner part of the early wood (Fig. 1, A to D) as well as those of the succeeding late wood in which the radial diameter remains almost constant to the border of the ring.

In the transverse section the medullary rays are rather inconspicuous since their elements are compressed and almost dissolved.

Longitudinal sections show the tracheids in a very different state of preservation, as could be expected from their appearance in the transverse view. In many of the tracheidal walls tiny spiral thickenings of the inner surface of the wall are conspicuous (Plate II. A and B) and are most distinct in those elements of the late wood where a tangential cut has exposed the inner surface. In the early wood especially the spirals


Fig. 1. Taxoxylon amentotaxoides n.sp. A-D, transverse sections showing resiniferous xylem parenchyma and surrounding tracheids. $(\times 400)$. Salten.
are most commonly separate from the rest of the wall and are often found tangled together or forming a coil in the lumen. In such cases their former connection with the wall is only traceable by the scars left in the terminal lamella. In the wider tracheids these thickenings appear as two, delicate, concurrent spirals more or less steeply ascending and when the lumen is compressed they are reduced to zig-zag lines. In the


Fig. 2. Taxoxylon amentotaxoides n.sp. A-C, parts of tracheids in radial section and E, in tangential section, showing the annual or spiral thickenings of the wall. E also shows a part of a ray and the finely beaded wall separating two resiniferous xylem parenchyma elements. D, cross-field area. $(\times 400)$. Salten.
narrowest tracheids the thickening sometimes only appears as tiny double rings. The Fig. 2, A, B, C and E show the variations of the spirals.

The bordered pits of the radial walls of the tracheids are only visible where the spirals are dissolved or loosened. They are 14 to $16 \mu$ in diameter and are most commonly arranged in only one row. Tangential bordered pits are rather common.

The irregular radial course of the rays is evidently caused by deformation and it is rare to obtain a large, undamaged group of ray tissue in longitudinal sections that are suitable for figuring. The horizontal walls of the ray cells appear somewhat thickened, with a maximum of 4 to $6 \mu$, but have a rather uneven profile with thinner and thicker parts irregularly alternating and sometimes showing an intercellular space between the thickening layers of the wall due to disintegration (an 'interstitium'). The tangential walls are thin (1 to $2 \mu$ ) and without visible sculpture (Fig. 2, D).

Cross-fields between ray cells and tracheids show one to two, or in the marginal cells sometimes three, circular or elliptical blind pits. Where cross-fields are formed between ray cells and resinous parenchyma the corresponding walls show simple pits; the details are not easy to discern, but the number and shape of the pits seem to vary considerably. The lengths of the resiniferous elements vary from 100 to about $200 \mu$ and are consequently rather short. The transverse walls of the parenchyma cells are partly thin and without sculpture but most often they are somewhat thickened and more or less distinctly bead-like pitted (Fig. 2, E). Transverse sections cleared in a weak sodium hypochlorite solution and stained with vesuvine, show the types of pitting more distinctly.

The medullary rays are most commonly 5 to 12 cells high, but sometimes reach a height of 20 cells. In tangential sections small, triangular, intercellular spaces occur between the adjacent tracheidal wall and the transverse wall of the ray cells.

## Diagnosis

A gymnospermous wood of the Taxaceous type. Growth rings well accentuated. In the outer part of the early wood an almost regular, tangential line of thin-walled, resiniferous elements surrounded by tracheids markedly smaller in diameter than those of the adjacent tissue. Spiral thickenings of the inner side of the tracheidal wall normally developed as two very tiny concurring bands. Cross-fields of rays and tracheids exhibit 1 to 3 circular, blind pits, with a variable number of simple pits between ray cells and parenchyma. Transverse walls of parenchyma cells are thin and even, or somewhat thickened and slightly pitted. Bordered pits occur most commonly in single rows on the radial walls and are scattered but rather common on tangential walls.

## Affinities

Samples of fossil wood which might be referred with certainty to the Taxales seem to be of rare occurrence. According to R. Kräusel (1919 and 1949) only Taxites scalariformis Göppert, of somewhat uncertain geological age, is reliable. Comparing our fossil with the wood of recent Taxaceae and Cephalotaxaceae all details point towards the East Asian genus Amentotaxus, the wood of which, according to P. Greguss (1955, p. 147), is characterized anatomically as follows: - Amentotaxus argotaenia Pilger "Latewood portion of the growth increment considerably larger than the earlywood portion, the latter conspicuous for the presence among the tracheids of numerous widelumened paranchyma cells, not infrequently in whole rows or groups. This disposition of the parenchyma cells and their difference in size from the surrounding tracheids are features so very characteristic as to permit an immediate separation of this species from all other conifers on the basis of the transverse section". The character of the spiral thickenings of the tracheids agrees in the fossil and the recent analogue; in both the spiral thickenings in the tracheids develop as two tiny concurring bands.

In spite of the close similarity between the fossil material and Amentotaxus argotaenia some differences may be noted. In the transverse section of A. argotaenia figured by P. Greguss (1955, Plate 73) the difference between the tracheids of the early wood and the late wood appears far less marked than in the fossil described here. Another difference is that Greguss mentions the occurrence of numerous round or elliptical pits in the radial walls to the parenchyma cells; these are not clearly seen in the fossil, but this may be caused by the disintegration of the wall substance obscuring such details.

A sample of Amentotaxus wood obligingly placed at my disposal by the Forest Department of Yale University, U.S.A., agrees anatomically very well with the sample figured by P. Greguss (1955). However, it is not stated from which part of the axis the sample is derived and as samples of known morphological position have not been available a thorough, detailed comparison, which should also embrace wood from roots and stumps, has consequently not been possible.

Anyhow, the principal characters of the fossil agree so well with those of the recent Amentotaxus that the plants from which they originate may be considered as at least being closely related so that the fossil might conveniently be termed Taxoxylon amentotaxoides n.sp.

According to a paper by Hui-Lin Li (1952) the genus Amentotaxus can be subdivided into four species, the salient characters of which are the form and size of the leaves, and the mutual proportions between the broadness of the two stomatal bands on the under side of the leaf bordering the midrib and the green marginal bands devoid of stomata. The four species are all East Asian and since details of the anatomy of the wood are not available for comparison small specific differences may consequently occur.

The occurrence of Amentotaxus leaves in the Tertiary of Europe has been stated several times. A find from the Lower Miocene at Salzhausen (Wetterau, Rhineland) was described by R. Kräusel (1935) who also gives the epidermal anatomy of the leaf. H. Weyland (1937) has mentioned the same species (A. florini) from Upper Oligocene layers at Kreutzau near Düren (Rhineland). J. S. Gardner (1883-1886) has figured some leaves as "Podocarpus Campbelli" from the Eocene of Great Britain which might be referable to a species of Amentotaxus.

## Saxegothaeoxylon miocenicum n. sp.

The four samples of fossil gymnospermous wood on which this species is based were collected from the lignites of the Troldhede area (State quarry). All four samples have the same state of preservation, they show tolerably well preserved late wood while the early wood has unfortunately suffered almost total obliteration which, as will appear from the photograph of Plate III, A, has had the effect of making the borders of the growth rings and the transition from early to late wood very conspicuous.

The photographs, Plate III, B and Plate IV, A, show transverse sections more highly magnified. Numerous thin-walled resin cells are seen especially in the compres-
sed early wood, the dark coloured content of the cells making them easily perceptible. The transition from early to late wood is rather abrupt as only in a few places are there tracheids intermediate in size and wall thickness. Two types of late wood elements are discernible; one shows a dark wall while the other, ocurring isolated or in radial groups, shows a bright or only slightly coloured, highly refractive wall. The tracheids of the first type show a far smaller radial extension than those of the second which evidently represents the primary shape. The wall exhibits the normal double refraction in polarized light so that the primary part of the wall as well as the subsequent thickening layers are distinctly discernible while the dark coloured elements have totally lost their double refraction properties as well as the distinctness of the details of the wall structure. It is supposed that they were deformed by shrinkage and disorganization of the microstructure of the wall. In the less altered type there is a certain slight swelling of the wall substance.

The rays are always uniseriate. They confirm the explanation offered on the transformation of the tracheids under fossilization as where they cross a group of brightwalled elements their radial walls are smooth and closely cohering to the bordering tracheidal walls (Fig. 3, A to D), whereas in places where they traverse groups of dark coloured and radially shrunken elements their radial walls are partly separated from the tracheidal walls and are pressed up into folds towards the lumen of the ray cell. By the reduction of the radial diameter of the tracheids in these places the walls of the very thin-walled ray cells have evidently been partly detached, firstly in the centre part of the cross-fields, where the pit has offered a weaker area, subsequently also from the neighbouring parts of the wall, and finally they have been plicated inwards so as to form one or two folds. On the upper and lower borders of the pores the folds often form single loops easily perceptible in the photographs under a reading glass. The thick, horizontal walls of the ray cells have been forced to undergo a similar, radial shrinkage compressing and transforming their pits into tiny tangentially orientated slits.

The bright tracheidal elements (Plate IV, B, D and E) are very conspicuous in the longitudinal sections. D shows elements which have remained almost intact in shape and size while small rings of the fibre in the left of the photograph have undergone a sideward dislocation agreeing with what is found in rotted and machanically treated vegetable fibres, e.g. of Linum. B and E show partly intact tracheids in which the transformation towards the dark coloured type has commenced accompanied by an essential reduction in the radial diameter. Most of the tracheids figured in C have undergone such a reduction. Only a few bordered pits are discernible on the radial walls (D) which may be taken as evidence that the apparently intact tracheids have also undergone certain modifications.

A part of a ray passing through a group of transformed but not totally collapsed tracheids is shown in Plate IV, C. The folds on the radial walls here appear as slight vertical configurations, usually only one in each cross-field. In some cases a pair of tiny, vertical stripes forming an x can be discerned corresponding to the folds bordering


Fig. 3. Saxegothaeoxylon miocenicum n.sp. A-D, transverse sections of late wood showing ray cells running through groupes of tracheids with only slightly altered walls. E-I, parts of rays in radial section, H, showing the parts connecting the ray cells with the resiniferous xylem parenchyma. J, tangential section of a ray.
( $\times 400$ ). Troldhede State Quarry.
the compressed, cross-field blind pit in the transverse section. Where these pits are slightly less altered the "podocarpoidal" characters are more pronounced than those of the "cupressoidal" type (Fig. 3, G and I).

The horizontal walls of the ray cells attain a considerable thickness, up to $8 \mu$ (4 to $8 \mu$ ). They are usually coarsely pitted and in unaltered or only slightly altered parts, such as those figured in Plate IV, C and in Fig. 3, E to H, the pits appear somewhat funnel-shaped, 1 to $2 \mu$ broad. Pits are also perceptible on the horizontal walls seen in transverse sections and may be very conspicuous as is seen in Fig. 3, A to D. Where the horizontal walls are more or less reduced in length by contraction, the pits are radially compressed and appear far less extended often being only perceptible as tiny vertical slits. Under extreme deformation the walls may appear irregularly thickened and so swollen as to obliterate the pitting completely. Fi.g 3, H shows stages of this trans formation. The tangential walls of the ray cells are rather thin and only slightly sculptured or more often quite smooth.

In the tangential section the rays are composed of 1 to 11 vertical rows of cells with thick horizontal and thin radial walls. The walls are especially distinct where the ray traverses a group of relatively unaltered tracheids. Bordered pits on the tangential tracheidal walls are common but difficult to distinguish and are rather small with a diameter up to $4 \mu$. The elements of the resiniferous parenchyma attain a length of 250 $\mu$, the transverse walls separating them appear to be smooth and unthickened. In the cross-field between parenchyma and ray cells the wall shows from one to five simple pits.

## Diagnosis

Growth rings distinct. Rays uniseriate $1-11$ cells high with horizontal walls thick, densely and strongly pitted and thin tangential walls smooth or slightly pitted. The cross-fields show 1 to 2 (4) blind pits, circular in outline and of a type intermediate between the cupressoidal and podocarpoidal form. Wood parenchyma resiniferous, thin-walled with 3 to 5 simple pits in the cross-field and transverse walls thin and smooth, Bordered pits in a single row on the radial as well as on the tangential walls of the tracheids. Indentures are not developed.

## Affinities

The four samples described represent a type of gymnospermous wood of very peculiar structure agreeing anatomically with the wood of the recent Saxegothaea. The genus Saxegothaea is commonly referred to the Podocarpaceae but the wood is distinguished from that of the other genera of this family by the very thick, dense and coarsely pitted horizontal walls of the ray cells. S. conspicua Lindley was thoroughly studied anatomically by P. Greguss (1955), but F. Beust (1885) had already noted the special character of the ray cells as also had W. Gothan (1905) who 1.c. p. 56-57 described and figured some peculiarities of the anatomy of Saxogothaea wood. P.

Greguss describes Saxegothaea in connection with the wood of the Taxodiaceae mainly because the cross-field pitting in his opinion is of the cupressoidal type rather than the podocarpoidal. At any rate the fossil wood is anatomically closely allied to the recent Saxogothaea, and exhibits a well definable xylotomic unit. It is suggested that it represents a special organo-genus Saxogothaeoxylon and miocenicum would probably be a convenient specific name.

A description of the fossil is nearly covered by that given by P. Greguss (1955) for the analogous recent species. The description is partly contained in his keys for determination (l.c. p. 103-107) and partly in the text which enters into more detail (p. 183). Yet some differences ought to be pointed out. According to his figures the wood of the recent Saxegothaea appears more homogeneous than in the fossil described here but the early and late wood may be somewhat variable in volume. According to P. Greguss the rays only attain a maximum of seven stories, but as his sample originates from a branch only 8 years old and 5 cm in diameter the height in the older wood might be greater. As the cross-field pitting of the early wood in the fossil cannot be used for comparison, due to compression and folding, the character of the pitting of this part cannot serve for drawing a parallel.

Saxegothaea conspicua Lindley is at present restricted to southern Chile and Patagonia. The enormous geographical gap from South America to the occurrence of the genus in Tertiary Europa has not been bridged through finds in the intermediate area. The discovery of a fossil plant remain, such as Saxegothaeoxylon described here, seems to be of interest as it widens the possibility of demonstrating Tertiary types in the northern hemisphere which now only occur in the far south.

Pinus palaeostrobus (C. v. Ettingshausen) O. Heer.
C. v. Ettingshausen (1855) p. 35, Table VI, figs. 23 to 33. (Pinitis palaeostrobus). O. Heer (1855) p. 56, Table XXI, figs. 6 a to 8 . G. de Saporta (1865 I) p. 74, Table III, figs. 1, A-C ; Table IV, fig. 3 A. O. Heer (1869) p. 56, Table XIII, figs. 1 to 2. L. Lesquereux (1878) p. 83, Table VII, figs. 2 and 5 to 30. O. Heer (1883) p. 65, Table LXX, fig. 8; Table LXXXVII, figs. 5 and 6.

A dwarf shoot of a species of Pinus carrying five needles was found in the fossiliferous clay at Fasterholt. It is so far the only certain evidence of a Pinus of this type in the Danish Tertiary flora.

The photograph (Plate V, D) shows the shoot magnified three times. It was not possible to examine the full length of the needles as they were badly damaged on splitting up the hard and brittle matrix, but they have evidently been rather short and did not exceed 4 cm in length. Of the two turned upward in the photograph the right hand needle was broken off at its base and the left hand one was broken a little higher up. The scale leaves that once covered the short, somewhat bulb-shaped, dwarf shoot have left broad scars. The needles are triangular in section with fine, longitudinal stripes on the surface.

The diagnosis of Pinus palaeostrobus given by O. Heer (1869, p. 56) runs briefly as follows: P. foliis quinis, elongati filiformibus, tenuissimis, laxis. When the needles are
described as "flabby" it may be because they often appear bent or curved from which O. Heer concluded that the substance of the needles had been rather soft. O. Heer too noted that the needles may show fine, longitudinal stripes.

Cones or cone scales that could be referred to a Pinus of the section strobus were not found; the apical of the scales would make them easily recognizable. A badly damager cone of a Pine, referred to "Pinus laricio thomasiana" O. Heer by N. Hartz (1909), is recorded from the lignitic layers at Sønderskov (Silkeborg area).

Dwarf shoots referred to Pinus palaeostrobus O. Heer are found and described from numerous Swiss localities of Aquitanian age, from Rixhöft (Samland, Kaliningrad region, U.S.S.R.), S.E. France, and outside Europe from west Greenland (Aumarûtigssat, Hare Island and Atanikerdluk) and North America (Castillos Ranch, Florissant, Colorado).

Pityosporites spp.
A few pollen grains referable to Abietinous gymnosperms, probably species of the genus Pinus, were separated from the lignitic clay in the brown coal deposit at Silkeborg Vesterskov. The Fig. 14, A to C, shows the types noted.

The pollen grains are elliptical in outline, the largest measuring from 60 to $80 \mu$ in diameter. Each grain has two bladder-like extensions of the exine with a net-like design; the rest of the surface is finely dotted. Two pollen types are recognizable. One (Fig. 14, A) has only slightly protruding bladders, the other (B and C) has bladders more strongly protruding and markedly restricted at the base. The pollen grains of the first type might be referred to the "Haploxylon type" of K. Rudolph (1935) while the second type may be referred to R. Pilger's and K. Rudolph،s "Pinus silvestris type". The types are not strictly bound to the two subgenera Haploxylon and Diploxylon (R. Pilger, 1926); the Haploxylon type is confined to the subgenus but the subgenus also contains other types, e.g. in Pinus strobus, while not all species of the subgenus Diploxylon show the Diploxylon type typically developed so that R. Pilger has preferred the term Pinus silvestris type in preference to the term Diploxylon type.

Remains of Pinus species of both the subgenera Haploxylon and Diploxylon have been found in the Danish lignite deposits as dwarf shoots and wood respectively.

The term Pityosporites was adopted by A. C. SEward (1919) for pollen of gymnosperms provided with bladder-like extensions of the exine. Besides the recent Abietineae such pollen occurs in certain Podocarpaceae, but foliage remains referable to this family seem not to have been demonstrated with certainty in the Neogene of Europe (R. Florin 1926).

Pinuxylon sp. cf. P. paxii R. Kräusel
G. Kraus (1866) Pityoxylon sp. R. Kräusel (1919) p. 248, Taf. 18, Fig. 8, 13; Taf. 23, Fig. 5, \& Text Fig. 32, 33. R. Kräusel (1920) p. 422, Taf. 28, Fig. 1 to 3; Taf. 36, Fig. 12. R. Kräusel und G. Schönfeld (1924), p, 270. Tafel XXII, Fig, 16 to 18. R. Kräusel (1949).

Among the samples of fossil wood procured from the Torvig State Quarry at Troldhede was a specimen which according to its anatomical structure can only be referred to the genus Pinus.

On the whole it is in a tolerably good state of preservation. The difference in thickness of the tracheidal walls of early and late wood elements is not considerable, and the border is only marked by relatively few layers of narrower tracheids so that growth rings must have been rather faintly accentuated. In the present state of preservation the borders of the growth rings are easily recognizable by the layers of collapsed or almost collapsed early wood elements. Plate V, A, shows a portion of a transverse section including some gaps which mark the position of vertical resin canals together with their accompanying thin-walled parenchyma of which there are still some remains. The gaps are rather scarce; their resinous contents have totally disappeared.

Tangential sections show that the wood also possessed normally developed horizontal resin ducts (Plate V, B). Rays enclosing such ducts deviate in form from the simple ones by attaining a broad fusiform shape. The original presence of the resin ducts is most often only recognizable by the occurrence of an irregularly circumscribed lacuna in the middle of the broader part of the ray produced by the solution of the epithema and the surrounding parenchyma. The parenchyma of the simple rays was also found to be mostly dissolved and the rays sometimes have the appearance of that illustrated as Fig. 4, G. The secondary thickening of the tracheidal wall is segregated as steeply ascending spirals and is also partly dissolved.

The drawings D and F in Fig. 4 show rays with almost intact resin ducts, E exhibits a ray in which no resin duct has developed and the resiniferous parenchyma forms a coherent mass.

The figures of radial sections (Fig. 4, A to C) are drawn after the slides have been cleared with dilute sodium hypochlorite solution. Most of the ray parenchyma has disappeared so that what appears as "oëopores" of the radial ray cell walls really only represent the counterparts of the ray pits in the corresponding wall of the bordering tracheids. It is evident that each cross-field between ray and tracheid has possessed only one large "oëopore", elliptical to almost circular in outline. Sections not exposed to the action of dissolving chemicals show the horizontal walls of the ray parenchyma cells irregularly thickened with thicker and thinner parts alternating causing sometimes a coarse poring (Fig. 4, A). Locally the secondary thickening has somewhat disintegrated giving rise to indistinct interstitia. The tangential walls of the ray cells are always only slightly thickened.

The marginal tracheids bordering the upper and lower edge of the larger rays show irregular thickenings on the horizontal and tangential walls which often penetrate into the lumen as small teeth. The small bordered pits connecting the marginal


Fig. 4. Pinuxylon sp. cf. P. paxii R. Kräusel. A, B and C, radial sections. D-F, tangential sections of rays including resin ducts or coherent resiniferous parenchyma. $G$ and $H$, simple rays; in the ray figured in $G$ the tissue is partly dissolved. ( B and $\mathrm{C} \times 250$, A and $\mathrm{D}-\mathrm{H} \times 400$ ). Troldhede State Quarry.
tracheids with the vertical tracheidal elements of the wood are mostly rather difficult to discern, but the bordered pits on the tangential, more or less slanting walls are, in most cases, quite distinct. How much of the thickness of the walls of the ray tissue is original and how much is caused by secondary bulging is of course impossible to ascertain.

Among the fossil Pinus woods (Pinuxyla) the specimen described here shows agreement with the Pinuxylon paxii R. Kräusel from the Silesian brown coal, probably of late Miocene age. In the fossil described here as well as in P. paxii (R. Kräusel 1920, Plate 28, Fig. 1) the growth rings are only slightly accentuated since the differences in diameter and wall thickness between the tracheids of the early and late wood are insignificant.

According to R. Kräusel and G. Schönfeld (1924) P. paxii might be referred to a Pinus species of the section pinaster. Consequently it is related to the recent widely distributed Pinus silvestris L., without being identical with it or, as far as can be seen after comparison with the xylolomical details given by P. Greguss (1955), without being quite identical with any other living Pinus sp.

Pinuxylon paxii occurs in the Neogene Tertiary of Silesia and other places in central Europe (Oligocene to Miocene).

## Sciadopitys tertiaria P. Menzel

The material investigated was obtained from a fragment of a bore-core about 10 cm in diameter brought up from a depth of about 20 m . The boring was sunk near the Grindsted dairy (central Jutland) in the year 1925. (For details see the publication of H. Odum and W. Christensen, 1936). The headmaster of the school at Grindsted, Mr. M. C. Nielsen, who examined the material brought up, was struck by the peculiar appearance of a layer, about 20 cm thick of a type of light lignite which enclosed numerous, glossy particles not unlike flattened pieces af straw. A part of the core including this layer was handed over to the Mineralogical and Geological Museum of Copenhagen University for the determination of these fossils.

After boiling part of the matrix with a solution of sodium carbonate the lignite disintegrated and it was possible to pick out the glossy particles. These appeared as rectangular pieces varying in length from 1 to $2 \mathrm{~cm}, 2,5$ to 4 mm broad and 0.5 mm thick, of an olive brown colour. They were finely striped on one surface while the other was showing a broad and rather deep longitudinal furrow still filled by the coaly matrix.

The obtainment of preparations showing surface views made no difficulty. After clearing with a dilute solution of sodium hypochlorite most of the inner tissue was dissolved, and it was then easy to split up the pieces parallel to the flat side. The preparation showed the characters of a leaf.

It proved far more difficult to obtatin transverse sections suitably thin and yet coherent. By clearing the sections under a cover-glass preparations were obtained
suitable for drawing; unfortunately it was not possible to keep them as permanent mounts (Fig. 5, A).

The median furrow of the underside represents a stomatiferous band. Here there is a dense covering of short, bluntly-ended hairs which represent papillose protuberances from the outer wall of the epidermal cells. The rest of the surface is smooth, devoid of stomata and in front view appears as composed of longitudinally stretched, rectangular elements with thin and finely pored side walls. By fine adjustment of the depth of focus of the microscope a certain part of the extremely thick outer wall is seen to contain numerous small cavities giving the stratum a somewhat gritty appearance (Fig. 5 C).

A hypodermal layer consisting of coherent tissue of thin-walled, spindle-like elements is found under the epidermis outside the stomatiferous furrow.

The stomata are placed at the same level as the surface of the epidermis. They are individually encircled by a group of 10 to 14 polygonal epidermal cells similar in size and shape to the other epidermal elements of the stomatiferous band but differing from these by their papillose protuberances. The preparations of the surface most often only show the basal, rather thick-walled parts of the papillae (Fig. 5, F), while in the top the thickenings of the wall are commonly dissolved so that only the finely warted cuticle is left.

The thickness of the outer wall of the epidermis is apparent from the transverse sections (Fig. 5, D, G and H). The zone of small cavities is seen to form an arch about the middle of the wall. The side and inner walls of the cells normally appear in a state of dissolution in the preparations as well as the elements of the hypodermis. Balsam ducts are traceable here and there but the remains of the star-shaped idioblasts (Fig. 5, I) and the rather large, thin-walled cells of the mesophyll can only rarely be made out. The vein tissue has completely disappeared.

The anatomical agreement of the fossil with the "symphyllodium" (double needle) of the recent Sciadopitys verticillata Siebold et Zuccarini is evident. The small cavities in the outer wall of the epidermis are produced by the solution of crystals (calcium oxalate) which are common in the epidermis of the recent species where there is also an arch-shaped crystal layer in the middle part of the outer wall. In the double needle of the recent Sciadopitys the hypodermal layer is composed of spindle-like, rather thin-walled elements.

Leaves (symphyllodia) and cones of Sciadopitys are known from the Tertiary of central Europe and were first described by P. Menzel (1913) under the name

Fig. 5. Sciadopitys tertiaria P. Menzel. A, transverse section of a symphyllodium. B and C, surface views of epidermis outside the stomatiferous furrow, $C$ shows the crystal-bearing stratum of the outer wall. D, G and H , transverse sections of epidermis and hypodermis, in the part figured in H a balsam duct is included in the mesophyll. E and F, epidermal elements from the stomatiferous furrow, in the part figured in F seen from the inner side. I, transverse section of a part of the stomatiferous furrow; the mesophyll includes an asterosclereid. $(\mathrm{A} \times 30, \mathrm{~B}-\mathrm{I} \times 400)$. Grindsted.
Sciadopityoxylon wettsteinii K. A. Jurasky. J-M, radial sections and N, tangential section of rays ( $\mathrm{J}-\mathrm{L} \times 250$, M and $\mathrm{N} \times 400$ ). Troldhede.


J
M


Sciadopitys tertiaria. A list of occurrences of fossil Sciadopitys in Poland and adjacent territories is given by Z. Zalewska (1960, p. 32). A survey of the fossil Sciadopitys and Sciadopitys-like leaf types is given by R. Florin (1922) who also has given some important anatomical details. S. tertiaria is known from western Germany and Poland (Jarnov) and ranges from the Lower Miocene to the Upper Pliocene. The recent analogue is indigenous to the mountain-forests of Japan and can be grown in northern and central Europe in sheltered places. The parallelism between the recent species and the fossil seems to be very complete.
S. tertiaria appears to have had a considerable extension in Europe, probably occurring in isolated groups in the forests of that time (K. A. Jurasky 1928). It represents an ancient type, a fact already maintained by J. Velenovsky: "Die Gattung Sciadopitys darf nach allen ihren vegetativen und Blütenteilen überhaupt mit keiner der früher genannten Familien (incl. Taxodineae) verbunden werden. Es ist dies ein isolierter Typus, ohne nähere Verwandschaft und höchst wahrscheinlich aus uralten geologischen Zeiten herübergekommen". Fossil remains of Sciadopitys had not yet been discovered at the time J. Velenovsky wrote those lines (R. Florin 1922).

The fragments of the symphyllodia, at least when they occur in larger quantities, give a very peculiar aspect to the brown coal. In Germany this type of lignite is termed "Graskohle" (W. Gothan 1936); compare the first impression Mr. Nielsen, the collector of our material, received : glossy particles, not unlike flattened pieces of straw.

## Sciadopityoxylon wettsteinii K. A. Jurasky

Four samples of fossil wood, one from the Lystrupsminde quarry and three from the Troldhede district, are referable to this type. Of the three pieces from the Troldhede district one was found in the State quarry and two in the Torvig quarry. The state of preservation proved fairly good save for the rather advanced segregation of the thickenings of the tracheidal walls into their fibrillary components.

The transverse section (Plate VI, A) shows a gymnospermous wood of a rather uncomplicated type. The early wood appears mostly compressed with collapsed tracheids; where the original shape of the elements is traceable it is evident that they do not differ much in size from those of the late wood. The growth rings have thus been histologically almost homogeneous, yet the limits are tolerably well marked. The outline of the tracheids tend to be of the angular type but minute intercellular spaces are not rare. The monoseriate rays are composed of uniformly thin-walled cells which in the slide figured are not very conspicuous.

In longitudinal sections (Plate VI, B and C) the more or less advanced dissolution of the tracheidal walls is evident. In the radial section some bordered pits (arranged in one row) are still traceable; in the middle of the photograph (Plate VI, B) they appear in front view, and to the right som pits of the tangential walls are seen in section.

The two rays in Plate VI, B show the type of the cross-field pitting with one, rarely two blind pits in each field. The outline of the pits is not very conspicuous; the drawings in Fig. 5, J to M will be supplementary to the photographs. The pits appear elliptical, somewhat slanting, broader in the cross-field of the early wood, more slender in the late wood. Through a lens the outline is traceable as is also, in a few cases, the corresponding slit in the tracheidal wall; most often these details are obscured by defibrillous disintegretion of the tracheidal wall which has split up the border and affected a "tailed" outline of the pit.

The cross-field pitting is characteristically of the "oëoporous" type. In the drawing Fig. 5, M it has been possible to sketch the whole of the circumference of the pits.

In the photograph (Plate VI, C) of a tangential section some rays are shown. They are most commonly low, composed of 1 to 3 cell rows, but higher rays occur. The elements are extremely thin walled, the pits are quite small and sometimes confluent.
K. A. Jurasky (1928) has described a fossil wood which he refers to the recent genus Sciadopitys under the name Sciadopityoxylon wettsteinii n.sp., from the lignite at Düren (Grube Zukunft) situated near the quarry "Marie Theresia" by Herzogenrath near Aachen, the same locality from which the Sciadopitys tertiaria of P. Menzel originates, and probably of early Miocene age. The resemblance between the fossil and its recent analogue is indeed very striking, and the description, accompanied by some excellent microphotographs, settles the determination beyond doubt. Sciadopityoxylon is distinguished from the collective type Plyllocladoxylon, comprising fossil wood represented by the secondary xylem of the recent genera Phyllocladus, Microcachrys, Pherosphaera, Podocarpus spp. and Dacrydium, by the "ungleichmässige Aussehen der Eisporen und vor allem durch den auch im Frühholz auftreteden weiten Hof". (K. A. Jurasky 1928). These characters are also acceptable to E. J. Slyper (1933).

As the fossil described here agrees very well with S. wettsteinii, and the geological age of the two specimens is probably the same, the name Sciadopityoxylon wettsteinii K. A. Jurasky can be applied to our fossil.

It should be noted that the growth rings in a sample of Sciadopitys wood of Japanese origin are far less homogeneous than those of the fossils described; the early wood being composed of tracheids considerably wider in outline and far more thin walled than those of the late wood and in transverse section of a strictly angular shape.

According to a statement of P. Greguss (1955, p. 147) "Wood parenchyma cells [in Sciadopitys] were not seen, not even exceptionally, though some investigators claim their occurrence". Neither were wood parenchyma cells found in my recent Japanese material used for comparison, nor noticed by K. A. Jurasky or occurring in the fossil samples investigated by me. The identity of the other investigators mentioned by P. Greguss is not given.

As was pointed out by K. A. Jurasky (1928) it is of course not strictly demonstrable, but at least rather probable, that all the Tertiary fragments referred to Sciadopitys appertain to the same species closely agreeing with the recent S. verticillata Siebold et Zuccarini. Cones and seeds are not known from the Danish lignites, but leaves
(symphyllodia), pollen (P. Ingwersen 1954) and wood have been identified as appartaining to a Sciadopitys sp. According to the commonly admitted rules of nomenclature for fossil plants it is not at the present state of our knowledge allowed to include these fragments under the same species so they have to be mentioned as representing as many organo-genera.

## Sequoia couttsiae O. Heer (1863)

Foliage twigs, cones and seeds referable to this type are fairly common in the fossiliferous clay at Moselund. Seeds are also found in the lignitic layers at Fasterholt and here and there in the coal itself.

The diagnosis of Sequoia couttsiae (O. Heer 1863), completed by P. Menzel runs: Sequoia ramis curvata-adcendentibus alternis; ramulis junioribus elongatis, gracilibus foliis ramorum innovationumque squamaeformibus basi adnata decurentibus, rigidis, imbricatis, semipatentibus, sulfalcatis, acuminatis, dorse levitur carinatis; foliis ramulorium productionibus, laxe imbricatis, falcato-sublinearibus; amentis masculinis axillaribus, rotundis, e braeteis conferte imbricatis; strobilis globosis vel sub globosis, ad ramulorum apices plerumque solitarie appensis; squamis paucis, peltatis, rhomboideis, medio brevissime mucronolatis, rugosis, seminibus curvatis, compressis, alatis (P.Menzel 1900, p. 91).

Plate VII, A shows a bunch of foliated twigs, two of them terminated by cones. The leaves here are rather scaly, but terminate in a sharp point with a tendency to be inwardly bent. The Fig. 6 shows parts of some isolated twigs in which the foliage is more open and the leaves distinctly acute and falcate.

Anatomically the leaves show an epidermis of axially extended, rather thickwalled elements only interrupted by four, narrow, almost marginal lines of short cells, two on the upper and two on the under side of the leaf, in which the stomata are localized. The guard cells are surrounded by 4 to 5 epidermal elements. The outer wall of the epidermis contains numerous small dots each representing a cavity probably originally filled with a crystal of calcium oxalate. Outside the stomatiferous lines there is an almost continuous hypodermal layer of more or less thick-walled prosenchyma cells, undoubtedly contributing to the admirable preservation of the fossils. By maceration in a solution of sodium hypochlorite the mesophyll is dissolved and the hypodermal layer becomes less conspicuous. Predominantly in the base of the leaf a few peculiar prosenchymatous elements in the mesophyll are found though often difficult to discern in the macerated material. They are stout, short, somewhat irregularly shaped, bluntly tapering and thick-walled, and in some places covered with a thin, finely granular sheet, evidently representing a thin crystal layer.

The cones figured in Plate VII, A, B and D are almost intact. The highly compressed specimen of Plate VII, C might also be related to Sequoia couttsiae, The cones are small $(10-12 \mathrm{~mm})$ with an estimated number of only 20 to 30 scales. The escutcheon corresponds well with the figures given by J. S. Gardner (1883-1886),
P. Menzel (1900) and Z. Zalewska (1960). A few seeds were isolated by splitting up an intact cone. In size and shape the seeds correspond with the figures given by, e.g. Z. Zalewska (1960), and show the characters of the diagnosis.

Some anatomical information was obtained by macerating a cone like that figured in Plate VII, B. Numerous spindle-shaped prosenchyma cells were found embedded in the thin-walled, brown parenchyma which occupies the central part af the scale, a character also found in the cone scales of the extant Sequoias.


Fig. 6. Sequoia couttsiae O. Heer. Parts of foliage twigs ( $\times 2$ ). Moselund, Mrs. E. Nordmann del.

A series of seeds agreeing anatomically and referable to $S$. couttsiae are shown in Plate VII, E, F and G. The cuticle of the epidermis appears finely striated with the subepidermal layer developed as a sheet composed of almost isodiametric sclerenchyma cells which are finely and densely pitted and here and there show the outlines of a crystal having filled out the tiny lumen. The main part of the testa consists of axially extended, spindle-shaped sclerenchyma cells (Fig. 7, H), the rather thick walls of which show numerous, quite small but distinct bordered pits.

Remains referable to Sequoia couttsiae occur over a wide range and in age reach from the Upper Oligocene to the Miocene (compare, for example, the table p. 76 of Z. Zalewska (1960) covering the localities in Poland and adjacent areas). A number of allied systematic units are described (P. Menzel 1900) but can hardly be maintained as distinct species. The anatomy of the leaf (H. Bandulska 1923, Z. Zalewska 1960) agrees very closely with the anatomy of the extant Sequoia gigantea (J. Lindley) J. Decaisne (Sepuoiadendron J. T. Buchholz) (R. Florin 1931), commonly regarded as a living analogue. An anatomical character of the S. giganteum hitherto, as far as I know, overlooked, is the occurrence of the peculiar stout, spindle-shaped, bluntly pointed prosenchyma elements covered with a thin layer containing minute crystals
at the decurrent base of the leaf as well as in the pericyclic layer of the axis. This layer is not directly part of the wall of the prosenchyma cells but is formed in the walls of the adjacent parenchymatous elements, it is not always distinguishable in the fossil as the thin, frail walls of the mesophyll here are more or less destroyed.

The twigs of Sequoia couttsiae are generally far more slender and the leaves smaller than in Sequoiadendron giganteum. A marked difference is also noticeable in the size of the cones which in the living analogue attain a considerable size $(60 \times 40 \mathrm{~mm})$ while in the fossil they are always quite small. The seeds almost agree in size and shape but differ in anatomical details. A common feature of the seeds of all Taxodiaceae is the development of a subepidermal layer of small, almost isodiametric, thick-walled sclerenchyma cells, often containing crystals of calcium oxalate, but they are not developed to the same extent in all the genera.

As is shown in Fig. 7, A, B and C the transverse sections of the seeds of the two extant Sequoias differ considerably in outline; the marginal wing is broader in Sequoiadendron giganteum than in Sequoia sempervirens. Other differences are found in the histology of the testa; in S. sempervirens the tissue is markedly heterogeneous, composed of mixed groups of thin and thick-walled elements, axially extended and highly pitted, while in Sequoiadendron giganteum the tissue is almost homogeneous with a mesotesta composed of thin-walled, somewhat branched cells. The fossil seeds (Plate VII, E-G), referred to $S$. couttsiae, are very much like the seeds of $S$. giganteum in size and shape being broad winged and with a curved embryo, but they are well defined histologically. The main elements of the testa, including the subepidermal layer of isodiametric sclereids, are far more solid in S, couttsiae than in Sequoiadendron giganteum (Fig. 7, H and G).

The fossil seeds approach in size and shape the seeds of Metasequoia (Z. Zalewska 1960). The Melasequoia seeds are easily distinguished from those of $S$, giganteum by having two larger, or a number of smaller, ducts of schizogenous development, but mostly devoid of resin (Fig. 7, D, E and F). The mesotesta is homogeneous, composed of thin-walled elements. Often the seeds show a slight incision in the top so conspicuous that it gives the outline an almost obcordate appearance. Remains referable to Metasequoia have not yet been found in Danish lignitic layers.

In a recent paper by O. Schwartz and Heinz Weide (1962) a new interpretation of the systematic interrelation between the genera Sequoia, Sequoiadendron and Metasequoia is advanced in which they are considered so closely related that they are included in one and the same generic unit. According to the rules of priority this generic unit must then be named Sequoia.

Some anatomical details concerning the structure of the secondary xylem and the seed seem to have escaped the attention of these authors. As was pointed out by J. T. Bechholz (1939) the genus Sequoia St. Endlicher contains two types differing sufficiently to justify the division into two genera, Sequoia (sempervirens) and Sequoiadendron (giganteum). Metasequoia seems most conveniently kept apart as a special genus. An adequate solution of this somewhat complicated question would probably


Fig. 7. A-F, transverse sections, drawn in outline, of seeds, A of Sequoia sempervirens (A. B. Lambert) St. Endlicher. B and C, Sequoiadendron giganteum (J.Lindley) J. T. Buchholz and D-F, Metasequoia glyptostroboides H. H. Hu and C. Cheng. G, exo- and mesotesta of S. giganteum and H, of S. couttsiae (Moselund). H is drawn from macerated material $(\mathrm{A}-\mathrm{F} \times 20, \mathrm{G}-\mathrm{H} \times 200)$.
be to interpret the two types in question as monotypical representatives of as many subgenera, to which might be added the fossil $S$. couttsiae as a third. As for the specific rank of the last named unit the remark of the authors cited (1962, p. 187) seems somewhat arbitrary: "S. couttsiae (O. Heer 1863) umfasst ein Gemisch [?] von S. Langsdorffii und S. Reichenbachii was durch die Originaldiagnose bestätigt wird. Die Vorwendung dieses Binomens ist ebenfalls inkorrekt". The original diagnosis and the corresponding diagnosis by O. Heer in his Flora fossilis arctica (1868) as well as in his Miocene baltische Flora (1869) are verbally identical, and the accompanying figures agree with the text and illustrate the type very well.

Sequoia couttsiae considered as a distinct species has, as is well known, caused some discrepancy. In the paper of P. Menzel (1900) the difficulties are faced and a close study made which terminated in the more elaborate and detailed diagnosis cited above. But relying only on the olde rstatements of O. Heer it should be possible to maintain $S$. couttsiae as a well established species. The numerous and excellent photographs of isolated twigs, cones and seeds published in the paper of Z. Zalewska (1959) justify this interpretation.

Sequoioxylon canadense (C. Schröter) nov. comb.
Sequoia canadensis C. Schröter 1880, Sequoia wellingtonioides W. Prill 1913, Cupressinoxylon canadence (C. Schröter) R. Kräusel 1919 and Z. Zalewska 1953.

All the numerous samples referable to this type of fossil wood were collected in the Troldhede area. In the lignites of Torvig quarry a number of stumps were found (compare Part I, p. 19). Since the wood of the stumps had only been subjected to compression parallel to the fibres the anatomical structure was but slightly altered and the preservation almost perfect. A sample of such a stump was chosen to represent the type. Unfortunately it has not been possible to secure a whole stump for the Mineralogical and Geological Museum of Copenhagen University since the wood is broken up into concentric flakes, 5 to 10 mm thick, each representing a few growth rings. No traces of bark are left.

Transverse section. The growth rings are of a uniform thickness and well delimited (Plate VIII, A) with a gradual transgression from early to late wood. The rays are composed of one row of thin-walled, radially extended elements. Resiniferous xylem parenchyma is diffuse or somewhat crowded in the late wood. Vertical resin ducts could not be detected.

Radial section. Plate VIII, C and D show tracheids of early and late wood. The broader elements of the early wood have two rows of opposite bordered pits often separated by rather faintly pronounced crassulae. The narrower tracheids of the late wood show only one row of bordered pits. The rays are composed of thin-walled, radially extended cells without any sculpture on the horizontal or tangential walls and are slightly ascending. Indentures are rare and only feebly developed. The cross-field shows 2 to 4 cupressoidal-taxodioidal blind pits. In the photographs the inner borders of the pits are diffuse while the connecting slits to the treacheids are distinct.

Tangential section (Plate VIII, B). The photograph only represents a part with low rays, but the rays may reach a height of 30 cell rows or more. The small tangential bordered pits are visible in some cases with a reading glass. Of salient importance is the structure of the horizontal walls of the resiniferous xylem parenchyma which appear smooth or almost so, in the latter case they only show a fine bead-like structure.

Horizontal resin ducts were not seen in the investigated sections.
Under the name "Cupressinoxylon wellingtonioides" R. Kräusel (1919, p. 293)
has given a short diagnosis of the species based on a small piece of a branch about 3 cm thick and showing a number of 2 to 4 mm broad growth rings and a few vertical traumatic resin ducts in the early wood of one of the rings. Apart from the last detail the fossil wood of this type from Torvig quarry agrees with the diagnosis.
W. Prill (1913) discusses the systematic relations of his "Sequoia wellingtonioides" to other species of fossil wood and the extant Sequoias and places it as closely related to Sequoia gigantea J. Lindley (J. Decaisne) (Sequoiadendron giganteum (J. Lindley) J. T. Buchholz). S. couttsiae is mentioned as a fossil type with a wood anatomy closely connected with what is known about S. giganteum. The lack of traumatic resin ducts is no hinderence to referring our samples to the Sequoias since they are not always demonstrable in the two extant species (E. C. Jeffrey 1903).
A. Schenk (1869) is inclined to refer a fossil wood of the type in question to S. couttsiae, but his short description is inadequate and not accompanied by figures.

Considering the wide extension in time and space of Sequoia couttsiae it seems curious that wood referable to the Sequoiadendron giganteum type is not more common in the lignites of Europe. The arctic S. canadense (C. Schröter) was regarded by R. Kräusel (1919, p. 296) with some hesitation as a "Sequoioxylon" and the specific name canadense was finally adopted for the type: ("Cupressinoxylon canadense (C. Schröter) nov. comb., C. wellingtonioides (Prill) Kräusel, das mit Sequoia canadensis Schröter (vergl. Kräusel 1919 b, p. 240) vereinigt werden muss") (Krä́csel 1949, p. 116). According to recent investigations it seems to be most convenient to retain the generic name Taxodioxylon (Gothan 1905) for fossil wood agreeing with or referable to the recent Taxodium and Sequoia sempervirens type.

According to the undoubtedly taxodiaceous characters of our fossil it must be admissible to refer the wood of this type to a Sequoia (in sensu latiore); the only feature connecting it with the Cupressinoxyla would be the type of cross-field pitting but, as noted above, the pitting is often tending to the taxodioidal type, and as a sole criterion, it cannot be regarded as decisive. The double rows of bordered pits frequently ocurring in the early wood as well as the remarkably high rays also points in the direction of the Taxodiaceae.

The cones, seeds and foliage twigs commonly described under the name Sequoia couttsiae are undoubtedly of a Sequoia-like appearance and mutually related. Our fossil wood is probably of the same specific origin as the accompanying remains of S. couttsiae, but the interdependence with Sequoiadendron is not so clearly demonstrable as, for example, is the case with the remains referable to S. langsdorffi and the recent $S$. sempervirens, so it seems a little premature to create a new genus. The name Sequoioxylon may be retained - at least provisionally - to designate the wood in question.

A sample of gymnospermous wood from the Torvig quarry (Troldhede) shows a peculiar appearance (Plate IX). Short and broad rays of an almost uniform shape and homogeneous structure occupy a considerable part of the bulk of the wood. They
are most conspicuous in the tangential section but are also prominent in both the transverse and radial sections, while rays of the normal type are comparatively rare and of a less salient appearance. The rays are composed of rather thin-walled elements varying in size and shape; the horizontal and tangential walls without sculpture, the radial walls showing 2 to 4 cupressoidal-taxodioidal blind pits in the cross-field.

The resiniferous xylem parenchyma appears somewhat diffuse and the horizontal walls are smooth or slightly bead-like pitted. In the early wood there are 2 to 3 rows of opposite bordered pits; crassulae are distinct.

According to these characters it seems permissible to refer this wood to a Sequoia but evidently originating from an anomalous part of an axis, probably from a protuberance developed on a stem, a common feature in the extant Sequoias. The shape of the rather small sample supports such an origin since it is curved both radially and tangentially.
R. Kräusel has described and figured an irregular development of the ray tissue in a "Maserknolle" (1919, Taf. 23, Fig. 2 and 4, Taf. 24, Fig. 7, 8 and 11 ) which he refers to a Cedroxylon (Physematopitys salisburioides Göppert) (p. 230 l.c. et seq.), the systematic position of which seems a little doubtful.

A protuberance of Sequoia sempervirens, kept in The Botanical Museum of the University of Copenhagen, shows an irregular development of the ray tissue not unlike that noted by R. Kräusel but differing greatly from that found in the sample described here, while in a bulb-like protuberance from a "knee" of Taxodium distichum multiserial rays were regularly developed. Anomalous wood of Sequoiadendron giganteum was not available.

Sequoia langsdorffii (A. T. Brongniart 1828) O. Heer
Foliage twigs and cones referable to this species occur rather commonly in the lignitic clay at Moselund.

In European and Arctic Tertiary deposits, ranging in age from Eocene to Pliocene, remains of this Sequoia are common and consequently described and figured in numerous papers. Lists of the relevant literature, compiled by P. Friedrich (1883) amd M. Staub (1887), the latter comprising 94 titles, covers the literature up to the years cited since when may be added those of P. Menzel (1900) and R. W. Chaney (1951).

The foliage twigs are partly preserved as carbonized leaf substance and partly only as imprints (Plate X, A to F). At the base of the twigs there are a few, small, scaly leaves. The samples agree closely with the diagnosis given by P. Menzel (1900, p. 89) : "'Sequoia foliis rigidis, coriaceis, linearibus, apice oblusiusculis vel breviter acuminatis, planis, basi augustatis, adnato-decurrentibus, patentibus, distichis, confertis; nervo medio valido; strobilis breviter ovalibus vel subglobosis, squamis compluribus, peltatis, mucronolatis".

The decurrent leaf bases are better shown in the camera lucida drawings of Fig. 8, A to E. Both in the structure of the epidermis and in the mesophyll the different
appearance of the upper and lower sides of the leaves are very marked. The stomata on the upper side are few in numbers and arranged in axially extended, small groups while on the under side of the leaf there are two broad bands of stomata, one on each side of the midrib, extending from the base to the apex of the leaf.

A hypoderma, composed of rather thick-walled prosenchymatous elements, forms an almost continuous layer on the upper side while on the under side the prosenchyma is more scattered and thus permits ample stomatic communication whereas stomata on the upper side only occur where lacunae are formed in the subepidermal layer.


Fig. 8. Sequoia langsdorffii (A. T. Brongniart) O. Heer. Deciduous foliage twigs. Moselund.

On both the upper and lower sides the outer wall of the epidermis shows a finely dotted structure, the dots representing cavities from which crystals of calcium oxalate have been dissolved.

The type of foliage twigs figured by Z. Zalewska (1959) as Plate IX, Figs. 2-4, are also found in our material but an anatomical inspection has not been possible.

The cones reproduced in Plate X, G to K are probably also referable to Sequoia langsdorffii. They were all collected from the lignitic clay at Moselund. The scales of the mature cone are squarrose and as the interspaces in the fossils are filled with matrix the cones are in most cases impossible to isolate without injury. Plate X shows fractions of the cones. The cones are 15 mm in diameter and the axis about 20 mm long. The number of cone scales is estimated as 30 to 40 . The shape of the cone is ovoidal. All the cones were fully developed and the seeds dispersed.

The morphology of the foliated shoots and the anatomy of the leaf of the fossil Sequoia langsdorffii appears very much like that of the recent S. sempervirens (D. Don) St. Endlicher. According to P. Friedrich (1883) and P. Menzel (1900) the number of cone scales in the fossil is about 50 , while only about 20 are found in S. sempervirens; the latter should accordingly have smaller cones, but the material I have had access to shows cones of the same type and size as those of the fossil and with a corresponding number of cone scales, so the size may vary considerably.

As a character of $S$. sempervirens R. Pilger (1926) mentions the squarrose cone scales, his Fig. 151 b showing the apperance of a mature cone very like that of the
fossils. The inner sides of the cone scales show a fine, fan-shaped striation which is also discernable under a reading glass in the photographs of Plate X.

The seeds of S. langsdorffii are lacking in my material, but if it is assumed that the seeds of S. langsdorffii correspond morphologically and anatomically with the seeds of the recent analogue they would be easily discernable if present. The seeds of $S$. sempervirens are of a dark brown colour, highly variable in size from 2.8 to 3.5 mm , irregular, inverse conical-prismatic in shape, with a relatively faintly protruding wing. The embryo is almost straight, scarcely conspicuous on the surface of the seed. The testa is mainly composed of rather thick-walled, lignified elements which give a conisderably greater weight to the seed than, e.g. in Sequoiadendron giganteum. For comparison reference is made to Fig. 7 which shows transverse sections of the seeds of S. sempervirens, Sequoiadendron giganteum and Metasequoia glyptostroboides.

According to the authors cited by P. Friedrich (1883) the type shows a considerable variation which has caused the establishment of a series of species. These have been criticized by P. Friedrich and are probably not to be maintained.

Taxodioxylon gypsaceum (N. R. Göppert 1842) R. Kräusel
(Sequoia gypsaceum (N. R. Göppert) nov. comb. P. Greguss 1967)
Only one specimen referable to this type of fossil wood has been found (the State quarry at Troldhede). It appears in an excellent state of preservation.

The fossil anatomically agrees very closely with the wood of the extant Sequoia sempervirens (A. B. Lambert) St. Endlicher, the well known "Redwood" of the western states of the U.S.A. The very thorough study by I. W. Bailey and Anna F. Faull (1934) allows a detailed comparison to be made between the fossil and its recent analogue.

Transversesection. In the transverse section the growth rings are well marked and narrow with a gradual transgression from early to late wood. The rays are 1 to 3 cell rows broad with thin-walled elements. Resin cells are scarce, mainly occurring isolated towards the border of the growth rings, or scattered.

Radial section. The tracheids of the early wood typically show two (or three) rows of bordered pits with a well-marked torus and distinct crassulae.

The pits tend to be more numerous and crowded towards the overlapping ends of the tracheids. In the early wood tracheids the opposite pitting sometimes changes to become alternating and crowded. The rays attain a considerable height. The tangential and horizontal walls of the ray elements are smooth, or almost so, and indentures are lacking or only faintly developed. The radial ray walls of the early wood show 1 to 2 transverse rows of typical taxodioidal blind pits with an elliptical, radially extended outline; the aperture is never slit-like, but broad elliptic forming a crescentshaped configuration on both sides of the pits. Occasionally, and prominently in the first formed layers of the early wood, the pits tend toward the circular, glyptostroboidal type with a small or no border (Plate XI, C and D, Plate XII, B and C). The late wood shows the connecting pits with a stunted, slit-like porus.

The transverse walls of the resiniferous xylem parenchyma are smooth or finely pored, exhibiting in the section a bead-like appearance.

Tangential section. The late wood tracheids have numerous bordered pits which are considerably smaller than those of the radial walls of the early wood. The


Fig. 9. Taxodioxylon gypsaceum (N. R. Göppert) R. Kräusel. A and C, radial and B, tangential section D, G and $H$, parts of strand tracheids. E and F , horizontal walls of resiniferous xylem parenchyma (A, B and $\mathrm{C} \times 250, \mathrm{D}-\mathrm{H} \times 400$ ). Troldhede State Quarry.
height of the rays is exceedingly variable with rays of 1 to 5 cell rows intermingled with rays 10 to 20 rows or more, and rays of 30 to 40 rows high are a common occurrence. In a few cases a maximum height of 70 cell rows has been noted. The rays are usually uniseriate, but bi-and triseriate rays are not uncommon, and as far as can be stated, occur much more frequently here than, for example in the wood of the fossil Taxodium or Glyptostrobus (Plate XIII, B and C).
"Strand Tracheids", i.e. non-resiniferous tracheidal elements divided by horizontal walls, are seen in the late wood (Plate XII, A, and Fig. 9, D, G and H). The horizontal walls are most commonly quite thin while in some places they attain a certain thickness.

Ray tracheids have not been found and traumatic resin ducts are not developed in the wood of the sample examined.

The fossil material described here agrees closely with its recent analogue Sequoia sempervirens on the following characters: the structure of the growth rings found in the stem or branch wood, the distribution of resiniferous parenchyma, the pitting of the radial walls of the tracheids, the types of rays (the very high and the bi- and triseriate rays intermingled with relatively low ones), the pitting of the cross-field, the smooth or slightly bead-like pitting of the horizontal walls of the xylem parenchyma and lastly the occurrence of "Strand Tracheids".

Our fossil also anatomically agrees very well with the sample af Sequoia gypsaceum (Göppert) described and figured by P. Greguss (1967, no. 9). As will appear from the generic name chosen by Greguss he considers the fossil wood to correspond so closely anatomically with the wood of the recent S. sempervirens that he has taken the decisive step of establishing a still closer connection of the fossil with its extant analogue by adopting the generic name Sequoia. This is supported by the fact that foliage twigs as well as cones of $S$. langsdorffii, which is evidently closely related to S. sempervirens, occur in the same Tertiary lignite layers as the wood referable in Sequoia sempervirens. The two species might be mutually interdependent but, of course, this is not strictly demonstrable even if it is very probable.

It must be kept in mind that Sequoiadendron giganteum (J. Lindley) J. T. Buchholz 1939 possesses wood of another anatomical structure and has been classed as a Cupressinoxylon due to its type of cross-field pitting. The organo-genus Taxodioxylon Gothan is mainly based on the shape of the blind pits of the radial ray walls and not on the pitted structure of the horizontal walls of the xylem parenchyma which certainly is most strongly and most typically developed in Taxodium, but occasionally also occurs in S. sempervirens (1. W, Bailey and A. F. Faull 1934, Plate 106, Fig. 52 and 55) and so it might possibly also be found in the fossil. I have considered it safest to retain, at least provisionally, the generic name Taxodioxylon given by W. Gothan (1905) comprising fossil wood of the Taxodium and $S$. sempervirens type.

Taxodium dubium (K. von Sternberg 1838) O. Heer 1855
(Taxodium distichum miocenum O. Heer 1869)
The lignitic clays at Moselund, Fasterholt and Silkeborg Vesterskov are particularly rich in deciduous, foliage twigs, cone scales and seeds referable to Taxodium. The material from Moselund and Silkeborg Vesterskov, especially, is partly in an excellent state of preservation thus facilitating the anatomical study of the remains. Foliage twigs of Taxodium are sometimes also found in the brown coal itself.

In European, North American and Arctic Tertiary deposits, ranging in age from Eocene to Pliocene, remains of Taxodium are locally exceedingly common and consequently described and figured in numerous papers. Besides the very complete lists of relevant literature compiled by P. Friedrich (1883), M. Staub (1887) and P. Menzel (1900) there are the important references in the critical review by R. W. Chaney (1951).

A selection of the most commonly occurring types of deciduous, foliage twigs with distichous leaves referable to Taxodium dubium is figured in Plate XIV. All the specimens are from the lignitic clay at Moselund. The leaf substance of the twigs figured in A, D and G of Plate XIV was sufficiently coherent to allow the preparation of the cuticles and partly also of the mesophyll. The distribution of the stomata in two narrow stripes on the upper and two broader on the under side of the leaf, as well as the orientation of the palisade cells agrees very well with that found in the recent Taxodium species (R. Florin 1931, Plate 41, Figs. 1 and 2). In the outer wall of the epidermal cells a fine dotted structure is perceptible signifying the former presence of minute crystals of calcium oxalate, and on the upper side of the leaf here and there remains of scattered subepidermal, thin-walled prosenchymatous elements are recognizable.

The mesophyll is mostly collapsed but the arrangement of the elements in transverse lamellae, running from the transfusion tissue enclosing the midrib to the margin of the leaf, is sometimes traceable as well as the structure of the thin-walled tracheids of the transfusion tissue itself.

Cone scales referable to Taxodium are rather common in the lignitic clay at Moselund and Silkeborg Vesterskov, whereas entire cones do not occur. Plate XV, A shows a selection of such scales. The sculpture of the abaxial (dorsal) side of the cone scale is conspicuous, though the scales are highly compressed. The adaxial (ventral) side does not show any details, the tissue here being mainly composed of rather thinwalled elements while, as in the extant Taxodia, the dorsal shows an abundant development of subepidermal sclerenchyma as well as scattered brachysclereids throughout the whole of the mesophyll. A transverse cut of the scale shows one or two brownishyellow stripes, each representing a balsam cyst.

The seeds vary much in size as is also the case in the extant Taxodium, those from the base of the cone being larger than those from the apex. They are characterized by their peculiar shape and especially by the sharply salient, longitudinally running ridges which in the larger specimens are developed as low wings (Plate XV, B-J). The brittleness of the material did not allow the preparation of satisfactory sections so the anatomy had to be studied by maceration of the entire seed.

Both the outer and inner sides of the testa have an epidermis of rather large elements with brown, irregularly undulating side walls. In the preparations the epidermis is mostly dissolved so that only the finely dotted cuticle is left. The exotesta as well as the endotesta consists of a few layers of thick-walled, finely pitted, sclerenchyma cells which, according to the shape of the lumen, often have enclosed a crystal (calcium oxalate). The mesotesta is composed of a parenchymatous tissue with rather thin-walled cells which in the fossils have collapsed. Along two opposing stripes running from the seed cavity out to the flanks the parenchymatous tissue grades into a tissue of small, rectangular elements each sculptured by a set of parallel, transverse thickenings.

The anatomical details of the fossil material agree with the recent Taxodium spp., and $T$. distichum seems to be especially closely allied. The fossil seeds differ somewhat
in shape from the seeds of the recent analogue, the testa here having a far more markedly winged and irregular outline.
O. Heer has figured single scales, entire cones (1869), seeds and even male inflorescens (1870) so very much like those of T. distichum (L.) L.-C. Marie Richard that he was unable to distinguish the fossil form from the extant species and thus considered them specifically identical (Taxodium distichum miocenum O. Heer). This view seems to be shared by most of the subsequent authors [e.g. W. P. Schimper and A. Schenk (1890), P. Menzel (1900) and Z. Zalewska (1959)] and has remained almost unchallenged. Yet A. C. SEward (1919) has expressed some doubt and probably it would be safer to term the remains simply as Taxodium miocenum, but according to R. W. Chaney (1951) the name Taxodium dubium (Taxites dubius K. von Sternberg 1838) has priority and this name is also used by O. Heer for a fossil species of Taxodium considered as allied but differing slightly from his Taxodium distichum miocenum.

A rather slight, but as it seems, constant difference occurs between the anatomy of the secondary wood in the recent $T$. distichum and the pieces of fossil wood in our collections, undoubtedly referable to a Taxodium sp., as well as in the material described as Taxodioxylon taxodii Gothan from other European localities (see below).

The Mexican Taxodium mucronatum M. Tenore (T.mexicanum) differs from T. distichum in its growth form, its partly persistent foliage twigs and mainly by the smaller cones with more prominantly mucronate scales.

In the recent Taxodium species the seeds adhere to the cone scale and, as the tissue connecting the scale with the axis is brittle, the scales of the mature cone are easily detached and shed together with the adhering seeds.

Root knees of Taxodium, a salient character of the extant T. distichum, have not been seen in our lignites and they seem rarely to occur as fossils though they are known in a calcified condition from the Neogene deposits at Parschlug in Steiermark (E. Hofmann 1927).
R. W. Chaney (1951) in his critical and comprehensive memoir has revised the fossil Taxodia. In support of the opinion of F. N. Knowlton he states as a conclusion that the fossil Taxodium of North America is not specifically different from T. dubium and, making use of the recent discovery of Metasequoia, he succeeded in correcting many previous determinations which erroneously had referred foliage twigs of Metasequoia, as well as those of Sequoia langsdorffii, to Taxodium. As remains of Metasequoia are also found in European Tertiary deposits (Z. Zalewska 1959, M. europaea n.sp.). a correspondingly critical review of the European material is required.

Taxodioxylon taxodii W. Gothan
Pieces of fossil wood referable to this organo-genus are among the most common macrofossils in the lignites of Jutland and in some places form a considerable part of the brown coal itself. Imbedded in the coal matrix they are most often highly altered by compression so that a reliable determination is not always easy. However, it was
possible to collect some specimens in a perfect state of preservation from the quarries at Troldhede and the following description is based mainly on the study of this material.

In our collections the determinable specimens appear in several forms, mainly distinguishable by the proportion between early and late wood. The transverse section figured in Plate XVI, A represents the most common type (type I-15 samples); the thickness of the growth rings is variable but the transgression from early to late wood is always even. A second type (type II - 10 samples) is shown in Plate XVII, A; it exhibits quite narrow growth rings of rather uniform thickness with an abrupt change from early to late wood, the latter only composed of a few layers. The third type (type III -2 samples) (Plate XVIII, A) is characterized by relatively broad growth rings, mainly composed of uniformly narrow, rather thick-walled tracheids of the late wood type. The first type (type I) might represent the normal stem and branch wood, the second (type II) anatomically agrees with the type commonly developed in the root of gymnosperms, and the third type (type III) might represent a "compressed" state of development, such as is found, e.g. on the underside of horizontal branches, a feature occasionally also seen in the Taxodium group. The boundary between the growth rings is always distinct.

Transverse section. Resiniferous parenchyma is common and perceptible as dark brown elements scattered throughout the growth ring or arranged in tangential groups. The side walls are rather thin. Where the cut has touched near a horizontal wall and the resin content disappeared the pitting of this wall is easily perceptible. The Fig. 11, D to G show the common feature; the central part of the wall forms a solid, lenticular disc and the pores are concentrated near the circumference.

The rays are uniseriate and pits are not visible in the horizontal walls. The circumference of the tracheids is, as a rule, regularly hexagonal with here and there the elements of a single radial row tending towards a rounded outline. In the early wood the tracheids sometimes attain a radial diameter of $40 \mu$.

Radial section. In the early wood the first formed and more thin-walled tracheids commonly show two rows of juxtaposed bordered pits, the pit pairs separated by distinct crassulae. Sometimes the pits are few and scattered but the arrangement in two rows is still traceable. A very regular, two rowed pitting is developed in the relatively broad early wood of the type II ("root wood"), the pitted area covering the greater part of the radial wall. Here the number of bordered pits in the horizontal rows may increase to three. In the narrower tracheids the uniseriate pitting dominates and consequently prevails in type III. The bordered pits attain a diameter of $16 \mu$.

The ray cells are rather thin-walled in the early wood and somewhat more solid in the late wood, with horizontal walls smooth or appearing sporadically slightly pitted. Interstitia occur but are rare and only feebly developed. The blind pitting of the radial wall is of the well known taxodioidal type, most typically developed in the early wood but are rather variable in size and arrangement. In the type III wood the taxodioidal


B


Fig. 10. Taxodioxylon taxodii W. Gothan. A, C, E, F and G, selected parts of rays in which the pitting of the tangential walls is prominent. B and D , tangential view of rays of the same type. ( $\times 400$ ). Troldhede.
pits are confined to the first formed early wood. The tangential walls of the ray cells may be smooth and without any sculpture, but most often exhibit a feeble pitting giving the wall a bead-like appearance if strongly accentuated it produces a knotty outline approaching the "Juniperus Tüpfelung" of W. Gothan (1905). The latter appearance is especially developed in the late wood and therefore most common in the wood type III, but a single or a few knots may also appear even in the most thin-walled, marginal ray cells of the early wood. The thickenings are most conspicuously developed in the wood of type II. In type I it is not rare to find areas of the ray tissue in which most of the tangential walls are quite smooth. The various types of tangential ray cell pitting may, however, occur irregularly intermingled (Fig. 11, H).

Tangential section. The tangential section shows small, bordered pits on the walls of the last formed of the late wood tracheids.

The vertical extension of the rays is highly variable. In the samples of type II they rarely exceed a height of 10 cell rows while in types I and III a height of 25 to 30 rows is not rare and this number may occasionally be exceeded to 40 or even more rows. Such rays are, for example, sometimes found in wood of type I where a maximum height of about 60 rows was noted. Where a tangential ray cell wall with bead-like thickening is included in the sectional plane 1 to 5 transverse bars, or bars forming a network, are observed with the more or less fine pitting appearing as fine horizontal stripes (Fig. 10, B and D), the bars and pits corresponding respectively to the beadlike thickenings on the tangential walls, and the intermediate unthickened parts. As a single ray cell may cover 8 to 10 tracheidal rows the tangential walls appear rather rarely in the thin microtome sections.

The details of the horizontal (transverse) walls of the resiniferous parenchyma are much more conspicuous in the tangential sections of the wood than in the radial since the elements often are somewhat broader tangentially. Fig. 11, A and B show the highly projecting middle part of the wall and the pits of the circumference; where the transverse wall is notably thinner the pitting may only cause a bead-like pattern (Fig. 11, C). The vertical walls of the parenchyma are provided with half bordered pits where the walls joins a tracheid; where two parenchymatous elements have a wall in common the pitting is simple.

## Affinities

A diagnosis of the organo-genus Taxodioxylon is given by R. Kräusel (1949, p. 168) which runs as follows: "Tüpfel im Spätholz mit schräg-spaltenförmigen, im Frühholz mit breitem $\pm$ wagerechten Porus (Taxodioide Tüpfelung, W. Gothan). Markstrahlwände meist glatt, Holzparenchym häufig, im Wundholz zuweilen Harztaschen',

Among the extant genera of gymnosperms this diagnosis only covers the types referable to Taxodium and Sequoia sempervirens, while the wood of Sequoiadendron (J. Lindley) giganteum J. F. Buchholz anatomically tends towards the Cupressinoxylon
type (W. Gothan 1905). This also applies to the wood of other recent genera which are commonly referred to the Taxodiaceae (Athrotaxis, Cryptomeria, Taiwania), while Glyptostrobus and Cunninghamia, through their dominating "glyptostroboidal" cross-


Fig. 11. Taxodioxylon taxodii W. Gothan. A, B and C, tangential section of xylem parenchyma; A and B show thick and highly pitted horizontal walls, C represents a type of thinner horizontal walls with a more bead-like pitting. $\mathrm{D}-\mathrm{G}$, horizontal walls of xylem parenchyma as they appear in transverse section. H, part of a ray with feebly developed pitting of the tangential walls. $(\times 400)$. Troldhede.
field pitting, form a particular type deviating from the rest of the group. Metasequoia also forms a special type.

The fossil genus Taxodioxylon was first delimited by W. Gothan (1905, p. 49) whose description adds supplementary information to that of R. Kräusel. According to W. Gothan Taxodium has a blind pit type intermediate between the cupressoidal and the glyptostroboidal cross-field pitting as the pit is markedly widened in the early wood but does not take the shape of a real oëopore.

Other details of value for the systematic anatomy of the wood structure of the Taxodiaceae are given in the analytic tables of E. J. Slyper (1933), R. Kräusel (1949, p. 94-95) and P. Greguss (1955) which mainly concerns the wood of extant conifers. A diagnostic table covering the anatomical characters of the groups of the analogue fossils is also given by R. Kräusel (1949, p. 150-151).

According to the definition the anatomical features of all our specimens agree with what is considered as characteristic for the wood of the extant Taxodium and for the fossil Taxodioxylon taxodii. Yet an important difference, probably in part overlooked, and, at any rate, hitherto not taken sufficiently into consideration, is found which taken alone would change the systematic position of the fossil from the Taxodioxylon to the Juniperoxylon group.

On a close examination of perfect material from our specimens a distinct pitting of the tangential walls of a good many ray cells could be demonstrated. In the keys cited above for the determination of gymnospermous wood of the Taxodioxylon type this character is not mentioned. W. Gothan (1905) has noted that the organo-genera Taxodioxylon and Glyptostroboxylon are devoid af "Juniperus Tüpfelung" which is correct in that they do not show the often highly conspicuous and mostly uniformly developed knotty thickenings of the tangential ray cell walls found in the recent Juniperus spp. (J. drupacea (Arceutos), it is true, is an exception). In his paper of 1906 W. Gothan amends his remarks on Taxodioxylon sequoianum (Mercklin) W. Gothan in the way that: "....man bei ihm sowohl im Radial- wie im Tangentialschnitt eine schwache der Juniperus-Tüpfelung ähnliche Verdickung der Markstrahlzell Tangentialwände sah, die ich jedoch bei ihrer schwachen Ausbildung und ihrem unregelmässigen Auftreten diagnostische Bedeutung nicht beimesse".

Through the liberal kindness of the late Professor R. Kräusel, Frankfurt am Main and the late Professor W. Gothan, Berlin, I have obtained samples of Taxodioxylon taxodii and $T$. sequoianum from the lignites at Senftenberg for comparison (for details see Fig. 12). Anatomically they agree with the descriptions, but I found that the knotty character of the tangential ray cell walls in the samples described and figured as Taxodioxylon sequoianum agrees closer to T. taxodii (probably a misunderstanding has crept in concerning the two species being discussed). W. Prill (1913) states that the bordered pits in the radial walls of the tracheids in the genera Taxodium, Glyptostrobus and Sequoia, in contrast to those in the Cupressaceae, are most often arranged in two (or more) rows in the early wood. This observation was considered important by the early authors (R. Kräusel 1919, p. 208) and certainly must be regarded as a character of some value and corresponding to the commonly far larger diameter of early wood tracheids in the Taxodiaceae than in the Cupressaceae.

A fossil wood termed Juniperoxylon silesiacum (W. Prill) R. Kräusel has been thoroughly investigated and the salient details of the anatomy figured in the paper of R. Kräusel and G. Schönfeld (1924). In this paper a considerable number of similar specimens ( 77 samples of wood of the "trunk type" and 34 of the "root type") of the material collected from the same layers of the "Braunkohle" at Süd-Limburg were com-


Fig. 12. Taxodium distichum (L.) L.-C. Marie Richard. In A is shown the transition of the medullary parenchyma iuto the first fosmed tissure of the rays. B shows similar features in Glyptostrobus pensilis A. B. Lambert. ( A and $\mathrm{B} \times 400$ ).
Taxodioxylon taxodii W . Gothan. C and D , tangential sections of rays and $\mathrm{E}-\mathrm{G}$ radial sections; the tangential walls of the ray cells are strongly pitted in the parts selected for drawing. ( C to $\mathrm{G} \times 400$ ). Material from the lignitic layers at Senftenberg. Germany.
pared. The state of preservation was satisfactory and partly excellent. The photographs (R. Kräusel and G. Schönfeld 1924, Plate XXII, Figs. 1-4) show transverse sections of wood which agree very well with the sections of the first and second types of our fossils from the Danish lignites. The radial section in their figures exhibits one, or very frequently two, rows of bordered pits, the pit pairs segregated by distinct crassulae, or the pits are alternating. The horizontal walls of the resiniferous parenchyma, according to their description, are either bead-like or provided with prominent knots and consequently more or less distinctly pitted (this character is not figured). Concerning the ray cells it is stated: "Tangentialwände körnig bis schwachknotig - im Tangentialschnitt leiterformig seltener netzartig verdickt" (R. Kräusel and G. Schönfeld 1924, p. 261). The cross-field in the late wood shows 1 to 2 blind pits of the cupressoid type while in the early wood the number of pits increases to six often arranged in two to three horizontal rows and, according to their photographs (Plate XXII, Figs. 8 and 9, and text Fig. 4) tend more towards the taxodioidal type or even approach the glyptostroboidal (i.e. circular in outline and almost without borders). These authors, as mentioned, refer their material to "Juniperoxylon silesiacum" (W. Prill) R. Kräusel (1919).

It seems justified to bring together the woods described by R. Kräusel and G. Schönfeld (1924) and W. Gothan (1906) with the material from Denmark. Kräusel and Schönferd are inclined to unite other specimens from the lignites, formerly described as Juniperoxyla ( $J$. pachyderma and $J$. pauciporosa), with the $J$. silesiacum but in that case $J$. pachyderma (Göppert), as was pointed out by R. Kräusel (1949), has priority. Z. Zalewska (1953) has described the type under this name.

According to Z. Zalewska (1953) the fossils from Turów on the Lusatian Neisse (Poland) agree anatomically very well with those described by R. Kräusel and G. SChönfeld. The thickenings of the transverse walls of the xylem parenchyma appear markedly developed and so is the structure of the tangential ray cell walls with their peculiar alternation of quite smooth membranes along with those showing knotty thickenings. The bordered pits on the radial tracheidal wall of the early wood are frequently opposite and the pit pairs separated by crassulae. 15 cell rows was the maximum height of the rays noted.
F. Stockmans and Y. Willière (1934) have demonstrated the presence of the type in the Neogene Tertiary layers (Oligocene to Lower Miocene) of Belgium. These authors express doubts on their systematic position citing a remark found in a paper of W. Gothan and T. Sapper (1933 - non vidi) "Gelegentliche Verdickungen der Art, wie sie Kräusels Juniperoxylon zeigt, können auch bei andere Hölzern, z.B. Taxodicen, vorkommen, woraus die Mahnung zur Vorsicht ergibt".

In a recent work P. Greguss (1967) has described Taxodioxylon taxodii but without mentioning the sculpture of the tangential ray cell walls. In several places in the accompanying photographs (Table LXXVII, 7 and 8) it seems to me that a structure agreeing with what occurs in the Danish fossils can be traced under a reading glass. The figures cited show a cross-field pitting tending towards the glyptostroboidal type.

When all the details are considered it must be regarded as rather doubtful whether the type in question should be referred to the organo-genus Juniperoxylon. According to P. Greguss (1955), for example, the secondary wood of the extant Cupressaceae is mostly far more homogeneous than is usual in the Taxodiaceae; the difference between the width of the tracheids of the early and the late wood being smaller, or insignificant, and consequently the bordered pits on the radial walls are most commonly only uniseriate. In the genera where the tangential walls of the ray cells have locally thickened parts (knots) these are typically of a more uniform development than in the fossils considered here where the walls, which have highly protruding knots, alternate irregularly with walls in which the knots are only slightly protruding, and where the walls having knotty thickenings are intermingled with walls of a bead-like appearance or almost smooth (Z. Zalewska 1953). It should be noted that the fine pitting in sections giving the wall a bead-like appearance is also a common feature among the Cupressaceae. The horizontal walls of the resiniferous elements agree with what is considered as typical for Taxodioxylon, but some Juniperus species also show a similar development. The pitting of the cross-field is of a type distinctly pointing towards the Taxodiaceae and this is supported by the presence of the occasional very high rays.

The fully grown secondary stem wood of the extant Taxodium distichum is devoid of thickenings on the tangential walls of the ray cells, or they are at any rate extremely rare, and they are practically absent also in the wood of the roots and the knees. In the wood of $T$. mucronatum I have sought for them in vane, according to P. Greguss (1955), they may be developed in the wood of $T$. adcendens but seem also here to be rare. As is shown in my drawing (Fig. 12, A) the thickenings are not quite alien to $T$. distichum, the first formed parts of the ray tissue showing a mode of pitting in the horizontal and tangential walls approaching the "Juniperus Tüpfelung" (W. Gothan 1905) and agreeing closely with that found in the mature wood of the fossils. But this pitting rarely reaches the border of the first year's growth and still more rarely is it found outside this. The pitting of the radial walls, connecting the ray cells with the adjacent tracheids, is composed of numerous quite small oculipores which outwards gradually change to the typical taxodioidal type.

Unfortunately I do not possess twigs of the fossil thick enough to show these details. For the exact systematic position of the Taxodioxylon taxodii type of wood the characters derived from the structure of the medulla would also be of great interest. It is to be hoped that further finds will throw light on such details.
M. N. Doyle and J. Doyle (1948-50) and B. Kubart (1924) have given valuable notes on the structure of the medulla of the extant Taxodiaceae. It appears from these papers that Taxodium distichum differs greatly from its nearest extant relative, Glyptostrobus, by possessing a homogeneous medulla (Plate XIX, B and D). The slides figured in Plate XIX were cut from thin ( 4 to 5 mm thick) branches and agree with those given by M. N. Doyle and J. Doyle, but in the medulla of Taxodium from a thick trunk ( 30 cm diameter) the elements are far more irregular in shape and the tissue tends to be somewhat heterogeneous. In the photographs of Plate XX, A and B there appear
to be groups of vertically arranged, thin-walled and feebly pitted elements interspersed with a surrounding tissue composed of thick-walled, distinctly pored cells often divided by secondary transverse walls. I should like to add that the medulla of T. mucronatum M. Tenore, in contradiction to the account by M. N. Doyle and J. Doyle, can also be heterogeneous. In my material (T. mucronatum M. Tenore, San Diego, Valle de Tehuaean, collected by Liebmann 1841-42, and verified by P. B. Standley 1930), which consists of two samples of about 5 mm thick twigs, some sclereids are present (Plate XX, C and D). They differ from those of Glyptostrobus by retaining the shape of the surrounding, regularly arranged elements.
R. Kräusel and G. Schönfeld (1924) have had the opportunity to study the structure of the medulla of " $J$. silesiacum". Their photographs, l.c. Plate XXII, Figs. 7 and 15 , represent the view of a radial and transverse section respectively and their text figure is supplementary. The irregular disposition of the elements is conspicuous in the radial section accompanied by a difference in shape and thickness of the wall which gives a heterogeneous aspect to the tissue closely agreeing with what is found in Taxodium distichum. The authors cited have called attention to the alternation of the medullary structure in Taxodium during the growth, "Eine Schwierigkeit besteht allerdings darin, dass das Mark im Laufe der Jahre nicht unerhebliche Veränderungen erleidet" (loc. cit. p. 266). This alternation is evident in Taxodium distichum when Plate XIX, B and D is compared with Plate XX, A and B.

The resemblance of the medullary structure of the mature trunk in Taxodium to the medulla of "J. silesiacum" figured (e.g. Tab. XXII, Fig. 7 loc. cit.) is rather striking and corraborates the systematic position of this fossil wood that is suggested here.

The anatomical characters of our fossils may be summed up as follows thus forming a diagnosis which may serve as a guidance for the type of the fossil wood Taxodioxylon taxodii.

## Diagnosis

Growth rings distinct and of various thicknesses, the proportion between early and late wood highly variable. Several types discernable, corresponding to what may be considered as the normal stem type and the root type. The thinwalled tracheids of the early wood hexagonal in transverse section, measuring up to $40 \mu$ in width, the thick-walled tracheids of the late wood here and there tending to a rounded outline.

Xylem parenchyma copious, the elements single or occurring in tangentially extended groups. Rays uniseriate, composed of thin-walled elements often greatly extended radially. The tracheids of the early wood, with numerous bordered pits most often arranged in pairs, separated by distinct crassulae, or more irregularly disposed, but commonly forming two vertical rows. Diameter of the border $16 \mu$. The ray cells of early wood with typical taxodioidal pitting sometimes even tending towards the glyptostroboidal type. Tangential ray cell walls in some areas smooth, but often bead-
like thickened or showing one to five more or less prominent knots which in the late wood often approach the Juniperous type of thickening, corresponding to which the wall in tangential view shows a characteristic sculpture of simple pits. The separating bars sometimes form a network. The rays are of very variable extension; in the stem type of wood they sometimes attain 60 cell rows in height.

The transverse walls of the xylem parenchyma in section are exhibiting a more or less lenticular thickened central part with a peripheral circle of easily perceptible pits. Half bordered pits connect tracheids with parenchyma cells whereas simple pits connect adjacent elements of xylem parenchyma.

The commonly occurring thickenings of the tangential ray cell walls form a marked difference between the fossils here termed Taxodioxylon taxodii and the wood of the extant Taxodium spp. These thickenings might in some cases have been overlooked in the fossils by the investigators (they are often somewhat difficult to ascertain especially in the late wood) but there seems to me, considering the unquestionable variation of the character even in the same sample, to be rather insufficient evidence to admit the existence of two biological types of the Neogene fossil Taxodium. It remains to be noted that both R. Kräusel (1919) and Z. Zalewska (1953), besides their Juniperoxylon pachyderma, have described and figured a fossil wood of the same type but without the thickenings of the tangential ray cell wall under the name Taxodioxylon taxodii. A few samples in our material show the thickenings, but rarely.

That the genus was abundantly represented in the lignitic floras of our continent must be regarded as above all doubt; the common occurrence of foliage twigs, cones (usually isolated cone scales, rarely entire) and seeds form unquestionable evidence. The very resistant wood of the Taxodium type should consequently be expected to be of common occurrence in these strata, as in fact is the case when the supplementary characters in the diagnosis are included. Remnants of Cupressaceae showing the true "Juniperus Tüpfelung" (W. Gothan 1905) character of the rays are, on the other hand, rare. The berry-like strobili referred by Z. Zalewska (1960) to Arceutos (A. drupacea) seems to be the best established remnants of a fossil Juniperus.

Glyptostrobus europaeus (A. T. Brongniart) O. Heer
Foliage twigs, cones and seeds referable to this species are common in the lignitic clay of Moselund and Fasterholt and are often so well preserved that an anatomical investigation is possible. In the lignitic layer of Silkeborg Vesterskov such remains were not found, but among the samples of fossil wood from the Troldhede area several specimens could, with certainty, be referred to the type of fossil wood named Glyptostroboxylon.

A very complete list of references concerning the fossils referred to this species and covering the literature from 1821 up to the year 1886 has been compiled by M. Staub (1887). It comprises more than a hundred relevant papers and gives an idea
of the widespread occurrence of this plant in the European Paleogene and Neogene. P. Menzel has later continued the list up to 1900 . The older determinations are not supported by anatomical studies and some of them, where only leaf-bearing twigs are concerned, may be uncertain; where cones are also considered the identification should be reliable. In a paper appearing in 1959 Z. Zalewska has completed the account of the characteristic features of Glyptostrobus europaeus with photographs of the epidermis of the leaf.

According to P. Menzel (1900) an adequate diagnosis of fossils included under the name Glyptostrobus europaeus may be expressed as follows: Glyptostrobus ramulis strictis; foliis spiraliter insertis, in ramis perennibus squamaeformibus, adpressis, oviformibus, apicem versus latioribus, breviter acuminatis, dorso $2-3$-striatis, basi decurrentibus, in senioribus ramis saepius apice patentibus; in ramulis annuis deciduis foliis subdistichis, erectis, linearibus, apice acuminatis, basin versus numquam angustatis, late decurrentibus, nervo medio valido; amentis masculinis apicalibus, rotundatis, multifloris, basi foliis brevibus, ovalis, acutis circumdatis; amentis femineis terminalibus ad ramulos breves laterales foliis squamaeformibus instructos, ovalibus; strobilis obovatis vel subglobosis; squamis lignescentibus, imbricatis, maturis hiantibus, e basi cuneata in discum ovalem, sulcatum incrassatis, disco sub apice mucronato, margine anteriore toro semicirculari 6-9 crenato et longitudinaliter sulcato circumdatis; seminibus sub quavis squama duobus, ovatis, arcuatis, erectis, marginibus alis angustis, basi ala producta instructis.

It is apparent from this diagnosis that the author has considered a certain dimorphy of the leaf-bearing twigs. This is indeed a salient feature and caused O. Heer (1859) to establish two closely related fossil species, G. europaeus and G. ungeri, the first with only scaly leaves and the second with scale leaves and leaves of the Taxodium type but much narrower than in the typically developed Taxodium. The recent Glyptostrobus is markedly heterophyllous and in 1833 A . T. Brongniart chose this character as the basis of his specific name ("Taxodium heterophyllum"), but at that time the plant had already been described by A. B. Lambert (1832) under the name Thuja pensilis, and his specific name consequently claims priority.

As is evident, e.g. from the paper by Augustine Henry and Marion McIntyre (1926), the leaves of the recent Glyptostrobus are extremely variable in size and shape and it might be useful to cite their very clear and thorough statements as far as they are relevant to the fossil material dealt with here. "The foliage of Glyptostrobus is heterophyllous, two or three kinds of leaves being born on an individual tree at the same time; and the foliage also varies in character with the age of the tree, being different in the seedling, young and adult stages".
"Three quite distinct types of leaves occur in Glyptostrobus in addition to the cotyledons, which may be looked upon as a fourth type. As a rule only one kind of leaf occurs on any one branchlet, but occasionally the leaves towards the base of an axis may differ from the rest in shape. It is interesting to note that these three types simulate the leaves which are characteristic of the three allied genera, Taxodium,

Cryptomeria, and Cupressus [the latter in shape only as they are not oppositely arranged]; and in the following description they will be named accordingly Taxodioid, Cryptomeroid and Cupressoid"'. (p. 94-95).

The accompanying figures illustrate these facts very clearly. Their figures (Plate III, 9 and IV, 1) show branchlets in which the leaves from the base upwards to the middle part are "cupressoid" while the foliage of the upper half is taxodioid or crypto-


Fig. 13. Glyptostrobus europaeus (A. T. Brongniart) O. Heer. A-I, foliage twigs ( $\times 2$ ). Moselund.
meroid. Z. Zalewska (1959) Plate IV, Fig. 1 and 2 has given excellent photographs of twigs of Glyptostrobus pensilis with markedly cryptomeroid leaves as well as photographs of young cones.
A. Henry and Marion McIntyre in summing up their results concerning the fossil Glyptostrobus have written as follows - "The Tertiary specimens are referable to one species, correctly named $G$. europaeus Heer. The material, however, can be sorted into two kinds. In one set, to which Heer at first limited his species G. europaeus, the branchlets often bear flowers and ripe cones, but have only Cupressoid foliage, thus corresponding to the winter stage of the living species in China. In another set of specimens the branches bear both Cupressoid and Cryptomeroid foliage, and must
have been blown off in the summer, when the trees were carrying their annual branchlets. They constitute G. Ungeri, Heer; but this name must be abandoned, as it indicates merely a stage of growth, and not a distinct species". (p. 100).

The leaves of the taxodioid type of the extant Glyptostrobus are commonly much narrower than the normal Taxodium leaf, scarcely more than 1 mm broad, and almost


Fig. 14. A-C, pollen grains of the Pityosporites type $(\times 250)$. Moselund. Glyptostrobus europaeus (A. T. Brongniart) O. Heer. D and E, cones drawn from casts, $F$ and $G$, foliage twigs. ( $D-G \times 3$ ). Moselund.
rhomboidal in transverse section. The Glyptostrobus ungeri O. Heer is characterised by similar narrow leaves and agrees with material from taxodioid branchlets obtained from the Botanical Museum of Copenhagen University, but according to R. Florin (1931, Taf. 10, Fig. A) similar foliage also occurs on Taxodium

In our fossil material branchlets with "cupressoid" leaves predominate. The Fig. 13, A to I show such branchlets while Fig. 14, F and G show other specimens with leaves of a slender form and more patent. Heterophyllous branchlets are rare; some specimens representing this type are illustrated in Fig. 15, A to C; but anatomical ve rification could not be obtained as the branchlets were found as imprints in the yellow part of the "gyttja" at Moselund and most of the leaf substance has been reduced to powder. The determination as Glyptostrobus might have remained doubtful if it had not been for the marked heterophylly on the same branchlet.

The ample supply of subepidermal prosenchyma is a very salient character of the leaf and has probably contributed to the commonly excellent state of preservation.

These elements have originally been rather thick-walled but the thickening layers have mostly dissolved, so that tracing them in the fossil material is often difficult. The prosenchyma is mostly developed on the under (abaxial) side of the leaf where it forms an almost continuous layer only interrupted by two rather broad, longitudinally stretched gaps under which the covering epidermis has stomata of the same type as those of the upper (adaxial) side.

The stomata on the upper side of the leaf are especially numerous just inside the margin where they form a broad band on either side from the base of the leaf to the apex as in the leaf of the Glyptostrobus pensilis figured by R. Florin (1931, Taf. 15).


Fig. 15. Glyptostrobus europaeus (A. T. Brongniart) O. Heer. Foliage twigs showing dimorphous leaves $(\times 2)$. Moselund. Mrs. E. Nordmann: del.

The type of the stomatal apparatus agrees completely with that of the recent Glyptostrobus (cf. R. Florin 1931, Taf. 14 and 15); the transfusion tissue also agrees. Intermingled with the small crystal cavities (the contents of which are dissolved) there occur markedly larger crystal cavities (R. Florin 1931, p. 362, Taf. 14, Fig. 7) especially in the epidermis of the abaxial side of the leaf in the recent as well as in the fossil Glyptostrobus. The tissue of the leaves is remarkably well preserved and by clearing the leaf substance with a dilute solution of sodium hypochlorite satisfactory preparations were obtained so that most of the branchlets drawn could be anatomically verified.

Cones of Glyptostrobus are found in the hardened lignitic clay at Moselund and in the state quarry at Fasterholt and occur also in the brown coals themselves (Fasterholt, Torvig and Gammel Ry). Even though damaged by compression and partly dissolved the cones are usually easily recognisable.

The photograph of Plate XV, K shows an exceptionally fine specimen from Fasterholt. The three partly split up cones each proceed from a short twig and the common axis is mostly preserved. The drawings of Fig. 14 D and E (Moselund) were executed from casts produced by filling out the cavity left in the matrix after the carbonized substance of the cones had been removed. This is the only way of studying the surface


Fig. 16. Glyptostroboxylon tenerum. N. Conwentz (G. Kraus). A-E and K, radial sections of rays (E, cross-fields from the late wood type). F. tangential section of ray. G and H, xylem parenchyma in tangential section. I and J, transverse sections of xylem parenchyma, showing the pitting of the horizontal walls. ( $\times 400$ ). Troldhede.
of the cone scales of our material since the cones always split when the matrix is removed as the bracts are distended and the clay penetrates between them thus preventing the intact cone from coming loose from the enclosing clay.

The cones are obovate to almost globular with somewhat outstanding scales when ripe. The scales have a cuneate basal part and in their upper portion they widen out in a rhomboidal semicircular part with a crenate margin and on the front there are furrows in continuation of the incisions of the margin. An upturned, transverse ridge on the escutcheon, extending in a small mucro, separates the upper part of the scale from the lower cuneate part.

Good figures of entire cones have been given by O. Heer (1855, Plates XIX and XX) and J. Velenovsky (1881, Plate I).

I refer the winged seeds shown in Plate VII, H and I to Glyptostrobus. As mentioned in the diagnosis given by P. Menzel (1900) the seeds of Glyptostrobus are unilaterally winged. The size and shape of the fossil corresponds well to his description, and finally I must mention that on the back side of an isolated cone scale there were impressions that correspond perfectly in shape and size with the fossil seeds. According to P. Menzel (1900) C. v. Ettingshausen gives figures of seeds of the fossil Glyptostrobus in his Fossile Flora von Schoenegg (Plate I, Fig. 40-68). This paper has not been accessible to me. P. Menzel states that C. v. Ettingshausen regards the fossil described and figure by O. Heer (1859, Plate IX, Fig. 1-6) as seeds of Glyptostrobus, and they correspond in shape to our seeds, but are somewhat larger. Anatomically our fossils agree very well with the seeds of the recent Glyptostrobus

Glyptostrobus europaeus (A. T. Brogniart) O. Heer extends throughout the whole of the Tertiary, including the Pliocene, in Europe and the Arctic (M. Staub 1887, A. Henry and M. McIntyre 1926).

Glyptostroboxylon tenerum (G. Kraus,) N. Conwentz 1882 (Glyptostrobus tener G. Kraus 1866).

Material referable to this species occurs as four samples from the Torvig quarry, Troldhede. The detailed structure is tolerably well preserved and the samples agree anatomically.

In the transversesection the growth rings are distinctly defined. The transition between the thin-walled tracheids of the early wood and the few cells thick late wood is rather abrupt. Resiniferous parenchyma occurs frequently, especially in the late wood and, as the early wood is not compressed, the thin-walled rays appear straight.

Radial sections show one to two rows of bordered pits; crassulae are frequent. The pitting of the cross-fields in the early wood appears to be of a rather mixed type differing somewhat from that commonly regarded as normal for the species: purely oëoporous throughout the whole of the early wood. This mode of pitting is only distinct in the cross-field of the first formed tracheids where it is typically developed with circular blind pits in the thin corresponding wall of the tracheid. (Fig. 16, A to D and K).

The rest of the crossfield pits are of a more or less elliptical shape, typically oculiporous in the late wood but most often showing a narrow margin. The tangential walls of the ray cells are thin, smooth, sometimes with a bead-like sculpture, or exhibiting 1 to 3 prominent thickenings. The horizontal walls are rather diffusely pored with the smooth bordering walls of the marginal cell rows quite thin. The resiniferous parenchyma has horizontal walls which commonly are smooth and finely pored, bead-like, and rarely with more prominent thickenings, in the latter case they approach the prevailing type in the wood of Taxodium.

Tangential section. Numerous, small, bordered pits form a rather characteristic feature on the tangential walls of the late wood tracheids, especially in the last developed tracheidal layer where the pits are of uniform size and only 8 to $11 \mu$ in diameter. The photograph $9(?)$ of Plate 22 of R. Kräusel (1919) illustrates this character very well. The rays were found to attain a height of up to 25 rows of cells. The small bordered pits on the tangential walls are often confluent (Plate XXII, A).

The structure of the ray cells and the resiniferous parenchyma is in accord with recent Glyptostrobus material. A difference occurs in the frequency and distribution of the oëopores (blind pits) on the radial walls of the ray cells; most commonly the oëoporous type is stated to dominate in the whole of the early wood and most published figures show this, but the Fig. 3, Plate 186 given by P. Greguss (1955) shows an example in which the oculiporous pitting dominates throughout the growth ring. The material is stated to be derived from "a fair-sized piece of a stem (Shanghai)". Whether this structural detail is the most common in the older axes is still an open question. There seems to be a certain relation between the type of the cross-field pitting and the thickness of the tracheidal wall as well as the diameter of the tracheids. A sample of wood of the recent Glyptostrobus from the Forest Department of Yale University, which according to the curve of the growth rings must have been taken from an axis of considerable thickness, shows the relations hitherto considered as normal.
B. Kubart (1924) and K. Rudolph (1935) have drawn attention to several difficulties in distingushing the wood of Taxodium and Glyptostrobus. In all the Glyptostrobus material examined the transverse wall of the resiniferous parenchyma, which is normally smooth, is often found intermingled with walls that show a bead-like thickening. But they admit that the thickenings in Glyptostrobus are commonly far less pronounced than in Taxodium, to which I would add also far more rare: "Da wären wohl noch zum Beispiel die Kreuzungsfeldtüpfel zu berücksichtigen gewesen, nach meinen Beobachtungen an rezentem Materiale erscheint mir aber die Unterscheidung der beiden Gattungen auf Grund der Kreuzungsfeldtüpfel gerade nicht immer gar so leicht" (K. Rudolph 1935). I would support this opinion. Z. Zalewska (1953, Figs. 8, 10 and 12) has figured transverse walls of resiniferous parenchyma with well pronounced thickenings, a character also found in my material (Fig. 16, G and H; I and J).

Axial parts with well preserved medulla and the first growth rings are unfortunately not represented in our fossil material. This part of the stem would probably exhibit several anatomical details of systematic value.

In the recent G. pensilis the first growth ring shows the radial and horizontal walls of the ray cells highly pitted (Fig. 12, B), the radial walls with pits ( 6 to $8 \mu$ ) of the oëoporous type. The marked pitting of the walls rapidly gives way to the normal structure of the mature wood. The medulla is composed of large, rather thin-walled and only slightly pored elements, intermingled with groups of the thick-walled scleroides pre-eminently developed in the persisting twigs (Plate XIX, A and C).

Glyptostroboxylon tenerum (G. Kraus) N. Conwentz is noted, according to R. Kräusel (1949), from several European deposits of Miocene to Pliocene age. The sediments from Turów (Poland) probably range from the Middle Oligocene to the Middle Miocene (Z. Zalewska 1953).

A sample of lignitic wood referable to Glyptostroboxylon, but showing a somewhat curious state of preservation, was collected by the late Mr. V. Milthers at Fiskbæk by Herning in 1936 . While most of the early wood has collapsed sporadic patches are almost unaltered (Plate XXII, C). The change from early to late wood is abrupt. In the tracheidal elements of the early wood there are 2 to 3 rows of bordered pits in the radial walls discernable under a reading glass in the photograph. In the late wood most of the tracheids show bordered tangential pits. Resiniferous parenchyma cells are common and often form tangential groups. The transition from well preserved early wood to the collapsed and pressed state can be followed at the tips of the tangentially stretched and unaltered groups of early wood elements.

In the radial section, cleared in a weak solution of sodium hypochlorite, the collapsed parts appear as composed of extremely altered, thin-walled elements, while in the unaltered parts the pit rows are found separated by distinct crassulae. The poring of the cross-field is distinctly glyptostroboid. The tangential section of the late wood is characterized by the numerous, quite small, bordered pits, and the transverse walls of the resiniferous parenchyma vary from smooth to beaded or occasionally knotted. The rays attain a height up to 35 rows of cells, most common are rays of 5 to 15 rows.

In these details the wood in question agrees very well with what is regarded as characteristic for Glyptostroboxylon, and I do not hesitate to refer it to this organo-genus.

## Cupressinoxylon callitroides $n$. sp.

Under this heading are described a few samples of fossil wood from the quarries at Troldhede. They differ somewhat in transverse section (Plate XXIII, B and C) but histologically they agree very well with each other, individual differences not being more accentuated than what occurs among other gymnospermous woods. The type which is figured in Plate XXIII, C is a transverse section which might represent the "root type" while that figured in Plate XXIII, B might be accepted as the corresponding "stem type" of the organo-species.

The "root type" is conspicuous for its well delimited growth rings, some rather broad but most of them narrow, consisting of only a few layers of both early and late wood with an abrupt transition.

In the "stem type", figured as B, there is a gradual transgression from the innermost part of the growth ring to its outer border. The tracheids of the early wood are somewhat more thick walled and their walls have undergone a more advanced disintegration of the thickening layers than the tracheids of the "root type".

In the transverse section the outline of the tracheids is roundish, most markedly in the "stem type". Resin containing elements appear thinner walled than the surrounding tracheids and are conspicuous by their dark contents. The rays are always uniseriate.

Plate XXIV, A represents a radial section through the "stem wood type" while Plate XXIV, B shows a radial section through the "root wood type".

In the longitudinal sections the resiniferous parenchyma with its thin and smooth transverse walls and brown resin drops is very conspicuous. The radial tracheidal walls show one, very rarely two, rows of bordered pits. As it appears from the radial section figured in the photograph Plate XXIV, A there is a marked difference between the bordered pits of the size which may be termed as normal ( 8 to $10 \mu$ in diameter) and those occurring here and there in the tracheids of the early wood, where they only attain a diameter of 4 to $5 \mu$. The last type appears mainly in the areas where the normal pitting is lacking. Especially in the tracheids of the early wood thin transverse septa are of common occurrence. They are provided with one, or a few, quite small bordered pits, visible in the transverse sections (Plate XXIII) under a reading glass.

The central black spot in most of the pits figured in Plate XXIV, A and B probably represents the outline of the torus; the aperture is quite small, scarcely exceeding $2 \mu$ in diameter. Crassulae are not visible. The rays are composed of thin-walled elements 20 to $24 \mu$ high in which the horizontal walls may or may not have a few scattered, unthickened parts forming slightly marked pits, and smooth tangential walls. Indentures are few and narrow. The pitting of the radial wall is very characteristic. It most commonly shows two to four blind pits only 4 to $6 \mu$ in diameter, but their number increase, especially in the early wood, to 6 or 7 and even more ( 8 or 9 are sometimes found). If there are 6 or 8 they are very regularly arranged in 3 or 4 horizontal rows. In the last case the cross-field is almost totally occupied by the borders of the blind pits; sometimes two neighbouring pits are confluent and show two extremely small apertures (Plate XXIV, C) a character also occurring in the small pits of the tracheidal wall (see above). The borders of the pits and their apertures are discernable with a reading glass in the plates. Frequently there are found ray cells in which the inner surface is entirely covered with small, densely set excrescences and thus attain a papillose appearance (Plate XXIV, C and Plate XXVI, C); sometimes these excrescences attain an almost thread-like shape filling up the lumen. Small papillae are also
commonly developed on the inner surface of the tracheidal wall giving it a very marked appearance (Plate XXVI, B). Most of the tracheids exhibit what looks like a fine granulation of the tertiary lamella. The separate granules are only perceptible under high magnification; in Plate XXVI, B and C they can be traced under a reading glass. Under low magnification this structure appears as a soft lustre of the inner surface, not unlike that of mother of pearl. Here and there the tracheidal wall shows a distinct structure of rather broad but only slightly accentuated spiral bands (Plate XXIV A and C, XXV, A).

The tangential section shows the generally rather low ( 1 to 6 storied) rays (Plate XXVI, A) but higher rays ( 12 to 18 stories) occur. Tangential bordered pits, somewhat smaller than those of normal size on the radial walls and here and there confluent, are locally numerous in the late wood.

## Diagnosis

Wood of a cupressoid gymnosperm representing both "root type" and "stem type". The two types show the usual anatomical differences in the structure of the growth rings but are otherwise quite similar. The outline of the tracheids is more or less markedly rounded in transverse section and resiniferous parenchyma is abundant. The tracheids are commonly devided by thin transverse septa, provided with one or a few, quite small bordered pits. Tracheidal walls of the early wood have one or rarely two rows of bordered pits differing greatly in size. The pits of the smaller type ( 4 to $6 \mu$ ) are confined to areas of the early wood where pits of the normal size are lacking on the radial walls. Bordered pits are numerous on the tangential walls of tracheids of the late wood. Rays uniseriate, 1 to 12 , most commonly 3 to 6 , cells high, elements thin walled with 4 to 6 , or up to 7 to 9 , minute blind pits on the radial walls; when numerous the pits are regularly arranged in 3 to 4 superposed rows, sometimes two neighbouring pits are confluent and show two extremely minute apertures. Horizontal walls are indistinctly pitted with indentures not very pronounced. The inner surface of ray cells and tracheids are often markedly verrucous, the tracheidal inner surface commonly exhibiting a more or less conspicuous, fine granulation of the terminal lamella, producing a soft nacreous lustre on the wall.

## Affinities

According to the relevant literature these fossils show a marked anatomical parallelism to the wood of some species of the recent genus Callitris constituting a genus comprising about 20 species. At the present time Callitris is only indigenous in Australia, Tasmania and New Caledonia. Besides the specific differences concerning foliage and shape and size of the cones there are also histological details in the xylotomy which are of systematic value.
E. J. Slyper (1933), on the basis of xylotomy, has divided the 17 Callitris species considered in his keys, into several groups, primarily based on the presence or absence of transverse bars on the inner surface of the tracheidal wall running over the bordered pits (pp. 406-408, "Bars of Kleeberg").

The first group is subdivided in two divisions, 41 a "Auf den Kreuzungsfeldern stehen zusammengesetzte Hoftüpfel mit zwei Poren" and 41 b "Keine zusammengesetzte Hoftüpfel mit zwei Poren', 41 a contains 7 species including the widespread $C$. robusta R. Brown and C. glauca R. Brown, and 41 b includes C. arnosa A. Gunn. and C. intertropica, Bentham.

The second group, (42, no "Bars of Kleeberg" running over the bordered pits) includes, besides species of Cupressus and Libocedrus also Widdringtonia, Actinostrobus and several (5) Callitris sp. The three last named genera are further characterized by the rare occurrence of bordered pits on the tangential walls of the tracheids.

No details are mentioned concerning the occurrence of the "zusammensetzte Hoftüpfel mit zwei Poren' (confluent pits) in the subdivisions of $42 ; 43 \mathrm{a}$ and b . According to my experience they occur also in Widdringtonia but are rare. In the group of the five Callitris species mentioned I could not demonstrate them in the investigated woods of C. oblonga L.-C. Marie Richard and C. rhomboidea R. Brown, so the basis of the division is probably applicable to the purpose.

According to these statements confluent pits with two apertures commonly occur in the group 41 a and are lacking or very rare in the subdivisions $41 \mathrm{~b}, 43 \mathrm{a}$ and b . There seems to be a contradiction between the characters set out in the paragraphs of E. J. Slyper, which cover the combinations found in the extant Callitris sp., and those found in our fossil: the absence of "Bars of Kleeberg" combined with the common presence of confluent pits.

The wide gap of time as well as the space of geographical distribution might have called for a deveropment of types in which another combination of these details was made possible. Fossil remains (foliage twigs and cones) referable to the Callitris type have not been demonstrated in the European or North American Tertiary. In English Eocene layers cones are found which may be referred to the related genus Tetraclinis.

The pittings of the cross-field closely resembles that of C. glauca, but it has been impossible to draw a parallel to extant species since material for a closer comparison was not at hand; only 3 to 4 mm thick twigs were available for investigation.

A spiral structure of the tracheidal wall, composed of rather broad bands, is present in several extant Callitris sp. P. Greguss (1967, Plate XLVI, Figs. 18 and 19) has figured this character, the presence of which in our fossil might support the validity of our referring this type to the genus. The structure described here of the inner lamella of the tracheids and ray cells is not unfamiliar in species of Callitris, but is notably more pronounced in the wood of some Widdringtonia sp.
P. Greguss (1967 p. 55) describes a sample of fossil wood under the name of(?) Callitroxylon. The very poor material has unforlunately not allowed a closer study, but the crowded and occasionally paired pittings, and also the presence of trace
able spirals might point towards the said author's Platyspiroxylon (Permian and Lower Liassic). As the locality is mentioned as Gant (Hungary) the geological age is recorded as Lower Eocene. This find claims some interest as the Platyspiroxylon type of fossil wood probably might be considered as related to the extant Callitris type (P. Greguss loc. cit.) and its presence in the Paleogene Tertiary would demonstrate the existence of such a type of gymnosperm at past times in the Northern Hemisphere. In fact details in the anatomical structure of our still younger fossil show certain characters pointing towards such ancestors, details which are only faintly present in the extant Callitris spp.


Fig. 17. Cupressinoxylon thujoides n.sp. A and B, parts of tracheids in radial, and C , in tangential section. $D$ and E, rays in tangential view. $F-J$, transverse wall of xylem parenchyma showing variations in the mode of pitting. K and L cross-field pitting in the early wood. $(\times 600)$. Troldhede State Quarry.

Cupressinoxylon thujoides n. sp.
Only one sample referable to this type has been found the State quarry, Troldhede). The condition of preservation is fairly good but the structural details of the tracheidal walls are somewhat obscured by the disintegration of the fibrillae of the thickening layers.

The transverse section exhibits a series of growth rings (Plate XXVII, A) with the early wood gradually transcending into the late wood. The texture is "fine grained" yet somewhat coarser than in C. biotoides (p. 59). Minute intercellular spaces are common, corresponding to the rounded outline of the tracheids. The radial and tangential walls of the elements composing the uniseriate rays are thin; the horizontal walls show here and there a row of simple pits.

Resin cells are rather rare and are evenly distributed in the growth ring.
A part of a radial section is reproduced as Plate XXVII, C. The bordered pits are arranged in only one row and attain a diameter of 12 to $13 \mu$, with a minute aperture. In the photograph the fine spiral pattern of the inner part of the tracheidal wall has obscured the bordered pits so that they are hardly recognisable. The Fig. 17, A and B show the proportions between the outline and aperture.

In the early wood especially the cross-field shows a type of pitting characteristically different from the common Cupressinoxyton type and approaching the taxodioidal type. Fig. 17, K and L show such cross-fields. The blind pits of the radial ray cell wall of the late wood are from almost circular to somewhat elliptical in outline and the border of the pit is rather narrow. The radial as well as the tangential walls of the ray cells are thin and without any sculpture; the horizontal walls are considerably thicker, scarcely pitted and provided with numerous and partly highly developed indentures.

Some rays, as they appear in the tangential section, are shown in Plate XXVII, B. They are usually low ( 1 to 4 cell rows) but they may attain a somewhat greater height, up to 8 stories of cells.

The Fig. 17, D and E figure some rays in which the horizontal cell wall is broken; the rupture occurring in the middle part of the wall indicating a marked difference compared with what is commonly found in the ray cells of Biota (compare the figures of rays of Thuja with those of Biota and C, biotoides in Figs. 18 and 19).

Fig. 17, C shows some bordered pits on the tangential walls of the tracheids; they measure 5 to $9 \mu$ in diameter and are consequently far smaller than those on the radial walls.

The transverse walls of the resiniferous parenchyma cells are locally thickened in a rather characteristic way (Fig. 17, F to J), a feature mentioned by A. S. Pierce (1937) for the recent Thuja spp. and here, as well as in our fossil, easily discernable under a high power objective.


Fig. 18. Cupressinoxylon biotoides nov. comb. A and B, parts of tracheids in radial and tangential section. $\mathrm{D}-\mathrm{H}$, view of rays in tangential section; in all the figures the ruptures in the horizontal walls fo the ray cells are conspicuous. C , K and L, cross-field pitting; K and L also show indentures. I and J, transverse walls of xylem parenchyma. M, transverse view of ray showing the fairly even distribution of simple pits in the horizontal wall. $(\times 600)$. Lystrupsminde.

## Diagnosis

A gymnospermous wood of the Cupressinoxylon type. Growth rings distinct with a gradual transition of the tracheidal elements from early to late wood. The tracheids in transverse section show a rounded outline and between them there are commonly occurring small intercellular spaces. Rays uniserial with the horizontal walls irregularly pitted. Interstitia numerous and well developed. Resiniferous parenchyma rather common with the horizontal walls distinctly, but irregularly, pitted. Bordered pits on the radial wall of the tracheids always in one row, 12 to $18 \mu$ in diameter, aperture small. The tangential wall of the late wood tracheids with scattered bordered pits, measuring 5 to $9 \mu$ in diameter. Rays 1 to 5 (8) cell rows high. In the cross-field of the early wood there are 1 to 4 elliptical, almost taxodioidal blind pits while the pitting of the late wood cross-field is normally cupressoidal. Radial and tangential walls of ray cells thin and the latter without sculpture.

## Affinities

According to the anatomical details our fossil may be referred to the genus Thuja and agrees especially well with $T$. occidentalis L. A specific correspondence to this species is, of course, impossible to demonstrate on the material available, so the name Cupressinoxylon thujoides is proposed as a suitable name for the fossil material. It seems that twigs referable to Thuja and Biota have not yet been anatomically confirmed.
Z. Zalewska records the presence of a Thuja sp. (T. cf. occidentalis L.) in the lignites of Turów (Aquitanian) and figures a cone and a supposed twig (Z. Zalewska 1960, Plate XV). In Table 11 (l.c.) the same author lists the occurrence of supposed fossil Thuja (and Biota) spp. in Poland and the adjacent territories.

Cupressinoxylon biotoides nov. comb. (Biota orientalis (L.) St. Endlicher var. miocenica W. Prill 1913)

Among the samples of fossil wood gathered from the lignite of the Lystrupsminde quarry a small piece (about $5 \times 3 \times 2 \mathrm{~cm}$ ) was conspicuous by its almost black colour and hardness. The anatomical details proved to be, for the greater part, perfectly preserved.

Plate XXVIII, A shows a photograph of a transverse section exhibiting tree growth rings. The elements of the early wood are collapsed, sometimes in such a way that the lumen forms a sand-glass shaped figure so that the apparently small lumina consequently only represent less than half the original size of the lumen of a tracheid. The transgression from early to late wood seems rather abrupt but, in fact, the elements do not differ much in thickness of the wall; evidently the wall material of the late wood tracheids has also here been more resistant. Outwards the elements of the late wood gradually diminish only slightly in size. As a whole the wood shows an uncommonly even and densely fine texture. In transverse section all the tracheids show a
decidedly rounded outline. The rays are uniseriate. Small intercellular spaces between the elements are not uncommon and are especially often found between the very thin radial walls of the ray cells and the bordering tracheids. The rather thick, horizontal wall of the ray cell shows a low, radial furrow, most often extending the length of the cell, in which simple pits are common and evenly distributed (Fig. 18, M). Resin cells occur especially in the outer part of the growth ring where they are discernible by their black contents.

A part of a radial section is reproduced in Plate XXVIII, B. A very conspicuous feature is the regular spiral pattern of the innermost part of the tracheidal wall in the larger part of the section and is especially well developed in the middle and outer part of the late wood. The dark coloured spirals probably represent a special structure of the innermost part of the thickening lamella of the tracheidal wall. This structure is made more conspicuous through partial destruction of the terminal lamellae on fossilization and is also locally seen in the wood of recent Cupressaceae (e.g. Biota). It is not to be confused with the more steeply inclined spirals so commonly observed in all types of gymnospermous wood where it represents a texture produced by disintegration of the thickening layers. The tiny spirals in Biota show double refraction and under polarized light and crossed nicols appear as sharply discernible light greyish bands.

The bordered pits on the radial walls of the tracheids are always arranged in one row. Their diameter attains a value of 10 to $12 \mu$ with an extremely minute aperture measuring only 1.5 to $2 \mu$. In the photograph Plate XXVIII, B the pits are mostly hidden by the spirals. Fig. 18, A shows the proportions between porus and the outline. The "tailed" appearance of the blind pits of the rays is due to intervening spaces in the first formed thickening lamellae of the bordering tracheids. The pits of the crossfields are typically cupressoid. They are in fact circular or almost so with a diameter of 5 to $6 \mu$. Interstitia in the horizontal walls of the ray cells are rather common (Fig. 18, K and L ). In places where the horizontal wall crosses the vertical intercellular spaces between the tracheids bordering a ray four minute dots forming a small rhombic figure are sometimes perceptible (Fig. 18, C). The horizontal walls of the rays appear distinctly pored (Fig. 18, C and M) and also the transverse walls of the resiniferous parenchyma show a fine and irregular poring (Fig. 18, I and J).

In tangential section the spiral pattern of the inner surface of the tracheids is of a very striking appearance (Plate XXVIII, C). On the tangential walls of the tracheids bordered pits of the same type and almost the same size as those of the radial walls are rather common (Fig. 18, B). The proportions between the aperture and the diameter of the pits in the photograph (Plate XXVIII, C) is more conspicuous than in that of the radial section. The rays attain a height of 7 rows of cells. The form of the ray cells is somewhat variable, most often, especially in those of only a few cell rows, axially elongated. Some important peculiarities are not discernible in the photograph but the drawings make up for this disadvantage. In the Fig. 18, D to H some rays are shown in tangential view. In the middle part of the ray cell, where it
communicates with the adjacent tracheids through the blind pits, the wall is rather thin, increasing in thickness towards the upper and lower parts of the cell where it passes into the thick horizontal walls. A rupture of the wall is very common and is always effected in such a manner that the connection between the horizontal and the radial walls is broken in the coterminous parts in such a way that the horizontal wall shows


Fig. 19. Biota orientalis (L.) St. Endlicher. A, B and D, rays in tangential section. C and G, radial section of rays showing the cross-field pitting and in G indentures. E, radial and F, tangential sections of tracheides. $(\times 600)$. Materiel from the Botanical Garden of the University, Copenhagen.
a blunt, regular wedge while part of the radial wall has a corresponding triangular cavity (Fig. 18, D to H). The wall at his place is obviously liable to fracture due to the presence of the two (or two pairs) of divergent pits departing from the very small intercellular space between the corresponding ray cell walls and the bordering tracheids; one (or one pair) is pointing upward and the other downward, crossing, but not perforating, the thickened part of the adjacent ray cells. The pits are also sometimes discernible in the radial sections where they form the small, diaphanous points mentioned above (Fig. 18, C), but owing to the darkness of the medium they were often difficult to ascertain.

## Diagnosis

A gymnospermous wood of the Cupressinoxylon type. Growth rings distinct. In transverse section the tracheids show a rounded outline with small intercellular spaces notably common between rays and the bordering tracheids. Rays uniseriate with the horizontal walls distinctly pitted. Interstitia numerous and well developed. Resiniferous parenchyma rather common with transverse walls thin and faintly and irregularly pitted. In the tracheids the bordered pits on the radial walls are always in one row, 10 to $12 \mu$ in diameter with a very small aperture, while on the tangential walls the bordered pits are scattered but are almost of the same size and type as those on the radial walls. Rays 1 to 7 cell rows high with 1 to 2 circular blind pits in each crossfield. In the ray cells the transition between the thin radial walls and the horizontal wall is formed by a markedly thickened part which is often traversed by minute pits running from the triangular intercellular space between ray and tracheid through the thickened layers of the ray cell as far as the terminal lamella.

## Affinities

According to Pilger (1926) the genus Thuja is subdivided into two sections: a) Euthuja, comprising three species including Thuja occidentalis, and b) Biota, only represented by a single species, Thuja orientalis L., which is most conveniently considered as a separate genus (Biota orientalis (L.) St. Endlicher). According to the keys for the determination of recent and fossil gymnospermous woods by W. Gothan (1905), W. Prill (1913), E. J. Slyper (1933), A. S. Peirce 1937) and P. Greguss (1955) only Biota can be considered as offering a recent analogue to the fossil described here. In fact, W. Prill has established (1.c. p. 52) a species of fossil wood under the name of Biota orientalis (L.) St. Endlicher var. miocenica based mainly on the curious mode of poring in the thickened part of the wall of the ray cell. He recognized the same character ("umgewendete Markstrahlintercellularen") in the fossil as in the living Biota orientalis while it is lacking in the other species of cupressoid wood which he examined, including Thuja occidentalis. His description of the fossil wood is short and incomplete, without figures, and is insufficient for the foundation of a variety of a recent species which is not otherwise known as a fossil. Yet, probably, he is right to refer his Tertiary fossil wood from Friendorf near Bonn to the Biota subdivision of Thuja.

While the pits of the radial walls of the ray cells in Biota orientalis remain almost circular throughout the growth ring, in the early wood of $T$. occidentalis they appear more or less elliptical in outline. This character is accepted as diagnostic by all the authors. A character which is very characteristic for Biota is the close agreement in size of the bordered pits on the radial and tangential walls of the tracheids while in Thuja they follow what is usual in gymnospermous wood, viz. they are notably smaller on the tangential than on the radial walls.

A paper published by F. Hollendonner (1912) with the special aim of giving an exact anatomical distinction between the wood of Thuja orientalis (Biota) and Thuja
occidentalis is rich in details and is accompanied by excellent figures. According to this paper the main differences may be summed up thus: in Biota the outline of the blind pits is circular and extremely small ( 1.5 to $2 \mu$ ), while in Thuja occidentalis it is elliptical with the longer axis extended horizontally and notably larger ( 3 to $5 \mu$ ). On the special mode of pitting of the ray he states: "Es gibt ausserdem noch einen Unterschied in den zwischen Markstrahlzellen und Längstracheiden auftretenden Intercellularräumen, welche im Tangentialschnitt bei Thuja dreieckig sind - bei Biota aber gehen aus dem Intercellularraum zwei gabelig verläufende Kanälchen gegen den Hohlraum der übereinander stehenden parenchymatischen Markstrahlenzellen und erstrecken sich, die mächtige sekundäre Lamelle (hier) durchstreckend, bis zur tertiären Lamelle". In our Fig. 19, B and D this structure is demonstrated for Biota orientalis. In Thuja occidentalis, where the ray cells are almost uniformly thin walled, no such canals are found. The character is mentioned by P. Greguss (1955) but is not claimed as being strictly confined to Biota orientalis. In fact it also occurs, but more rarely, in the wood of Thuja standischii. As W. Prill has already pointed out, this special feature causes a certain weak point in the structure of the horizontal wall within the ray cells and thus often gives rise to ruptures in fossil material during the preparation of slides for microscopy. My experiences confirm the statements made by him.

The fossil described here seems to agree very well with the wood of the living Biota orientalis. Specific agreement with the recent analogue is, of course, impossible to demonstrate so the name Cupressinoxylon biotoides is suggested. The anatomical peculiarities of the recent genus Biota seem to be so well differentiated that the establishment of a fossil analogue organo-genus migtet be justifiable.


Fig. 20. Sequoia couttsiae O. Heer. H. V. Vestergaard del. ¹/1 Moselund, 1919.

## Selected Bibliography

Banke Rasmussen, L. (1961): De miocæne Formationer i Danmark. Danmarks geolog. Undersøgelse IV. Række, Bd. 4. No. 5.
Bailey, I. W. and Anna F. Faull (1934): Structural variability in the Redwood, Sequoia sempervirens, and its significance in the identification of fossil woods. (The cambium and its derivative tissues. IX). Journal of the Arnold Arboretum. Harvard University. Vol. XV. 1934.

Bandulska, Helena (1923): A preliminary paper on the cuticular structure of certain Dicotyledonous and Coniferous leaves from the Middle Eocene flora from Bournemouth. Journal of the Linnean Society. Bot. Vol. XLVI. London.
Baumberger, E. und P. Menzel (1914): Beitrag zur Kenntnis der Tertiärflora aus dem Gebiete der Vierwaldstätter Sees. Mémoires de la Société Paléontologique Suisse. Vol. XI. Genève.
Beust, F. (1885): Untersuchung über fossile Hölzer aus Gronland. Dissertation. Zürich. Neue Denkschriften der allgemeinen Schweizerischen Gesellschaft der gesammten Naturwissenschaften. Bd. XXIX.
Buchholz, J. T. (1939): The generic segregation of the Sequoias. American Journal of Botany. Vol. 26. Pag. 535. Baltimore.
Chandler, M. E. J. (1922): Sequoia Couttsiae Heer, at Hordle, Hants: A study of the characters which serve to distinguish Sequoia from Athrotaxis. Annals of Botany. Vol. XXXVI. Pag. 385 London.
Chaney, R. W. (1930) : A Sequoia forest of Tertiary age on St. Lawrence Island. Science. New Series. Vol. LXXII. New York.
Chaney, R. W. (1951): A Revision of fossil Sequoia and Taxodium in Western North America based on the recent discovery of Metasequoia. Transactions of the American Philosophical Society. New Series. Vol. 40. Part 3. Philadelphia.
Committee on Nomenclature, International Association of Wood Anatomists 1933: Glossary of terms used in describing woods. Tropical Woods. 36.
Conwentz, H. (1882) : Fossile Hölzer aus der Sammlung der Königl. geologischen Landesanstalt zu Berlin. Jahrbuch der Königl. Preussischen geologischen Landesanstalt XIV. und Bergakademi für 1881.
Dallimore, W. and A. Bruce Jackson (1948): A Handbook of Coniferae including Ginkgoacea. 4. Ed. Revised by S. G. Harrison 1966. London.
Dotzler, Auguste (1938): Zur Kenntnis der Oligozänflora des Bayerischen Alpenvorlandes. Palaeontographica, Abt. B. Bd. LXXXIII. Stuttgart.
Doyle, Mary N. and J. Doyle (1948-50): Pith structure in Conifers. I. Taxodiaceae. Proceedings of the Royal Irish Academy of Science. Sect. B. Vol. 52. Dublin.
Endô, S. (1933): A Neogene species of Sequoia from Japan. Botanical Gazette. Vol. 94. Chicago.
Endô, S. (1936): Note on new fossil Species of Sequoia from the Far East. Proceedings of the Imperial Academy of Japan. Vol. XII. Tokyo.

Ettingshausen, C. v. (1855): Die tertiäre Flora von Häring in Tirol. Abhandl. der Kaiserl. Königl. geologischen Reichsanstalt Wien. Bd. II. Abt. 2. No. 2. Wien.
Florin, R. (1922): Über das Vorkommen von Sciadopitys im Deutschen Tertiär. Senckenbergiana. Bd. 4. Heft 1/2.
Florin, R. (1922): On the geological history of the Sciadopitineae - A preliminary note. Svensk Botanisk Tidskrift. Bd. 16. Hefte 2.
Florin, R. (1926): Waren Eupodecarpeen (Koniferen) in der alttertiären Flora Europas vertreten oder nicht. Senckenbergiana. Bd. VIII. Heft. 2. Frankfurt am Main.
Florin, R. (1931): Untersuchungen zur Stammesgeschichte der Coniferales und Gentales. I. Morphologie der Epidermisstructur der Assimilationsorgane bei den rezenten Coniferen. Kungl. Svenska Vetenskapsakademiens Handlingar. Tredie Serien. Bd. 10. Nr. 1.
Florin, R. (1940): Notes on the past geographical distribution of the genus Amentotaxus Pilger (Coniferales). Svensk Botanisk Tidskrift. Bd. 34. Hefte 2.
Florin, R. (1963): The Distribution of Conifer and Taxad Genera in Time and Space. Acta Horti Bergiani. Bd. 20. Nr. 4. Uppsala.
Friedrich, P. (1883): Beiträge zur Kenntnis der Tertiärflora der Provinz Sachsen. Abhandlungen zur geologischen Spezialkarte von Preussen und den Thüringischen Staaten. Bd. IV. Heft. 3. Königl. Preuss. geolog. Landesanstalt. Berlin. Text and Atlas.
Gardner, J. S. (1883-1886) : A Monograph of the British Eocene Flora. Vol. II. Gymnospermae. Palaeontographical Society Publications. London.
Gothan, W. (1905) : Zur Anatomie lebender und fossiler Gymnospermen-Hölzer. Königl. Preuss. geolog. Landesanstalt u. Bergakademie. Neue Folge. Heft XLIV. Berlin.
Gothan, W. (1906): Die fossilen Coniferenhölzer v. Senftenberg. Abhandlungen der Königl. Preuss. geolog. Landesanstalt (Neue Folge) Heft XLVI. Berlin.
Gothan, W. (1909): Über Braunkohlenhölzer des rheinischen Tertiärs. Jahrbuch der Königl. Preuss. geolog. Landesanstalt. Bd. XXX. Teil I. Heft. 3. Berlin.
Gothan, W. (1936) : Nochmals die "Graskohle": Nadeln der Schirmtanne (Sciadopitys). Braunkohle 1936. Heft. 40. Düsseldorf.
Greguss, P. (1950): Xylotomischer Bestimmungsschlüssel der heute lebender Konifern-Gattungen. Acta Biologica Acad. Scient. Hungarica. I. Budapest.
Greguss, P. (1955): Identification of living Gymnosperms on the basis of xylotomy. Budapest.
Greguss, P. (1967): Fossil Gymnosperm Woods in Hungary from the Permian to the Pliocene. Budapest.
Göppert, N. R. (1842) : Über die fossile Flora der Gypsformation zur Derschel in Oberschlesien. Verhandlungen der Kaiserlichen Leopoldinisch-Carolinischen Akademie der Naturforscher. Tom. XIX. Part II. Breslau und Bonn.
Göppert, N. R. (1850): Monographie der fossilen Coniferen. Natuurkundige Verhandelingen van de Hollandsche Maatschappij der Wetenschappen te Haarlem. II. Versameling. 6. Deel. Leiden.
Hartz, N. (1909): Bidrag til Danmarks tertiære og diluviale Flora. Danmarks geol. Undersøgelse. II. Række. Nr. 20. København.
Herr, O. (1855-61): Flora Tertiaria Helvetica. I. 1855. II. 1856. III. 1859. Winterthur.
Heer, O. (1863): On the Fossil Flora of Bovey-Tracy. Philosophical Transactions of the Royal Society of London for the Year 1862. Vol. 152. London.
Heer, O. (1868): Flora fossilia arctica I. Zürich.
Heer, O. (1869) : Miocene baltische Flora. Beiträge zur Naturkunde Preussens. 2. Herausgegeben von der Königl. physikalisch-ökonomischen Gesellschaft zu Königsberg. Königsberg.
Heer, O. (1870): Über die Braunkohlenpflanzen von Bornstedt. Abhandlungen der Naturforschenden Gesellschaft zu Halle. Bd. XI. Halle.
Heer, O. (1883): Flora fossilis Gronlandica I-II. Zürich.

Henry, A. and Marion McIntyke (1926): The swamp cypresses, Glyptostrobus of China and Taxodium of America with notes on allied genera. Proceedings of the Royal Irish Academy. Vol. 37. Sect. B. No. 13. Dublin.
Hofmann, E. (1927): Vergleichende anatomische Untersuchungen an rezenten Pneumatophoren von Taxodium distichum sowie an fossilen Pneumatophoren aus Parschlug in Steiermark. Berg- und Hüttenmännisches Jahrbuch. Bd. 75. Nr. 3.
Hollendonner, F. (1912) : Über die histologische Unterscheidung des Holzes von Biota orientalis Endl. und Thuja occidentalis L. Zeitschrift der Botanischen Section der Königl. Ungarischen Naturwissenschaft. Gesellschaft. Bd. XI. Nr. 2.
Hui-Lin Li (1952): The genus Amentotaxus. Journal of the Arnold Arboretum. Vol. 33. Pag. 192-198. Cambridge, Mass., U.S.A.
Ingwersen, Peter (1954) : Some Microfossils from the Danish Late-Tertiary Lignites. Danmarks geol. Undersogelse. Skrifter II. Række. Nr. 80. Kobenhavn.
Jeffrey, E. C. (1903): The comparative anatomy and phylogeny of the Coniferales. Part I. The Genus Sequoia. Memoirs of the Boston Society of Natural History. Vol. V. Boston.
Jurasky, K. A. (1928): Paläobotanische Braunkohlen Studien. III. Ein neuer Fund von Sciadopitys in der Braunkohle (Sciadopityoxylon Wettsteinii n.sp.) Senckenbergiana. Bd. 10. Nr. 6. Frankfurt a.M.
Kirchheimer, F. (1950): Das Vorkommen von Sciadopitys im mitteleuropäischen Tertiär und die Bedeutung ihres Pollens für die Stratigraphie der Braunkohlenschichten. Neues Jahrbuch für Geologie und Paläontologie. Heft 2. Stuttgart.
Kobbe, F. (1887): Über die foss. Hölzer der Mecklenburger Braunkohle. Dissertation. Rostock.
Kräusel, R. (1913): Beiträge zur Kenntnis der Hölzer aus den Schlesischen Braunkohlen. Teil I. (Dissertation) Botanisches Centralblatt. Bd. CXXIII. Jena.
Kräusel. R. (H. Reimann, E. Reichenbach, P. Meyer und W. Prill) (1919): Die Pflanzen des Schlesischens Tertiärs (Braunkohlenhölzer. Pag. 191). Jahrbuch der Preussischen geol. Landesanstalt für 1917. Bd. XXXVIII. Teil. II. Heft 1-2. Berlin.
Kräusel, R. (1919): Die fossilen Koniferen hölzer, (unter Ausschluss von Araucarioxylon Kraus). Palaeontographica. Abt. B. Bd. LXII. Stuttgart. Nachtrag: Senckenbergiana. Bd. 2. 1920. Frankfurt a.M.
Kräusel, R. (1920): Nachträge zur Tertiärflora Schlesiens. II. Braunkohlenhölzer. Jahrbuch der Preussischen geolog. Landesanstalt für 1918. Bd. XXXIX. Teil I. Heft. 3. Berlin.
Kräusel, R. und G. Schönfeld (1924): Fossile Hölzer aus der Braunkohle von Süd-Limburg. Abh. der Senckenbergischen Naturforsch. Gesellschaft. Bd. 38. Heft 3. Frankfurt a. M.
Kräusel, R. (1935): Palaeobot. Notizen. XX. Die Koniferengattung Amentotaxus Pilg. im Tertiär der Wetterau. Senckenbergiana. Bd. 17. Nr. 3/4. Frankfurt a.M.
Kräusel, R. (1949): Die fossilen Koniferen-Hölzer (unter Ausschluss von Araucarioxylon Kraus). II. Teil. Kritische Untersuchungen zur Diagnostik lebender und fossiler Koniferenhölzer. Palaeontographica. Abt. B. Bd. LXXXIX. Stuttgart.
Kraus, A. (1866): Mikroskopische Untersuchungen über den Bau lebender und vorweltlicher Nadelhölzer. Würzburger Naturwissenschaftliche Zeitschrift. Bd. VI. Würzburg.
Krystofovich, A. (1929): Evolution of the Tertiary Flora of Asia. New Phytologist. Vol. 28. London.

Kubart, B. (1924): Einige Bemerkungen über den diagnostischen Wert des Markkörpers bei Koniferenhölzern. Berichte der Deutschen Botanischen Gesellschaft. Bd. 42. Berlin.
Lesquereux, L. (1878): Contributions to the Fossil Flora of the Western Territories. Part II. Report of the U.S.A. Geological Survey of the Territories. Botany VII. Washington.
Lingelsheim, A. (1908): Über die Braunkohlenhölzer von Saarau. 85. Jahresbericht der Schlesischen Gesellschaft für Vaterländische Cultur. Bd. LXXXV. Abt. II. Naturwissenschaften. Zoolog. Bot. Section. Pag. 24-36. Breslau.

Linnell, T. (1938) : Om tertiära vedrester av Sequoia typ i nordöstra Skånes Kvartärformation. Sveriges Geologiska Undersökning. Ser. C. Nr. 406. Arbok 31. Stockholm.
Lotsy, J. P. (1911): Vorträge über Botanische Stammesgeschichte etc. Bd. III. Cormophyta Siphonogamia I. Jena.
Mathiesen, F. J. (1965): Palaeobotanical Investigations into some Cormophytic Macrofossils from the Neogene Tertiary Lignites of Central Jutland. Kgl. Danske Videnskabernes Selskab. Biolog. Skrifter. Bd. 17 no. 3. Copenhagen.
Menzel, P. (1900): Die Gymnospermen der nordböhmischen Braunkohlenformation. Abhandlungen der naturwissenschaftlichen Gesellschaft Isis in Dresden. 1900. Theil I-II.
Menzel, P. (1913): Beiträge zur Flora der Niederrheinischen Braunkohlenformation. Jahrbuch der Königl. Preussischen geolog. Landesanstalt. 34. Teil 1. Berlin.
Phillips, E. W. J. (1941) The Indentification of Coniferous Woods by their Microscopic structure. Journal of the Linnean Scoiety, Botany. Vol. 52. London.
Pierce, A. S. (1935): Anatomy of the xylem of Sciadopitys. American Journal of Botany. Vol. 22. Baltimore.
Peirce, A. S. (1936): Anatomical interrelationships of the Taxodiaceae. Tropical Woods. No. 46. Yale University. School of Forestry.

Peirce, A. S. (1937): Systematic Anatomy of the woods of the Cupressaceae. Tropical Woods. No. 49. Yale University. School of Forestry.
Pilger, R. (1903): Taxaceae. A. Engler: Das Pflanzenreich. IV. 5. Leipzig.
Pilger, R. (1926): Gymnospermae. A. Engler und K. Prantl: Die natürlichen Pflanzenfamilien Bd. 13.
Prill, W. (1913): Beiträge zur Kenntnis schlesischer Braunkohlenhölzer. II. Teil. Dissertation. Breslau.
Radais, M. (1894): Contribution à l'étude de l'anatomie comparée du fruit des conifères. Annales des Sciences Naturelles, Botanique. Sér. 7. Tom. 19. Pag. 165-368. Paris.
Regnéll, Gerhard (1940): Et nytt fynd av tertiär ved i Södra Skåne. Kgl. Fysiographiska Sällskapets i Lund Förhandlingar. Bd. 10. Nr. 11. 1939-1940. Pag. 123-127. Lund.
Reid, Clement and Eleanor M. Reid (1910): The lignites of Bovey Tracey. Philosophical Transactions of the Royal Society of London. Series B. Vol. 201. London.
Robertson, Agnes (1907): The Taxodieae; a phylogenetic study. New Phytologist. Vol. VI. London.
Rudolph, Karl (1935): Microfloristische Untersuchungen tertiärer Ablagerungen im nördlichen Böhmen. Beihefte zum Botanischen Centralblatt. Bd. LIV. Abt. B. Dresden.
Saporta, G. de (1862-73): Études sur les végétaux du Sud-Est de la France à l'époque tertiaire. Annales des Sciences Naturelles. Botanique IV. Sér. Tome XVI. 1862. IV. Sér. Tome XVII. 1862. V. Sér. Tome III. 1865. V. Sér. Tome IV. 1865. V. Sér. Tome IX. V. Sér. 1867. Tome XVII. 1873. Paris. In the V. Sér. Tome III. 1865 are described and figured foliag twigs and cones of Taxodium and Sequoia from Armissan.
Saxton, W. T. (1910): Notes on the anatomy of Widdringtonia and Callitris. South African Journal of Science. Pag. 282. Cape Town.
Schenk, A. (1869): Über einige in der Braunkohle Sachsens vorkommende Pflanzenreste. Botanische Zeitung. 27. Jahrgang. Leipzig.
Schimper, W. Ph. (1869-1874): Traité de Paléontologie végétale ou la flore du monde primitif dans ses rapports avec les formations géologiques et la flore du monde actuel. Vol. II. 1870. Conifères. Pag. 227-385. Paris. + Atlas.

Schimper, W. Ph. und A. Schenk (1890): Abt. II. Paläophytologie: K. A. Zittel: Handbuch der Paläontologie. München und Leipzig.
Schnarf, K. (1937): Anatomie der Gymnospermen-Samen. K. Linsbauer: Handbuch der Pflanzenanatomie. II. Abt. Bd. X. 1. Berlin.

Schröter, C. (1880): Untersuchung über fossile Hölzer aus der arctischen Zone. (O. Heer: Flora fossilis arctica VI. 1 and 2. Zürich 1880). Dissertation.
Schwartz, O. and Heinz Weide (1962): Systematische Revision der Gattung Sequoia. Feddes Repertorium. Vol. 66. Berlin.
Schönfeld, G. (1955): Metasequoia in der westdeutschen Braunkohle. Senckenbergiana. Bd. 36. Heft 5-6. Pag. 389-399. Frankfurt a.M.

Seward, A. C. (1919): Fossil Plants, Vol. IV. Ginkgoales, Coniferales, Gnetales. Cambridge.
Shaw, W. R. (1896): Contribution to the life-history of Sequoia sempervirens. Botanical Gazette. Vol. XXI. Chicago.
Slyper, E. J. (1933): Bestimmungstabelle für rezente und fossile Coniferenhölzer nach mikroskopischen Merkmalen nach Angaben in der Litteratur zusammengestellt. Recuil des Travaux Botanique Néerlandais. Vol. XXX. Amsterdam.
Staub, M. (1887): Die Aquitanische Flora des Zsilthales im Comitate Hunyad. Mittheilungen aus dem Jahrbuch der Königl. ungarischen geolog. Anstalt. Bd. VII. Heft 6. Budapest.
Steinböck, H. (1926): Über den anatomischen Bau des Markkörpers einiger Coniferen. Österreichische Botanische Zeitschrift. Bd. 75. 1926. Wien.
Sternberg, K. von (1821-1838): Versuch einer geognostisch-botanischen Flora der Vorwelt. I-VI. Leipzig und Praha.
Stockmans, F. et Y. Willière $(1934,1936)$ : Notes sur des bois fossiles récoltées en Belgique. I, II. Bulletin de Musée royale d’Histoire naturelle de Belgique. Tome X. Nr. 11 et 30. Bruxelles.
Takamatsu, M. (1929): Fossile Koniferenhölzer aus Sendai-Tertiär. I. Science Reports Tohoku Imperial University, 4th Series (Biology). 55. p. 333-342. Tokyo.
Thiergart, F. (1940): Die Sciadopityszone und der Sciadopitys. Braunkohle. Jahrg. V. Nr. 153. Düsseldorf.
Unger, Fr. (1847): Chloris protogæa. Beiträge zur Flora der Vorwelt. Leipzig.
Unger, Fr. (1861-1866): Sylloge Plantarum fossilium. Sammlung fossiler Pflanzen, besonders aus der Tertiär-Formation. Pugillus primus, secundus et tertius. Denkschriften der Kaiserl. Akademie der Wissenschaften. Mathem.-Naturwiss. Classe. Bd. XIX (1861). Bd. XXII (1864). Bd. XXV (1866). Wien.

Vaupell, Chr. (1853): En botanisk Undersøgelse af det fossile Træ, der findes i Leer- og Sandlagene i Danmark og af Havet opkastes med Ravet paa de Danske Kyster. Manuscript and Plates in the Library of the Bot. Museum. Copenhagen. Text published by N. Hartz in the Meddelelser fra Dansk geologisk Forening. Nr. 12. Pag. 43-64 1906.

Velenovsky, J. (1881): Die Flora aus den ausgebrannten tertiären Letten von Vršovic bei Laun. Abhandlungen der Königl. Böhmischen Gesellschaft der Wissenschaften. VI. Folge 11. Band. Mathem.-Naturwiss. Classe nr. 1. Praha.

Weyland, H. (1937): Beiträge zur' rheinischen Tertiärflora, II. Palaeontographica Abl. B. Bd. LXXX. Abl. 13. Stuttgart.

Walton, J. (1927): On some fossil woods of Mesozoic and Tertiary age from the Arctic zone. Annals of Botany. Vol. 41. London.
Wieler, A. (1940): Die Bedeutung der Innenhaut für die Zelle und die Structur der secundären Verdickungsschichten. Protoplasma. Bd. 34. Wien.
Witusek, N. (1941): Über fossile Hölzer aus dem Egerer Tertiärbecken mit vergl. Untersuchung zur Erkenntnis der Hölzer lebender Taxodiueen. Lotos. Bd. 87. (1939-40).
Yasur, K. (1917): A fossil wood of Sequoia from the Tertiary of Japan. Annals of Botany. Vol. 31. Pag. 101-104. London.
Zalewska, Zofia (1953): Tertiary remains of fossil wood from Turów on the Lusatian Neisse. Pt. I. Acta Geologica Polonica. Vol. III. Nr. 4. Pag. 481-543. Warszawa.

Zalewska, Zofia (1955): Tertiary remains of fossil wood from Turów on the Lusatian Neisse. Pt. II. Acta Geologica Polonica. Vol. V. Nr. 2. Pag. 277-304. Warszawa.
Zalewska, Zofia (1959): The fossil Flora of Turów near Bogatynia (II) 1. Coniferae, Taxodiaceae. Warszawa. Museum Ziemi Publications.
Zalewska, Zofia (1960): Coniferae. Taxaceae, Podocarpaceae, Pinaceae, Taxodiaceae, Cupressaceae. The fossil Flora of Turów near Bogatynia. II. Pt. 2. Pag. 19-49 and 93-102. Systematic description of plant remains. Warszawa. Museum Ziemi Publications.
Ødum, H. og Werner Christensen (1936): Danske Grundvandstyper og deres geologiske Optræden. Danmarks Geologiske Undersøgelse. III Række. Nr. 20. København.

## CORRIGENDA

Plate II. radial sections. Read: longitudinal sections.
Plate V. Pinus palaeostrobusoo. Heer. Read: Pinus palaeostrobus. O. Heer.
Plate IX. (A and $\mathrm{B} \times 40, \mathrm{C}$ and $\mathrm{D} \times 175$ ). Read: $(\mathrm{A}$ and $\mathrm{D} \times 40, \mathrm{~B} \times 60$ and $\mathrm{C} \times 175$ ).
Plate XI. langential. Read: tangential.
Plate XII. langential. Read: tangential.
Plate XIX. thisk. Read: thick.

PLATES

Plate I
Taxoxylon amentotaxoides n.sp. A and C, transverse sections. B, tangential section. (A $\times 40, \mathrm{~B}$ and $\mathrm{C} \times 175$ ). Salten.


Plate II
Taxoxylon amentotaxoides n.sp. A and B, radial sections showing the spiral thickenings of the tracheidal wall. $(\times 175)$. Salten.


Plate III
Saxegothaeoxylon miocenicum n . sp. A and B, transverse sections. (A $\times 40, \mathrm{~B} \times 175$ ). Torvig State Quarry.


## Plate IV

Saxegothaeoxylon miocenicum n.sp. A. transverse section. B, D and E, longitudinal sections of tracheides in various stages of deformation and dissolution of the thickening layers of the wall. C, part of a radial section which shows the cross-field pitting and the pits of the horizontal walls of the ray cells. ( $\times 175$ ). Torvig State Quarry.


Plate V
Pinuxylon sp. cf. P. paxii R. Kräusel. A, transverse section. B, tangential and C, radial sections. $(\times 175)$. Torvig State Quarry.
Pinus palaeostrobusoo. Heer. D, a dwarf shoot which has carried five needles $(\times 3)$. Fasterholt.

PL. V



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Plate VI
Sciadopilyoxylon wettsteinii. K. A. Jurasky. A, transverse section. B, radial and C, tangential sections. (A $\times 40, \mathrm{~B}$ and $\mathrm{C} \times 175$ ). Lystrupsminde.


Plate VII
Sequoia couttsiae. O. Heer. A, bunch of foliage twigs, two terminated by cones. B-D, cones, C, highly compressed. $\mathrm{E}-\mathrm{G}$, seeds $(\mathrm{A}-\mathrm{G} \times 3$ ). Moselund.
Glyptostrobus europaeus. H and I, seeds $(\times 3)$. Moselund.


Plate VIII
Sequoioxylon canadense (C. Schröter) nov. comb. A, transverse section. B, tangential section. C and D, radial sections. $(\times 175)$. Torvig State Quarry.


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## Plate IX.

Sequoioxylon canadense (C. Schröter) nov. comb. Anomalously developed wood. A, transverse section. B and C, radial sections. D, tangential section. (A and B $\times 40, \mathrm{C}$ and $\mathrm{D} \times 175$ ). Torvig State Quarry.



Plate X
Sequoia langsdorffii. (A. T. Brongniart) O. Heer. A-F, deciduous foliage twigs. G-K cones in transverse and longitudinal planes. $(\times 2)$. Moselund.


Plate XI
Taxodioxylon gypsaceum (N. R. Göppert) R. Kräusel. A, transverse and B, langential sections. C and D, radial sections. ( $\times 175$ ). Troldhede State Quarry.


## Plate XII

Taxodioxylon gypsaceum (N. R. Göppert) R. Kräusel. A, langential section. B and C, radial sections. (B $\times 80$, $A$ and $C, \times 175$ ). Troldhede State Quarry.




## Plate XIII

Taxodioxylon gypsaceum (N. R. Göppert). R. Kräusel. A-C, tangential sections. D, radial section. (A $\times 40$, B-D $\times 175$ ). Troldhede State Quarry.

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Plate XIV
Taxodium dubium. (K. v. Sternberg 1838). O. Heer 1855. Deciduous foliage twigs. ( $\times 2$ ). Moselund.


Plate XV
Taxodium dubium (K. v. Sternberg). O. Heer. A, cone scales. B-J, seeds. (A $\times 2, \mathrm{~B}-\mathrm{J} \times 4$ ). Silkeborg Vesterskov. K, Glyptostrobus europaeus O. Heer. Foliage twigs carrying cones ( $\times 2$ ). Fasterholt.


## Plate XVI

Taxodioxylon taxodii W. Gothan. Wood of the stem type. A, transverse section. B and D, tangential sections. C, radial section. (A and D $\times 40, \mathrm{~B}$ and $\mathrm{C} \times 175$ ). Troldhede State Quarry.


## Plate XVII

Taxodioxylon taxodii W. Gothan. Wood of the root type. A, transverse section. B, tangential section. (A and B $\times 40$ ). C, radial and D, tangential sections ( $\times 175$ ). In C the slide is focused so as to show the schulpturing on the tangential ray cell walls. Troldhede State Quarry.

PL. XVII



## Plate XVIII

Taxodioxylon taxodii W. Gothan. Wood of the compressed type. A, transverse section. B, tangential and C, radial sections ( $\mathrm{A} \times 40, \mathrm{~B}$ and $\mathrm{C} \times 175$ ). Troldhede State Quarry.


## Plate XIX

Glyptostrobus pensilis (A. B. Lambert). A, transverse and C, radial section of medulla. ( $\times 135$ ). Taxodium distichum (L.) L.-C. Marie Richard. B, transverse and D, radial section of medulla. ( $\times 135$ ). From twigs about 5 mm thisk.


## Plate XX

Taxodium distichum (L.) L.-C. Marie Richard. A, transverse and B, radial section of medulla from a trunk about 60 cm thick. $(\times 135)$.
Taxodium mucronatum M. Tenore. C, transverse and D, radial section of medulla from a twig about 5 mm thick. ( $\times 135$ ).


Plate XXI
Glyptostroboxylon tenerum (G. Kraus) N. Conwentz. A, transverse section. ( $\times 40$ ). B and C, radial sections. ( $\times 175$ ). Troldhede.


## Plate XXII

Glyptostroboxylon tenerum (G. Kraus) N. Conwentz. A and B, tangential sections of late wood ( $\times 175$ ). Troldhede. C, transverse section ( $\times 40$ ) (from a quarry at Fiskbæk).

PL. XXII


## Plate XXIII

Cupressinoxylon callitroides n.sp. A, shows the variation in the thickness of the growth rings. ( $\times 40$ ). B, a growth ring in wood of the stem type and C, some growth rings in wood of the root type. Transverse sections ( B and $\mathrm{C} \times 175$ ). Troldhede.


## Plate XXIV

Cupressinoxylon callitroides n.sp. A, radial section of wood of the stem type and B, radial section of wood of the root type. C, radial section of ray cells the inner surface of which shows a papillose appearance; confluent pits with double aperture occur here and there. ( A and $\mathrm{B} \times 175, \mathrm{C} \times 600$ ). Troldhede.


## Plate XXV

Cupressinoxylon callitroides n.sp. Tangential sections of wood of the stem type A, and of the root type B. $(\times 175)$. In A the spiral structure of the tracheidal wall is distinct, e.g. to the right in the photo. Troldhede.


Plate XXVI
Cupressinoxylon callitroides n.sp. A, tangential section. B, tangential section showing the papillose inner surface of a tracheid. C, radial section, the ray cells are partly papillose ( $\mathrm{A} \times 40$, B and $\mathrm{C} \times 600$ ). Troldhede.

PL. XXVI


Plate XXVII
Cupressinoxylon thujoides n.sp. A, transverse section. B, tangential and C, radial section. (A $\times 60, \mathrm{~B}$ and C $\times 175$ ). Troldhede State Quarry.


## Plate XXVIII

Cupressinoxylon biotoides nov. comb. (Biota orientalis (L.) St. Endlicher var. miocenica R. Prill). A, transverse section, the growth rings of the early wood has partly collapsed. B, radial and C, tangential sections. The regular spiral structure of the innermust thickening layer of the tracheidal wall is standing in high relief caused by the solution of the terminal lamella. ( $\mathrm{A} \times 60$. B and $\mathrm{C} \times 175$ ). Lystrupsminde.


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