MAGNUS DEGERBØL AND BENT FREDSKILD

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

Det Kongelige Danske Videnskabernes Selskab Biologiske Skrifter 17, 1



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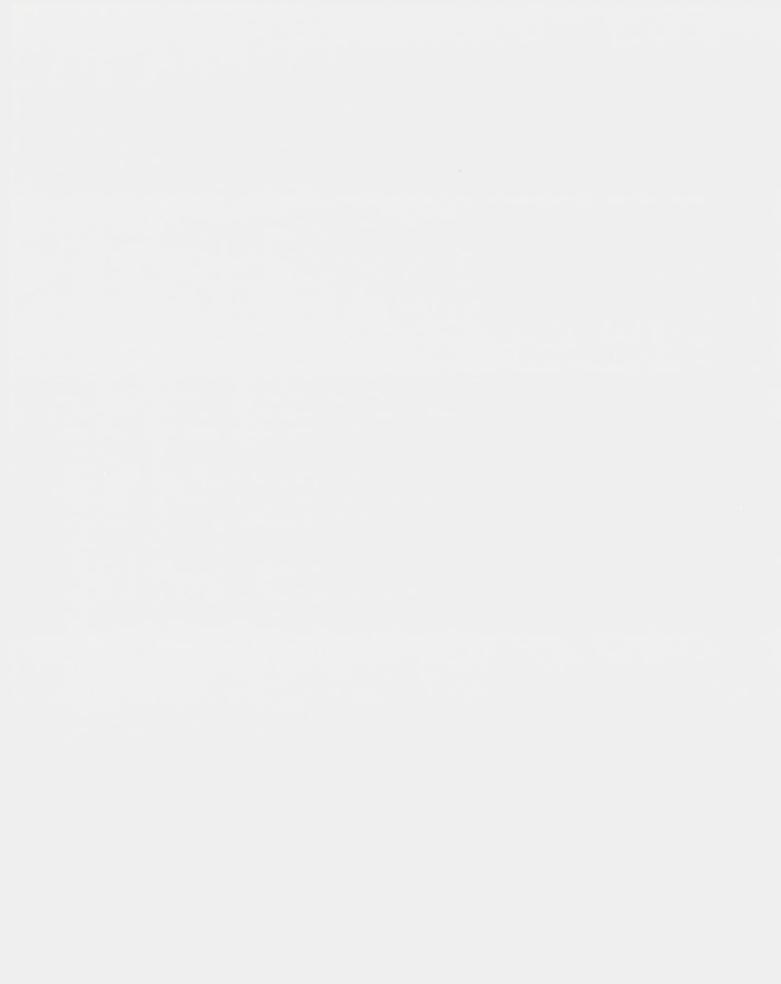
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Synopsis

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 Ertebølle 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.

CONTENTS

Т	Zoological Part (Magnus Degerbøl)	Page
1.		5
	Introduction	6
	A Survey of the <i>Urus</i> Material (<i>Bos primigenius</i>)	7
	Remains from the Late Dryas Period (Zone III)	7
	Remains from the Preboreal Period (Zone IV)	8
	Remains from the Boreal Period (Zones V and VI)	10
	Zone V	10
	Zone VI.	12
	Remains from the Atlantic Period (Zone VII)	16
	Remains from the Subboreal Period (Zone VIII)	17
	Remains from the Subatlantic Period (Zone IX)	23
	Remains from Finds Pollen Analyzed, but Dating Uncertain	24
	Bos-remains in the Kitchen Middens	$\frac{24}{25}$
	Remains of Uncertain Age	42
	Zoological Investigations of the Material	51
	Females	51
	Comparison between Males and Females, Sex Dimorphism	63
	Skulls	63
	Mandibles and teeth. — Microevolution	86
	Limb Bones	95
	Shoulder Height	127
	The Occurrence in Time and Space and Ecological Conditions	130
	B Domesticated Cattle (Bos taurus domesticus L.)	136
	Survey of the Dated Finds	136
	Were Bullocks Represented in the Neolithic Period in Denmark?	152
	Concluding remarks	163
	Summary	168
	Table I–III	170
	Plates I–XIV after p.	178
Т	Palynological Part (Bent Fredskild).	
1.	Introduction	179
	Sources of Error	180
	Comments on Table A	181
	Comments on Table B	181
	Dating of the Individual Finds	187
	Comments	187
	Bos primigenius	188
	Summary of the Datings of the Urus	202
	Bos taurus domesticus	205
	Appendix	211
	Bos primigenius	211
	Bos taurus domesticus	214
	Table A–B	217
it	erature	227



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. 128–133), 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).

3 On this complete skull Winge (1904) remarks: "Uncertain age, from a peat-bog near

Gon 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).

3 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-m 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).

3 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).
 - 3 Skull and almost complete skeleton.

In the lower jaw the hindmost molar (m 3) 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.

9

- 4. Grænge A, 2 km. S.E. of Sakskøbing, Lolland (L. Kring, 1942).

 3 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.
- 5. Gøderupgaards moor, A., S. of Roskilde (Siegfred Nielsen, 1941).

A. Andersen and K. Møller. D.G.U. IV R. Bd 3. Nr. 1. 1946. - Pl. II.

- 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. Viesø, Turup, N.E. of Assens (F. Lund, 1942).
 - ♂ 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.
- 8. Munke-Bjergby, Tørnegaards moor, 8 km. N. of Sorø (Louise Kloster, 1941).
 - 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).
 - ♂ 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.
- 11. Røde Mølle Aa, 13 km. N.E. of Vejle (Høst, 1855).
 - 3 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 mm. Pl. II.

- 12. Funen (Appeldorn-Steenstrup).
 - 3 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. Svebølle, 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).

 3 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).

 ♀ 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. Rønnebæksholm, S.E. of Næstved (Francisca de Carlsen, 1857).
 - ♂ 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.
- 16. *Knabstrup* (No. 3), 10 km. S.W. of Holbæk.

 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).

 3 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).
 - ♀ 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).

 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).
 3 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).

 ♀ Brain-case, broken through frontal, between horn cores and orbits. Cf. p. 56. − Pl. VIII.
- 25. Sakskøbing, Lolland (K. A. Jacobsen, Jægershvile, 1948).
 - 3 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).
 - ♂ 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 Skoybrugsmuseet).
 - $\ensuremath{\mathfrak{F}}$ 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).

 3 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).

 3 Part of left horn core, broken about the middle, with a small part of the frontal; fragmentary exoccipital. Diameters at base 118×103 mm.; circumference 365 mm. Width across condyli occipitales very large, about 146 mm. (73×2).

29. Jonstrup Vang, 15 km. N.W. of Copenhagen (Birte Andersen, 1946).

3 Left horn core with small part of frontal, tip missing. Diameters 120×101 mm.; circumference 348 mm. – Fragmentary parts of right horn core.

- 30. Falster, locality not specified (F. H. Møller, 1944).

 3 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
 - 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).

 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.

- 34. Lorup Hede, near Ringe, Funen (Johs. Bredsdorff, 1915).

 \$\frac{1}{3}\$ Brain-case, broken between horn cores and orbits. Horn cores very thick, diameters at base 138 \times 113 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).
 3 Upper part of roof of brain-case. With a large, nearly circular artificial hole (diameters 60×57 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). 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).

 ♂ 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 102×80 mm.; circumference 300 mm.
- 38. Bisserup, Rude, 13 km. E.S.E. of Skelskör (E. Jørgensen, 1946).

 ♂ Fragmentary left mandible with m 2 and m 3 very much worn. Length 85.7 mm. Length and width at the base of m 3 = 51.8 × 20.8 mm. Scapula, humerus, and tibia from right side, one costa.

 From the beginning of the zone.
- 39. Gøderupgaard B., S. of Roskilde (Sigfred Nielsen, 1941).

 ∂ Metacarpus, with an artificial hole.
- 40. Gojs moor, Kongsted, W. of Faxe (J. P. Rasmussen, 1943).

 3 Mandibles, small skull-fragments, (exoccipitale) 9 vertebrae. 16 costae.
- 45. 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).

 3 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; (naviculo-cuboideum (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 G³) 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 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, 68, 70 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 calcanei; 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 VIII (Th. Mathiassen, 1943). Here, too, bones of the *Urus* are common on the sites from the Boreal period (M. Degerbøl, 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 (m 3) from 2 individuals; 3 lower m 2, 2 upper m 2; nasal; parts of 5 scapulae, lower part of humerus; parts of 3 allases; 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 (3 l and 4 r) lunatum 7, triquetrum 2, pisiforme 2, capitatum 7 (5 l, 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 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 (Degerbol, 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. Undløse Bro, Aamosen. N.W. Zealand. Antebrachium, large. Cf. p. 111.

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,

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.

/2, 1880. — From Zone II to V. (Cf. p. 57). – Pl. VIII.

- 54. Bønnelykke, 7 km. S.E. of Rudkøbing, Langeland (Boesgaard, 1861).
 - 3 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).
 - 3 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.
 - ♂ 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. (М. Degerbøl, 1962). From an early part of the zone. Pl. VI.
- Pindstrup, Ryomgaard, Djursland, 30 km. W.S.W. of Grenaa (Naturhistorisk Museum, Aarhus, 1951).
 - ♀ 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 (82×52 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).

 3 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).

 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).

 ♂ Complete skull, and some postcranial skeletal parts. This skull has belonged to an old Biol. Skr. Dan. Vid. Selsk. 17, no. 1

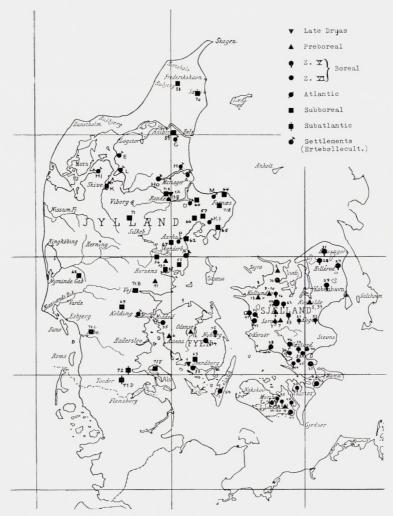


Fig. 1. Map showing the dated finds of Bos primigenius in Denmark.

1 Millinge, Faaborg. 1 A Terp. 2 Vig. 3 Stokholthuse, Soro. 4 Grænge A. 5 Gøderupgaard A. 6 Vieso. 7 Vigersted. 8 Munke Bjergby. 9 Knabstrup 1. 10 Knabstrup 2. 11 Røde Mølle 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 Lørup 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 Ogaarde II. 49 Hesselbjerggaard. 50 Magleø I. 51 Kongemose. 52 Ulkestrup Lyng. 53 St. Taastrup. 54 Bønnelykkegaard. 55 Orting. 56 Ostbirk. 57 Pindstrup. 58 Ugilt. 59 Klarup. 60 Auning. 61 Toftum. 62 Aarhus. 63 Korinth. 64 Bønnerup. 65 Holme Mose. 66 Hornslet. 67 Hørning. 68 Ølgod. 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 Trønninge-Kundby. 103 Højby. 104 Gl. Køgegaard. 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 Løgismølle. 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 Olholm. 152 Fuglekjær. 153 Gjødvad. 154 Formyre. 155 Aakjær. 156 Løgenkjær. 157 Odder. 158 Vintved. 159 Ølgod. 160 Egum. 161 Barrit. 162 Horsens Fjord. 163 Staugaards Mose, Torring. 164 Rathlousdal. 165 Norre Vissing. 166 Stilling Lake. 167 Aarhus Molleaa. 168 Aarhus Harbour. 169 Bjørnekjær, Lading. 170 Rosenholm. 171 Tjerrild. 172 Thorsager. 173 Benzon Estate. 174 Vindum. 175 Hvidbjerg. 176 Vibholm. 177 Ortoft. 178 Serridslev. 179 Hørbylund. 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 Nørlund. 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.
- 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. Bønnerup, 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 metalarsus, right metalarsus, upper part of left metalarsus, left calcaneus, part of right calcaneus, left astragalus (80 × 49 mm.), 2 right astragali (80 × 50 mm. and 77 × 47 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 Æbeltoft (ØRTING, 1868).
 ♂ 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 Single-Grave people. − Pl. VI.
- 66. Hornslet, Djursland, 23 km. S.E. of Randers (Silkeborg Museum).

 3 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 (m 3) 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 mm., 193–195 mm., and 153–153 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. Hørning, 8 km. N.E. of Skanderborg (Dr. Poulsen, 1868).

 ♂ 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. Øllgaard, N. Raunkjær, 1941). Horn core.
- 69. Tranekær moor, Staus Hede, Gesten, 15 km. N.W. of Kolding (Leo Novrup, 1945).
 - (a) 3 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 above-mentioned 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.
- 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).
 - З 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. Мөнг with a folding rule.
- 71a. Læsten, at the source of the Skals river, 12 km. N.N.W. of Randers (Naturhistorisk Museum, Aarhus, 1961).
 - ♂ 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 Mølle, 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).

 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.
- 71d Tinglev Lake, 18 km. S.W. of Aabenraa, Southern Jutland (King Frederik VII, 1858). Skull. Premaxilla and parts of maxilla are missing. The following postcranical 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:

71e. Ørum Aa, 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 ulna 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, metalarsus, phalanx) of a not quite full-grown 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 Bønnerup. (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. Bundsø, 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.

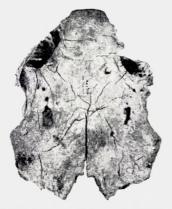
Remains from the Subatlantic Period (Zone IX).

72. Rise, 4 km. W. of Aabenraa (Agnete Bisgaard, Aabenraa Statsskole, 1942). From the bank of a brook.

Brain-case, broken in front of *orbitae*; 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



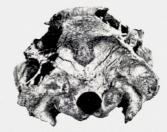


Fig. 3A and B. Brain-case of *Bos primigenius* from Rise (Aabenraa). Subatlantic. Zone IX. Horn cores cut off. – A. Frontal view. B. Occipital view. – Scale as in plates.

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: Willlow $1^{0}/_{0}$, birch $6^{0}/_{0}$, pine $9^{0}/_{0}$, alder $62^{0}/_{0}$, elm $1^{0}/_{0}$, lime $7^{0}/_{0}$, oak $7^{0}/_{0}$, ash $1^{0}/_{0}$, beech $5^{0}/_{0}$, hornbeam $1^{0}/_{0}$, *Picea* $1^{0}/_{0}$. Besides hazel $11^{0}/_{0}$, herbs $109^{0}/_{0}$, heather $2^{0}/_{0}$.

The pollen flora is greatly influenced by culture, thus $7^0/_0$ cereals, $7^0/_0$ plantain, $3^0/_0$ Rumex, and $2^0/_0$ 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 106×85 mm., circumference 320 mm., curvature 330 mm. (tip missing), length of lower m 1–m 3 is 111 mm. at the base, length and width, at the base, of m 3 are 48.5×19.5 mm.

Zone VII or VIII.

- 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 VIII.

75. Mariager (Cement works "Dania", 1949). 2 horn cores.

Zone VII or VIII.

- 76. Mjesing, Skanderborg (A. Andersen, D.G.U., 1917).
 Part of tibia. The smallest diaphysis width is 58 mm. Table 17.
- 77. Asaa, 23 km. S. of Sæby (E. Dalsgaard, 1947). Horn core.

78. Understed, 10 km. S.S.W. of Frederikshavn (Hans Jensen, Johs. Boolsen, 1960).

♂ Left half of occipital-frontal region, with horn core broken in the middle, 2×3 molars. Diameters at the base of horn core 114×90 mm., circumference 330 mm.; width across condyli occipitales 139 mm.

79. Julianelyst, 10 km. N.W. of Horsens (N. Lund, 1882).

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. – Pl. VII.

Bos-remains in the Kitchen Middens (Shell Mounds)

and other Settlements from the Ertebølle 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 Ertebølle 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 Ertebølle 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 Ertebølle 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 Ørum 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. Ertebølle, on the Limfjord, 18 km. S. of Løgstør.

Winge (1900, p. 87) writes about the bovine bones: "Bos taurus 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 Ertebølle 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 BRØNDSTED, 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 Ertebølle 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 Ertebølle 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 Ertebølle 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. Aamølle, on the south side of Mariager Fjord.

Winge, 1900, p. 103, writes: "Bos laurus urus. Part of lower end of ulna; metacarpus, with 5th 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 104×38 mm., and 54×39 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 Bønnerup 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 (m 3) 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 Aamølle 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 Th. 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. Havnø, 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 Havnø kitchen midden belongs to the Dyrholmen II. phase (including thick-walled Ertebølle 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 Ertebølle culture were described, viz. from Faarevejle, on the drained Lammefjord, N.W. Zealand, and Klintesø 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. Degerbøl, 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 Bierget 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 (\circlearrowleft), part of left frontal, with part of orbit (\circlearrowleft), 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 47.1×19.0 , and 43.5×18.5 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 mm., width of articular surface 99 mm., greatest width anteriorly-posteriorly 54 mm. 3 ("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 Lindø, 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 Bønnerup cows; total length 80–82 mm. (Cf. Table 19). A lower m 3, 40.8×17.2 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 3 67 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-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, 3. 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, 3.

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., ♀; distal width 75 mm., ♂; lower part of metacarpus, partly soot-coloured, distal width 80 mm., ♂; lower part of metacarpus, distal width 77 mm., ♂; 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. 3.

From the year 1915: Upper half of metacarpus, proximal width 82 mm., 3. Upper and lower part of metatarsus; prox. width 62 mm., 3, dist. width 78 mm., 3; 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 Winge, 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 8^{1b}). 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. t. t. In the publication by Troels-Smith 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 Bønnerup 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 Tingley, 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 *naviculo-cuboideum* represents the *Urus* cow. (Cf. Table 20).

A medial part of a 1st 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 mm., 27 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 39×26 mm. and 35×27 mm., as compared with 41×29 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



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). × $^{1}/_{2}$.

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 98×80 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 *astra-qalus* 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

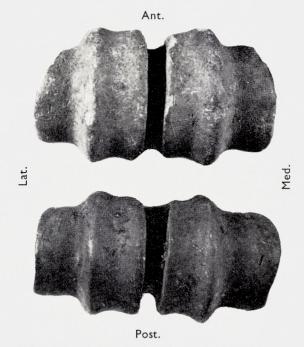


Fig. 6. Distal ends, from below, of metatarsals of the Urus cow from Dyrholmen, at the top (No. 3 in fig. 5), and of the domestic bull (bullock) from Holmene, Hillerød, at the bottom (No. 5 in fig. 5). — In the Urus the anterior-posterior width of the sagittal ridge of the trochlea is larger than in domestic oxen. Further information in text. \times $^{1}/_{1}$.

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 Bønnerup, 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 (m 3) 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 mm.×18.7 mm., as compared with 42.5×18.5 mm. in the Ugilt skull, but the 2 other specimens are smaller, 41×18 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-m 1, is similar to the corresponding part of the Ugilt skull, in fact a little larger. The p 2-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. Reffs-Gaard. Skive Museum).

Bos primigenius.

Lower part of right horn core with small part of frontal bone, diameters 85×63 mm. \circlearrowleft . Left premaxilla and maxilla. Fragment of mandible with m 3, worn, 43.8×19.0 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 mm., \(\varphi\), 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.), ♂, large. Medial side of upper end of radius, anterior-posterior width 53 mm., J. Lower part of right antebrachium, distal width 110 mm., β , large. Distal end of right antebrachium., 97 mm., φ , a little larger than the Ullerslev specimen. Distal end of left antebrachium 101 mm. (art. 90 mm.), 3, as the Tinglev specimen. Proximal end of left metacarpus, prox. width 86 mm. (trans.) × 49 mm. (art. 45 mm.), anterior-posterior, ♂, large. Distal end of metacarpus, distal width 66 mm., diameter of trochlea 37.5 mm., \(\varphi\). Medial side of upper end of metacarpus. 3 distal ends of metatarsus, distal width 64-64-75 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., 3. Posterior part of shaft of tibia, 3. Right astragalus, greatest length 90 mm., distal width 56 mm., height 46 mm., ♂. Right astragalus 81×53× 42 mm., respectively; anteriorly soot coloured, φ. 2 right naviculo-cuboidea, greatest width 79 mm., ♂, and 70 mm., ♀. Left naviculo-cuboideum 67 mm. long, ♀. Lunatum, Proximal phalanx (pes), greatest length, lateral 74 mm., diaphysis width 29 mm., proximal width 34.8 mm., ^Ω, similar to the Ullerslev cow; proximal halves of two proximal phalanges, width 41 and 42 mm., 3, 3; medial phalanx, proximal width 42 mm., diaphysis width 33 mm., ♂; two distal phalanges, greatest length 96 mm., ♂, 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 Møhl, 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

VII a and VII b. A C-14 analysis of charcoal from the layer gave ages of 3780 ± 120 and 3730 ± 120 B.C.

As Møhl does not give any measurement I shall call attention to some of the more remarkable bones.

Two mandibular hindmost molars (m 3) are present, they are comparatively small, as also pointed out in several kitchen middens mentioned: 45.2×18 mm. and 43.5×18.2 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, 44.5×18 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., β , 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 84×50 mm.; φ , almost as in the Pindstrup cow.

The transversal width of two *naviculo-cuboidea* is 75 mm. in both (33). 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 ± 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 (QVISTGAARD, 1850).
 - 3. 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).
 - ♂. 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).
 - 3. Skull, kept by the regional salvage corps.
 - * Regarding measurements cf. Tables 1-23, and I-III.

43

- 100. Mørkøv, 15 km. S.W. of Holbæk (Fr. Wulff, 1875).
 ♀. 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 118×96 mm., circumference 350 mm., outer curvature about 610 (575+) mm.
- 102. Trønninge, Kundby moor, 10 km. W. of Holbæk (G. H. Thomsen, 1943).

 ♀. 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 Køgegaard, W. of Køge (Carlsen, 1872).
- 105. Ollerup Vestermose, 6 km. N.N.E. of Slagelse (P. L. Peitersen, 1903).
- 106. Hove, 15 km. N.E. of Roskilde (MERTZ NIELSEN, 1942). Part of left maxilla.
- 107. Vanløse, 15 km. N.N.E. of Sorø (National Museum, 1944).

 3 Mandible, metacarpus, right humerus (upper part missing), 6 vertebrae (lumbales), 3 ribs.
- 108. Hedehusene, W. of Copenhagen (Hög, 1941).

 3 Part of right horn core with small part of frontal. Diameters at base 100×94 mm.
- 109. Gentofte, 7 km. N. of Copenhagen (Steenstrup).

 ♂ Horn core with small part of frontal. Diameters at base 109×85 (+) mm.
- 109 a. *Brønshøj*, Copenhagen (Р. Juhl, 1923).
- 110. Jonstrup Vang, 15 km. N.W. of Copenhagen (BIRTE ANDERSEN, 1946).

 3 Left horn core with small part of frontal, tip missing. Diameters 120×101 mm.; circumference 348 mm. Fragmentary parts of right horn core.
- 111. Alsonderup, 6 km. N.W. of Hillerød (L. Rasmussen, 1957)., β Part of left horn core, broken about the middle, with a small part of the frontal; fragmentary exoccipitale. Diameters at the base 118×103 mm.; circumference 365 mm. Width across condyli occipitales about 144 mm. (72×2) .

Postcranial skeletal parts (Not previously mentioned).

- 112. Ganløse. 20 km. N.W. of Copenhagen (Aa. Nemming, National Museum, 1959).

 3 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. Østrup, Viksø, 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).
 3 Left tibia (Table 17), astragalus (Table 19), phalanx (innermost, prox. width 42, length, lateral, from incisure, 69 mm.).
- 117. Strødam, Hillerød. (Jarl, 1944).

 3 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.
- 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). 3 Antebrachium.
- 121. Holbæk. From a moor below the road to Roskilde (Holbæk Museum, 1955).

 Metatarsus.
- 122. Faarevejle, 20 km. S.W. of Nykøbing S. (M. Knudsen, 1951). 3 Left antebrachium.
- 123. Faarevejle, 20 km. S.W. of Nykøbing S. (Troels-Smith, 1942).
 Below the Faarevejle kitchen midden (together with remains of Lagenorhynchus).

 3 Part of left humerus, very stout, smallest width of diaphysis 60 mm.
- 124. Løgismølle, 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).

 3 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, Rønnede, 15 km. E. of Næstved (L. Jensen, 1907).

 3 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).

 3 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.

Funen

- 132. Bro, 7 km. S.W. of Bogense (Mineralogical Museum, 1839).

 3 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).

 3 Brain-case, broken in front of horn cores; horn cores greatly granulated at base.—
 Pl. VII.
- Tevring, 12 km. S.S.E. of Bogense (National Museum, 1851).
 horn cores (H.W. 1904).
- 135. Dømmestrup, Nr. Lyndelse, 10 km. S. of Odense (J. Nielsen, 1941). 5 vert. costales, 5 vert. lumbales.
- 136. Næsbyhoved Mølle, 2 km. N.W. of Odense (Trolle, 1848).

 3 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).

 Brain-case (cast).
- 138. Broby, 14 km. N. of Faaborg (Steenstrup and Lütken, 1852). 3 Antebrachium, lower part missing.
- 139. Osterby, from calcareous deposit. 4 km. N.N.W. of Faaborg (H. Rasmussen, 1919). 3 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. Ejsemoseløkke, Broholm, 10 km. N.E. of Svendborg (Broholm Collection). Scapula. (Sehested, 1878, pp. 237, 280; H.W. 1904, p. 289).
- 143. Bøllemose, Gudbjerg, 10 km. N.N.E. of Svendborg (Broholm Collection). Some teeth and skeletal parts. Ibid. Idem., p. 280.
- 144. Barløse, 7 km. N.E. of Assens (Vedel Simonsen, 1858).

 ♀ Horn core with small part of frontal.
- 145. Frøbjerg, 15 km. N.E. of Assens (Johansen, 1912).

 3 Right scapula, right humerus, os coxa, vertebra lumbalis, costa.
- 146. Turup, Viesø, 7 km. N.E. of Assens. (F. Lund, 1942). 3 Lower end of humerus, greatest width of trochlea 106 mm.

Lolland

- 147. Handermelle, V. Ullerslev (G. Larsen, 1945).

 3 Left scapula, left antebrachium, left femur, costa.
- 147 a. The Ballic 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).

 3 Skull, broken through maxilla; hind limb. Teeth much worn. Pl. VII.
- 150. Ølholm, 4 km. E.S.E. of Tørring (Amtsvejvæsenet, 1961).
 ♂ Skull, nasals missing. Brought to light by road work. Teeth much worn. Pl. VII.
- 151. *Ølholm* (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.

- 156. Løgenkjær, 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). ♂ Brain-case, broken just in front of horn cores. Fig. 7.
- 158. Tønder, Vintved Canal (F. Jensen, 1932. Jagt- og Skovbrugsmuseet).
 ♂ Two horn cores with part of frontal. Yellow coloured.
 ♂ Part of horn cores of a second specimen. Dark coloured. Porous. Diameters at the base 107×85 mm. A young but large specimen.
- 159. Ølgod, Egknud, 23 km. N.N.E. of Varde (J. Bondesen, H. Øllgaard, 1945).

 3 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, $3^{1}/_{2}$ m. away, a Younger Stone-age axe was found.
- 160. Egum, 4 km. N.N.W. of Fredericia (O. IVERSEN, about 1917. Fredericia Museum). する 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 104×86 mm.



Fig. 7. Brain-case of Bos primigenius from Odder (No. 157). × ca. ab. 1/6.

- 161. Barrit Forest, 22. km. E. of Vejle (Вкоскеннииз Schack).

 З Right horn core with small part of frontal, tip missing. Diameters at the base 117×96 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).
- Horsens Fjord (National Museum, Seligmann, 1896).
 Horn core.
- 163. Staugaards moor, Tørring, 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 (Ногм, 1850). З Occipital part. Width across condyli occipitales 134 mm.
- 165. Nørre Vissing. 12 km. N.N.W. of Skanderborg (Danmarks geologiske Undersøgelse, 1941).

 3 Left and right horn core with small parts of frontal, granulated at the base. Diameters at the base 121×99 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).

 3 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. Bjørnekjær, 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).
 ♂ 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 (ØRNÆS CHRISTENSEN, 1947).

 ♂ Small part of frontal with right horn core broken in the middle; diameter 113×90 mm., circumference 328 mm. Fragment of left horn core; part of 2 horn cores, diameters 100×97 mm.

 ♀ Left radius, left metacarpus, small; total length 231 mm., proximal width 69×42 mm.; width of diaphysis 38 mm.
- 172. Thorsager, Søndervang moor, Djursland, 26 km. N.W. of Kalø Vig. (Jagt- og Skovbrugsmuseet, 1948).
 ♂ 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. Kjærsgaard, 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. Hørbylund, 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).

 3 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. $^3/_4$ m. water.
- 185. Kolding (E. Walther, 1957).

 3 Left scapula; upper part missing. Width of collum 83 mm.
- 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, 3 large. Calcareous deposits.
- 189. Løsning, 15 km. N.E. of Vejle (Naturhistoriske Museum Aarhus, 1934). & Metacarpus.
- 191. Solbjerg Lake, 5 km. N.E. of Skanderborg (M. Martin, 1951). & Right scapula.
- 192. Silkeborg (Godske Nielsen, 1922).

 \$\tilde{\gamma}\$ Calcaneus. Washed together with other bones at the paper-factory, from stone age or later.
- 193. Randers Fjord (M. Brunse, 1951).

 3 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 Riismøller, 1945). 4 verlebrae cervicales.
- 195. Nørlund Forest, in a moor, 14 km. N.N.W. of Hobro (H. Hansen, 1897).

 3 Metacarpus. In marl, about a depth of two metres; 1/3 m. from the bottom.
- 195 a. Nørlund Forest.

 3 Left humerus, upper end missing. Smallest diaphysis width 55 mm., trochlea width
- 196. Feldborg Plantation, in a moor, 18 km. E. of Holstebro. (Jensen Tusch, and Gad, 1881). ¿ Left humerus, upper end damaged, antebrachium, upper end of ulna missing.
- 197. Vinderup, 20 km. N.E. of Holstebro. (Stæhr-Larsen, 1947).

 ♀ Metatarsus, tibia, upper free epiphysis missing, calcaneus.

105 mm.; anterior-posterior medialis 117 mm.

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).

 $_{\rm J}$ 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 160×147 mm., of the left horn core 146×140 mm.; just laterally to this swelling the diameters are 130×116 and 130×110 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).
 - $\ensuremath{\mathfrak{F}}$ 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).
 - 3 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.
 - 3 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).
 - 3 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 Białowies, 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	Material Locality		Zone	Remarks
1. Complete skeleton	Ullerslev	(15)	V	
2. Skull	Grænge	(18)	V	Nasals missing.
3. Incomplete skulls		(21) (57)	V VIII	Broken in front of rows of teeth. Broken in front of rows of teeth. Mandible and parts of postcranial skele
	St. Taastrup Skaarup Bønnerup	(53) (74) (64)	II–V Not dated VIII	ton are present. Mandible present. Fragmentary parts. Very fragmentary horn cores, 6 upper molars, postcranial skeletal parts.
4. Brain-cases	Knabstrup Svebølle Bjerregrav Flintinge Toftum	(7) (10) (13) (13 b) (24) (61)	IV IV IV IV V	Broken in front of horn cores. Frontlet. Broken between horn cores and orbits Mandibles present. Broken in front of nasal base.
	Fuglekjær (Mørkov (Gjødvad (Aakjær ((62) (63) (152) (100) (153) (155) (151)	VIII VIII Not dated Not dated Not dated Not dated Not dated	Broken in the middle of orbits. Broken through nasal base. Broken through orbits. Broken through orbits. Broken between horn cores and orbits. Broken in front of nasal base.
5. Horn core	Barløse ((144)	Not dated	
6. Mandibles	Tørring (Gesten B (Hvidbjerg (Løgenkjær (nninge (102) (163) (69) (175) (156)	Not dated Not dated Not dated Not dated Not dated 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, 66×66 mm., as compared with 83×66 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 *Grænge* 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 (Ølholm, 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 Grænge 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

Nr. 1 55

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 82×71 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

Nr. 1 57

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 Grænge 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 84×67 mm. and 80×60 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 (m 3) 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 Bønnerup.

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

Nr. 1 59

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 45.5×18.7 mm., as compared with 48.5×19.8 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 65×57 mm. and 60×52 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 Bønnerup 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 Bønnerup 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, 55×65 mm.

Six finds, from Skaarup, Mørkøv, Fuglekjær, Ølholm, Gjødvad, and Aakjær, 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 73×57 mm. The molars are fairly large, the length of m 1–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.

Mørkøv. As no Urus find is known from the island of Zealand later than Zone VI it is probable that the Mørkøv 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 Fuglekjær 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 condulus 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 (m 3) 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 Ølholm 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 Ølholm 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 Gjødvad 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 Aakjær 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.

Barløse. 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. (110×2) , in the middle of the frontal 240 mm. The circumference at the base of the horn core 233 mm., diameters $76 \times 65 \text{ mm}$. 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 Svebølle 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 Svebølle horn core). The circumference at the base is 215 mm., diameters 71×61 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 Østbirk, 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

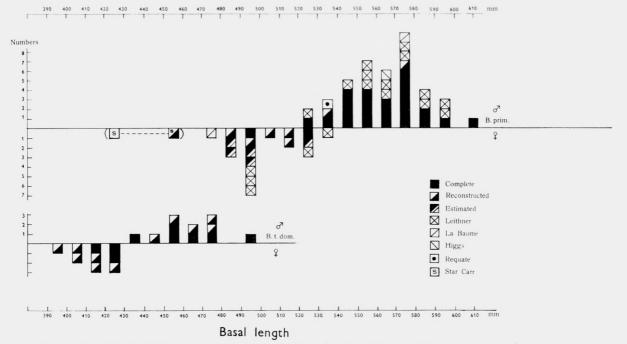


Fig. 8. Basal length. Males are placed above the line; females below. — Measurements in 10 mm. groups: 401/410-411/420 etc. The largest female skull from Denmark (Ullerslev, Zone V), just reaches the smallest male skull (Østbirk, Zone VIII). Only one skull (from Holmene) of domestic cattle (male or bullock)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

Table 1.
Basal length.
Bos primigenius.

ೆ ರೆ	Zone	Ş♀ Zone
Østbirk 525	VIII	Pindstrup (reconstr.) 490 VIII
(Tinglev 532)	VIII/IX	(Ølholm, Aarhus, estimated)
(Gøderup, subad 532)		Grænge 496 V
Ugilt (ad. jun.) 542	VIII	(Gjødvad, Korinth, estimated)
Bønnelykke 543	VII	Fuglekjær (reconstr.) 500
Fæsted 548	VIII	St. Taastrup (reconstr.) 510 II/V
Danmark (Min. Mus.) 549		Bjeverskov (reconstr.) 515 V
Ørting 551	VIII	Toftum (reconstr.) 520 VIII
Grænge A (ad. jun.) 553	IV	Ullerslev 525 V
Læsten 554	VIII	(Flintinge, estimated)
Bro 555	(Fyn)	
Tepstrup 562	IV	From Leithner, 33: 526, 546, 554, 555, 558, 566,
Grevinge 564	VI	566, 575, 577, 588, 590, 592,
Grænge B 565	V	593.
Auning 571	VIII	From Leithner \$\perp\$: 496, 500, 500, 528, 534.
Lyngby 571	(Sjælland)	From La Baume 3: 573.
Ølholm 572		From La Baume ♀: 475.
Sorø 575	IV	From Higgs 3: 568.
Vig 580	IV	From Requate 3: 532.
(Grejs Mølle 580)	VIII	From Fraser and King Q: (Star Carr) 429 (Condy-
Store Damme 581	(V)	lobasal length 459).
Aagerup 583	(Sjælland)	
Rønnebæksholm 583	IV	
Bregninge 597	VI	
Faaborg (Millinge) 612	III	

Bos taurus domesticus

33	99
[Vedbæk I, jun 405]*	Gammellung 400 (calculated)
Snoldelev 435	Nyrup III 403 (calculated)
Store Lyng, subad	Øgaarde III, subad 410 (calculated)
Vedbæk II 455	Øgaarde II 411 (calculated)
Vedbæk III 455 (calculated)	Sandhuse 413
Gammellung 455	Sandhuse II 415 (calculated)
Verupgaard 465	Holmene 426
Veddinge 470 (calculated)	Nyrup I 427
Ærø 475 (calculated)	Nyrup II 430 (calculated)
Søndersø 480 (calculated)	
Bodal 480	
Holmene 497	
* [] not plotted.	

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.

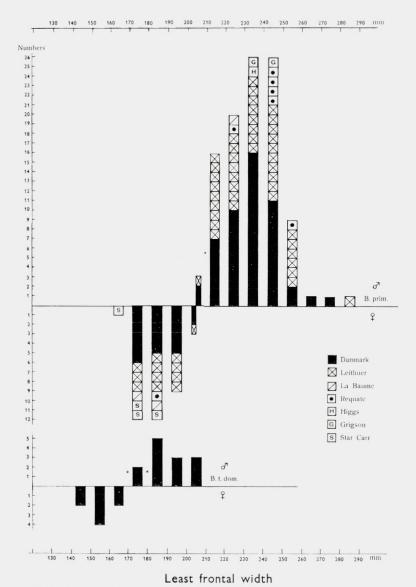


Fig. 9. Least frontal width is in Urus cows outside the range in Urus bulls, but co-extensive with the range in domestic bulls. Here, too, the largest measurements of females come from the geologically oldest skulls (Ullerslev, Flintinge, Zone V).

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. Bos primigenius.

ೆ ರೆ		ೆ ರೆ
Ølholm	207	Rønnebæksholm
Fæsted	210	Bedsmose
Klarup	212	Bregninge
Tinglev	214	Lørup Hede
Tranekær	216	Danmark (2. afd.)
Mors	217	
Hornslet	220	
Hallenslev (jun.)	220	QQ
Danmark (Stud. Coll.)	220	Korinth
Ugilt (ad. jun.)	222	Fuglekjær
Danmark (2. afd.)	225	Ølholm
Knabstrup 1	226	Pindstrup
Tepstrup	226	Grænge
Læsten	228	St. Taastrup (ad. jun.)
Fyn	230	Aarhus
Store Damme	230	Vigersted
Gøderup (subad.)	230	Skaarup
Aabenraa	230	Bjeverskov
Holme Mose	230	Gjødvad
Vig	231	Kærsted
Danmark (CN. 1891)		Knabstrup
Julianelyst		Mørkøv
Knabstrup 3	234	Aakjær
Grevinge		Toftum
Røde Mølle Aa	235	Ullerslev
Bro	236	Flintinge
Tranemosegaard	237	
Lading	237	
Grejs Mølle		
Sorø		Leithner 33: 205, 211, 212, 214, 216, 216, 218,
Auning	238	220, 220, 220, 221, 224, 225, 225,
Grænge A (ad. jun.)		226, 226, 227, 228, 231, 232, 232,
Grænge B		232, 233, 233, 237, 240, 241, 241,
Niverød		241, 242, 242, 244, 245, 245, 245,
Lyngby		249, 252, 252, 255, 257, 260, 260,
Faaborg		289.
Bønnelykke		LEITHNER \$\precep\$: 179, 179, 179, 182, 185, 190, 190,
Aagerup		192, 194, 194, 197, 202.
Østbirk		REQUATE 33: 224, 246, 247, 249, 250, 254.
Kulemile		♀: 189.
Ørting		La Baume ♂: 230. ♀♀: 180, 189.
Hørning		GRIGSON 33: 240, 243.
Sakskøbing		Higgs 3: 234.
Danmark (Min. Mus.)		Fraser \$\partial \text{:} 170, 178, 179, 180.
Hastrup	250	(Star Carr)

Table 2 (continued). Bos taurus domesticus.

$\varphi\varphi$
Sandhuse I
Øgaarde II
Gammellung II 151
Nyrup III
Nyrup I
Holmene
Nyrup II
Sandhuse II

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.

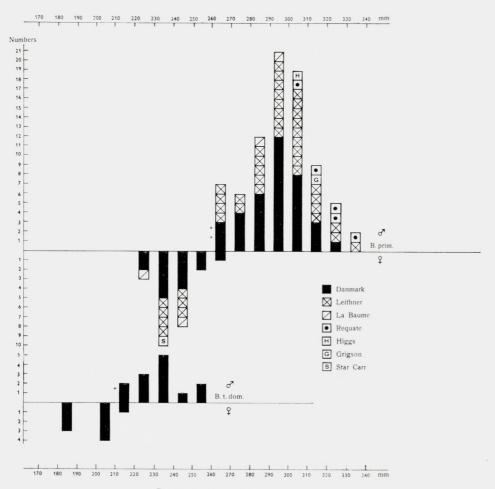
Table 3. Postorbital width. Bos primigenius.

<i>ತೆ</i> ಕೆ		<u> </u>
[Hallenslev, jun	254]*	Korinth
[Gøderup, (subad.)	260]	Pindstrup
Ugilt (ad. jun.)	262	St. Taastrup
Fæsted	266	Fuglekjær
Hornslet	268	Gjødvad
Tranekær	274	Ølholm 240
Ølholm	275	Vigersted
Tinglev	280	Mørkøv
Læsten	280	Grænge
Knabstrup 1	285	Kærsted
Holme Mose	286	Bjeverskov
Tranemosegaard	287	Toftum
Tepstrup	287	Knabstrup
"Stud. Coll."	289	Ullerslev
Bønnelykke	290	
Bro		
Mors		LEITHNER 33: 261, 270, 270, 270, 273, 280, 285,
Aabenraa		288, 290, 290, 290, 292, 295, 296,
Grevinge		297, 297, 298, 299, 300, 301, 302,
Aagerup		302, 303, 303, 304, 305, 308, 310,
Grænge A (ad. jun.)		314, 315, 316, 320, 324, 326, 336.
Fyn		\mathfrak{PP} : 232, 233, 236, 240, 242, 247, 249.
Auning		La Baume ♂♂: 286, 295. ♀♀: 221, 243.
"2. Afd."		Higgs 3: 305.
Vig		Grigson 3: 313.
Knabstrup 3		Fraser ♀: 231 (No. 2).
Røde Mølle		
Lyngby		
Sorø		
Grænge B		
Grejs Mølle		
Julianelyst		
"Min. Mus."		
Rønnebæksholm		
Østbirk		
Ørting		
Faaborg		
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.

ೆ ಂೆ	ÇQ
[St. Lyng (subad.)"	Sandhuse I
Snoldelev	Øgaarde
Gammellung II	Gammellung
Løgtved	Sandhuse II (jun.)
Gammellung I	Nyrup I
Vedbæk III	Nyrup II
Veddinge	Nyrup III
Verupgaard	Holmene
Vedbæk II (Maglemosegaard)	
Ærø	
Bodal	
Holmene	
Søndersø	



Postorbital width

Table 4. Mastoid width. Bos primigenius.

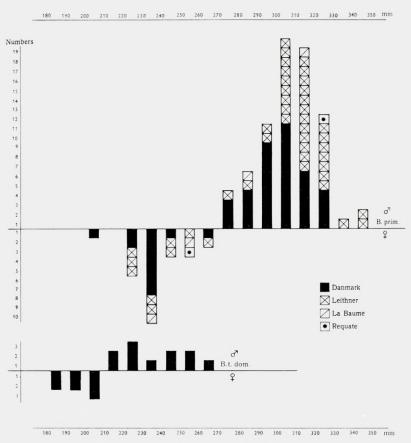
ేరే		99
[Hallenslev (jun.)	244]	Korinth
[Gøderup (subad.)	262]	Pindstrup
Hornslet ab.	270	Fuglekjær
Knabstrup 1	275	St. Taastrup (ad. jun.)
Ugilt (ad. jun.)	280	Bjeverskov
Tranemosegaard	281	Mørkøv
Fæsted	285	Grænge
Vig	288	Gjødvad
Danmark (CN. 1891)	290	Ølholm
Fyn	292	Vigersted
Tranekær	293	Knabstrup
Tinglev	294	Ullerslev
Ølholm	295	
Bro	295	
Klarup	300	From Leithner 33: 280, 285, 295, 300, 301, 304
Holme Mose	300	304, 306, 307, 308, 310, 310
"2. Afd."	300	310, 311, 312, 312, 313, 314
Mors	300	315, 315, 316, 316, 317, 320
Læsten		320, 321, 322, 325, 325, 326
Grevinge	303	327, 328, 337, 346, 350.
St. Damme	305	"
Knabstrup 3	305	246, 251, 261.
Sorøab.		From Requate ♂: 323, ♀: 255.
Lyngby		From La Baume 3: 289, 315. \(\text{Q: 235, 260.}\)
Rønnebæksholm		
Tepstrup		
Auning		
Bønnelykke		
Grænge A (ad. jun.)		
Lørup Hedeab.		
Bedsmose		
Ørting		
Østbirk		
"Min. Mus."		
Grænge B		
Aagerup		
Faaborg		
Røde Mølle		
Bregninge	320	

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.

ೆ ರೆ	<u> </u>
[Vedbæk I (jun.)	8] [Viksø I (subad.)
[Snoldelev II (jun.)	1] Sandhuse I
[St. Lyng (subad.)	5] Sandhuse II
Gammellung III	5 Øgaarde II
Gammellung I	6 Nyrup IIIab. 200
Snoldelev I	7 Nyrup I 202
Vedbæk III	0 Holmene
Verupgaard	0 Nyrup II 207
Vedbæk II (Maglemosegaard) 23:	2
Ærø	5
Veddinge 24	9
Bodal	6
Søndersø	6
Holmene	3



Mastoid width

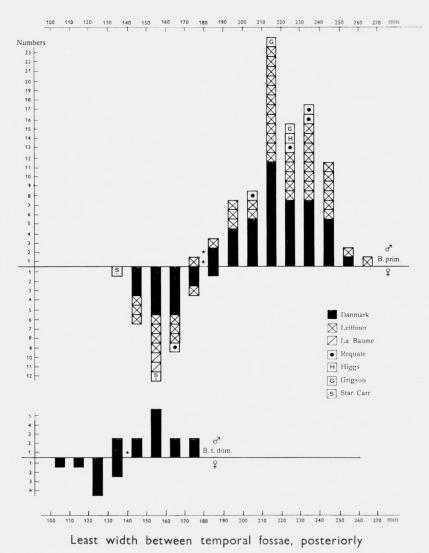


Fig. 12. Width between temporal fossae, posteriorly. The width in the young Ugilt bull is slightly smaller than in the large Flintinge cow, 183 and 185 mm., respectively. — As in most other width measurements the ranges of variation in *Urus* cows and domestic bulls are overlapping.

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.

ೆ ರೆ	- 1	$\varphi\varphi$
[Gøderup (subad.) 1	180]	Korinth
[Hallenslev (jun.) 1	184]	St. Taastrup 145
Ugilt (ad. jun.) 1	185	Pindstrup
Knabstrup 1 1	189	Vigersted 153
Store Damme 1	192	Aarhus
Sorø 1	198	Grænge
Tranemosegaard	198	Ølholm
Grænge A 2	200	Bjeverskov
Bønnelykke 2	203	Fuglekjær
Ølholm 2	205	Mørkøv
Grevinge	210	Gjødvad
Knabstrup 3 2	210	Bjerregrav 168
Fæsted	210	Knabstrup 169
Julianelyst	211	Ullerslev
Vig 2	212	Toftum
Bedsmose	212	Flintinge 185
Tinglev 2	213	
Mors 2	215	
Grænge B 2	215	Enom I province 44, 175 [190 colf] 196 101 106
Bregninge 2	216	From Leithner 33: 175, [180 calf], 186, 191, 196,
Læsten	218	200, 207, 210, 211, 211, 212,
Bro 2	219	212, 215, 215, 215, 216, 217, 217, 220, 220, 224, 224, 227,
Fyn 2	219	227, 229, 231, 232, 233, 233,
Klarup 2	220	235, 236, 237, 239, 241, 241,
Østbirk	222	242, 248, 248, 248, 257, 267.
Trøstrup 2	222	00. 144 149 150 154 155 155
Faaborg 2	222	, , , , , , , , , , , , , , , , , , ,
Rønnebæksholm	226	From Requate 33: 105, 225, 235, 238.
Tepstrup 2	226	C 121
"Stud. Coll." 2	226	, , ;: 164. From La Baume ♀: 152, 155.
Min. Mus	230	From Higgs 3: 225.
Lørup Hede 2	231	From Grigson 3: 219, 228.
Thorsager 2	232	From Fraser \$\ \text{\$\gamma\$}: 140, 153.
Holme Mose	233	1. 140, 155.
Grejs Mølle 2	235	
"2. Afd." 2	238	
Ørting 2	240	
Røde Mølle 2	240	
Aagerup 2	244	
Lyngby 2	244	
"Danmark" (CN. 1891)	245	
Niverød 2	245	
"2. Afd." 2 2	247	
Auning	260	
	,	

Table 5 (continued). Bos taurus domesticus.

33	99
[Vedbæk I (jun.)	Sandhuse I 108
[Snoldelev II (jun.)	Øgaarde II 116
St. Lyng (subad.)	Nyrup III 126
Snoldelev I	Sandhuse II
Gammellung I	Gammellung
Løgtved Enge	Nyrup II 129
Verupgaard	Nyrup I 133
Vedbæk III	Holmene
Gammellung III	
Bodal	
Vedbæk II (Maglemosegaard)	
Søndersø	
Ærø	
Veddinge 171	
Holmene	

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, however, 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 indicate 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.).

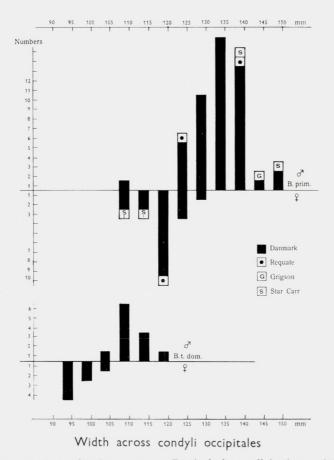


Fig. 13. Condylus width. Much overlapping occurs. - Particularly small is the condylus width (110 mm.) in a robust Urus bull skull from Mors.

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

..... 107 111 116 116 117 117 118 118 120 125 127

⊊: 118.

♀♀: 110, 113.

Table 6. Width across condyli occipitales. Bos primigenius.

	Bos prin	ugenius.
ನೆ ೆ		22
Mors	110	Skaarup
Terp		Toftum
Danmark (CN. 1891)		Pindstrup
Bro		Mørkøv
		Bjeverskov
Tinglev		
Grænge B		Fuglekjær
Holme Mose		Knabstrup
Store Damme		Vigersted
Faxe (Gøjs Mose)		Korinth
Grevinge		Ølholm
Julianelyst		Gjødvad
Aagerup		Aarhus
"Min. Mus."	128	St. Taastrup
Ølholm	129	Svebølle
Bregninge	129	Grænge
Knabstrup 3	130	Ullerslev
Røde Mølle	131	Flintinge
Fæsted	131	
Bønnelykke		pri_Carrier
Knabstrup 1		F D 44, 495, 495
Østbirk		From Requate 33: 125, 137.
Klarup		From Grigson 3: 143.
Lyngby		From Star Carr 33: 139, 146.
Vig		
Aabenraa		
Hornslet		
Nørre Vissing		
Rathlousdal		
Læsten		
Viesø (jun.)		
Fyn		
Bedsmose		
Rønnebæksholm		
Tranemosegaard		
Trøstrup		
Auning	136	
Ugilt	137	
"2. Afd." 2	137	
[Gøderup (subad.)	138]	
Understed	139	
Faaborg	139	
Sorø		
Tepstrup		
Grænge A		
Hørning		
Ørting		
Alsønderup		
Lørup Hede		
Lorup Heae	147	

Table 6 (continued).

Bos taurus domesticus.

ೆ ೆ	29	
[St. Lyng 100	0] [Vedbæk I (subad.)	94]
[Snoldelev II (jun.)		
Gammellung 10	2 Sandhuse	92
Snoldelev I 10	6 Nyrup I	92
Verup 10	6 Øgaarde II	95
Bodal		95
Holmene	8 [Sandhuse II (subad.)	96]
Veddinge 10	8 Nyrup II	97
Gammellung II	0 [Viksø (subad.)	98]
Løgtved Enge	2 Nyrup III	98
Vedbæk II		
Søndersø	4	
Ærø	8	
30 140 150 160 170 180 190 200 210 220 230 240 250 260	270	410 420 11

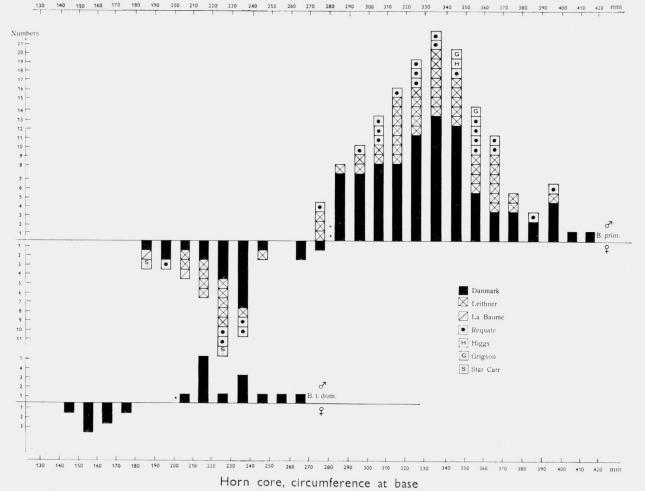


Fig. 14. Circumference at the base of horn cores. Even in young Urus bulls the horn cores are comparatively thick, being outside the range in Urus cows. It is remarkable that the width of horn cores in domestic bulls almost coincides with that of Urus cows.

 $\begin{array}{c} \text{Table 7.} \\ \text{Circumference at the base of the horn cores.} \\ \textit{Bos primigenius.} \end{array}$

33	ೆ ೆ
[Hallenslev (jun.)	
[Viesø (subad.)	
Læsten	
Ugilt	
Fæsted	6 Ørting 340
Brabrand	5 Thorsager
Hornslet) Hastrup 340
Ølholm	6 Hørning 340
Tinglev	St. Damme
Næsbyhoved	6 "Mus. Min."
Tranemosegaard	Sakskøbing
Lundby	345 Kulemile
Holme Mose) ''2. Afd.(1)''
Taageby 300	Knabstrup 3 345
Danmark 1 305	6 Aagerup 345
Knabstrup 1 303	5 Danmark (4) 346
Vintved	5 Jonstrup Vang 348
Dyrholmen	5 Fyn
Egum 305	Rønnebæksholm
Hedehusene	350 Skellingsted
Danmark (5) 308	B Danmark (6)
Grænge A	Nørre Vissing
Terp Mose	6 Mors
Gøderup (subad.)	Danmark (7) 357
Grænge B	5 Lyngby 358
Grevinge	5 Alsønderup
Gentofte	5 Auning 365
Bro	Horsens Fjord
Sorø	Bregninge
Jelling	Trøstrup
Bedsmose	2 Danmark (Lotze)
Klarup 323	3 2. Afd
Østbirk	Julianelyst
Vig	5 Danmark (2) 395
Falster	5 Lørup Hede 397
Røde Mølle 325	5 Østersøen
Danmark (9) 325	5 Faaborg 400
Tepstrup 325	Brændholt, Nyrup 405
Tjerrild	Danmark (CN 1891)
Understed 330	((left) 420
Danmark (8)	
Niverød	
Bundsø	
Odder	
Lading	
G ! 31 11	

Table 7 (continued).

99		From Leithner	33:	275,	280,	280,	288,	293,	294,
Pindstrup	181			310,	310,	312,	313,	315,	318,
Aarhus	195			320,	320,	323,	324,	328,	330,
Ølholm	195			330,	333,	333,	334,	334,	339,
Skaarup	206			340,	340,	343,	345,	350,	350,
Dyrholmen	215			350,	357,	358,	360,	360,	361,
Korinth	220			363,	367,	368,	370,	370,	378,
Grænge	225			378,	398.				
Fuglekjær	227		99:	203,	208,	212,	215,	216,	220,
Mørkøv	227			222,	222,	223,	225,	227,	237,
Barløse	233			246.					
Bjeverskov	235	From La Baume	3:	320.		99:	190,	205.	
Aakjær	235	From Requate	33:	275,	298,	304,	307,	309,	316,
Gjødvad	235			325,	325,	330,	331,	333,	341,
Taastrup	240			351,	352,	354,	360,	365,	365,
Knabstrup	240			290,	392.				
Vigersted	240		99:	200,	224,	228,	232,	235.	
Bjerregrav	240	From Grigson	33:	343,	355.				
Svebølle	245	From Higgs	3:	342.					
Ullerslev	270	From Fraser.							
Toftum	270	(Star Carr)	çq:	189,	224.				
Flintinge	275								

Bos taurus domesticus.

33	99
St. Lyng (subad.)	Sandhuse I
Veddinge	Øgaarde II
Gammellung III	Gammellung 157
Vedbæk III	Sandhuse II
Løgtved Enge	Holmene
Vedbæk II (Maglemosegaard) 220	Nyrup III 170
Verupgaard	Nyrup II
Snoldelev I	
Ærø	
Holmene	
Bodal	
Gammellung I	
Søndersø	

cores are comparatively thick, being outside the range in females; this applies, e.g., to the subadult bulls from Hallenslev and Viesø, 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.

ೆ ಂ		් රීරී	
Ugilt	495	No information	
Brabrand	500	Ørting(600+) 680	
Sakskøbing	515	Danmark (CN. 1891)	
Grevinge (475+	515	Horn core 1	
Bro	525	St. Damme	
Fæsted	540	Røde Mølle	
Lundby	540	"Min. Mus"	
"Stud. Coll."		Dyrholmen (VII H ₂)	
Hornslet	. 550	Odder	
Ølholm	552	"2. Afd. (2)" 710	
Aagerup		Terp	
Bundsø		Faaborg(700+) 780	
Knabstrup 1			
Grænge B			
Tranemosegaard		00	
Læsten		99	
Horn core, 2		Pindstrup	
Thorsager		Gjødvad	
Vintved		Ølholm	
Sorø		Mørkøv	
Bønnelykke		Grænge	
Mors		Aarhus	
Julianelyst		Fuglekjær	
Lading		Bjerregrav	
Egum		Ullerslev	
Tinglev		Korinth	
Skellingsted(575 +		Toftumab. 480	
Fakse		Vigersted	
Knabstrup 3 (580 +		Aakjær (445+) 500	
Lyngby			
Klarup(510 +		From Leithner 33: 460, 490, 530, 540, 545, 549,	
Hastrup		550, 556, 559, 575, 578, 580,	
Østbirk		580, 583, 597, 600, 604, 607,	
Rønnebæksholm		608, 610, 610, 612, 615, 626,	
Tranekær		631, 639, 640, 643, 646, 650,	
"2. Afd. (1)"		657, 658, 670, 680, 688, 720,	
Trøstrup		730, 730, 736, 740, 780.	
Rosenholm		♀♀: 335, 357, 371, 377, 395, 396,	
Tepstrup		420, 426, 445, 450, 488, 530	
Auning		(r), (488 l.).	
Grænge A.		From La Baume &: 555. \$\mathcal{2}\$: 360.	
Fyn		From Requare 35: 548, 588, 601, 605, 618, 655,	
Kulemile		660, 693, 695, 720, 752.	
Vig		Q: 415.	
Nyrup		From Higgs 3: 785.	
Grejs Mølle		From Grigson 35: 705, 735.	
Orojo Mono	. 010	1 10111 011135011 00. 100, 100.	

Table 8 (continued). Bos taurus domesticus.

33	99
[Snoldelev II (jun.)	[Øgaarde III (subad.)
[Vedbæk II (subad.)	Sandhuse I (185)
Veddinge(295)	Øgaarde II
Gammellung III(295)	Nyrup III
Holmene	Gammellung II
[St. Lyng (subad.)(310)]	Holmene
Gammellung I(335)	Nyrup II
Vedbæk II (Maglemosegaard)(340)	Sandhuse II
Verupgaard(375)	
Snoldelev I(380)	
Bodal(385)	
Søndersø(415)	
Ærø(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 Svebølle 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 (Østbirk, 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 26,7 mm., Ærø 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 (Østbirk).

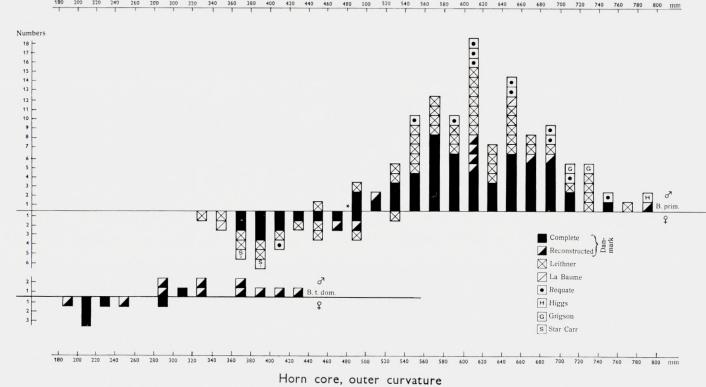


Fig. 15. Length along outer curvature of horn core. In fully adult Danish animals no overlapping between Urus bulls and cows exists. The range in domestic bulls largely overlap that in Urus cows.

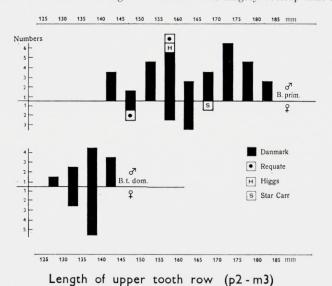


Fig. 16. In *Urus* cows the *length of upper tooth rows* falls within the range in *Urus* bulls, not, however, reaching the maximum length in bulls. Between small and old *Urus* bulls and large domestic males there is a small overlapping.

 $\begin{array}{c} {\rm Table~9.} \\ {\rm Length~of~upper~tooth~row~(p2-m3).} \\ {\it Bos~primigenius.} \end{array}$

ೆ ರೆ		Zone	22	Zone
Ostbirk	143	VIII	Skaarup	-
Fæsted	143	VIII	Bjeverskov	V
Læsten	145	VIII	St. Taastrup	II/V
Ølholm	147	_	Grænge	V
Min. Mus	151		Ullerslev	V
Ugilt	154	VIII	Pindstrup	VIII
Ørting	155	VIII		
Tinglev	155	VIII/IX	From Requate 3: 157. 9: 145.	
Auning	156	VIII	From Higgs 3: 159	VIII
Hornslet	158	VIII	From Star Carr 3: 168	IV
Tepstrup	158	IV	0	
Røde Mølle	158	IV		
Rønnebæksholm	160	V		
St. Damme	161	IV/V		
Bønnelykke	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		
Sorø	174	IV		
Grænge B	175	V		
Faaborg	179	III		
Vig	180	IV		
Tranemosegaard	180	V		
[Gøderup (subad.)	180]	IV		
Grevinge	182	V		
Maglemose (IIJ 10 ²)	182	V		

Bos taurus domesticus.

ೆರೆ	22
Snoldelev I	Øgaarde II
Verupgaard	Nyrup III
Veddinge 134	Gammellung II
Holmene I	Sandhuse
Vedbæk II (Maglemosegaard) 138	Nyrup I
Bodal	Holmene II
Gammellung I	Nyrup II
Søndersø	[Viksø I (subad.)
Ærø	
Vedbæk III	
[St. Lyng (subad.)	

86 Nr. 1

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 Viksø 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 border-line 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 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 Løgenkjær—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 (Søndersø, Maglemosegaard); on several points, however, somewhat larger, cf. e.g. the smallest length, anterior-posteriorly, 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

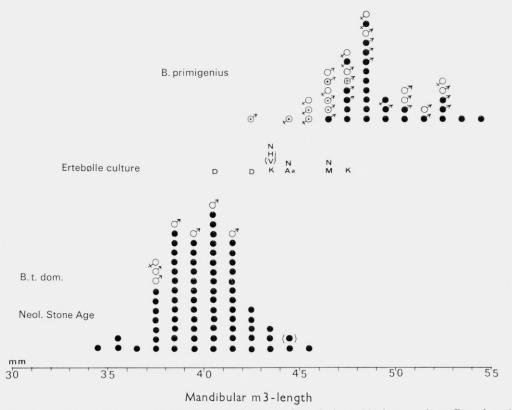


Fig. 17. Urus teeth marked ● originate from single finds of teeth from Maglemose sites; Boreal period. Teeth attached to skulls or mandibles, the sex of which is stated, are marked as to sex, ♂ or ♀. A filling in the sex signatures indicates animals older than Zone VII. From Zone VII only one skull is 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.

Ertebølle 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 (m 3). 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.

										•		
					Bos p	orimige	enius d	13				
Zone			IV				V		1	V I	IV/V	Т
Mandibles	Grænge	Vig	Sorø	Gøderupgaard subad.	Røde Mølle	Rønnebæksholm	Nyrup	Falster	Bisserup	Fakse	St. Damme	
	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 - m 3 length	179	_	173	194	160	172		177	168	186	167	
12. p 2 – 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 $= \times \dots$	×	×	×	×	×	×					+	

^{*} No. 9 associated with scapula, humerus, and tibia.

In fig. 17 the *Urus* teeth marked \bullet 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, 3 or 3 or 4. 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 Grænge 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 p	rimige	nius Z	3							Bos	primi	genius	99	
VII			VIII						Uncert	ain age	9			,	V	HV	V	III	U. a.
Bønnelykke	Grejs Mølle	Ugilt	Klarup	Gesten A	Tinglev	Bro Mølle	Vanløse	Jelling	Ortoft	Aarhus Havn	Gesten C	Danmark (2. afd.)	Danmark (Schmidt)	Ullerslev	Grænge	St. Taastrup	Pindstrup	Toftum	Gesten B
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		$\begin{cases} 410 \\ 425 \end{cases}$	387	415	380	425	405
455	487	450	455	460	(450)	470	460	450	465					455	420	445		450	_
383	417	380	(372 (395	390	385	395	400	400	400			408		375 395	350	380	345	390	355
88	96	90	63 71	85	83	96	90	95	90			83		§ 91 78	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 35	78 36	82 33	81	80	74	83	76	80	78	86	86	86	86	80	78	84	76	82	73
173	168	158	40 174	171	32 166	33 179	34 176	34 167	38 170		35 176	36 175	35 168	34 170	32 169	33 178	31 165	32 166	32 167
59	(63)	58	174	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
×	×	×			×	×	_		_				_	×	×	×	×	×	

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 (45.5×18.7 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 (44.3×18.6 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

_			Bos pi	rimigei	nius 🗣	9				
	Zone		Une	certain	age		Var.			
	Mandibles	Kundby	Tørring Staugaardskjær	Hvidbjerg	Løgenkjær	Vindum subad.	ేరే	\$5	Aamølle	Mejlgaard
		32	33	34	35	36			37	38
2. 3. 4. 5. 6. 7. 8. 9.	i 1, post. bord. — proc. condyloideus. For. mentale — proc. condyloideus i 1, post. bord. — proc. angularis For. mentale — proc. angularis. For. mentale — p 2 Smallest length of ramus verticalis Smallest depth of diastema. Depth at m 2, medial. Depth behind m 3, medial. Largest thickness	465 396 (422) 355 66 65 31 68 79 36	(455) 395 (425) 365 78 70 28 67 77	(465) 405 (435) 365 71 69 31 66 77 34	455 390 420 355 68 67 31 68 82 34	445 385 412 354 75 61 32 67 84	485-532 420-465 450-487 (372)-417 (63)71-98 65-77 32-39 (54)65-77 74-88 32-40	450–485 380–425 420–455 345–395 68–91 65–72 28–32 58–72 73–84 29–36		
	p 2 - m 3 length	175	177	175	171	(177)	158–179	165–178		
12. 13.	p 2 - p 4 length. m 1 - m 3 length. m 3 length at lower half.	62 108 45.8	64 114 46.9	59 113 \{\) 48.8 \} 49.3	59 114 52.2	(69) (105) 47.5	56-65 100-124 42.5-52.3	57–65 104–114 44.3–49.8	 44.5	63
	m 3 width, at base	18.5 112	18.8 109	,	(19.7) 116	19.5 133	18.3–21.5 121–150	18.5–19.8 109–132	18.7	18.3

^{*} 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 (40.8×17.2 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 $(43.8 \times 19.0$ mm.) and Aamølle (44.5×18.7) , 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 Aamølle 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 $(42.7 \times 18.7 \text{ mm.})$ no doubt must be grouped with the *Urus*. The two smaller ones $(41 \times 18 \text{ mm.})$ are,

Nr. 1

(continued).

				Bos	prim	igeniı	lS							$B\epsilon$	os taur	us don	nesticu:	S		
				Kitc	hen n	nidde	ns													Var.
Krabbesholm	*	Hjerk Nor	Virksund	Dyrholmen II K 1	Dyrholmen M 13	Dyrholmen VI A 10	Dyrholmen VII G 7	Norslund	Norslund	Norslund	Gammellung	Maglemosegaard & Vedbæk II	Holmene	Søndersø 3	Bodal 3	St. Lyng & subad.	Sandhuse II	Viksø	Bundsø (♀)	ೆ ೆ
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
						1														

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

TABLE

					Bos pr	imigenii	18 FF				
Zone	I	H	1	IV		,	V		IV/V		
Metacarpus	Terp	Sorø	Grænge A ad., jun.	Munkebjergby	Grænge D	Nyrup	Falster	Lundby (Degerbøl 1942)	St. Damme	Gøderupgaard B	
	1	2	3	4	5	6	7	8	9	10	
I. Total length. Length, smallest, medial. II. Proximal width: 1. Transversal. 2. Anterior-posterior, greatest. 3. Articulation, anterior-posterior. III. Diaphysis width: 1. Middle, transversal, smallest. 2. Middle, anterior-posterior.	251 240 89.5 55 48 53 35	258 	252 235 87 52 50 52 35	252 238 82 53 44.5 51 36	245 230 83.5 49 45 49 31	245 232 86.5 54 45 53 35	249 235 78 46 43 50 32	253 241 84 51.5 47 51.5 32	258 246 86 55.5 50.5 48.5 34	248 235 77 50 43 50 33	
3. Smallest width, anterior-posterior IV. Distal width: 1. Transversal	31.3 85.5 45	30.5 85 45.5	87.5 45.5	82 42	83.5	88 46	81 44	86 44.5	84.5 46.5	43	
Index: II/I	35.7 21.1 34.1	33.7 19.4 32.9	34.4 20.6 34.7	32.5 20.2 32.5	34.1 20.0 34.1	35.3 21.6 35.9	31.3 20.1 32.5	33.2 20.4 34.0	33.3 18.8 32.8	31.1 20.2	

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 Ertebølle 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

11.

							Bos pri	migeniu	s 33							
VI		VII			VIII				Uncert	ain age		Settle	ments ((Fragme	ntary	bones)
Holmegaard 386/48	Sværdborg (Degerbol, 1942)	Aamølle	Ugilt	Klarup	Gesten D Tranekær Mose	Grejs Mølle	Tinglev	Vanløse	Kongsted	Nørlund	Løsning	Sværdborg	Ogaarde	Наvnø	Hjerk Nor	Holmegaard 1928
11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
264 250	248 233	248 231	264 250	249 235	244 230	278 262	249 236	250 238	252 242	256 242	260 247		_			
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 34.5 31	51 35 29.5		49 33 32	49 33 30	47 35	52 38 36	45 33.3 31	52 32 30	49.5 30.5 30	53 33.5 32	53 35 31	_		_		(48) 31.5
83 45	84.5 42	82 45	84 45	81 46	80 42	88 46	80 42.5	84 45.5	81.5 43.5	(83)	83 43	84.5	85 46.5	80		_
31.4 19.3 31.4	35.1 20.6 34.1	33.3 — 33.1	32.6 18.6 31.8	32.5 19.7 32.5	34.0 19.3 32.8	31.7 18.7 31.7	32.5 18.1 32.1	34.8 20.8 33.6	31.0 19.6 31.9	33.6 20.7 (32.4)	34.6 20.4 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 Ørum Aa five m 3 specimens exist, the largest measuring 41.5×18.4 mm. They, no doubt, all belong to Bos taurus domesticus. From Bundsø only two m 3 teeth are longer than 40 mm.: 44.4×18.2 and 44.0×18.2 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.

TABLE 11

					D		- 00			
					Bos pr	rimigeni	us \q	100		
Zone	V		VI		H	I-V		VIII		
Metacarpus	Ullerslev	Holmegaard	Sværdborg XXIII C 4	Sværdborg (1918, A)	St. Taastrup	St. Taastrup	Pindstrup	Вøппегир	Bønnerup	Alminddalen
	28	29	30	31	32	33	34	35	36	37
I. Total lengthLength, smallest, medialII. Proximal width:	246 235	235 227	243 239	244 234	249 238	245 231	235 225	245 234	230 219	240 228
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:										
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:										
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 (45.5×18.5) originates from Lindø, but it is highly curved from side to side, indicating a Bos taurus domesticus (H. Winge, 1928, p. 48). From Lyø an m 3 measures 42.8×17.5, 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 44.8×18.5 mm., but the m 2–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 m 3 (43.1×19.3 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.

Nr. 1

(continued).

			B	os primi	igenius (79						Bos tai	ırus dor.	nesticus		
Uncerta	ain age			Settle	ments (Fragme	entary	bones)					VIII			
Tjerrild	Vittrup	Auning/ Pindstrup	Sværdborg	Vinde Helsinge	Ogaarde	Mejlgaard	Hjerk Nor	Brabrand (II C 64-5)	Brabrand	Store Lyng (3)*	Maglemosegaard (♂) (Vedbæk II)	Vedbæk III (♂)*	Borremose (♂)*	Holmene	Holmene (left) (♂)*	Holmene (right)
38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
231	253 242	232 220	_		_	_				201	199 189	204 194	217 207	205 195	210 199	216 205
69 42	75.5 46	70 44	_	72.7 44	66			65.5 41.0	72 45	62 37	64 40	63 38	72 44	61 36	67.0 41.3	68 41
40	39.5	39	_	39.5				36.2	40	34	34	36	37	31	36.0	36
38	43	39	_	37.5	35.5		_	36.2		33	39	36	37	33	37.5	38.7
28 26	32 32	28 27	_	27		_	_	_	-	25 23.5	25.5 23.5	23.8 21.8	26.5 23.8	24.5 22.0	28 23	28 23
_	70 40	67 39	71.5			71 40	66 37.5	_	_	61	65 34.5	68 34.7	73 37.5	59 32.0	70 36	70 35.7
29.9	29.8	30.2								30.8	32.2 19.6	30.9 17.6	33.2 17.1	29.8 16.1	31.9 17.9	31.5
16.5	17.1 27.7	16.8 28.9	_	_	_	_	_			30.3	32.7	33.3	33.6	28.8	33.3	17.9 32.2

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 Lyø 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

			В	os tauri	is dome	sticus			
					VIII				
Viksø	Hallebygaard	Bunds θ (δ)*	Bundsø (♀)	Bunds θ	Bundsø (♀)	Bundsø (♀)	$\begin{array}{c} \text{Troldebjerg} \\ (\mathfrak{Z}) \end{array}$	Troldebjerg $(\delta)^*$	Aamosen 1941 (δ)*
55	56	57	58	59	60	61	62	63	64
187	177	(215)	204	196	202	196	210	212	210
180		205	192	185	192	190	199		199
48	52.5	67	62	60.5	60	53.3	66.5	68	69
30	31	39	37	40	34.5	34			41
28		36		_			38	38	38
22.5	26.5	36.6	35	35	30	27.5	40	38	36
18.5	_	25.7	22.2	23,4	23.6	21.8	28	28.5	26
18.7		25.2			_		26	23	25
48	48.5	63.7	63.5	63.5	57.8	58.8	67.5	70	69
27.5	27	34.5	34.2	34.7	29.6	31	35.7	37	35.7
		(31.1)	30.4	30.9	29.7	27.2	31.7	32.1	32.8
	15.0	(17.0)	17.2	17.9	14.9	17.3	19.0	17.9	17.1
		(29.6)	31.4	32.6	28.6	30.0	32.1	33.0	32.8
	187 180 48 30 28 22.5 18.5 18.7 48 27.5	55 56 187 177 180 — 48 52.5 30 31 28 — 22.5 26.5 18.5 — 18.7 — 48 48.5 27.5 27 — 15.0	55 56 57 187 177 (215) 180 — 205 48 52.5 67 30 31 39 28 — 36 22.5 26.5 36.6 18.5 — 25.7 18.7 — 25.2 48 48.5 63.7 27.5 27 34.5 — — (31.1) — 15.0 (17.0)	Parents <	Parents Parents <t< td=""><td>VIII gg gg</td><td>Egy Her Properties Egy Her</td><td>$\begin{array}{c ccccccccccccccccccccccccccccccccccc$</td><td>$\begin{array}{c ccccccccccccccccccccccccccccccccccc$</td></t<>	VIII gg gg	Egy Her Properties Egy Her	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$

^{*} 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, Bønnerup, 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 Mølle are exceptionally long, astoundingly dated at the Subboreal period; the metacarpal length is 278 mm., as compared with

(continued).

			$B\epsilon$	os taurus do	mesticus					Bos prin	nigenius	В	t. dom.
			VIII				Rec	cent		V	ar.		Var.
Ørum Aa (Winge 1900)	Kærup, Bjerget (♂)	From Імно г	From Jewell	From Hescheler & Rüeger 1942	Prize bull (Stamtyr) (Fr. the year 1870)	Red Danish breed (Rød dansk mæl- kerace) (7 years)	K 565 (Bullock)	A 740	A 588	ੱਤੇ (Nos. 22)	(Nos. 13)	Holmene 🌣	(Nos. 6)
65	66	67	68	69	70	71	72	73	74	75	76	77	78
	210	179- 221	186- 218	175–215 (Nos. 15)	200	228	2 2 3	205	214	244-278	230–253	205	199–217
_	199	(Nos. 45)	(Nos. 13)		-	217	219	194	204	230–262	219–242	195	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
∫ 57− 66.5	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 (Degerbøll, 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.) (Degerbøll, 1962). It should be emphasized that small metapodials occur already in the Boreal period. From Holmegaard settlement

1	Bos primigenius ささ													
Zone	III		IV		V	VI	IV/V			V	/III			
Metatarsus	Terp	Vig	Sorø	Grænge A ad. jun.	Lundby (Degerbøl 1942)	Ogaarde III F 65	St. Damme	Ugilt	Klarup	Auning (Lykkegaard)	Gesten (Tranekær)	Grejs Mølle	Tinglev	
	1	2	3	4	5	6	7	8	9	10	11	12	13	
I. Total length (posterior) Length, lateral, smallest II. Proximal width: 1. Transversal 2. Anterior-posterior III. Diaphysis width: 1. At middle, transversal 2. At middle, anterior-posterior 3. Smallest, anterior-posterior, distal. IV. Distal width: 1. Transversal 2. Trochlea medialis, antpost	287 274 71 66 43 41 36.4 79 44.5	293 287 68 — 44 — 82	304 291 69 66 42 41 35.5 78 45.5	288 276 67 67 41 41 35.5	280 271 71 65 41 42 34.5 73 44.2	(285) 275 37 37 32.5 77 44.5	73 71 42 42 35 81 47	295 284 68 67 39 40 35 79 45	283 269 68 66 41 39 33 74 45	285 276 73 67 43 45 37 75 44	270 254 65 63 38 38 34 73 41	315 298 72 68 42 43 39 79 45	283 266 65 60 39 39.5 33.2 74 41.6	
3. Index ² / ₁	56.3		58.3	57.0	60.5	(57.8)	58.0	_	60.8	58.7	(56.9)	57.0	56.2	
II/I III/I IV/I	24.7 15.0 27.5	23.2 15.0 28.0	22.7 13.8 25.7	23.3 14.2 27.4	25.4 14.6 26.1	(27.0)	24.7 14.2 27.5	23.1 13.2 26.8	24.0 14.5 25.1	25.6 15.1 26.3	24.0 14.1 (26.7)	22.9 13.3 25.1	23.0 13.8 26.1	

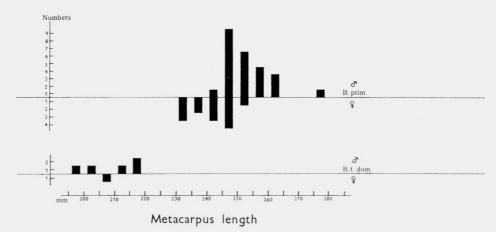


Fig. 18. Metacarpus length. The metacarpal lengths of domestic oxen are widely outside the range of that in Urus.

Bos primigenius ඊට්											Bos pi	rimiger	ius 😭)					
	Unc	ertain	age				Settle	ments			V		VI	II		U.	age		
Hvalsø (Sonnerupgaard)	Holbæk Museum	Næsbyhoved	Stilling Sø (Skanderborg)	Mors	Ogaarde	Ogaarde	Hjerk Nor	Norslund	Неѕснеген & Кじебен	Неѕснеген & Rüeger	Ullerslev	Pindstrup	Bønnerup B	Bønnerup A	Ørum Aa	Tørring	Vinderup Struer	Maglemose 1949	Sværdborg (Degerbøl 1942)
14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
293 275	308	290 282	278 265	293 275					280	302	280 269	275 260	283 270	268 257	275 263	281 267	270 255		_
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	_	-

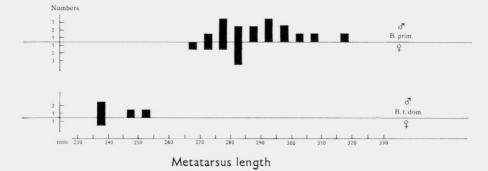


Fig. 19. Metatarsus length. Cf. fig. 18.

Table 12

												1 /11/1	
			Bos	primi	Bos taurus								
Zone				Kitch	en mi	ddens							
Metatarsus	Ogaarde	Krabbesholm	Hjerk Nor	Hjerk Nor	Hjerk Nor	Dyrholmen	Dyrholmen	Mejlgaard	St. Lyng	Maglemosegaard	Vedbæk III	Borremose ♂*	Holmene ?
	34	35	36	37	38	39	40	41	42	43	44	45	46
I. Total length (posterior) Length, lateral, smallest	_	_			_	_	_	_	(235)	235 224	236 228	247 235	236 228
II. Proximal width: 1. Transversal	57 54	_	_				_	57 55	50 50	52 48	49 49	59 54	49 47
III. Diaphysis width:1. At middle, transversal2. At middle, anterior-posterior3. Smallest, anterior-posterior, distal	34.4 37 29.5	_ _ 30	_	_	_	(34) — 32.7	_ _ 31	32	27 31 26	34 31 27.5	29 29 25	28 35 26.5	27 29 25
IV. Distal width: 1. Transversal	66	65	66	64	64	66	63.5		_	60	58	65	55
2. Trochlea medialis, antpost 3. Index ² / ₁	39.7 60.2	38 58.5	37.5 56.8	39 60.9	38 59.4	39.3 59.5	37.5 59.1	_	_	33.5 55.8	33.5 57.8	35.8 55.1	31.5 57.3
Index:						_		_	(21.3) 11.5 —	22.1 14.5 25.5	20.8 12.3 24.6	23.9 11.3 26.3	20.8 11.4 23.3

^{*} 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-

Nr. 1

(continued).

domesticus													Bos	prim.	$B\epsilon$	os t. dom.
				VIII						U.	age		Va	ar.		Var.
Holmene ♂*	Viksø	Kolind	Havnø	Bundsø, C 2 (Degerbor 1939) (♀)	Bundsø, C 2 (Degerbor 1939) IV F 8³ (♀)	Bundsø, C 2 (Degerbør 1939) (3)	Bundsø B (Degerbor 1939)	Aalborg (Winge 1900)	Aalborg (Winge 1900)	Aamosen – Holbæk 3*	Aamosen – Holbæk \$\delta^**\$ Bjerget \$\delta\$ Prize bull (From the year 1870)		ీరే (Nos. 18)	φο (Nos. 7–16)	Holmene	ೆ ನೆ
47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
250 240	212 204	230	_	237	224			_		239 230	244 (233)		270–315 254–298	268–283 255–270	236 228	235–250 224–240
55	39.5 38.5	49 46		47 45	43 41			_		52 50	59 56	66	64-73 60-71	50–62 50.5–57	49 47	49–59 –56
29.5 36 27	20.3 21.5 20	27 29	_	26 29 24	23 26 —		_		_	28 32 28.5	34 35 29	34 33.3 —	36.5–42 37–45 31–39	31–35.5 33–37 29.5–34	27 29 25	28-34 29-36 25-29
64	44.5	56	55 47	53	52	63	59.5	64	71	61	68	68	73–82	62-68	55	58-71
34.5 53.9	26.8 60.2	35 55.4	_	32 60.4	31 59.6	35.7 56.6	35 58.8	35.5 55.5	38 53.5	34 55.8	36.6 53.9	37.7 55.4	41–47 56.2–60.8	36-41.5 56.8-61 (63.2)	31.5 57.3	33.5–38 55.1–57.8
22.0 11.8 25.6	18.6 9.6 21.0	21.3 11.7 24.3	_	19.8 11.0 22.4	19.2 10.3 23.2	_	_		_	21.8 11.7 25.5	24.2 13.5 27.9	28.7 14.8 29.6	22.1–25.4 13.5–15.9 25–28	18.7–22.1 11.5–12.7 22.1–25.3	20.8 11.4 23.3	20.8–24.2 11.3–14.5 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

									TABLE						
	Bos primigenius ීරී														
Zone	III		I	V				V	I						
Scapula	Terp	Vig	Sorø	Grænge A	Gøderupgaard subad.	Grænge D	Nyrup	Bisserup	Sværdborg 1918						
	1	2	3	4	5	6	7	8	9						
Greatest width of cavitas glenoidalis:															
a. anterior-posterior (lateral)	85	79	85	82	78	82	81	84							
b. Transversal	71	69	75	74	67	72	70	69							
 Smallest width of collum, antpost Greatest width of collum, from proc. 	87	(81)	84	82	74	78	86	80	82						
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								
dorsalis at top of the spina scapulae	490		450	440	400	495	(450)								

	Bos primigenius ♀♀														
Zone	Maglemose settlements														
Scapula	Maglemose 1900 III B II¹	Maglemose 1904	Maglemose 1900 ad.	Maglemose 1900	Maglemose 1949	Sværdborg 1918	Ogaarde III I 10¹ ad.	Ogaarde III I 10¹ ad.							
	25	26	27	28	29	30	31	32							
1. Greatest width of cavitas glenoidalis: a. anterior-posterior (lateral) b. Transversal 2. Smallest width of collum, antpost 3. Greatest width of collum, from proc. coracoideus to post. border of cavitas 4. Width of upper end, greatest 5. Max. height	74 62 67 86	69 60 66 81 (235) (420)	69 60 63 86 (230) (210 ⁺) (380) (330 ⁺)	66 58 59 81	68 61 — 80 —	72 60 66 86	69 59 — 83	70 58 — 86							
6. Height from middle of cav. glenoid. to margo dorsalis at top of the spina scapulae			_												

^{*} Probably bullock.

					Bos prim	nigenius d	53							9
IV/V	V	II		VIII				Uno	certain a	ige			V	VIII
St. Damme	Bønnelykke	Krabbesholm	Grejs Mølle	Tinglev	Ugilt	Østrup Viksø	Kongsted	Frøbjerg	Handermelle	Kolding	Solbjerg Lake	Danmark	Ullerslev	Pindstrup
10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
87	87		88	79	86	(80)	76	88	91	86	81	84	70	70
71	70		77	64	68	74	70	73	77	74	73	74	60	58
82	84	75	84	80	79	85	70	92	78	83	84	76	69	63
110	102		100	95	105	102	93	113	105	98	96	96	89	82
295	275		_	260		_		295			_	270	(245)	_
505	486		520	490				(503)			_	495	(445)	_
495	463		500	465				491				475	(430)	_

	Bos prim.				Bos taurus domesticus												
		V	ar.														
Ogaarde III G 10³	Ogaarde III F 8⁴ ad. jun.	(Nos. 9-19)	(Nos. 10)	Holmene ç	Søndersø	Bundsø (Nos. 12)	Bjerget 3	From HESCHELER & RÜEGER (Nos. 3)	Nobis	om s, 1954 zenfels)							
33	34	35	36	37			40	41	42	43							
75	67	76-91	66-75	56	65	52-64	74	52-58	50	53							
58	56	64-77	58-62	49	55		63	45-48	40	45							
68		70-92	59-69	56	58			47–55	37	51							
88	78	93-100	81-89	69	74	74 61-77				_							
_	_	260-305	(235–245)	200	195		***************************************		Manager	Parade							
_		470-520	(380–445)	375	400			295-330	233	321							
		440–505 —		357	385												

Nr. 1

settlement (Degerbøl, 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 mm. In domestic cattle the trochlea width ranges from 32 mm. (Holmene \$\varphi\$ to 37 mm., as compared with 37–41 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 mm., and in *Urus* bulls 41–47 mm.

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

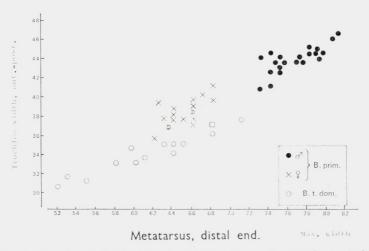


Fig. 20. Metatarsus, distal end. — Ordinate axis: absolute measurements, anterior-posteriorly, of the largest (medial) sagittal ridge of the trochlea; abscissa: absolute transversal width. Prize bull marked by a square. D. Dyrholmen. The transversal width in domestic cattle may be just as large as in 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.

Nr. 1

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 Goderup bull is smooth, whereas the muscular attachments in older animals are strongly marked.

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

Only two *scapulae* of domestic cattle, from Holmene, \circ , and Søndersø, 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 Ørum 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

											Bos p	rimige	nius	33		
Zone	III		I	V				V			VI	V/VI	VII	,	VIII	
Humerus	Terp	Vig	Sorø ad. jun.	Grænge A	Gøderupgaard ad. jun.	Grænge D	Grænge D	Grænge D	Nyrup	Bellinge	Bisserup	St. Damme	Bønnelykke	Ugilt ad. jun.	Tinglev	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1. Greatest length, tub. maj.—cond. med	430 358 143 64 70 105 108	410 — 51 — — 111	410 350 133 57 61 107 110	55 64 108 116	48 50 101 103	397 342 143 55 60 102 105	352 	56 	417 345 137 58 65 102 105	 350 56 61 103 106	347 	410 340 — 56 58 104 110	410 350 151 54 64 99 105	(360) 55 59 105 106	400 345 126 53 59 95 100	

^{*} Probably bullock.

cow—attached to the Taastrup antebrachium—the proximal epiphysis is still free, and the same holds good of the Sorø 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 Bønnerup. 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 Bundsø and Blandebjerg (Degerbøl, 1943, p. 24) may be recorded: Bundsø 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.

Nr. 1

											Bos	prim	. 99		l v	ar.		Dog		a don	esticus	
				Unc	ertain	age				V	II/V		VIII			ar.		D08 1	auru	s aon	iesticus	
Grejs Mølle	Frøbjerg	Vanløse	Ganløse ad. jun.	Faarevejle	Furup	Nørlund	Feldborg	Oresund	Zealand	Ullerslev	St. Taastrup ad. jun.	Pindstrup	Вøппегир	Bønnerup	(Nos. 8- 23)	(Nos. 2- 5)	Holmene	Maglemosegaard े	Søndersø å*	Borremose ♂*	Aamosen (Holbæk) 3*	Bjerget ै
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
425 360							360	_	422 348 141	359 309 127	367 340 130				342-360	359–367 309–340 127–130	250	290 250 85	315 280 112	342 290	(282)	344 300 120
61 63	61 67	59 61	52 56	60 67	_	55	59 62	52 54	58 62	46 50	48 52	42 44	45 46		51-64 54-70	42–48 44–52	39 40	32	41 44	49 50	40 43	49
106 112		107 109	101 103	_	102 106	105	102 114	105 —	100 104	89 92	98 99	81 86	83 85	_	95–108 100–116		75 76	75 79	81 83	89 90	85 86	90 91

Antebrachium

14.

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

									IABLE	
				Bos 1	primigen	us 33				
Zone	III		IV				V		V/VI	
Antebrachium	Terp	Vig	Sorø ad. jun.	Grænge A ad. jun.	Grænge D	Bellinge	Nyrup	Falster	St. Damme	
	1	2	3	4	5	6	7	8	9	
Ulna:										
1. Greatest length	478	500	481	(485)	461	470		(485)	487	
2. Olecranon width, greatest	96		(90)		93	96			94	
3. Olecranon width, smallest	82		77	75	78	82		77	81	
Radius:										
4. Length, medial	363	(367)	362	355	345	357	355	357	363	
5. Prox. width, transv	121	121	122	118	114	115	107	109	121	
6. Prox. width, articul	108		110	108	100	102	97	96	107	
7. Prox. width, medial, antpost	64	_	60	60	56	62	52	53	60	
8. Prox. width, medial, articul	52	_	53	53	51	52	48	48	54	
9. Diaphysis width, middle	70	68	64	65	67	63	68	64	69	
0. Distal width, greatest	113	109	109	110	113	106	104	101	108	
1. Distal width, articul	99		97	101	93	95	96	91		

			В	Bos prima	igenius ♀	7			Bos
Zone	\	7	II/V	V	92 102 95 84 93 86 — 46 51 48 56 42 — — — 50 56 50 56				
Antebrachium	Ullerslev	Grænge C	St. Taastrup	Pindstrup	Bønnerup	Havstrup Tørring	Tjerrild	Oresund	Krabbesholm
	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, antpost	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				ੈ 107
11. Distal width, articul	83	80	84	75	73				107

Nr. 1

15.

						Bos p	orimigeni	us 33						
	VII		VIII						Uncert	ain age				
Undløse Bro (A 35668)	Bønnelykke	Ugilt	Tinglev	Grejs Mølle	Klarup	Ganløse ad. jun.	Faarevejle	Tissø 1965	Handermelle	Broby	Torpe (Kalundborg)	Feldborg	Danmark I	Danmark II
10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
_	84 75	76	472 79 75	500 95 83			(472) — 81	(485) — 82	— — 80	_	482 91 84	_ _ _	486 92 80	490 90 81
371 (113 ⁺) 108 61 56 70 114 100	108	370 118 106 62 56 59 107 102	350 108 95 56 48 62.5 100 92	372 121 107 59 52 71 113 107	353 113 100 56 51 54 104 97	110 100 57 53 60	(360) 115 103 59 51 67 (107)	356 121 110 63 52 67 110	362 118 109 61 55 62 113 102	104 96 (60)	365 116 108 57 55 70 108 96	364 116 101 57 53 69 106 92	367 116 105 62 56 68 108 93	371 119 106 60 52 65 112 97

primigen.	Kitchen	middens			Bos t	aurus don	nesticus			Bos prin	nigenius
										V	ar.
Hjerk Nor ♀	Hjerk Nor	Hjerk Nor đ	Holmene ?	Nymp	Bundsø DS 2 (Degerbøl 1939)	Bundsø DS 2 (Degerbøl 1939)	Orum Aa (Winge 1900)	Bjerget 3	From Hescheler & Rüeger (Nos. 4)	(Nos. 11-22)	^{çç} (Nos. 3-8)
34	35	36	37	38	39	40	41	42	43		
			360 62 54			_		421 — 64	=	461–500 79–96 75–84	407–(465) 64–75 50–73
_	_	_	274	(290)	307		76	310 99	242–275	345–372	, 312–345
95	113		83	86	93	76 81	87	90	63–68	107–121	91–110
85	101		74	80						95-110	83-98
49	60.5		41	44			_	48	_	52-64	46-54
_	52.5		39	40			_	47	_	48-56	42-49
			42	45	43			50	34-40	63–71	47-57
97	ੈ 110	101	72	79	78	_	_	87	_	100-114	78-93
83	94	90	66				_	80	56-62	91–107	73-84

				Bos	primige	nius 33			
Zone	U. a.		I	V		,	V	IV/V	VII
Femur	Terp	Vig	Sorø ad. jun.	Grænge A ad. jun.	Gøderupgaard subad.	Nyrup	Falster	St. Damme	Bønnelykke
	1	2	3	4	5	6	7	8	9
. Greatest length, to condyle		518				509	470	524	_
Length, caput-condyle	475	495	470	467	(460)	465	440	470	
. Prox. width, transversal	_			174	_	168	164		
Diameter of caput			66	68		65	61	_	
Diaphysis width	67	57	54	57	47	59	52	57	
. Distal width, greatest	145	138	136	(133)	(126)		130	141	139

^{*} Upper and lower epiphysis free.

	E	Bos prim	igenius ♀	9	Bos p	orim.	В.	t. dom.
Zone		Uncert	ain age		Va	r.		Var.
Femur	Kundby	Kirkerup	Kirkeby	Grejsdalen	ੱਠੋਂ (Nos. 8-17)	(Nos. 2-8)	ŞŞ (Nos. 2)	od (Nos. 2-5)
	24	25	26	27	28	29	30	31
. Greatest length, to condyle	427		_		470-524	427-445	370	358-(430)
2. Length, caput-condyle	405	428	(428)		440-482	400-428	341	340-(395)
3. Prox. width, transversal	138				157-183	138-147	119	108-133
Diameter of caput	54	59	_		61-69	52-59	44.5	49.5 - 51
5. Diaphysis width	45	50	45	48	(47) 51–60	39-50	36	31 - 49
5. Distal width, greatest	(105)		(110)		122-146	105-116	98	98 - 118

^{*} 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 mentioned 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 metapodials, also has very large forearms; the total length of the *ulna* is 500 mm.; *radius* length, medially 372 mm.

			Bos	primigenii	us 33						Bos prim	igenius 🗜	9
	VI	H				Uncerta	ain age			V		VIII	
Ugilt	Gesten A Tranemosegaard	Grejs Mølle	Tinglev	Næsbyhoved	Handermelle	Danmark I	Danmark II	Gudsø Vig ad. jun.	Osterby	Ullerslev	Pindstrup	Bønnerup	Bønnerup
10	11	12	13	14	15	16	17	18	19	20	21	22	23
(470)	470 (440)	518 482 180	476 450 157	505 478 173	510 475 183	476 174	466		_	445 418 147	(400)	400	_
62		65	61	63	67	69	63			57	_	52	
51 132*	53 129	59 140	51 122	57 136	53 146	59 142	53 135	132	54 —	54 116	39	45 —	47

					Bos	taurus de	omesticus	S					
Holmene	Nyrup	Maglemosegaard	Søndersø ♂*	Borremose	Aamosen (Holbæk)	Bjerget	Імног (1964) З	Імног (1964) S	Імног (1964) 3	Імног (1964) б	Неѕснецев & Rüeger	Hescheler & Rüeger	HESCHELER & RÜEGER
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,

							1	Bos p	rimig	enius	33						
Zone	III		IV		VI	IV/V	VII		VIII				Unc	ertain	age		
Tibia	Terp	Vig	Sorø ad. jun.	Grænge A ad. jun.	Bisserup	St. Damme	Bønnelykke	Tinglev	Ugilt	Grejs Mølle	Gundsømagle	Sonnerupgaard	Næsbyhoved	Mors	Mjesing	Barrit Skov	Danmark
	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 Bundsø, 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

		B	os pri	miger	iius 9	29			Bos	prim.			1	Bos tau	rus do	mesti	cus			
V	IV/V		VI				ertair	n age	1	ar.										
Ullerslev	St. Taastrup	Pindstrup	Bønnerup (left) ad. jun.	Bønnerup (left)	Orum Aa	Grejsdalen	Vinderup	Lille Lyngby	(Nos. 12-17)	(Nos. 3-9)	Holmene	$^{\rm Nyrup}_{\scriptscriptstyle \phi}$	Bjerget उ	Bundsø (Degerbøl 1939)	Orum Aa (Winge 1900)	Weiszenfels (Nobis 1954)	Schafis (IMHOF 1964)	Lattrigen (Imhor 1964)	Lattrigen (Imhor 1964)	Lattrigen (Imhor 1964)
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		an	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 Søndersø, 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 Bønnerup.

									TABL
			E	Bos primi	genius 3	3			
Zone	IV	V	IV/V	VIII		Uncer	tain age		V
Calcaneus	Vig	Nyrup	St. Damme	Ugilt	Mors	Hvalsø	Danmark	Silkeborg	Ullerslev
	1	2	3	4	5	6	7	8	9
1. Max. length	185	189	190	189	187		190	178	165
2. Greatest length, lateral		181	181	183	181	_	181	173	161
3. Height, lateral		70	71	70	71	70	71	67	64
4. Width of fasc. art., posterior		22	22	20	24	23	21	22	19
5. Greatest width		54	57	49	58	58	55	51	46
Corpus:									
6. Length, upper		109	109	112	104	_	109	103	94
7. Length, greatest		122	123	127	119	_	124	115	107
8. Width, smallest, transversal		28	28	25	27	29	28	28	22
9. Height, smallest		50	47	46	48	52	50	44	42
10. Width, greatest, posterior		48	52	48	48		48	44	43

						99				
	Zone			S	Sværdboi	rg settler	nent (Z	. VI)		
	Calcaneus	XXXV H2	XXIV A 8	XXIV A 3	XXIV A 3	XXIV A 3	XXIV A 3	XXXVI H 10 jun.	XXXVI K 4 jun.	XXIV A 5 jun.
		27	28	29	30	31	32	33	34	35
1.	Max. length		_	167				(145)	(133)	_
2.	Greatest length, lateral			163	_					
3.	Height, lateral	_	_	69				(65)	(60)	_
4.	Width of fasc. art., posterior	_		20	_			(19)	(17)	(17)
5.	Greatest width	45	44	48	_			(45)	(40)	(42)
	Corpus:									
6.	Length, upper	106	96	92				(81)	(78)	(81)
7.	Length, greatest	119	109	105						
8.	Width, smallest, transversal	24	24	24			_	(22)	(19)	(18)
9.	Height, smallest	43	43	42	44		44	(37)	(34)	(34)
10.	Width, greatest, posterior	44	42	42	40	42	41	-	_	

	99			3	3		9	9			30	3			4	2
VIII	U.	. a.		Maglen	nose set	tlemen	(Z. V)				Sværdh	org set	tlement	(Z. VI)	
Bønnerup	Staugaardskær Tørring	Vinderup (epiphysis missing)	V A 3-9 (Bottom)	I B 71	1949	11 I 9ª	III F 26	1949	1918	XXXVI K 3	XXXVI C 10	1918	1918	1918	6 I IIIAXXX	XXXV E 2
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

		3	ð		9	3	B. p	rim.	ತೆ ತೆ		29	7	B. t.	dom.
		Holme	egaard	(Z. VI)			Va	ar.		Dyrh	olmen			
				sis	sis		°°° (Nos. 5-9)	ਨੂੰ ਨੂੰ (Nos. 5-13)			01			
1918	1922	1922	1922	1922 – epiphysis	1922 – epiphysis	Ogaarde VI H 37	Mag] settle	lemose ements	II B 5	VI D 2	XIX F 7 ² (porous)	I A 2	Holmene	Bjerget
36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
	178	179		(148)		171+	162-167	178-192	177		163		138	158
	173	176					156-163	173-187	175		160		130	154
(63)	67	69		(66)		67	62 - 69	(67)-69-77	72	73	64		53	62
(18)	22	24		(19)		22	18-20	22-26	22	24			15	20
(43)	51	53		(44)			44-48	51-60		_			38	45
(80 ⁺)	104	104		(84)		106	92–97 (106)	104-112	100		100	96	80	89
	117	117		_			105–109 (119)	116–124	(111)		(106)	(110)	90	103
(21)	24	22		(22)		25	23-26	24-31	24	27	22	22	18.5	23
(38)	44	48		(40)		48	41-44	44-51	48		42	44	34	40
	46	44	47	(29)	38	_	40-44	44-50	42		39	40	34	41

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 mm., greatest widths 44–48 mm., as compared with 178–192 mm. lengths, and 51–60 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 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 A + B. A. Posterior half of *calcaneus*; lateral view. B. Anterior view. - A medullary cavity occurs immediately behind the articular surface. \times $^2/_a$.



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 さる										Bos	prim	igeniı	ıs 😜	
Zone	III		IV		V	V	III	Unc	ertain	age	V		VIII		
Astragalus	Terp	Vig	Sorø	Grænge A ad. jun.	Nyrup	Ugilt	Tinglev	Gundsømagle	Hvalsø Sonnerupgaard	Mors	Ullerslev	Pindstrup	Bønnerup	Bønnerup	VII B 52
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Maximum length 2. Greatest width, distal 3. Lateral height, from upper incisure	93 63 48	90 62	93 61 48	90 62 47	89 59 48	89 59 46	84 57 44	89 61 47	92 62 47	92 63	83 52 43	82 52 42	80 50	77 47	93 62 48

	Astragalus													lme- ard
Zone			33						99				3	9
Astragalus	1918	1918	1918	1918	1918	1918	1918	1918	1918	1918	1918	juv.		
	36	37	38	39	40	41	42	43	44	45	46	47	48	49
1. Maximum length 2. Greatest width, distal 3. Lateral height, from upper incisure	97 63 49	92 63 50	91 60 44	90 56 46	89 53 45	85 50 43	85 52 40	81 52 40	81 52 39	(82) — 42	(83) 54	68 42 33	86 58 44	84 51 42

	Bos pri	migenius		Kitc	hen midd	lens (Bo	s primige	enius)	
Zone		settlements ar.			22			3	3
					Brabrand				
Astragalus	(Nos. 34)	(Nos. 21)	porous jun. ad.		porous		II A 103	Dyrholmen II D 9³	Dyrholmen VII 27
	70	71	72	73	74	75	76	77	78
Maximum length Greatest width, distal Lateral height, from upper incisure	79–86 49–55 39–45	86–97 (53) 56–63 44–50	84 51 41	81 51 41	81 48 40	79 48 39	76 49 41	90 60 46	87 56 46

Nr. 1

19.

N	Iaglem	ose set	tleme	nt						S	værdb	org se	ttlemer	nt					
d	3		99					33							9	2			
I B 91	I B 82	I K 23	1949	1949	XXXVI G 2	XXIII D 5	XXIV C 8	XXXVI K 9	XXIV E 3	XXXV B 4	XXXV H 2	XXIV B 4	XXXVI F 10 (porous)	XXIII C 4	XXXV G 2	XXXVI K 7	XXIII B 4	XXXV H 2	XXIV A 2 juv.
16	17	18	19	20	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

								Øg	aarde	settler	nent								
		33									9	19							
II D 10³	P V 54	IV C 34	III I 13	X K 10 ³	IV D 13	III G 84	V A 13		IV F 4	III 1101	IV A 63	IV D 32	I D 3²	III H 23	II H 2²	III K 1³	III B 10²	IV C 34	Hesselbjerggaard I H 8
50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
91 62 50	(90)	89 60 46	88 60 46	(88) 60 46	85 53 42	85 53 43	85 54 45	85 51 43	85 51 44	85 52 44	(83)	(85) 50	84 52 42	(82) (51)	81 51 41	80 51 41	80 52 40	80	82

		Kitch	nen mi	ddens	(Bos p	$rimig\epsilon$	enius)						Bos	tauru	s domesticu	1S	
9	9	9	3	9	3	9	9	9	9	3							
Dyrholmen XXX B 6	Kolind I	Kolind III (porous)	Hjerk Nor	Hjerk Nor	Norslund	Norslund	Krabbesholm	Krabbesholm	Orum Aa	Bjerget	Troldebjerg settlement	Troldebjerg settlement	Orum Aa settlement	Lindø settlement	Bundsø (Degerbol)	Orum Aa (Winge)	Aalborg (Winge)
79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
81	79	79	90	81	88	84	81	80	87	73	73	71	69	72	60-74	62-70	63-74
51 43	50 40	50 40	56	53	57 45	50 40	51 41	52 40	52 43	49 40	49 39	48 39	46 35	46 37	(Nos. 19)	(Nos. 15)	(Nos. 4)

TABLE

		Bos	prim	igeniı	ıs 33		\$	22				N	lagler	nose s	settle	ment
Zone	III		IV		V	V/VI	V	VIII			33					99
Naviculo-Cuboideum	Terp	Vig	Sorø	Grænge A ad. jun.	Nyrup	St. Damme	Ullerslev	Bønnerup	1 G 4	I B 7²	I B 9*	III B 4²	1949	1904 II H 6 ²	1904 II K 8	$^{1904}_{\rm II~G~1^2}$
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
. Greatest width	88 68	80	78 61	80 63	80 62	81 65	67 55	61 50	82 61	80 64	78 62	78 60	74 57	67 52	66 52	65 52
B. Height, greatest, anterior	31 22 73		31 22 71	30 20 73	30 18 71	31 21 77	26 17 61	24 16 63	29 19 78	28 19 75	30 18 72	30 19 72	27 18 68	26 17 62	26 18 63	26 17 62

	Hol	mega	ard se	ettlen	nent			Oga	arde			V	ar.
Zone	3	33 99					30	3		99		ತೆ ತೆ	99
Naviculo-Cuboideum	1922	1922	1922	1922	1922	I D 13	I D 63	II A 86	X B 104	IV A 2	III F 104 ad. jun.	(Nos. 18)	(Nos. 21)
	37	38	39	40	41	42	43	44	45	46	47	48	49
1. Greatest width. 2. Width, prox. articular surface 3. Height, greatest, anterior 4. Height, greatest, medial 5. Length, greatest, antpost. medial	76 59 27 18 69	75 57 27 16 67	66 52 25 16 66	66 51 26 16 60	63 53 27 15 59	81 63 32 21 75	80 62 30 19 71	80 62 29 19 71	78 61 30 20 70	70 54 25 17 63	65 55 24 15 60	74–82 57–64 27–32 16–21 67–79	(61) 63–72 (50) 51–57 23–29 14–19 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 definite 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, subadult 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, 3, and Pindstrup, 4, 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 mentioned above, these sites are so old that any intermixture with domestic oxen is ex-

									Sværdborg settlement												
					33									99							
$^{1904}_{\rm VII~K~4^2}$	1904 I K 6²	XXXVI F 6	XXIV G2	1918	1918	1918	XXXV 12	XXIII B 4	1918	XXXVI K 6	1918	1918	XXXV E 3	XXXVI D 6	XXXVI G 3	XXIV A 5	XL F 9	1918	1918 porous		
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
65	64	81	81	80	80	79	79	78	72	72	70	69	69	69	69	67	66	65	61		
51	54	63	63	62	61	60	61	60	57	57	57	53	55	53		56	53	54	50		
23	27	31	30	32	(27)	30	29	30	27	28	29	25	28	26		28	25	24	24		
15	17	20	20	19	19	21	19	21	16	19	19	16	18	18		18	16	14	13		
61	62	74	78	79	71	73	73	74	67	67	(65)	64	64	67	67		64	58	56		

	Kitchen middens (Bos primigenius)																	
9	ೆ ರೆ	5	99		3	9	2	3	3	9	- Bos taurus domesticus							
Brabrand (porous)	Dyrholmen XV 1 8 (porous)	Dyrholmen VII G 10	Dyrholmen XI H 8	Dyrholmen Brook	Hjerk Nor	Hjerk Nor	Hjerk Nor	Norslund	Norslund	Havnø	Holmene ਤੰ	Troldebjerg settlement	Troldebjerg settlement	Troldebjerg settlement	Lindø settlement	Orum Aa settlement	Havnø settlement	
50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	
61 (50)	75 60	73 57	61 48	61 52	79 61	70 57	67 54	75 59	75 58	69	62 49	60	57 47	57 46	57 46	60	59	
	_	28	24	25	29	26	25	28	30	(56) 27	24	22	24	23	23	49 24	47 22	
15 (59)	(69)	19 69	15 58	15 60	20 72	17 64	16 64	20 70	22 (66)	17 66	15 56	16 51	14 50	14 51	16 56	17 62	17 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 Bønnerup cows, from the Subboreal period, Zone VIII,

TABLE

	Bo	s primi	genius Z	33	Bos primigenius ♀♀								
Zone	I	V	U.a.	VIII	V								
Phalanx 1	Sorø Forelimb	Sorø Hindlimb	Mors Hindlimb	Tinglev Forelimb	Ullerslev Forelimb	Ullerslev Hindlimb	Pindstrup Forelimb	Bønnerup Forelimb	Bønnerup Hindlimb	Bønnerup 2 Forelimb			
	1	2	3	4	5	6	7	8	9	10			
1. Greatest length, lateral, posterior	77	81	77	69	69	72	68	68	74	63			
2. Greatest length, medial, anterior	76	79	75	71	68	70	65	67	72	60			
3. Smallest length, lateralis	71	75	70	65	64	66	62	65	69	59			
4. Smallest length, medialis	69	73	69	66	65	65.5	61	64	68	58			
5. Prox. width, greatest	45	43	40	41	39	35.5	34	35	34	34			
6. Prox. width, articular surface	40	37	35	37	33	32.5	33	34	32	32			
7. Prox. height, articul	41	43	42	39	36	39	35	34	35	34			
8. Diaphysis, smallest width, middle	37	34	32	34	33	29	29	31	28	29			
9. Diaphysis, height at middle	34	34	33	36	32	30	31	33	30	30			
10. Diaphysis, smallest, distal	27	26	26	26	22	23.5	22	22	22	21			
11. Distal width, articular surface, post	41	40	37	38	34	35	33	31	30	31			

^{*} 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 mm., come from the very old bull from Bjerget and the largest *astragali* out of numerous specimens from farmer settlements, i.a. Bundsø and Troldebjerg. The lengths of 19 *astragali* from Bundsø 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

Bos pr	imigeni	us (Kito	chen m	iddens)		Bos taurus domesticus										
3	3	9	9	9	3		2	3	3	1 3 *	3*	9	9	3	3	3
Orum Aa Hindlimb	Havnø	Brabrand Hindlimb	Dyrholmen (XXXI C 9²)	Dyrholmen (XV G³)	Dyrholmen (M 3)	Kolind (IV F 2 ⁵)	Hjerk Nor Hindlimb	Hjerk Nor Hindlimb	Hjerk Nor Hindlimb	Holmene Forelimb	Holmene Hindlimb	Holmene Forelimb	Holmene Hindlimb	Maglemosegaard Forelimb	Maglemosegaard Hindlimb	Bjerget Hindlimb
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	25	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

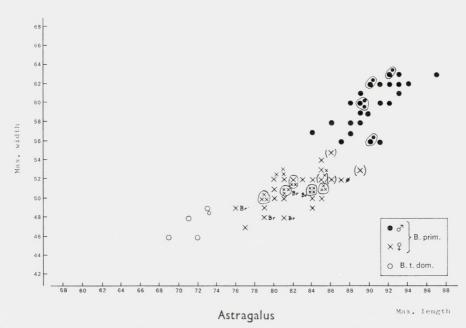


Fig. 23. Astragalus. Maximum width plotted against maximum length. Br. Brabrand. Encircled measurements are equal. — Even the small Brabrand astragali join the female group of B. primigenius. The B. t. dom. indicated represent very large animals.

TABLE

			Bos pri	migenius			Bos primigenius					
Zone		33			99		3	9	3			
Phalanx 2	Sorø Forelimb	Sorø Hindlimb	Mors Hindlimb	Ullerslev Forelimb	Ullerslev Hindlimb	Bønnerup Forelimb	Aamølle	Aamølle	Brabrand Forelimb			
	1	2	3	4	5	6	7	8	9			
1. Greatest length, lat. post	54	56	56	50	47	44	54	47	_			
2. Greathest length, med	47	50	49	45	46	41	48	_				
3. Smallest length, lat	42	46	44	38	41	35	41	36.5	38			
4. Smallest length, med	45	49	46	40	43	39	_	-	_			
5. Prox. width, greatest	43	42	40	36	34	32	39	33				
6. Prox. height, greatest	46	44	45	40	36	36		_				
7. Diaphysis, smallest width	34	31	31	28	27	26	33	26	32			
8. Diaphysis, height, smallest	36	33.5	31	30	26	28	34	27.5				
9. Distal width	38	33	36	31	29	28	33	28.5	_			

^{*} 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 99. Length and breadth: 84×51 mm., 81×51 mm., 81×48 mm., 79×48 mm., and 76×49 mm.

Dyrholmen I: 2 astragali are at hand, representing a \circlearrowleft (87×56 mm.) and a \circlearrowleft (81×51 mm.).

Kolind I (older than Dyrholm I): a single *astragalus*, $9 (79 \times 50 \text{ mm.})$.

Kolind III (Subboreal): $9 (79 \times 50 \text{ mm.})$.

Hjerk Nor: 2 astragali, \circlearrowleft (90×56 mm.), \circlearrowleft (81×53).

Norslund: 2 astragali, 3 (88×57 mm.), 9 (84×50 mm.).

Ørum Aa (Subboreal): a single *astragalus*, belonging to a $9 (87 \times 52 \text{ mm.})$.

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 Øgaarde (Zone VI). In 18 specimens the range of the greatest widths is

(Kitchen	middens)	Bos taurus dom.										
	2	9	9	3	3	9	9		3	3*		Ş)
	Brabrand Forelimb	Brabrand Hindlimb	Brabrand Hindlimb	Dyrholmen (VII K 6) Forelimb	Dyrholmen (porous) Hindlimb	Dyrholmen (II B 5) Forelimb	Dyrholmen (XXX G 9*) Hindlimb	Kolind (II B 7?)	Hjerk Nor	Holmene` Forelimb	Holmene Hindlimb	Holmene Forelimb	Holmene Hindlimb
	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
1				44	38	36	37	41		38	34	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 mm., in 21 specimens 61–72 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 mm. and 50–57 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 mm. According to Dottrens (*loc.cit.*) the range of greatest widths of 44 specimens of domestic Neolithic cattle is 43–57 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 p	orimi	genius	3	(1	Kitch	en m	idder	is)	Bos t. dom.			
Zone		33	33°		9				3	9	3*	3*	9	9
Phalanx 3	Sorø Forelimb	Sorø Hindlimb	Mors Hindlimb	Ullerslev Forelimb	Ullerslev Hindlimb	Aamølle	Dyrholmen (M 14)	Dyrholmen (XV 12	Hjerk Nor	Hjerk Nor	Holmene Forelimb	Holmene Hindlimb	Holmene Forelimb	Holmene Hindlimb
	1	2	3	4	5	6	7	8	9	10	11	12	12	14
Greatest length Length of upper margin	90 70	86 69	86 72	95 71	93 68	104	90 73	92 70	96	87	85 64	79 63	78 58	73 57
3. Length of rear margin (chord.) 4. Greatest width	65 35	63 32	63	61 32	57 29	38	61 31	(60)			56 29	54 28	49 27	46 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 Nor (3, 9, 9), 2 from Norslund (3, 3) and one from Havnø (9) are within the range of nav.-cub. from Maglemose sites. From superficial layers at Havnø 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 Bønnerup 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 9²) and Kolind (IV F 2⁵). 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

Mølle specimen is calculated at 183 cm. On the same basis the shoulder heights of the adult, but young bulls from Sorø 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 (Undløse (No. 10), Ugilt (No. 12) and Danmark II (No. 23)) are just as large as the Grejs Mølle 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 cm. \pm 5 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 Bønnerup 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 Bønnerup 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*. LILLJEBORG (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 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 $9-10^{-0}/_{0}$ higher than that of cows (Nobis, Kock), which at a rough estimate would give a shoulder height of 130-140 cm. in the bullocks from Holmene and Borremose (*metacarpus* length 216-217 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,

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 4th century A.D. Measured on a complete forelimb the shoulder height is 106 cm. (Length of metacarpus 159 mm.) (Møhl, 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° 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 conferous 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 (Heck, 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° 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 timber-cutting 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 Ertebølle 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 Mølle 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 Ertebølle 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 11th 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. Øgaarde complex, Undløse, Aamosen, N.W. Zealand (National Museum).

 φ 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).
 subadult. Skull with mandibles and postcranial skeleton-parts B-landnam. Zone VIII.
- III. Verupgaard, Niløse, Aamosen, N.W.Zealand (National Museum, 1942). Skull with mandibles. The very beginning of B-landnam.
- IV. Øgaarde complex, Undløse, Aamosen (National Museum 1943). $\$ Skull (Marked ''Øgaarde II''). Beginning of B-landnam.
- VI–VIIIA. Gammellung moor. Troldebjerg, Langeland (Langelands Museum). B-landnam. I β , skull. II β , incomplete skull. III β , brain-case. IV β , brain-case, subad.
 - IX-XA. Nyrup moor. 16 km. W. of Næstved (J. Ferdinand, Herlufsholm). About Blandnam. I $\ \$ (85/1945), incomplete skull and some limb bones. I $\ \$ (87/1945), brain-case. III $\ \$ Skull.
 - XI. Snoldelev. 8 km. S.S.E. of Roskilde (V. Mortensen, 1904). & Skull. B-landnam.
 - XII. Vedbæk. I. 20 km. N. of Copenhagen (1942).

 Skull. Subboreal transgression; the middle of Zone VIII.
 - XIII. Vedbæk II, Maglemosegaard. (P. Lorentzen, 1942).

 Skull with mandibles, metapodials, and toe-joints, vertebrae. Subboreal transgression. Probably just below the border of Zones. VIII-IX.
 - XIIIA. Vedbæk III. Idem.

 3 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, Hillerød. I (C. B. Jacobsen, E. Jensen, 1941).

3 Skull and limb bones. — Zone VIII. — B-landnam oldest possible dating.

- XVI. Holmene, Hillerød. II (C. B. Jacobsen, E. Jensen, 1941).

 § Skull and postcranial skeleton. Zone VIII, 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.
- - XX. [Vejlby. Kiselgurværk. 5 km. N.N.W. of Fredericia. (S. Th. Andersen, Danmarks geologiske Undersøgelse).

 Parts of fragmentary skeleton. Bronze Age.]
 - XXI. Ærø. In the cove of Ærøskøbing (Assessor Steenstrup, 1862).

 3 Skull. Zone VIII.
- XXII. Logtved Enge. 17 km. E. of Kalundborg. (Saltofte).
 3 Brain-case. The middle or late part of Zone VIII.
- XXIII. Viksø, Lindebjerggaard, Smørum. 18 km. W.N.W. of Copenhagen. (Thomsen, 1943).

 © Fragmentary skull. Zone VIII.
- XXIV. Viksø, Lindebjerggaard, Smørum. 18 km. W.N.W. of Copenhagen. (Simonsen, 1940).

 § Fragmentary skull with mandible, parts of postcranial skeleton. Zone VIII.
- XXV. [Holl, Alme, Græsted. 5 km. S. of Gilleleje. (Gilleleje Museum, 1941–42). (Lit. A. Andersen, 1943, pp. 64–65 (No. 64). Zone VIII.]
- 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). Skull. Late Bronze Age or early Iron Age. Zones VIII–IX.
- XXVIII. Snoldelev II. 8 km. S.S.E. of Roskilde. (Th. Mölby, 1945). 3 juvenile. Skull and postcranial skeleton. End of Zone VIII.
 - XXIX. Bodal. Ondløse. Aamosen. N.W. Zealand. (O. Schram, M. Rasmussen, 1940). Skull. Late Bronze Age or early Iron Age. J. Iversen.
 - XXX. Mors. (1891).

 ♀ Skull. Beginning of Zone IX. Litt.: Degerbøl, 1963.
 - XXXI. Gundsømagle. 12 km. N.N.E. of Roskilde (Mosegaard, 1945). Horn core. Zone VIII.
- XXXII. [Rislev. Litt.: U. Møhl, 1962].

XXXIII. Søndersø, Vestergaards moor. (O. A. Andersen, 1941).

 $\mbox{\ensuremath{\ensuremath{\mathcal{G}}}}$ Skull, skeletal parts. As the pollen analytical dating was uncertain, a C-14 dating was made with the result: 4070 ± 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 Øgaarde 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 1st molar is slightly worn, whereas the 2nd 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 $13^{\circ}/_{0}$ (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 $20^{\circ}/_{0}$; from the age of a year and a half to about $13^{\circ}/_{0}$.

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, \emptyset gaarde 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 "Zootomical-Physiological Museum", which was abolished 1841. Previously this last skull has several times been used at a comparison with a prehistoric material (Degerbor 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 mm., 440 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 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 19th 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 Øgaarde 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 (m 3) 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 1st and 2nd molar are moderately worn, and of the last molar the posterior column is unwerr. 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 (m 3) 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).
 - 3 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 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. VIII. Gammellung moor III, Troldebjerg (Langelands Museum).
 - 3 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.

3 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.

 $\[Q\]$ 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. Øgaarde 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.

\$\varphi\$ adult. As was the case in Nyrup Skull I, this skull, too, is a very light yellow-brownish 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 Øgaarde Skull II. The frontal widths are 164 mm., 158 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 (ml-ml) are fairly equal, 134 mm., 130 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.

 \eth 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.

3 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.

3 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.

3 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, Hillerød.

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 Jordløse, Sandhuse moor, two skulls, of females, are present, one narrowly built, the other fairly broad.

XVIII. Sandhuse moor I, Jordløse, Lille Aamose (Harald Andersen 489/46, K XXXIX 19).

Skull. A large, irregular hole, about 65×65 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 2 124 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. — Pl. XIII.

XIX. Sandhuse moor II, Jordløse.

 $\ensuremath{\mathbb{Q}}$ This incomplete skull was felled and no doubt was a sacrifice. The hole in the frontal is almost circular, 40×40 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. Ærø.

3 The Ærø 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, 3, and the Søndersø 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 Ærø skull belonged to a bullock. — Pl. XIII.

XXII. Løgtved Enge.

3 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. Viksø. Remains of two females from Zone VIII.

♀ 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 (m 3) 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. Q Parts of skull, but so severely broken that it cannot be assembled; left mandible; some vertebrae (allas, 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.

 $\ensuremath{\mathfrak{F}}$ As was the case with the Ærø 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.

♂ 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, Ondløse, Aamosen.

3 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*,

 $244~\rm{mm}.$ in the Bodal skull, as compared with $250~\rm{mm}.$ in the Bjeverskov skull. Also the zygomatic widths are equal, $213~\rm{and}~214~\rm{mm}.$, 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 $400~\rm{and}~385~\rm{mm}.$, respectively, the circumference at the base is a little smaller, $230~\rm{mm}.$, as compared with $240~\rm{mm}.$ in the Bodal skull; the diameters are $77\times67~\rm{mm}.$ and $81\times67~\rm{mm}.$, 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. 3 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 98×67 mm.

XXXIII. Søndersø.

3 A fragmentary skull, mandibles and some postcranial 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 Søndersø 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 Søndersø 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 Søndersø skull 380 mm., and the corresponding length in the two other skulls are 385 and 400 mm., respectively. The basal length in the Søndersø 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 93×71 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 94×74 , 90×74 , and 89×84 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 Søndersø skull was highly uncertain, but might indicate a comparatively late period, Bronze Age or Iron Age, I asked the C14-laboratory to try to carry out a C14-dating. The result was that the find belonged to a fairly early period, 2120 years B.C. $(4070 \pm 120 \text{ before } 1950)$. — 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 × 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 Søndersø (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 19th 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 (IMHOF).

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: Ærø 430 (235), Søndersø 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 basis— Jewell, 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 condules 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 sex-determination. 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 (Vedbæk 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 Ølholm 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.

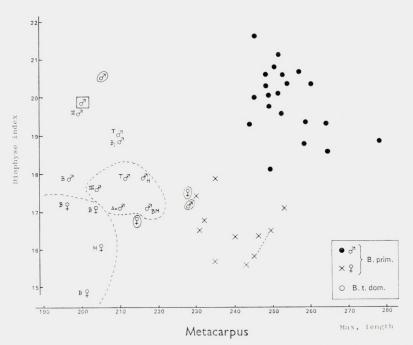
If the measurements of the Danish domestic male skulls, however, are inserted in the above-mentioned scatter diagram (Howard, loc. cit.), it appears that with one exception, the Gammellung skull I (indices 97–77), all adult skulls are grouped with bulls, though most of them are placed in the periphery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



 $\label{eq:continuous} Fig.~24.~~\textit{Metacarpus.} - \text{Ordinate axis: diaphysis index (diaphysis width/maximum length, Table 11)}. \\ & \text{Abscissa: maximum length.}$

The *Urus* bull on the extreme right is from Grejs Mølle, 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

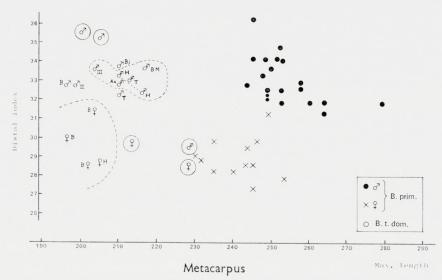


Fig. 25. Metacarpus. Distal index plotted against maximum length. Legend as in Figure 24.

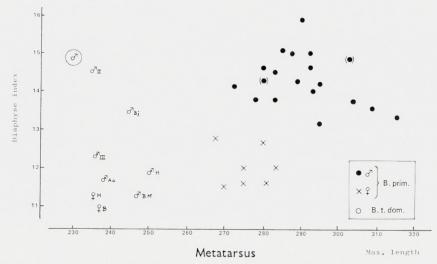


Fig. 26. Metatarsus. Diaphysis index plotted against maximum length. Legend cf. Figure 24. (\bullet) from Hescheler og Rüeger. The three longest metatarsi (Grejs Mølle, Holbæk (Aamosen), Soro) have the smallest diaphysis indices

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. - 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 \mathfrak{P} .

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 Søndersø 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 fronto-lacrymal 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 III*, 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 $\mathcal{E}r\theta$ 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 Løgtved 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, Bökönyi (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 Bökönyi 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 (Воезянеск, 1958, р. 73 and Jewell 1962, р. 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 Svebølle 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 (m 3) 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. (45,5×18.7 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.), Aamølle 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; Bt. 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 Ertebølle 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 (Ertebølle, 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 Ertebølle 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.)

(Quaternary-Zoological Department, University of Copenhagen)

TABLE

	1 ABL1											
Zone	I	III IV										
Bos primigenius 33	Faaborg (Millinge)	Terp	Vig	Sorø (Stokholt Huse)	Grænge A ad. jun.	Gøderup subad.	Viesø jun.	Knabstrup 1	Røde Mølle Aa	Funen	Tepstrup	Rønnebæksholm
	1	2	3	4	5	6	7	8	9	10	11	12
1. Total length. 2. Condylobasal length. 3. Basal length. 4. Occipital ridge — nasal base. 5. Nasal base — tip of premaxilla. 6. For. magnum upper border — nasal length. 7. Occipital ridge — nasal tip. 8. Occipital ridge — for. infraorbitale. 9. Cond. occipitalis — nasal tip. 10. Cond. occipitalis — orbita. 11. Cond. occipitalis — for. infraorbitale. 12. Orbita — for. infraorbitale. 13. Orbita — tip of premaxilla. 14. Nasal length, largest. 15. Nasal width, largest of both. 16. Length of premaxilla (outer side, chord). 17. Palatal length { palatinum, middle. 18. Orignmetres of orbits }	744 653 612 368 380 320 630 548 550 258 450 198 402 262 92 192 227 369 84	193	700 610 580 333 329 	715 608 575 337 379 290 600 532 515 232 425 190 382 258 — 170 215	685 592 553 330 357 290 510 230 412 185 365 250 169 207 83	645 567 532 307 339 272 460 218 378 163 350 190 83	(300) (520) (450) (460) (355) (220)				684 598 562 325 368 290 570 494 510 243 400 187 382 255 80 180 	700 625 583 325 382 295 588 505 545 250 427 193 395 260 — 190 — 361 71
$ \begin{array}{c} 19. \\ 20. \end{array} $ Diametres of orbits $\left\{\begin{array}{c} \vdots\\ \vdots\\ \end{array}\right.$	68		71	68	72	66			67		76	67
Least width between horn cores: 21. a. at occipital ridge. 22. b. at frontal, middle 23. Frontal width, least. 24. Postorbital width 25. Interorbital width { least, incisur anterior anterior 27. Maxillary width { m1-m1, outer border zyg. sut. 29. Premaxillary width { largest anterior 31. Zygomatic width 32. Mastoid width 33. Width, post. border of fossae temporalis 34. Condylus occipitalis, width 35. Height of fossa temporalis, least 36. Occipital height { for. magn., lower border for. magn., upper border 38. Greatest span of horn cores 40. Circumference of horn cores, base	248 335 242 315 255 252 164 196 123 — 256 325 222 139 37 230 178 1140 400 135	255 294 240 ——————————————————————————————————	258 306 231 299 250 ———————————————————————————————————	290 315 238 301 225 230 158 193 109 109 249 (305) 198 139 40 238 195 855 710 320 109	270 325 240 297 228 230 161 188 111 105 255 (310) 200 140 44 195 182 940 310 108	230 280 230 260 202 (190) 158 170 105 — 226 262 180 138 36 220 172 760 — 315	(280) (340) (220) (284) ————————————————————————————————————	270 300 226 285 ———————————————————————————————————	220 265 235 300 —————————————————————————————————	160 223 230 297 	198 220 226 287 215 225 (165) 187 114 110 237 308 226 139 44 223 178 812 664 325 113	170 220 250 310 255 250 167 198 135 114 245 308 226 136 41 232 185 800 580 580 120
41. Diametres of horn cores, base { 42. Length of horn cores, outer curvature	115 (770) 179 74 111	97 750 — 101	97 667 180 72 111	87 590 174 67 103	91 (660) 173 70 105	91 180 71 112	(85)	90 570 —	95 590 158 — (100)	95 660 —	91 615 157	110 625 160 65 102

L

Ι.																			
		V							VI			VII				VIII			
Knabstrup 3	Grænge B	Tranemosegaard	Sakskøbing	Hallenslev subad.	Niverød	Bedsmose	Bregninge	Lørup Hede	Kulemile	Grevinge	Store Damme (IV-VI)	Bønnelykke	Orting	Ostbirk	Ugilt ad. jun.	Grejs Mølle	Auning	Holme Mose	Hornslet
13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
	(690) 600 565 360 350 295 		(310)	(317) 270 462 195 366 169 180 75 63			716 635 597 345 375 305 520 		340	680 592 564 338 357 292 495 (244) 400 175 365 222 365 86 72	690 615 581 317 375 280 590 494 542 250 412 2185 390 270 96 192 210 355 68 69	650 580 543 311 283 530 468 483 225 370 356 220 83 170 221 75 67	685 581 551 314 365 278 492 — 250 402 183 360 — 177 — 322 79 59	630 555 525 308 330 285 520 467 475 228 390 170 343 215 185 200 64	660 577 542 318 358 278 566 475 505 214 386 178 374 264 — 202 210 330 82 67	700 (580) 342 366 595 502 	670 602 570 310 370 285 575 475 530 245 405 170 270 190 220 346 77 63		(570) (540) 305
215 260 234 300 243 305 210 130 220 180 785 345 122 97 580	193 220 240 302 225 230 170 185 120 — 250 320 215 125 40 215 170 818 705 315 113 87 570 175 70	250 305 237 287 287 245 281 198 136 41 226 169 797 600 295 100 85 570	187 250 247 	254 306 220 254 186 ———————————————————————————————————	205 230 240 ——————————————————————————————————	230 300 254 ———————————————————————————————————	146 (200) 255 328 — 270 170 200 123 130 255 326 216 129 37 225 180 750 — 375 123 103 490 + 174 62	232 295 270 270 (315) 231 147 40 230 178 397 138 113	160 205 242 286 	200 (285) 234 295 225 232 163 180 240 303 210 128 50 224 177 770 (700) 315 115 85 (515) 182 80 114	206 215 230 320 255 255 165 200 118 128 246 305 192 127 38 216 660 341 110 100 686 161 65	212 245 242 290 235 158 185 107 113 245 310 203 132 39 — 187 825 720 337 115 92 590 163 65	200 240 245 314 268 255 173 205 — 263 320 240 142 38 — 171 884 — 340 110 89 (680) 155 62 93	167 194 242 (310) 262 244 168 191 119 118 ——————————————————————————	215 265 222 262 294 153 194 106 101 238 280 185 137 52 205 160 774 705 283 97 82 490 157 64 95	235 287 237 303 256 256 ———————————————————————————————	173 200 238 298 258 235 160 180 112 118 246 310 260 136 38 205 155 845 700 365 132 100 650 156 65 95	190 210 230 286 ———————————————————————————————————	200 265 220 268 193 206 153 175 231 (270) 134 47 212 165 790 (765) 290 102 78 550 158 60 100

											Та	BLE I			
Zone				VIII				IX	Uncertain Age						
Bos primigenius 33	Hørning	Klarup	Tranekær Gesten	Læsten	Fæsted	Tinglev	Kjærsholm¹)	Aabenraa	Julianelyst	Aagerup	Lyngby	Danmark (Min. Mus.)			
	33	34	35	36	37	38	39	40	41	42	43	44			
1. Total length. 2. Condylobasal length. 3. Basal length. 4. Occipital ridge — nasal base. 5. Nasal base — tip of premaxilla. 6. For. magnum upper border — nasal length. 7. Occipital ridge — nasal tip. 8. Occipital ridge — for. infraorbitale. 9. Cond. occipitalis — nasal tip. 10. Cond. occipitalis — orbita. 11. Cond. occipitalis — for. infraorbitale. 12. Orbita — for. infraorbitale. 13. Orbita — tip of premaxilla. 14. Nasal length, largest. 15. Nasal width, largest of both. 16. Length of premaxilla (outer side, chord). 17. Palatal length { palatinum, middle 18.} Diametres of orbits {		(630) (585)	316	651 592 554 290 372 268 545 457 505 235 390 164 368 270 90 183 225 340 97	640 580 548 295 348 270 555 462 520 230 — 175 360 262 — 165 (190) — 75 64	(630) (555) 532 300 — 277 532 460 495 226 395 166 — 235 82 — — 77 64	(710) (610) (566) ———————————————————————————————————	315		700 617 583 322 380 290 585 502 533 246 415 180 382 258 83 200 230 362 71 66	706 616 571 (340) (380) 305	675 587 549 320 367 280 574 488 510 230 395 183 380 260 92 184 200 340 74 69			
Least width between horn cores:				70	04	04				00	7.1				
21. a. at occipital ridge. 22. b. at frontal, middle 23. Frontal width, least. 24. Postorbital width. 25. Interorbital width { least, incisur anterior. 27. Maxillary width { m1-m1, outer border. 29. Premaxillary width { largest. 30. Premaxillary width { largest. 31. Zygomatic width. 32. Mastoid width. 33. Width, post. border of fossae temporalis. 34. Condylus occipitalis, width. 35. Height of fossa temporalis, least. 36. Occipital height { for. magn., lower border. 37. Occipital height { for. magn., upper border. 38. Greatest span of horn cores. 39. Tip to tip of horn cores. 40. Circumference of horn cores, base	175 235 246 — — — — — — — — 140 — — 915 — 340 122	200 235 212 — — 300 220 132 — 228 180 — 323 109	204 262 216 274 ———————————————————————————————————	215 265 228 280 217 217 158 186 110 245 301 218 238 202 154 822 712 283	160 245 210 266 (238) ————————————————————————————————————	235 260 214 280 224 218 156 177 (119) 240 294 215 166 774 560 295	(240) (238) (300) ———————————————————————————————————	230 293 293 	187 218 231 305 226 ——————————————————————————————————	177 235 242 295 256 245 162 200 117 115 250 322 244 128 37 (220) 177 762 627 350	194 890 810 358 123 95	215 255 247 307 245 255 165 190 118 123 250 320 230 128 39 218 165 925 760 345			
42. Length of horn cores, outer curvature	505 +	(620)	630	575 145 61	540 143	610 155 60	(680) (145)	_	595	525 171 68	615 168 68	695 153 59			
45. Length of molars (m 1–m 3)	_			88	92	103	(94)		_	105	104	98			

¹⁾ Measured by a folding rule.

Nr. 1

(continued).

								Unc	ertain	Age								
Bro	Trøstrup	Mors	Olholm	Rosenholm	Thorsager	Hastrup	Vintved	Danmark (2. afd.)	Danmark (C. N. 1891)	Danmark (2. afd. 2)	Ørtoft	Danmark (Study Coll.)	Nørre Vissing	Rathlousdal	Alsønderup	Ladung	Odder	Baltic Sea
45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
669 586 555 328 347 290 		327 -285 	687 610 572 323 380 295 — (230) 405 195 395 — 240 235 365 74 62					305				320 						
225 255 236 291 220 210 150 175 112 236 295 219 123 42 223 3170 700 500 318	143 230 — — — — — — — — — — — — — — — — — — —	175 230 217 292 246 224 160 180 245 300 215 110 44 170 825 690 355	205 200 207 275 235 220 164 190 118 129 236 295 205 129 45 212 166 730 620 295	210 270 — — — — — — — — — — 890 745 338 113 97 645	180 225 — — — — — — — — — — — — — — — — — —	240 252 (250) — — — — — — — — 915 (810) 340 120 95 (620)	220 250 	193 220 225 298 249 251 ———————————————————————————————————	290 245 122 216 172 950 805 445 r 420 l 160 146 685 r 670 l		141 (273) (235) ————————————————————————————————————	155 188 220 289 233 225 — 235 (310) 226 (130) 36 238 171 720 555 355 122 88 — 548	134	134	146	210 250 237 ———————————————————————————————————	230	398
172 66 108	_	_	147 59 89		_	_	_	_		_	_			_	_	_		_

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

II.

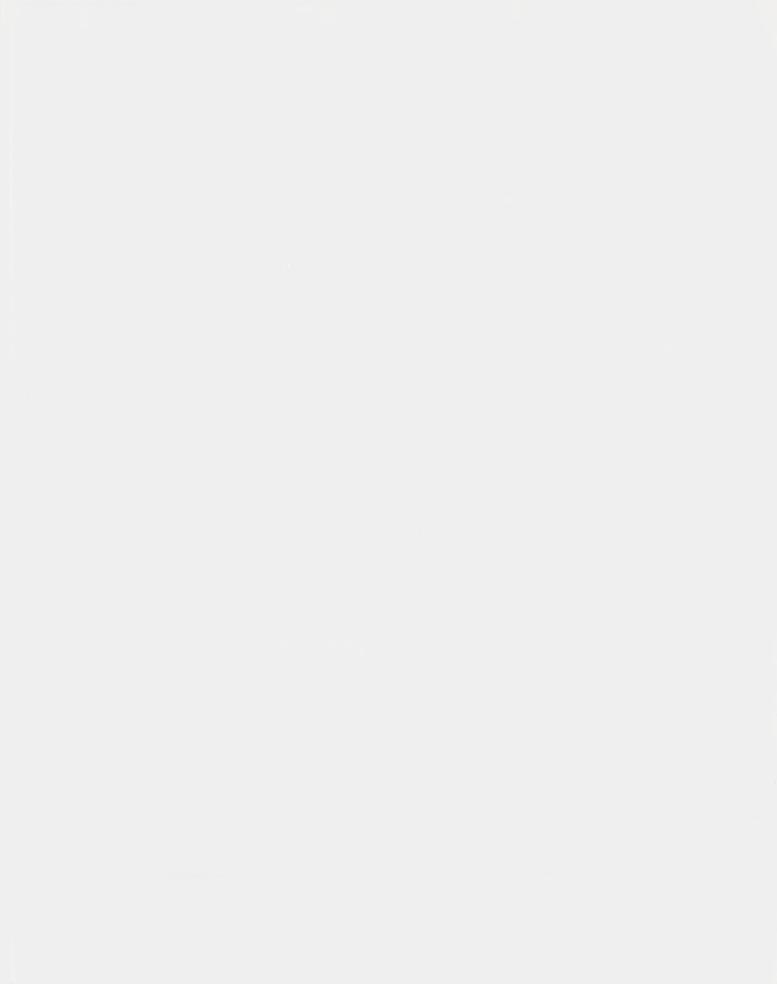
	II/V		V	III				Un	certain A	Age		
Flintinge	St. Taastrup	Pindstrup	Toftum	Aarhus	Korinth	Skaarup	Mørkøv	Barløse	Ølholm	Fuglekjær	Gjødvad	Aakjær
8	9	10	11	12	13	14	15	16	17	18	19	20
	(510) 285	(570) (520) (490) 255 — 245 — 412 — 190 355 158 — — — — 71 68	(555) (520) 290 273 273 216				208		275	(525) 500 270 — 241 — 198 — 72 65		
215 250 205 ——————————————————————————————	200 210 180 233 — 173 — — 232 145 120 — 212 165 — 240 84 67 — 160 — 99	190 220 178 230 168 172 140 207 ab. 225 148 111 38 178 135 500 360 181 60 52 365 162 67 97	186 220 200 253 190 ———————————————————————————————————	190 220 182 ———————————————————————————————————	162 178 175 222 204 (210) 144 117 42 178 137 630 520 220 78 64 465	186 	168 215 195 242 	(220) (240) ————————————————————————————————————	178 240 180 — 183 — 240 159 118 — 175 131 580 — 195 65 58	168 210 177 235 163	192 202 188 240 ———————————————————————————————————	174 200 195

													Т	ABLE
Bos taurus domesticus (Zone VIII)	Øgaarde ♀ II	Ogaarde ♀ jun. I	Ogaarde	Store Lyng & subad.*	Verupgaard ♂*	Gammellung I ♂*	Gammellung II ♀	Gammellung III ♂*	Gammellung IV subad.	Nyrup I	Nyrup II	Nyrup III	Snoldelev I 3	Vedbæk I S subad.*
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Total length. 2. Condylobasal length 3. Basal length. 4. Occipital ridge — nasal base 5. Nasal base — tip of premaxilla 6. For. magnum — nasal base 7. Occipital ridge — nasal tip 8. Occipital ridge — for. infraorbitale 9. Cond. occipitalis — nasal tip 10. Cond. occipitalis — orbita 11. Cond. occipitalis — for. infraorbitale 12. Orbita — for. infraorbitale	475 440 411 235 — 215 — 352 — 165 305 135	(362)	225 — 207 — — 158	510 460 433 265 245 240 — 372 — 175 317 131	545 495 465 270 282 250 — 400 — 195 242 142	513 478 455 254 257 240 411 381 395 194 335 135	(455) (430) (400) 221 — 215 — 334 — 170 296 125		215	455 427 	485 465 435 235 — 2222 — 360 — 170 315 135	(480) (430) (403) 242 208 355 165 290 121	510 465 435 240 271 210 410 376 380 170 320 142	484 432 405 250 238 229 — 358 — 163 306 125
13. Orbita – tip of premaxilla	_	206	_	280	295	279 139 (168)		_	_	282	_	_	282 169	258
15. Nasal breadth	162 	102 123 197 56 52	61	149 260 73 63	143 183 - 73 71	134 165 271 72 65	61 58			170 172 272 66 65	65 60	155 — 66 62	141 169 69 61	122 165 251 63 56
Least width between horn cores: 21. a. at occipital ridge	148 160 148 189 135 146 130 145 — 184 194 116 95	124 145 133 158 112 118 101 118 53 (52) 150 146 88	139 150 145 179 128 — — — 170 173 107 87	200 235 180 211 143 160 130 147 78 74 190 (215) 151 100	203 240 193 235 175 178 135 164 96 206 230 154 106	(180) (195) 177 226 165 177 141 154 91 89 195 216 134 102	145 154 151 189 132 143 125 144 — 172 — 128 95	175 192 183 223 — — — — — 215 158 110	210 — 192 212 147 — — 180 189 130	158 201 137 151 130 150 77 72 184 202 133 92	150 178 164 206 146 160 134 145 — 184 207 129 97	136 165 153 210 150 160 135 143 78 — 185 (190) 126 98	174 200 185 218 165 167 133 	165 190 161 190 145 142 119 142 69 69 167 188 130
35. Height of fossa temp., least	38 148 108 396	30 — 283 283	355 + 355 +	36 172 130 515 +	44 160 120 610	33 171 134 560 +	36 148 108 395	34 158 121 470 +	600 - 215	31	35 150 111 400 +	32 149 110 405 — 170	41 154 115 560 — 232	33 156 116 466 455 190
40. Circumference of horn cores, base	157	130 40 35 125	45 35 153	$205 \\ 68 \\ 62 \\ 240 + \\ (250)$	230 80 60 $275 + (365)$	$257 \\ 88 \\ 68 \\ 227 +$	157 57 40 $180 +$ (205)	215 75 50	71 66 250		60 46 $185 +$ (255)	58 45 $185 +$ (200)	78 60 (380)	66 49 233
43. Length of upper tooth row	133 52 82	(110) (61) (35)	_	149 63 92	134 51 82	139 58 84	136 53 85	_		139 56 86	140 61 85	133 56 82	125 — 75	(62)

^{*} Probably bullock.

III.

ard 3															IX	B. 8	t. dome	sticus.	- Rec	ente	Spanish fightting bull. CN. 2814
Maglemosegaard (Vedbæk II) ♂	III			e I	e 11					0	II v			Gundsømagle	Zone		1	II.	ii.	и.:	ight 281
oæk	Vedbæk 3*	Holmene	Holmene	Sandhuse	Sandhuse		Løgtved 3	ad.	Viksø II	/eddinge	Snoldelev	_	Søndersø	søn	1	860	296	Study Coll.	tudy Coll.	udy Coll. Bullock	d'X
agle	edb	olm	olm	lpun	nudl	Ærø	gt	Viksø I	ksø	ppe	old	Bodal	nde	md	Mors		51	udy	udy	ndy Bu	ani II. (
SK	> 40	H to	I o+	\$ 0+	\cdot	H *0	L C	5 o+	> 0+	2 %	S ₁	ŏ to	o * S	5	W O+	°C CY	CN.	S o+	St.	Sti	Sp
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
480 455	(480) (455)	525 497	450 426	440 413	(415) (390)	(505) (475)		411 382	_	(495) (470)	409 381	505 480	(505)	-	380	440	445	465	419	442	465
270	275	296	246	215	238	262	238			258	250	278	(480) 275		355 186	410 200	415 224	428 215	387 215	414 228	442 248
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
465 405	411	475 426	416 360	380 320	312	400		327		392	340	442 393	415	_	297	367 326	405	418	355	380	411
413		432	385	365				027			340	420	415		297	360	355 395	345 415	325 346	344 365	356 397
180	_	198	168	165	_	208		147	(150)		158	200	183		140	162	185	174	166	180	190
330	150	356	310	300	278	341		280		340	284	345	340		266	298	320	320	298	305	312
142	150	152	130- 140	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
-	_	_		_	_	_	_	_		_	_		_		_	_			_		65
166		172	152	142	_	150		110	_	-	118	148		_	_	146	138	165	120	129	137
_		180 300	168 273	174 270		176		156 241	_		142 230	178	(190)		$\frac{141}{222}$	174 265	$\frac{155}{256}$	178 273	144	155	158
72		75	56	64	62	76		57	_	66	71	72	78		58	66	62	68	241 65	280 62	270 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
232 188	229 190	235 208	172 159	150 148	198 170	$\frac{237}{204}$	220 184	158		226 184	218 187	210 192	238 208		136 135	158 161	163 159	164	200	157	252
237	233	257	220	188	201	239	225	178		234	210	244	260		167	200	200	155 200	165 196	163 212	197 233
-	180	192	162	130	(145)	171	163	128	_	171	156	184	_		108	131	139	130	134	152	169
138	142	202 155	171 142	144 124	120	188	-	120	(115)	183	158	195	190	_	119	146	143	148	147	159	
162	164	171	161	136	145	140 160		134	(115)	145 160	118 145	147 170	154		116 121	130 146	125 143	132 147	124 144	125 144	137 150
89		95	82	75	_	_		65			75	101			70	79	81	80	70	79	94
205		95	81	76	100	010	101	68	_	-	70	102			66	75	78	78	70	70	90
205 232	208 230	226 263	192 205	172 184	186 186	212 245	194	174 178	_	212 249	184 191	213 256	224 256		159	185	191	196	188	188	207
160	154	179	137	108	127	168	145	116		171	135	158	167	_	165 89	200	200 109	202 129	191 110	$\frac{210}{142}$	234 156
112	_	108	104	92	96	118	112	98		108	103	107	114	_	76	96	98	104	103	98	103
100	-	33	33	34	151	40	150	30	_	34	30	37	39		34	33	37	41	36	38	35
180 136		171	152 112	148 110	154 116	180 140	$\frac{152}{107}$	147 113	_	164 123	162 124	173 126	184 138		132 105	145 113	159	140	147	143	125
590		556	398	316	480	801	_			532	532	620	600	_	347	480	118 397	110 372	110 515	105 400	166 667
-	_	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 62	73 58	81 56	59 43	50 40	52 46	84 60	75 57	_	_	74 56	71 60	80 67	93 71	98 67	48 35	59 47	52 42	43 35	58 46	56 42	78
340	_	305	209	155 +	305	445	_			(295)	228	(385)		_	165	255	200	162	200	175	58 395
138	145	135 +	139	138		143		Jdp4	122	134	∫dp4	138	142		120	132	120	130	∫dp4	129	
58 +	58		60 +	58		57		(142)	51	50	(62)								(131)	132	143
85	90	82	83	85	85	88		82	76	87	(62) 92	55 89	62 (84)		49 73	53 80	56 73	53 78	(55) 85	54 79	59 86
													()					, 0	00	10	00



PLATES I—XIV

I–VII: Skulls of Bos primigenius, 33. VIII–IX: Skulls of Bos primigenius, 99.

X-XIII: Skulls of Neolithic Bos taurus domesticus.

Arranged according to geological age.

XIV: Skeletons of Bos primigenius, \mathcal{P} and \mathcal{J} .

PLATE I

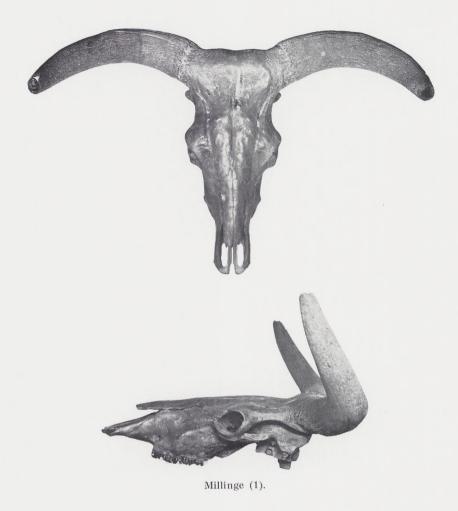


PLATE I: Skulls of Bos primigenius. 33. Zone III. Late Dryas.

1. Millinge/Faaborg; 1 A. Terp. (Transition to Zone IV).

Terp (1 A), - at the bottom.

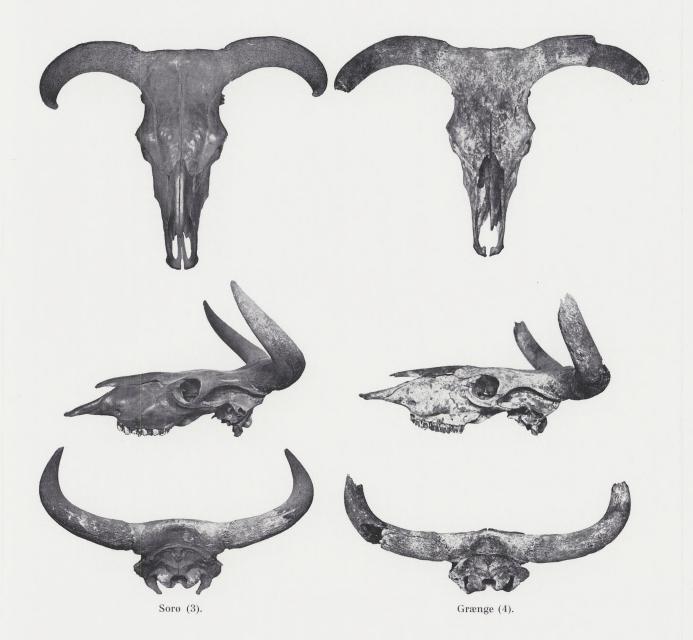
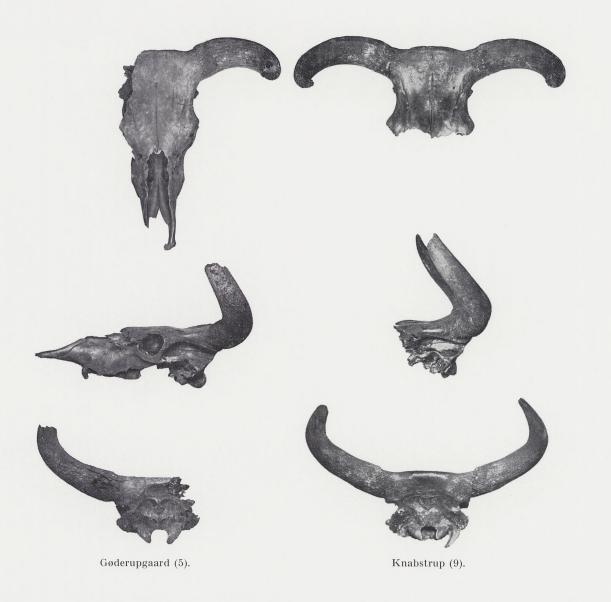


PLATE II: Skulls of Bos primigenius. 33. Zone IV. Preboreal.
(A) Nos: 3. Sorø; 4. Grænge; 5. Gøderupgaard; 9. Knabstrup; 11. Røde Mølle Aa; 12. Funen.





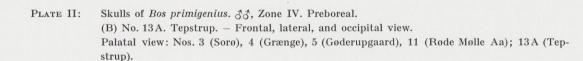






PLATE III: Skulls of Bos primigenius. 33. Zone V. Boreal.
Nos: 14. Rønnebæksholm; 16. Knabstrup 3; 17. Grænge B; 22. Tranemosegaard; 26. Hallens-

Palatal view: Nos. 14 (Rønnebæksholm); 17 (Grænge B); 26 (Hallenslev).

lev; 27. Niverød; 31. Bedsmose.







Niverød (27).



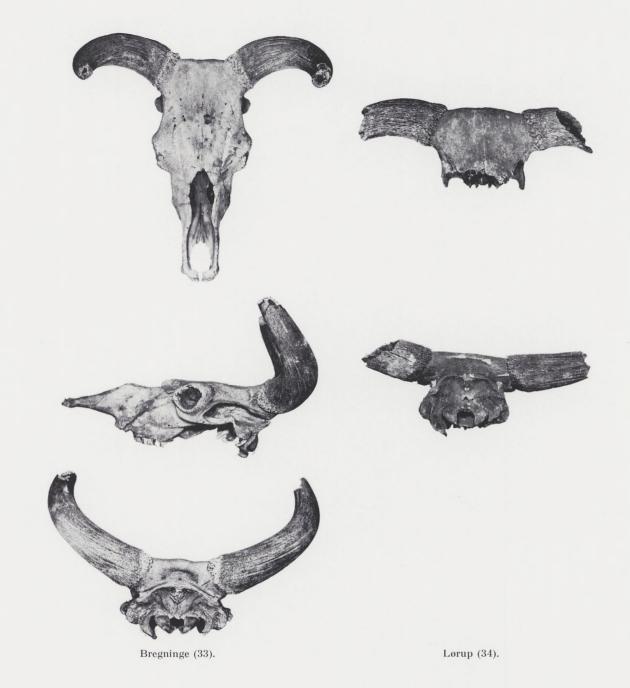


PLATE IV: Skulls of Bos primigenius. 33. Zone VI. Boreal.
Nos: 33. Bregninge; 34. Lørup Hede; 35. Kulemile; 36. Gundestrup, Grevinge; 42. Store Damme.
Palatal view: Nos. 33 (Bregninge); 36 (Gundestrup); 42 (Store Damme).



PLATE V



Bønnelykke (54).

PLATE V: Skull of *Bos primigenius*. 3. Zone VII. Atlantic. 54. Bønnelykke.

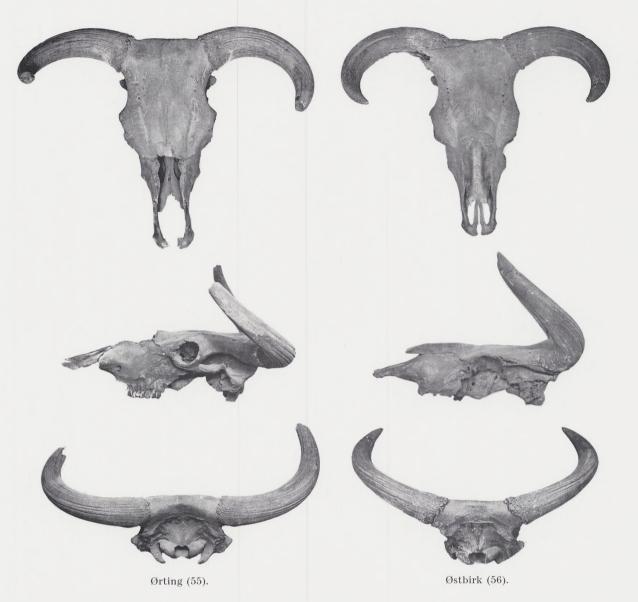


PLATE VI: Skulls of Bos primigenius. 33. Zone VIII. Subboreal.

(A) Nos: 55. Ørting; 56. Østbirk; 58. Ugilt; 59.Klarup; 66. Hornslet; 60. Auning; 65. Holme Mose; 67. Hørning; 69. Tranekær; 71 A. Læsten.







Tranekær (69).

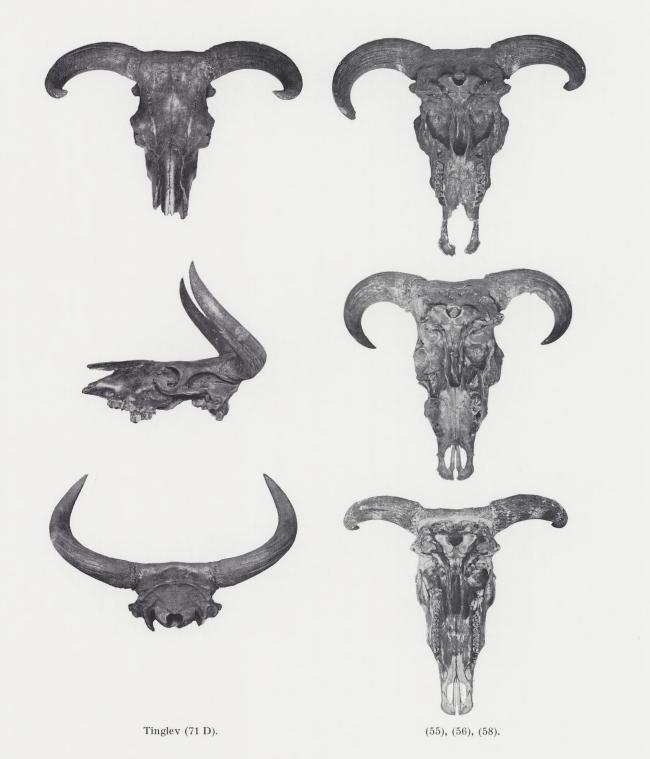
Læsten (71 A).



PLATE VI: Skulls of Bos primigenius. 33. Zone VIII. Subboreal.

(B) Nos: 71B. Grejs Mølle; 71C Fæsted, Ribe; 71D. Tinglev.

Palatal view: Nos. 55 (Ørting); 56 (Østbirk); 58 (Ugilt)); 60 (Auning); 71A (Læsten); 71 C (Fæsted); 71 D (Tinglev).













Julianelyst (79).

PLATE VII: Skulls of Bos primigenius. 33. Uncertain age.

(A) Nos: 79. Julianelyst; 97. Aagerup; 98. Lyngby; 132. Bro Mølle; 133. Trøstrup; 148. Mors;

150. Ølholm; 198. Danmark.

Aagerup (97).

Min. Mus. (199).

Rosenholm (170) Ørtoft (177) - the lowest figure.

PLATE VII: Skulls of Bos primigenius. 33. Uncertain age.
(B) Nos: 170 Rosenholm; 177. Ørtoft; 199. Danmark (Min. Mus.); 200. Danmark (2 Afd.);

Palatal view. Nos. 97 (Aagerup); 98 (Lyngby); 132 (Bro Mølle); 150 (Ølholm); 148 (Mors);

202. Danmark (Study Coll.).

199 (Min. Mus.).



Study Coll. (202).

2. Afd. (200).

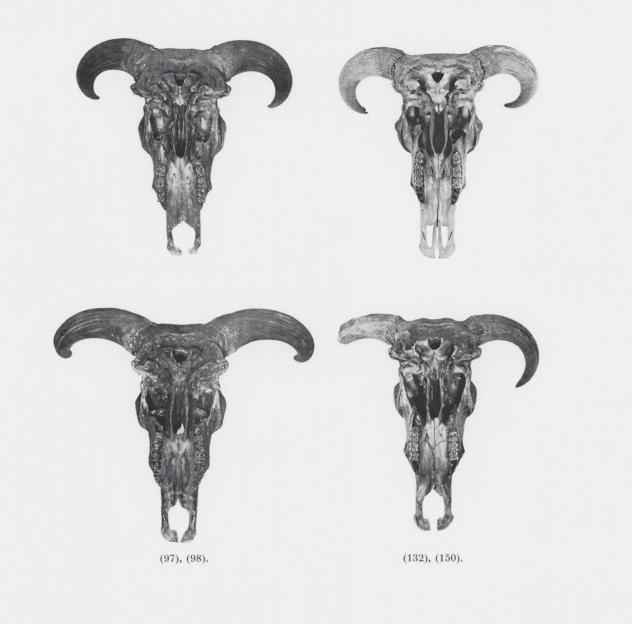


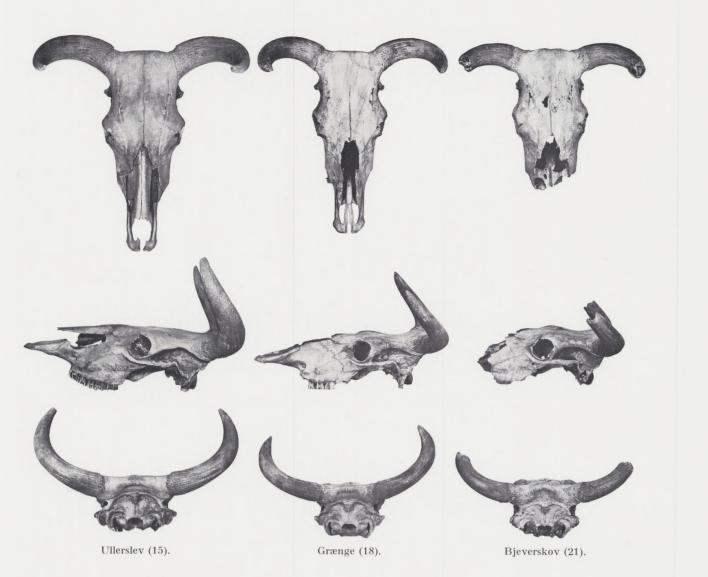


Plate VIII: Skulls of Bos primigenius. QQ.

Zone V. Three complete or almost complete skulls. Nos: 15 Ullerslev; 18 Grænge; 21 Bjeverskov, and brain-case 24 Flintinge.

Zone IV. Nos: 7 Vigersted; 10 Knabstrup 2; 13 Svebølle; 13B Bjerregrav. Zones II-V. No. 53 St. Taastrup.

Palatal view. Nos. 15 (Ullerslev); 18 (Grænge); 21 (Bjeverskov); 53 (St. Taastrup).





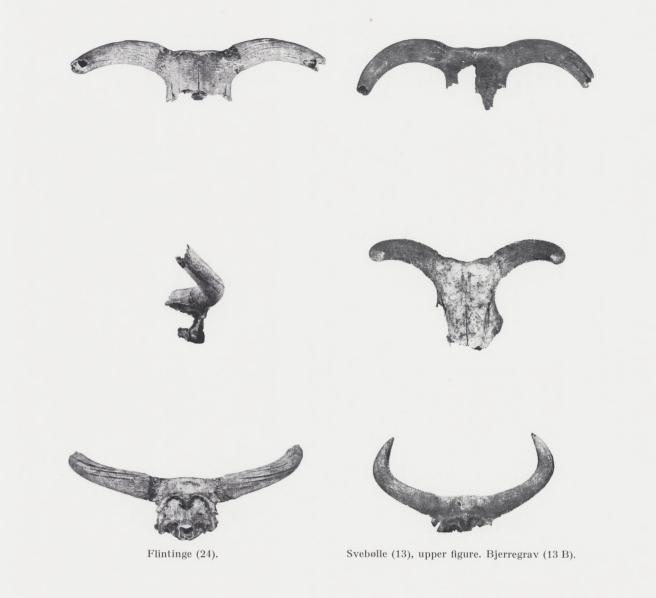


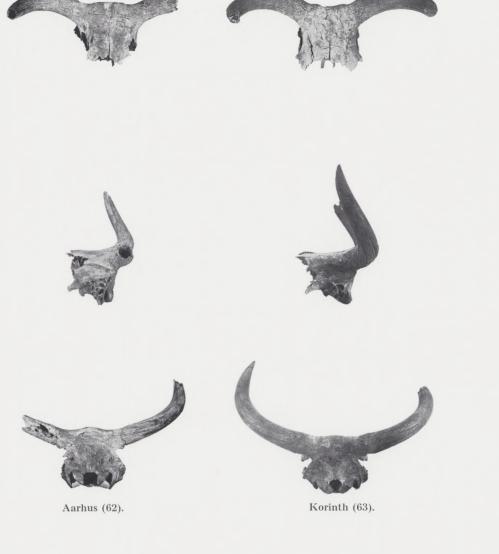


Plate IX: Skulls of Bos primigenius. \mathbb{Q} .

Zone VIII. Nos: 57 Pindstrup; 61 Toftum; 62 Aarhus; 63 Korinth. –

Not dated: 152 Fuglekjær; 151 Ølholm; 155 Aakjær; 153 Gjødvad; 100 Mørkøv. Palatal view: 57 (Pindstrup); 61 (Toftum); 152 (Fuglekjær).







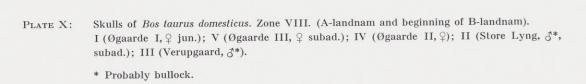


Aakjær (155). Gjødvad (153), the lowest figure.

Mørkøv (100).

(57), (61), (152).

PLATE X



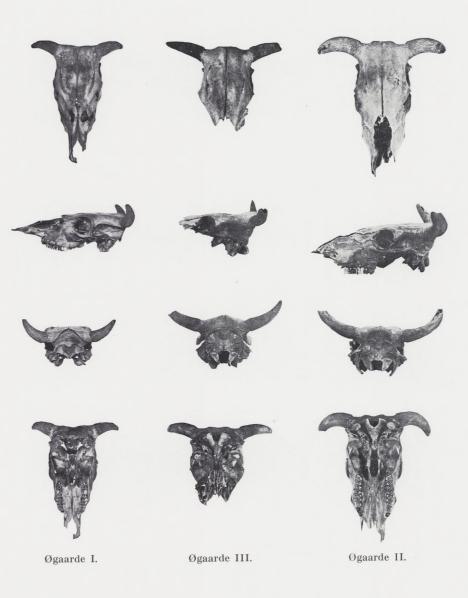
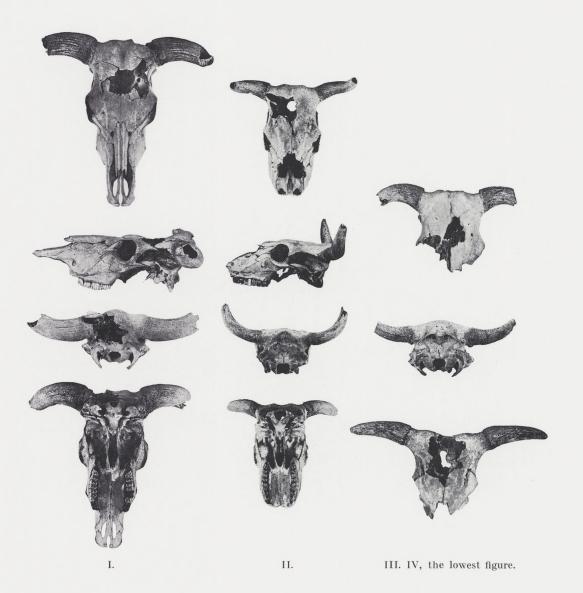


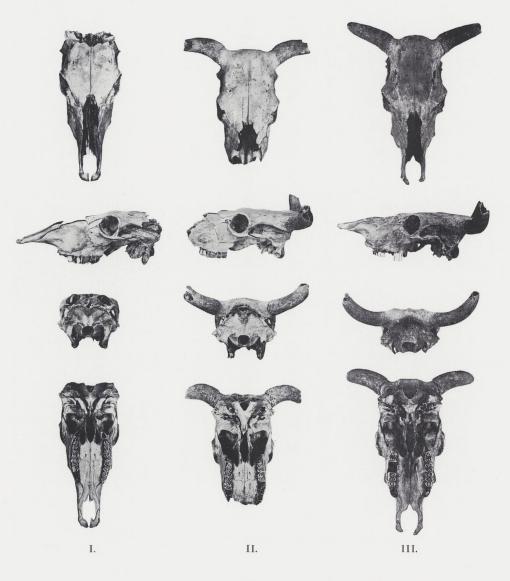


PLATE XI: Skulls of Bos taurus domesticus. Zone VIII. VI-VIIIA Gammellung, (I 3*, II $\cite{1}$, III $\cite{1}$, IV $\cite{1}$ jun.). IX-XA Nyrup, $\cite{1}$, $\cite{1}$, $\cite{1}$.

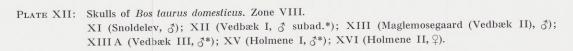
* Probably bullock.



Gammellung.

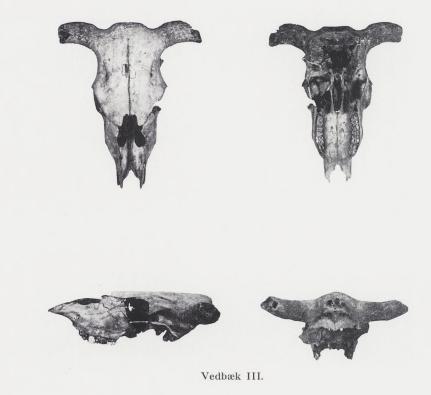


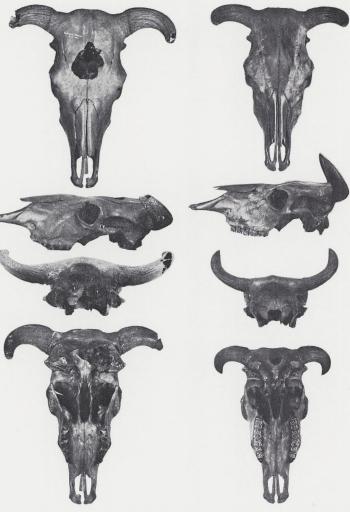
Nyrup.



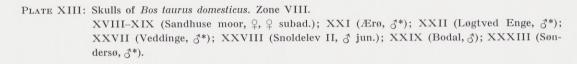
* Probably bullock.







Holmene.



* Probably bullock.







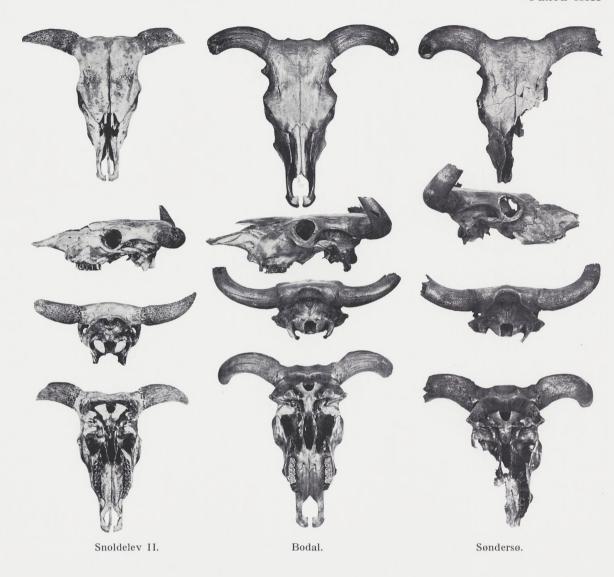


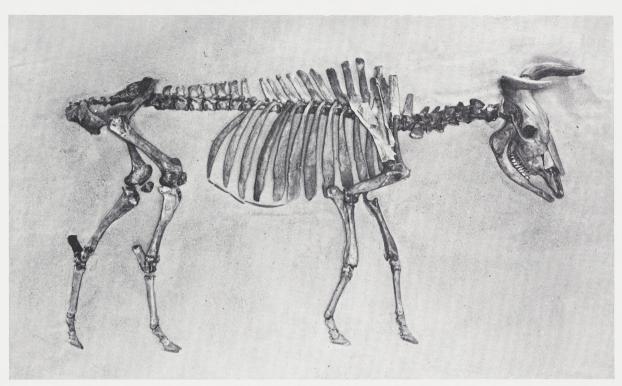
PLATE XIV: Bos primigenius. \$\varphi\$, from Ullerslev. Boreal period. (Zone V).

Mounted and photographed by U. Møhl.

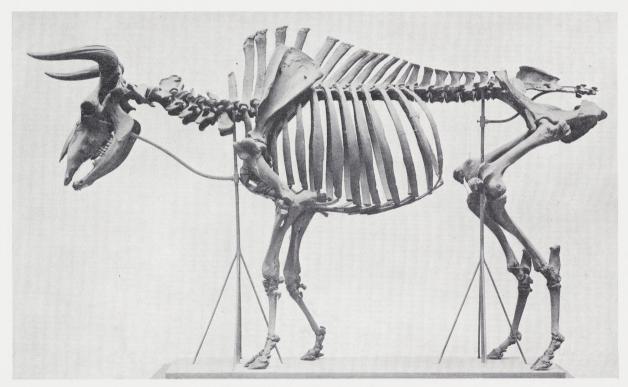
(Complementary bones: left calcaneus (black) of Bos primigenius, Sværdborg XXX E2; atlas, epistropheus from Bos taurus domesticus of similar size).

Bos primigenius. \$\frac{1}{2}\$, from St. Damme. Boreal period (H. Winge, 1904).

PLATE XIV



Bos primigenius. \mathcal{P} . – Ullerslev.



Bos primigenius. ♂. - Store Damme.

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. 211 13 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 % of Betula and 32 % of Pinus, besides the find of epidermis of pine needles, hair of

12

Biol. Skr. Dan. Vid. Selsk. 17, no. 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 skull—heavily 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. Øgaarde 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 Møller (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. 26a, another in 26b, but while 26b is obviously contaminated, 26a, originating from the middle of Zone V, or even more likely from Va, was clean. In this latter sample Ulmus, the only QM-constituent, represented only $0.3\,^0/_0$, 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. XA. 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. Fægri 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 VIII—IX. 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 VI a, three from VII b 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 (Beug 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.

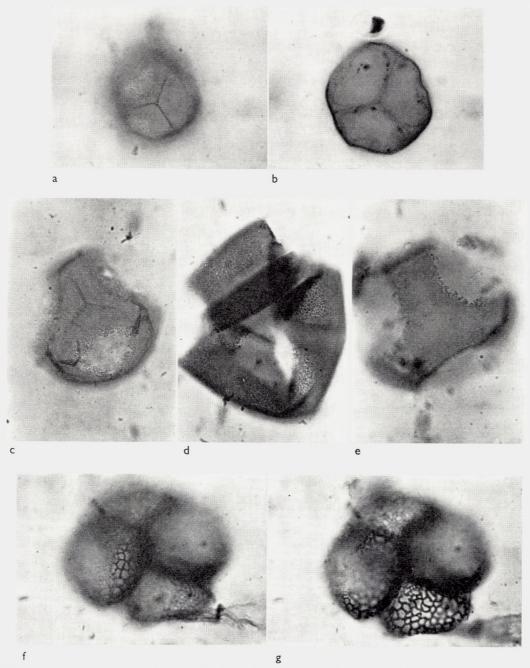


Fig. 1 a-b Recent Juncus trifidus I., boiled in KOH, stained (a: High level, b: Optical section).
c Recent Juncus compressus Jacq., high level, boiled in KOH, stained.

Recent Juncus articulatus L.; Lagerst. og Krok, boiled in KOH, acetolysed, stained. Fossil Juncaceae, boiled in KOH, acetolysed, stained (Andbjerg, Jutland, Pollen Zone IX).

f-g Fossil *Epipactis* type, boiled in KOH, acetolysed, stained (Veddinge, Zealand, Pollen Zone VIII). Magnification a, b, e ca. 775×: c, d, f, g ca. 700×.

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 Post-glacial 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 VIII-IX. 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 Møhl, taxidermist, The Zoological Museum, University of Copenhagen, T-S = Jørgen 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 1930es, 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 19th 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 $68^{9}/_{0}$ Betula and $32^{9}/_{0}$ 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 cm.: Surface layer of humified peat.

36-231 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. Gøderupgaard 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 $7.0^{\circ}/_{0}$), *Juniperus* (0.2 respectively $0.3^{\circ}/_{0}$) and of *Corylus* (1.2 respectively $0.4^{\circ}/_{0}$) indicate the middle of the zone.

6. Viesø.

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 $Corylus~(3.1^{\,0})_0$, 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* $(3.9^{\,0}/_{0})$, *Salix* $(4.8^{\,0}/_{0})$, and *Empetrum* $(0.9^{\,0}/_{0})$ 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 Dyrehavegård. A sample, (a) from the skull was analyzed by A.A. in 1942. The spectrum ($Pinus\ 22^{0}/_{0}$, $Betula\ 58^{0}/_{0}$, $Corylus\ 13^{0}/_{0}$, and $Alnus\ 6.5^{0}/_{0}$) 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. Røde Mølle 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 $1.1^{\circ}/_{0}$, 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. Svebølle.

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

 $(82^{0}/_{0})$, 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: $Salix\ 2^{0}/_{0}$, $Betula\ 34^{0}/_{0}$, $Pinus\ 57^{0}/_{0}$, and $Corylus\ 7^{0}/_{0}$. Late Zone IV or the beginning of Zone V seems to be the most likely dating.

13 B. Bjerregravs moor.

Vide p. 212.

14. Rønnebæksholm.

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 $32^{\,0}/_{0}$, 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 $53^{\circ}/_{0}$, QM between 0.4 and $0.6^{\circ}/_{0}$. The samples originate from Zone V, and, as most published diagrams from Fyn, have a Corylus-maximum of about $80^{\circ}/_{0}$. Va 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 $35^{\,0}/_{\!0}$, QM $0.1^{\,0}/_{\!0}$ and *Alnus* $0.1^{\,0}/_{\!0}$. 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 $42^{0}/_{0}$, QM $0.5^{0}/_{0}$, Alnus $0.4^{0}/_{0}$. 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 $86^{\,0}/_{0}$, 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 $1^{0}/_{0}$. 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. $1.5^{0}/_{0}$). The high frequency of Corylus (58 resp. $63^{0}/_{0}$), 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 $14^{0}/_{0}$, QM $0.2^{0}/_{0}$, Alnus 0).

25. Saxkøbing.

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 $45^{\,0}/_{\!0}$, QM $1.2^{\,0}/_{\!0}$, and *Alnus* $0.8^{\,0}/_{\!0}$, 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 P⁴. Both sediments were like (a). The three spectra (a), (c) and (d) are very similar. QM and Alnus are missing or constitute less than $0.5\,^0/_0$, and Corylus varies from 33 to $40\,^0/_0$. 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, Niverød.

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* $58^{\,0}/_{0}$, QM $1,0^{\,0}/_{0}$) 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: Belula $5.6^{\,0}/_0$, Pinus $62^{\,0}/_0$, Ulmus $2.8^{\,0}/_0$, Corylus $26^{\,0}/_0$, Varia $3.5^{\,0}/_0$ indicates the latter half of Zone V.

28. Alsønderup.

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 $25^{0}/_{0}$) indicate Va, whereas the frequencies of QM (1.0 respectively $1.7^{0}/_{0}$), and not least of *Alnus* (2.2 respectively $6.4^{0}/_{0}$) 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 (500–1000), 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 uncertain—the 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 $(32\,^0/_0\ Corylus,\ 1.6\,^0/_0\ Alnus,\ 1.6\,^0/_0\ QM)$. 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 $(Corylus\ 4.3\,^0/_0,\ QM\ totally\ missing)$. 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 $60^{\circ}/_{\circ}$, and of the $3.5^{\circ}/_{\circ}$ QM, Ulmus constitutes $2.5^{\circ}/_{\circ}$ and Quercus $1.0^{\circ}/_{\circ}$. Two grains of Hedera were found. The sample must therefore originate from the very beginning of Zone VI.

34. Lørup 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* $68^{9}/_{0}$).

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 $60^{\circ}/_{\circ}$, QM $7.6^{\circ}/_{\circ}$, with *Ulmus* $(4.4^{\circ}/_{\circ})$ as the dominant species, and *Alnus* $1.5^{\circ}/_{\circ}$, 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 Annexgården, 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 $0.2^{\,0}/_{\!0}$), *Populus* (5.4 respectively $2.5^{\,0}/_{\!0}$), and *Tilia* as frequent as *Ulmus*, 5 to 10 times as common as *Quercus*. *Corylus* is very frequent (56 respectively $67^{\,0}/_{\!0}$), *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 $3.1^{9}/_{0}$, out of which *Ulmus* constitutes $2.4^{9}/_{0}$, no *Alnus* found, and because of the extremely high frequency of *Corylus* $(79^{9}/_{0})$).

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 $31^0/_0$ Salix. As Ulmus constitutes more than half the QM and the Corylus percentage is very high $(48^0/_0)$ 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. Gøderupgaard.

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%).

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, Nykøbing F., was analyzed by A.A. in 1950. The sediment seems to be a gyttja $(18^{0}/_{0} Nymphaea)$. QM constitutes $7.3^{0}/_{0}$, Corylus $46^{0}/_{0}$, 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 20th 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. 43a (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 43b (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. Magleø 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. Jørgensen (1954, p. 183).

51. Kongemose.

A preliminary pollen-analysis by the excavator, Sv. Jørgensen (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. Jørgensen (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. Bønnelykkegaard.

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 M³, 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), Tubuli-florae (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* (94¹/₂–100), *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 $19^{0}/_{0}$ 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 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. $0.5^{\,0}/_{0}$) 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 $18^{0}/_{0}$ Rumex acetosella and/or R. acetosa, and this, together with $14^{0}/_{0}$ 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, $Rumex\ acetosella/acetosa$ 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 1940es, dating the animal at Zone VIII. The three spectra are very similar, and they have been averaged in Table A as No. 60a. 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 $(10-20^{\circ})_0$ 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*, Liguli-florae, *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 so (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 $2.7^{\circ}/_{\circ}$) might indicate the beginning of the zone.

64. Bønnerup.

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"): $Tilia\ 5.1^{\circ}/_{0}$, $Ulmus\ 1.1^{\circ}/_{0}$, Betula $21^{\circ}/_{0}$, and $Corylus\ 43^{\circ}/_{0}$, 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 finding-place.

67. Hørning.

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* $(7.0^{\,0}/_{\!0})$ in contrast to the low one of *Ulmus* $(1.8^{\,0}/_{\!0})$ and the high *Betula* percentage $(19^{\,0}/_{\!0})$, and six pollen grains of *Hedera* $(0.5^{\,0}/_{\!0})$, tend to date the sample to the stage just after the *Ulmus* decline and before the *Tilia* decline and the *Corylus* incline.

68. Ølgod.

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 lanceolata* 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

Nr. 1 201

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 $25\,^0/_0$ of Urtica and $57\,^0/_0$ of Alnus etc., in (a). This local over-representation may be the cause of the very high frequencies of Betula and Pinus (20, respectively $41\,^0/_0$) 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 $1.5\,^0/_0$, $Rumex\ acetosella\ type\ 2.6$, respectively $3.5\,^0/_0$, $Fagus\ 0.2$, respectively $0\,^0/_0$, and no Carpinus). In (c) $Plantago\ lanceolata\ was\ not\ found,\ but\ one\ P.\ major$.

- 71 A. Læsten. (Vide p. 212).
- 71 B. Grejs Mølle. (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 $2.1^{0}/_{0}$) 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 (Polamogeton $11^{0}/_{0}$ and Polypodiaceae $21^{0}/_{0}$) and in (b) with the swamp peat dominating (1.7, respectively $667^{0}/_{0}$). The pollen was highly destructed in both samples (D.b. 86, respectively $90^{0}/_{0}$). 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 $(23^0/_0 \ Tilia, 53^0/_0 \ Ulmus)$ 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 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 cm. The sediment of the pollen sample was sand with coarse drift. The spectrum was from Zone VIII $(1.1^0/_0$ 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%)0 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

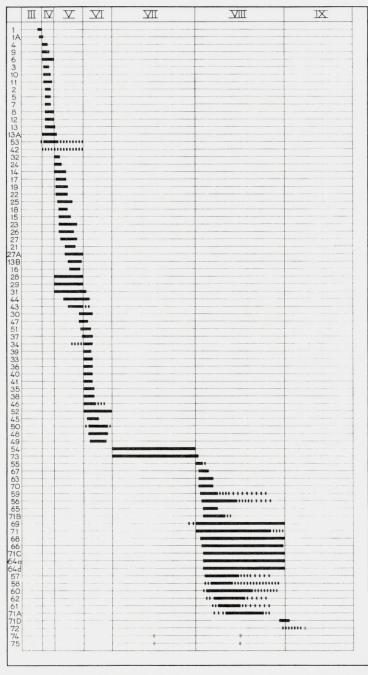


Fig. 2. Pollen-analytical dated finds of Urus (Bos primigenius) in Denmark, The finds No. 32A (Pollen Zones V–VI) and No. 90 (Zone VII) have not been included.

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 *Urus*es found in "kitchen-middens" from the so-called "Ertebølle culture" may originate from Zone VII, e.g. Brabrand (cf. p. 214), but as the problems concerning the dating of the Ertebølle 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 Ertebølle 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 Øgaarde 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 Iversex (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 $3.2^{0}/_{0}$) and especially of Ulmus (4.5, respectively $4.6^{0}/_{0}$) are relatively high, indicating the beginning of Zone VIII, but with $2.1^{0}/_{0}$ Fraxinus and $0.9^{0}/_{0}$ Plantago lanceolata in (b), a dating slightly later than the "A-landnam" is most likely.

IV. Øgaarde 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 $Tilia~(1.1-1.5^{\circ})_0$ and $Ulmus~(0.9-1.0^{\circ})_0$, more frequent $Fraxinus~(1.3-2.2^{\circ})_0$, plenty of $Corylus~(38-40^{\circ})_0$ and a relatively high frequency of $Plantago~lanceolata~(0.7-0.9^{\circ})_0$ 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 II.

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.

207

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 *Cenlaurea cyanus*, which has not otherwise been recorded between the Late Glacial and the 14th 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 mollusc shells, of *Mytilus edulis* and others.

The spectra are almost identical, with Alnus the dominating species (62, respectively $60\,^{\circ}/_{0}$). 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 (Troels-Smith 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 $0.3^{0}/_{0}$. (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, Hillerød.

A sample from one of the animals was analyzed by A.A. in 1942. The spectrum is characterized by $Corylus~(36^{9}/_{0})$ and $Alnus~(52^{9}/_{0})$. $1.3^{9}/_{0}$ 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 $(16^{\,0}/_{0})$ 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. Ærø.

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 $(10^{\,0}/_{\!0})$, 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. Løgtved Enge.

A sample taken in 1938 was analyzed by H.K. in 1945. The sediment was described as a gyttja, but with $76^{\,0}/_{\!0}$ 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. Viksø 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 II.

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 $(90^{\circ}/_{0} Alnus)$. 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 Aa.

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 $1.0^{\,0}/_{\!0}$) and Carpinus (0.4 $^{\,0}/_{\!0}$) 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. Gundsømagle (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 perielymenum* in (a) (cp. Troels-Smith 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. Søndersø.

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 VIII, 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 ± 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 $^{0}/_{0}$ and *Betula* between 31 and 33 $^{0}/_{0}$. *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 18-7-14, 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.l. 2-1-1, Σ 1184.5-1054-1194, Equisetum 11-8-9, Botrychium 2-2-3, Dryopteris

type 0-1-0, Selaginella 0-0-1, Sphagnum 2-3-1, Botryococcus 177-300-281, Pediastrum 1442-514-511, 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, Σ 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 $1^{0}/_{0}$, Betula $29 - 33^{0}/_{0}$, Pinus $43 - 57^{0}/_{0}$, Alnus $15 - 0^{0}/_{0}$, Ulmus $4 - 6^{0}/_{0}$, Tilia $3 - 0^{0}/_{0}$, Quercus $5 - 3^{0}/_{0}$, AP exclusive of Corylus 173 - 101, Corylus 116, respectively $200^{0}/_{0}$, Cyperaceae $7 - 3^{0}/_{0}$, Gramineae $0 - 1^{0}/_{0}$, Chenopodiaceae $0 - 2^{0}/_{0}$, Rosaceae $0.5 - 0^{0}/_{0}$, Calluna $0 - 1^{0}/_{0}$, 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 Passage-grave 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, Callha 1, Filipendula 1, Populus 1, Salix 1, Tilia 31, Ulmus 5, Umbelliferae 1, Urtica 2, a.i.d. 30, Σ 722. Dryopteris type 39, Thelypteris dryopteris 1, Polypodium 1, Pteridium 2, Sphagnum 40, Tilletia 11, charcoal c, D.b. 51.

71 B. Grejs Mølle.

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 $18^{9}/_{0}$, respectively) and the abundance of *Acer* 1.0, 4.6, 2.7, 11, and $4.9^{9}/_{0}$). 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, 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, Iucolum 3-1-1-0-1-6-2, Iucolum 3-1-0-1-3-0, Iucolum 5-6-0-1-2, Iucolum 7-1-2-2, Iucolum 5-1-1-2-1, Iucolum 1-2-1-6-2, Iucolum 1-2-1-2-2, Iucolum 1-2-1-0, Iucolum 1-2-1-0, Iucolum 1-2-1-0, Iucolum 1-2-1-2-2, Iucolum 1-2-1-0, Iucolum 1-2-1-2-1, Iucolum 1-2-1-2-2, Iucolum 1-2-1-0, Iucolum 1-2-1-2-1, Iucolum 1-2-1-2-1, Iucolum 1-2-1-2-1, Iucolum 1-2-1-2-2, Iucolum 1-2-1-2-1, Iucolum 1-2-1-2-1, Iucolum 1-2-1-2-2, Iucolum 1-2-1-2-2, Iucolum 1-2-1-2-3, Iucolum 1-2-1-1-0, Iucolum 1-2-1-2-1, Iucolum 1-2-1-2-2, Iucolum 1-2-1-1, Iucolum 1-2-1-1-1, Iucolum 1-2-1-1

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 $4.1^{\circ}/_{\circ}$, 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 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, $2\ 742.5-1261.5$, $Equisetum\ 1-4$, $Dryopteris\ type\ 152-358$, $Polypodium\ 1-0$, $Pteridium\ 8-8$, $Thelypteris\ dryopteris\ 1-0$, $Sphagnum\ 5-55$, $Botryococcus\ 1-1$, $Pediastrum\ 41-719$, $Tilletia\ 0-2$, $Charcoal\ c-c$, $D.b.\ 17-28$.

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 $4^{0}/_{0}$, Pinus $10^{0}/_{0}$, Alnus $21^{0}/_{0}$, Ulmus $21^{0}/_{0}$, Tilia $13^{0}/_{0}$, Quercus $29^{0}/_{0}$, AP exclusive of Corylus 183, Corylus $27^{0}/_{0}$. 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 (Troels-Smith 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, E 1231, Dryopteris type 10, Polypodium 5, Pteridium 9, Thelypteris 2, Botryococcus 3, Hystrix 45, "Pentagon" 30, rebedded pollen grains 3, D.b. $2.0^{9}/_{0}$.

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 Malmros 1966). They were found in layers 3 and 4, and both layers were radiocarbon dated (Layer 3, charcoal samples: 3780 and 3730 ± 120 B. C., Layer 4, shell fragments: 4470 ± 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 Σ 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, Cuercus~0-115-78, Cuercus~0-15-78, Cuercus~0-10-10, Cuercus~0-10-10-10, Cuercus~0-10-10-10, Cuercus~0-10-10-10-10-10-10-10-10-10-10-10-1

XXXI. Gundsømagle 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, Artemisia 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, Σ 1138.5. Dryopteris type 105, Pteridium 3, Botryococcus 21, Pediastrum 26, Ceratophyllum hairs 2, "Paraplya" 1, charcoal c, D.b. 7.3.

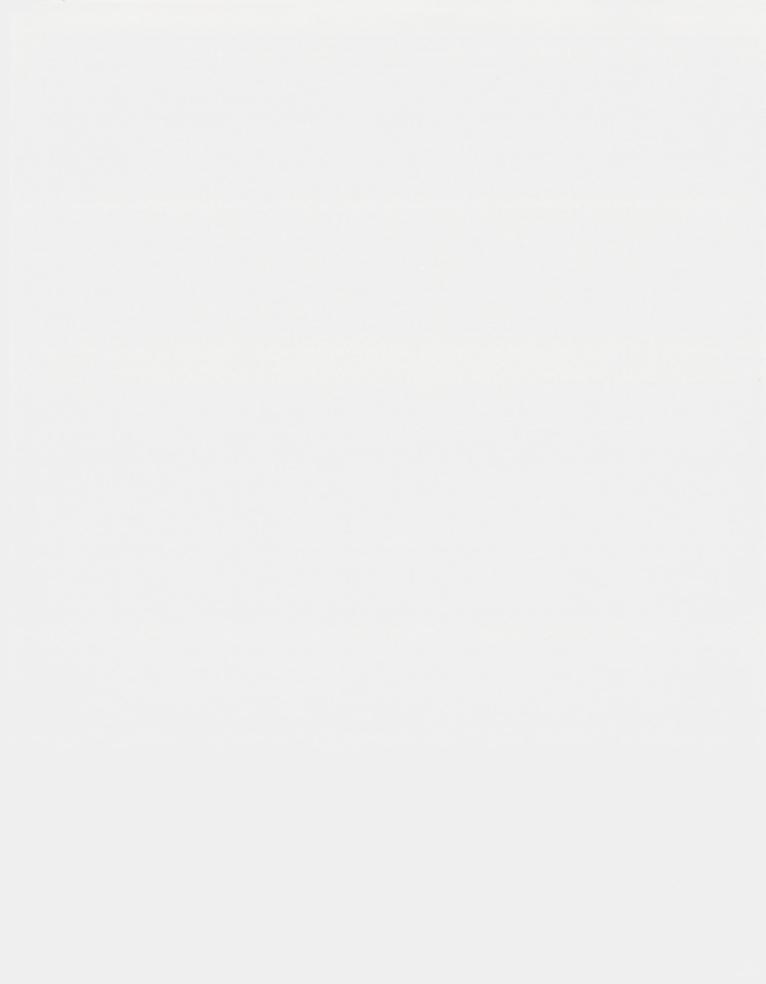




TABLE A.

				TABLE	Α.					
	1a	1b	1c	2a	2b	2c	2d	3	4	5a
Betula	61	63	62	74	77	76	66	65	66	52
Pinus	26	15	25	22	20	18	25	21	30	44
Salix	7.5	9.7	3.4	1.3	0.8	2.2	1.5	4.9	3.7	1.0
Juniperus	2.5	13	3.1	0.1				1.7		0.2
Populus			1.1	2.5	2.0	3.9	6.2	1.9		1.5
Viburnum	_				_					
Corylus			3.9	0.3	0.2	0.1	1.8	5.1		1.2
Quercus	0.6	0.3	0.7					0.4		0.1
Fraxinus										
Tilia			0.1							
Ulmus			0.1	0.1	0.1	0.1		0.2		0.1
Alnus	0.6		0.5							
Hedera	0.0									
Viscum	0.6									
Fagus	0.0		v			0.1		1.3		0.1
Calluna	36	25	11	3.1	2.3	3.7	3.6	11	12	18
Gramineae			27	1.6		1.2		35	12	5.4
Cyperaceae	29	36			1.7		1.8	0.7	0.8	5.4
Artemisia	3.1	2.8	3.9	0.1		0.1	0.1	0.7	0.0	
Rumex acet	0.6		0.1	0.1		0.1		0.5		
Plantago lanc	_									
Cerealea	4505	200	1100 5	1000 5	015	1.170	1105 5	1146	240	1024
Σ Α.Ρ	158.5	320	1162.5	1032.5	917	1479	1125.5		240	1034
Destruction D.b			0.0	1.0	1.1	0.3	1.0	0.3		4.7
	-	-	-			-		-	-	-
	5b	6	7a	7b	8a	8b	9	10a	10b	11
Betula	1	1								
Betula	51	66	48	54	41	45	55	58	72	62
Pinus	51 38	66 29	48 51	54 34		45 50	55 30		72 27	62 32
Pinus	51 38 2.8	66	48	54 34 2.1	41 53 —	45 50 1.0	55 30 4.8	58 22	72 27 0.3	62 32 3.3
Pinus	51 38 2.8 0.3	66 29	48 51 0.8	54 34 2.1 0.3	41 53 —	45 50 1.0	55 30 4.8 3.9	58 22 —	72 27 0.3 0.1	62 32 3.3 0.2
Pinus	51 38 2.8	66 29	48 51 0.8	54 34 2.1	41 53 — —	45 50 1.0 — 2.2	55 30 4.8 3.9 2.1	58 22	72 27 0.3 0.1 0.2	62 32 3.3
Pinus	51 38 2.8 0.3 7.0	66 29 1.1	48 51 0.8	54 34 2.1 0.3	41 53 — — —	45 50 1.0 — 2.2 0.2	55 30 4.8 3.9 2.1	58 22 —	72 27 0.3 0.1 0.2	62 32 3.3 0.2 1.4
Pinus	51 38 2.8 0.3 7.0 — 0.4	66 29 1.1 — — 3.1	48 51 0.8 — — 0.4	54 34 2.1 0.3 9.7	41 53 — — — 5.9	45 50 1.0 — 2.2 0.2 0.2	55 30 4.8 3.9 2.1	58 22 — — — — — —	72 27 0.3 0.1 0.2 0.1	62 32 3.3 0.2 1.4 — 1.1
Pinus Salix Juniperus Populus Viburnum Corylus Quercus	51 38 2.8 0.3 7.0 — 0.4 0.2	66 29 1.1 — — 3.1	48 51 0.8	54 34 2.1 0.3	41 53 — — — — 5.9	45 50 1.0 — 2.2 0.2 0.2 0.7	55 30 4.8 3.9 2.1	58 22 — — — 13 0.5	72 27 0.3 0.1 0.2	62 32 3.3 0.2 1.4 — 1.1 0.2
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus	51 38 2.8 0.3 7.0 — 0.4 0.2	66 29 1.1 — — 3.1	48 51 0.8 — — 0.4	54 34 2.1 0.3 9.7	41 53 — — 5.9	45 50 1.0 ——————————————————————————————————	55 30 4.8 3.9 2.1 3.9 0.2	58 22 — — — 13 0.5	72 27 0.3 0.1 0.2 0.1	62 32 3.3 0.2 1.4 — 1.1 0.2
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia	51 38 2.8 0.3 7.0 — 0.4 0.2	66 29 1.1 — — 3.1	48 51 0.8 — — 0.4	54 34 2.1 0.3 9.7	41 53 — — — — 5.9	45 50 1.0 — 2.2 0.2 0.2 0.7	55 30 4.8 3.9 2.1 3.9 0.2	58 22 — — — — 13 0.5	72 27 0.3 0.1 0.2 0.1	62 32 3.3 0.2 1.4 — 1.1 0.2
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus	51 38 2.8 0.3 7.0 — 0.4 0.2 — 0.1	66 29 1.1 — 3.1	48 51 0.8 	54 34 2.1 0.3 9.7	41 53 — — 5.9	45 50 1.0 ——————————————————————————————————	55 30 4.8 3.9 2.1 	58 22 	72 27 0.3 0.1 0.2 0.1	62 32 3.3 0.2 1.4 — 1.1 0.2
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus	51 38 2.8 0.3 7.0 — 0.4 0.2 — 0.1 0.2	66 29 1.1 — — 3.1	48 51 0.8 — — 0.4	54 34 2.1 0.3 9.7	41 53 — — 5.9	45 50 1.0 — 2.2 0.2 0.2 0.7 — 0.5	55 30 4.8 3.9 2.1 3.9 0.2	58 22 	72 27 0.3 0.1 0.2 0.1 	62 32 3.3 0.2 1.4 — 1.1 0.2 — 0.3
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera	51 38 2.8 0.3 7.0 0.4 0.2 0.1 0.2	66 29 1.1 — 3.1	48 51 0.8 	54 34 2.1 0.3 9.7	41 53 — — 5.9	45 50 1.0 — 2.2 0.2 0.2 0.7 — 0.5	55 30 4.8 3.9 2.1 3.9 0.2	58 22 	72 27 0.3 0.1 0.2 0.1 	62 32 3.3 0.2 1.4 — 1.1 0.2
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum	51 38 2.8 0.3 7.0 — 0.4 0.2 — 0.1 0.2	66 29 1.1 — — 3.1 — — ?0.3	48 51 0.8 	54 34 2.1 0.3 9.7	41 53 — — 5.9 — — 0.7	45 50 1.0 — 2.2 0.2 0.2 0.7 — 0.5	55 30 4.8 3.9 2.1 3.9 0.2	58 22 	72 27 0.3 0.1 0.2 0.1 	62 32 3.3 0.2 1.4 — 1.1 0.2 — 0.3
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus	51 38 2.8 0.3 7.0 	66 29 1.1 — — 3.1 — — ?0.3	48 51 0.8 	54 34 2.1 0.3 9.7	41 53 — — — 5.9 — — — 0.7	45 50 1.0 2.2 0.2 0.2 0.7 0.5 0.2	55 30 4.8 3.9 2.1 3.9 0.2	58 22 — — — — — — — — — — — — — — — — — —	72 27 0.3 0.1 0.2 0.1 	62 32 3.3 0.2 1.4 — 1.1 0.2 — 0.3
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna	51 38 2.8 0.3 7.0 — 0.4 0.2 — 0.1 0.2 — 0.2	66 29 1.1 — 3.1 — ?0.3	48 51 0.8 	54 34 2.1 0.3 9.7	41 53 — — 5.9 — — 0.7 —	45 50 1.0 2.2 0.2 0.2 0.7 0.5 0.2	55 30 4.8 3.9 2.1 3.9 0.2 	58 22 — ————————————————————————————————	72 27 0.3 0.1 0.2 0.1	62 32 3.3 0.2 1.4 — 1.1 0.2 — 0.3 — — 0.5
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae	51 38 2.8 0.3 7.0 — 0.4 0.2 — 0.1 0.2 — 0.2 30	66 29 1.1 	48 51 0.8 	54 34 2.1 0.3 9.7 	41 53 — — 5.9 — — 0.7 — — 1.3	45 50 1.0 2.2 0.2 0.7 0.5 0.2 12	55 30 4.8 3.9 2.1 3.9 0.2 	58 22 ——————————————————————————————————	72 27 0.3 0.1 0.2 0.1 0.1 15	62 32 3.3 0.2 1.4 — 1.1 0.2 — 0.3 — 0.5 3.8
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae Cyperaceae	51 38 2.8 0.3 7.0 — 0.4 0.2 — 0.1 0.2 — 0.2 30 7.6	66 29 1.1 	48 51 0.8 	54 34 2.1 0.3 9.7 	41 53 — — 5.9 — — 0.7 —	45 50 1.0 2.2 0.2 0.7 0.5 0.2 12 16	55 30 4.8 3.9 2.1 3.9 0.2 	58 22 ——————————————————————————————————	72 27 0.3 0.1 0.2 0.1 0.1 15 73	62 32 3.3 0.2 1.4 1.1 0.2 0.3 0.5 3.8 38
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae Cyperaceae Artemisia	51 38 2.8 0.3 7.0 0.4 0.2 0.1 0.2 0.2 30 7.6 0.1	66 29 1.1 	48 51 0.8 	54 34 2.1 0.3 9.7 	41 53 — — 5.9 — 0.7 — — 1.3 2.6	45 50 1.0 2.2 0.2 0.2 0.7 0.5 0.2 12 16 0.2	55 30 4.8 3.9 2.1 3.9 0.2 	58 22 ——————————————————————————————————	72 27 0.3 0.1 0.2 0.1 0.1 15 73 0.1	62 32 3.3 0.2 1.4 — 1.1 0.2 — 0.3 — 0.5 3.8 38 0.4
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae Cyperaceae Artemisia Rumex acet	51 38 2.8 0.3 7.0 0.4 0.2 0.1 0.2 0.2 30 7.6 0.1	66 29 1.1 — 3.1 — ?0.3 — x 14 3.4 0.3 0.3	48 51 0.8 	54 34 2.1 0.3 9.7 	41 53 — — 5.9 — — 0.7 — — 1.3	45 50 1.0 2.2 0.2 0.7 0.5 0.2 12 16 0.2	55 30 4.8 3.9 2.1 3.9 0.2 	58 22 ——————————————————————————————————	72 27 0.3 0.1 0.2 	62 32 3.3 0.2 1.4
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae Cyperaceae Artemisia Rumex acet Plantago lanc.	51 38 2.8 0.3 7.0 0.4 0.2 0.1 0.2 0.2 30 7.6 0.1	66 29 1.1 — 3.1 — ?0.3 — x 14 3.4 0.3 0.3	48 51 0.8 	54 34 2.1 0.3 9.7 	41 53 — — 5.9 — 0.7 — — 1.3 2.6	45 50 1.0 	55 30 4.8 3.9 2.1 3.9 0.2 	58 22 ——————————————————————————————————	72 27 0.3 0.1 0.2 0.1 0.1 15 73 0.1	62 32 3.3 0.2 1.4 1.1 0.2 0.3 0.5 3.8 38 0.4 0.4
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae Cyperaceae Artemisia Rumex acet Plantago lanc Cerealea	51 38 2.8 0.3 7.0 0.4 0.2 0.1 0.2 0.2 30 7.6 0.1	66 29 1.1 — 3.1 — ?0.3 — x 14 3.4 0.3 0.3	48 51 0.8 	54 34 2.1 0.3 9.7 	41 53 — — 5.9 — 0.7 — — 1.3 2.6	45 50 1.0 	55 30 4.8 3.9 2.1 3.9 0.2 	58 22 ——————————————————————————————————	72 27 0.3 0.1 0.2 0.1 0.1 15 73 0.1	62 32 3.3 0.2 1.4
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae Cyperaceae Artemisia Rumex acet Plantago lanc.	51 38 2.8 0.3 7.0 0.4 0.2 0.1 0.2 0.2 30 7.6 0.1	66 29 1.1 — 3.1 — ?0.3 — x 14 3.4 0.3 0.3	48 51 0.8 	54 34 2.1 0.3 9.7 	41 53 — — 5.9 — 0.7 — — 1.3 2.6	45 50 1.0 	55 30 4.8 3.9 2.1 3.9 0.2 	58 22 ——————————————————————————————————	72 27 0.3 0.1 0.2 0.1 0.1 15 73 0.1	62 32 3.3 0.2 1.4 1.1 0.2 0.3 0.5 3.8 38 0.4 0.4

Table A (continued).

			TABLE	. 11 (00	munue	u).				
	12	13a	13b	14	15a	15b	15c	15d	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	_		1.0							
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	0.1	7.0
Rumex acet	0.5	1.4	0.4	0.4	0.1	0.1	0.1	0.1		
Plantago lanc	0.1			0.4		0.1				
Cerelea										
Σ Α.Ρ	1052	73	512.5	242	2173	2551	2148.5	2135	472	85.5
Destruction D.b	0.0	24	37	242	0.5	0.4	0.1	0.7	42	57
Destruction D.B	0.0	21	07		0.0	0.4	0.1	0.1	12	07
	17a	17b	18a	18b	19a	19b	21	22	23a	23b
Betula	1						1			
Betula	27	23	16	18	19	20	8.8	37	14	12
Pinus	27 43	23 38		18 36	19 39	20 38	8.8 4.9	37 21	14 23	12 20
Pinus	27 43	23 38 1.1	16	18 36 0.3	19	20 38 0.3	8.8	37 21 1.7	14	12
Pinus	27 43 —	23 38 1.1 0.3	16 32 —	18 36 0.3 0.1	19 39 0.3	20 38 0.3	8.8 4.9	37 21 1.7 0.1	14 23 0.7	12 20 1.0
Pinus	27 43 —	23 38 1.1 0.3 2.2	16 32 —	18 36 0.3 0.1 1.9	19 39 0.3	20 38 0.3	8.8 4.9 0.1	37 21 1.7 0.1 2.3	14 23 0.7 — 3.7	12 20 1.0 — 2.2
Pinus	27 43 ———————————————————————————————————	23 38 1.1 0.3 2.2 0.1	16 32	18 36 0.3 0.1 1.9	19 39 0.3	20 38 0.3	8.8 4.9 0.1	37 21 1.7 0.1 2.3 0.1	14 23 0.7 — 3.7 0.2	12 20 1.0 — 2.2 0.1
Pinus	27 43 —	23 38 1.1 0.3 2.2	16 32 —	18 36 0.3 0.1 1.9 — 42	19 39 0.3 — — 41	20 38 0.3 	8.8 4.9 0.1	37 21 1.7 0.1 2.3 0.1 37	14 23 0.7 — 3.7 0.2 58	12 20 1.0 — 2.2 0.1 63
Pinus Salix Juniperus Populus Viburnum Corylus Quercus	27 43 ———————————————————————————————————	23 38 1.1 0.3 2.2 0.1 35	16 32 — — — 51	18 36 0.3 0.1 1.9 — 42 0.3	19 39 0.3 — 41 0.5	20 38 0.3	8.8 4.9 0.1	37 21 1.7 0.1 2.3 0.1	14 23 0.7 — 3.7 0.2	12 20 1.0 — 2.2 0.1
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus	27 43 ———————————————————————————————————	23 38 1.1 0.3 2.2 0.1 35	16 32 ———————————————————————————————————	18 36 0.3 0.1 1.9 — 42 0.3	19 39 0.3 — 41 0.5	20 38 0.3 	8.8 4.9 0.1 — — 86	37 21 1.7 0.1 2.3 0.1 37 0.2	14 23 0.7 — 3.7 0.2 58 0.1	12 20 1.0 — 2.2 0.1 63
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia	27 43	23 38 1.1 0.3 2.2 0.1 35	16 32 ———————————————————————————————————	18 36 0.3 0.1 1.9 — 42 0.3	19 39 0.3 	20 38 0.3 	8.8 4.9 0.1	37 21 1.7 0.1 2.3 0.1 37 0.2 —	14 23 0.7 — 3.7 0.2 58 0.1	12 20 1.0 — 2.2 0.1 63 0.3 —
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus	27 43	23 38 1.1 0.3 2.2 0.1 35	16 32 51	18 36 0.3 0.1 1.9 42 0.3 0.2	19 39 0.3 — 41 0.5	20 38 0.3 	8.8 4.9 0.1 — 86 — 0.1	37 21 1.7 0.1 2.3 0.1 37 0.2 — 0.2	14 23 0.7 — 3.7 0.2 58 0.1	12 20 1.0 — 2.2 0.1 63
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus	27 43	23 38 1.1 0.3 2.2 0.1 35 0.1 0.1	16 32 ———————————————————————————————————	18 36 0.3 0.1 1.9 — 42 0.3	19 39 0.3 41 0.5 0.8	20 38 0.3 	8.8 4.9 0.1	37 21 1.7 0.1 2.3 0.1 37 0.2 —	14 23 0.7 — 3.7 0.2 58 0.1	12 20 1.0 — 2.2 0.1 63 0.3 —
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera	27 43 ———————————————————————————————————	23 38 1.1 0.3 2.2 0.1 35	16 32 51	18 36 0.3 0.1 1.9 42 0.3 0.2	19 39 0.3 	20 38 0.3 	8.8 4.9 0.1 — 86 — 0.1 0.1	37 21 1.7 0.1 2.3 0.1 37 0.2 — 0.2	14 23 0.7 — 3.7 0.2 58 0.1	12 20 1.0 — 2.2 0.1 63 0.3 —
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum	27 43 ———————————————————————————————————	23 38 1.1 0.3 2.2 0.1 35 0.1 0.1	16 32 51	18 36 0.3 0.1 1.9 — 42 0.3 — 0.2 0.4 —	19 39 0.3 41 0.5 0.8	20 38 0.3 	8.8 4.9 0.1 — 86 — 0.1 0.1	37 21 1.7 0.1 2.3 0.1 37 0.2 — 0.2 0.1 0.4 —	14 23 0.7 3.7 0.2 58 0.1 0.4	12 20 1.0 — 2.2 0.1 63 0.3 — 1.2 —
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus	27 43 ———————————————————————————————————	23 38 1.1 0.3 2.2 0.1 35 0.1 0.1 0.1	16 32 	18 36 0.3 0.1 1.9 — 42 0.3 — 0.2 0.4 —	19 39 0.3 ———————————————————————————————————	20 38 0.3 	8.8 4.9 0.1 — 86 — 0.1 0.1	37 21 1.7 0.1 2.3 0.1 37 0.2 — 0.2 0.1 0.4 —	14 23 0.7 	12 20 1.0 — 2.2 0.1 63 0.3 — 1.2
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna	27 43 ———————————————————————————————————	23 38 1.1 0.3 2.2 0.1 35 0.1 0.1 0.1	16 32 51 0.3 0.3	18 36 0.3 0.1 1.9 — 42 0.3 — 0.2 0.4 — 0.1	19 39 0.3 	20 38 0.3 	8.8 4.9 0.1 	37 21 1.7 0.1 2.3 0.1 37 0.2 — 0.2 0.1 0.4 — — 0.1	14 23 0.7 	12 20 1.0 — 2.2 0.1 63 0.3 — 1.2 — —
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineea	27 43 ———————————————————————————————————	23 38 1.1 0.3 2.2 0.1 35 0.1 0.1 0.1 0.2 1.6	16 32 	18 36 0.3 0.1 1.9 — 42 0.3 — 0.2 0.4 — 0.1 15	19 39 0.3 	20 38 0.3 	8.8 4.9 0.1 — 86 — 0.1 0.1 — x 0.4	37 21 1.7 0.1 2.3 0.1 37 0.2 — 0.2 0.1 0.4 — 0.1 5.5	14 23 0.7 	12 20 1.0 — 2.2 0.1 63 0.3 — 1.2 — 0.1 0.1
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineea Cyperaceae	27 43 ———————————————————————————————————	23 38 1.1 0.3 2.2 0.1 35 0.1 0.1 0.1 0.2 1.6 4.9	16 32 51 0.3 0.3	18 36 0.3 0.1 1.9 — 42 0.3 — 0.2 0.4 — 0.1 15 12	19 39 0.3 	20 38 0.3 	8.8 4.9 0.1 ———————————————————————————————————	37 21 1.7 0.1 2.3 0.1 37 0.2 — 0.2 0.1 0.4 — 0.1 5.5 7.8	14 23 0.7 	12 20 1.0 — 2.2 0.1 63 0.3 — 1.2 — 0.1 0.9 1.3
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineea Cyperaceae Artemisia	27 43 ———————————————————————————————————	23 38 1.1 0.3 2.2 0.1 35 0.1 0.1 0.1 0.2 1.6 4.9 0.2	16 32 51 0.3 0.3	18 36 0.3 0.1 1.9 — 42 0.3 — 0.2 0.4 — 0.1 15 12 0.2	19 39 0.3 	20 38 0.3 	8.8 4.9 0.1 — 86 — 0.1 0.1 — x 0.4 0.1 0.1	37 21 1.7 0.1 2.3 0.1 37 0.2 — 0.2 0.1 0.4 — — 0.1 5.5 7.8 0.1	14 23 0.7 	12 20 1.0 — 2.2 0.1 63 0.3 — 1.2 — 0.1 0.9 1.3
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineea Cyperaceae Artemisia Rumex acet.	27 43 ———————————————————————————————————	23 38 1.1 0.3 2.2 0.1 35 0.1 0.1 0.1 0.2 1.6 4.9	16 32 51 0.3 0.3	18 36 0.3 0.1 1.9 	19 39 0.3 	20 38 0.3 	8.8 4.9 0.1 ———————————————————————————————————	37 21 1.7 0.1 2.3 0.1 37 0.2 — 0.2 0.1 0.4 — — 0.1 5.5 7.8 0.1 0.2	14 23 0.7 	12 20 1.0 — 2.2 0.1 63 0.3 — 1.2 — 0.1 0.9 1.3 — 0.1
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineea Cyperaceae Artemisia Rumex acet Plantago lanc.	27 43 ———————————————————————————————————	23 38 1.1 0.3 2.2 0.1 35 0.1 0.1 0.1 0.2 1.6 4.9 0.2	16 32 51 0.3 0.3	18 36 0.3 0.1 1.9 	19 39 0.3 ———————————————————————————————————	20 38 0.3 	8.8 4.9 0.1 ———————————————————————————————————	37 21 1.7 0.1 2.3 0.1 37 0.2 — 0.2 0.1 0.4 — 0.1 5.5 7.8 0.1 0.2 —	14 23 0.7 	12 20 1.0 — 2.2 0.1 63 0.3 — 1.2 — 0.1 0.9 1.3
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineea Cyperaceae Artemisia Rumex acet Plantago lanc. Cerealea	27 43 ———————————————————————————————————	23 38 1.1 0.3 2.2 0.1 35 0.1 0.1 0.1 0.2 1.6 4.9 0.2	16 32 ———————————————————————————————————	18 36 0.3 0.1 1.9 42 0.3 0.2 0.4 0.1 15 12 0.2 0.1	19 39 0.3 	20 38 0.3 	8.8 4.9 0.1	37 21 1.7 0.1 2.3 0.1 37 0.2 — 0.2 0.1 0.4 — — 0.1 5.5 7.8 0.1 0.2 —	14 23 0.7 	12 20 1.0 ——————————————————————————————————
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineea Cyperaceae Artemisia Rumex acet Plantago lanc.	27 43 ———————————————————————————————————	23 38 1.1 0.3 2.2 0.1 35 0.1 0.1 0.1 0.2 1.6 4.9 0.2	16 32 51 0.3 0.3	18 36 0.3 0.1 1.9 	19 39 0.3 ———————————————————————————————————	20 38 0.3 	8.8 4.9 0.1 ———————————————————————————————————	37 21 1.7 0.1 2.3 0.1 37 0.2 — 0.2 0.1 0.4 — 0.1 5.5 7.8 0.1 0.2 —	14 23 0.7 	12 20 1.0 — 2.2 0.1 63 0.3 — 1.2 — 0.1 0.9 1.3 — 0.1

Table A (continued)

	24	25	26a	26b	26c	26b	27	28a	28b	30
Betula	25	5.5	33	6.0	36	33	14	19	23	7.7
Pinus	53	47	18	24	22	19	25	47	40	55
Salix	1.0	0.4	1.3	0.5	2.2	1.4	0.5	1.0	1.2	1.3
Juniperus			0.3		0.1	0.2			0.4	0.3
Populus	6.3		6.0	0.5	6.0	5.7	1.4	2.6	2.7	0.7
Viburnum	0.2						0.9			0.3
Corylus	14	45	41	28	33	40	58	27	25	29
Quersus	0.2	0.8		1.4	0.1		0.2	0.6	1.2	1.4
Fraxinus	_	_		0.5						
Tilia				9.2					0.1	1.0
Ulmus		0.4	0.3	0.9	0.1		0.7	0.4	0.3	1.3
Alnus		0.8		29	0.3		0.5	2.2	6.4	2.1
Hedera			0.1	0.5		_				
Viscum				_			_		_	_
Fagus			_		_	_				
Calluna	_		0.1	0.5	0.3	0.2		0.1	0.1	
Gramineae	33	0.4	16	13	11	12	4.8	5.7	8.6	18
Cypericeae	31	13	10	16	9.2	8.3	5.0	6.4	6.0	25
Artemisia	0.3			0.5		0.4				0.3
Rumex acet		-	0.2							0.1
Plantago lanc										
Cerealea										
Σ Α.Ρ	587.5	238	976.5	217	786.5	1135	422	688	771	705
Destruction D.b	26		7.3	7.5	5.8	5.6	74	80	69	47

	31a	31b	32a	32b	33	34a	34c	35	36a	36b
Betula	33	40	21	12	17	18	15	13	21	17
Pixus	26	56	69	76	18	13	47	17	14	8.9
Salix	4.7		1.7	1.2	1.2		0.6	0.1	0.9	0.7
Juniperus										0,1
Populus					0.3			0.5	5.4	2.5
Viburnum					?0.7			_	2.2	0.2
Corylus	32	4.3	7.4	11	60	68	28	60	56	67
Quercus				_	1.0	0.2	3.5	3.1	0.3	0.2
Fraxinus					_					_
Tilia	1.0				_		0.3	0.1	1.7	1.6
Ulmus	0.5			_	2.5		5.4	4.4	1.4	1.8
Alnus	1.6		0.4	_	0.6	0.4	0.9	1.5		0.2
Hedera			_		0.3	_		0.1		0.1
Viscum						_				_
Fagus		_						_	_	
Calluna					0.3		0.6	0.3	0.1	0.1
Gramineae	20	1.9	5.8	3.1	0.4	0.5	2.5	1.9	0.9	0.5
Cyperaceae	17	1.2	20	43	1.2	14	28	2.6	8.1	4.1
Artemisia	5.7	0.6						0.1	_	0.1
Rumex acet		-					0.3	0.1	0.1	
Plantago lanc	_									
Cerealea			_							
$\Sigma \ \mathrm{A.P.} \ \dots \dots$	191.5	161	242	160	672	559	316.5	3171	1284	3225.5
Destruction D.b	-					_	40	0.5	11	6.1

Table A (continued).

			IABLE	A (co	THE CO	1).				
	37	38	39	40	41	46a	46b	53	54a	54b
Betula	2.4	2.4	14	21	9.1	11	10	64	8.4	8.0
Pinus	15	8.0	31	38	37	9.9	9.4	29	8.0	13
Salix	0.5	31	0.7		0.5	0.8	0.5	1.7		0.1
Juniperus										
Populus	0.3	0.1	0.4			0.3	0.4		0.4	1.1
Viburnum		1.2					0.1			
Corylus	79	48	51	33	46	72	76	2.5	17	15
Quercus	0.2	1.2	0.5	1.5	3.6	0.9	0.6		14	18
Fraxinus		0.1				0.1				0.1
Tilia	0.5	2.2	0.3	1.0	1.4	0.8	0.1		7.7	6.3
Ulmus	2.4	4.3	2.0	3.5	2.3	2.4	2.0	0.8	8.8	9.4
Alnus		3.0	0.3	2.0		2.1	0.4	1.7	36	29
Hedera		0.1				0.1	0.1		0.8	0.2
Viscum										0.3
Fagus										
Calluna	0.2	0.1	0.1							0.3
Gramineae	2.6	1.2	11	0.5	4.1	1.6	0.6	10		0.3
Cyperaceae	26	2.9	6.5	35	5.0	3.2	1.3	70	5.4	3.4
Artemisia			0.4			0.1	0.1	1.7		0.1
Rumex acet						0.1				
Plantago lanc										
Cerealea										
Σ Α.Ρ	578	2136	736	198.5	220.5	1304.5	1956	118.5	262	1614
Destruction D.b	71	65	29			4.3	3.5			1.8
	1			1						
	55a	55b	56	57a	57b	57c	57d	58	59a	59b
Betula	7.9	4.0	17	21	22	21	18	23	23	13
Pinus	2.7	1.1	3.9	0.7	2.3	2.2	2.1	4.9	7.8	15
Salix						4.4				
	0.2					0.2	0.4	0.4		
Jumperus	0.2	_	_	_				0.4		0.4
Juniperus			0.6				0.4			0.4
Populus	_	_	0.6			0.2	0.4		0.2	
Populus Viburnum	0.1	_			_	0.2	0.4	0.1	0.2	
Populus	0.1		 15			0.2	0.4	0.1	0.2 —	_
Populus Viburnum Corylus Quercus	0.1 — 6.1	4.2	_	14	18	0.2	0.4 — 0.2 — 26	0.1 — — 25	0.2 — — 17	 17
Populus	0.1 	4.2 6.2 2.0	15 19 1.1	14 19	 	0.2 ————————————————————————————————————	0.4 0.2 26 23	0.1 — — 25 17	0.2 — — 17 10	17 7.9
Populus Viburnum Corylus Quercus Fraxinus Tilia	0.1 	4.2 6.2 2.0 3.7	15 19 1.1 2.4	14 19 1.5	18 13 0.9	0.2 — — 10 10 0.5	0.4 0.2 26 23 3.0	0.1 — 25 17 0.7	17 10 0.5 4.5	17 7.9 0.4
Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus	0.1 	4.2 6.2 2.0 3.7 1.2	15 19 1.1 2.4 1.1	14 19 1.5 4.4 0.5	18 13 0.9 4.1	0.2 — 10 10 0.5 1.9 0.2	0.4 	0.1 25 17 0.7 6.2	0.2 17 10 0.5 4.5 3.6	7.9 0.4 6.6 2.8
Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus	0.1 	4.2 6.2 2.0 3.7 1.2 78	15 19 1.1 2.4	14 19 1.5 4.4	18 13 0.9 4.1 0.5 40	0.2 10 10 0.5 1.9 0.2 53	0.4 0.2 26 23 3.0	0.1 25 17 0.7 6.2 3.2 19	0.2 17 10 0.5 4.5 3.6 32	17 7.9 0.4 6.6
Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus	0.1 	4.2 6.2 2.0 3.7 1.2	15 19 1.1 2.4 1.1 40	14 19 1.5 4.4 0.5	18 13 0.9 4.1 0.5	0.2 — 10 10 0.5 1.9 0.2	0.4 	0.1 25 17 0.7 6.2 3.2	0.2 17 10 0.5 4.5 3.6	7.9 0.4 6.6 2.8
Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum	0.1 	4.2 6.2 2.0 3.7 1.2 78	15 19 1.1 2.4 1.1 40	14 19 1.5 4.4 0.5 39	18 13 0.9 4.1 0.5 40	0.2 10 10 0.5 1.9 0.2 53	0.4 	0.1 	17 10 0.5 4.5 3.6 32 0.2	7.9 0.4 6.6 2.8
Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus	0.1 	4.2 6.2 2.0 3.7 1.2 78 0.5	15 19 1.1 2.4 1.1 40	14 19 1.5 4.4 0.5 39	18 13 0.9 4.1 0.5 40	0.2 10 10 0.5 1.9 0.2 53 0.2 	0.4 	0.1 — 25 17 0.7 6.2 3.2 19 0.1 0.1	17 10 0.5 4.5 3.6 32 0.2 0.2	7.9 0.4 6.6 2.8
Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna	0.1 	4.2 6.2 2.0 3.7 1.2 78 0.5	15 19 1.1 2.4 1.1 40 — — 0.7	14 19 1.5 4.4 0.5 39 — — 0.5	18 13 0.9 4.1 0.5 40 0.5	0.2 	0.4 	0.1 	0.2 	17 7.9 0.4 6.6 2.8 36
Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae	0.1 	4.2 6.2 2.0 3.7 1.2 78 0.5 —	15 19 1.1 2.4 1.1 40 0.7 2.8	14 19 1.5 4.4 0.5 39 — 0.5	18 13 0.9 4.1 0.5 40 0.5 —	0.2 	0.4 	0.1 		17 7.9 0.4 6.6 2.8 36 — 4.1
Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae Cyperaceae	0.1 	4.2 6.2 2.0 3.7 1.2 78 0.5 — 4.7 1.2	15 19 1.1 2.4 1.1 40 0.7 2.8 19	14 19 1.5 4.4 0.5 39 	18 13 0.9 4.1 0.5 40 0.5 —	0.2 	0.4 	0.1 		17 7.9 0.4 6.6 2.8 36 — 4.1
Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae Cyperaceae Artemisia	0.1 	4.2 6.2 2.0 3.7 1.2 78 0.5 — 4.7 1.2	15 19 1.1 2.4 1.1 40 0.7 2.8 19	14 19 1.5 4.4 0.5 39 	18 13 0.9 4.1 0.5 40 0.5 — 18 10 0.5	0.2 	0.4 	0.1 		17 7.9 0.4 6.6 2.8 36 — 4.1 18 0.1
Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae Cyperaceae Artemisia Rumex acet.	0.1 	4.2 6.2 2.0 3.7 1.2 78 0.5 — 4.7 1.2 — 0.2	15 19 1.1 2.4 1.1 40 0.7 2.8 19 0.6	14 19 1.5 4.4 0.5 39 	18 13 0.9 4.1 0.5 40 0.5 — 18 10 0.5 0.9	0.2 	0.4 	0.1 		17 7.9 0.4 6.6 2.8 36 — 4.1 18 0.1 4.6
Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae Cyperaceae Artemisia Rumex acet Plantago lanc.	0.1 	4.2 6.2 2.0 3.7 1.2 78 0.5 — 4.7 1.2 — 0.2	15 19 1.1 2.4 1.1 40 0.7 2.8 19 0.6 0.2	14 19 1.5 4.4 0.5 39 	18 13 0.9 4.1 0.5 40 0.5 — 18 10 0.5	0.2 	0.4	0.1 		17 7.9 0.4 6.6 2.8 36 — 4.1 18 0.1
Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae Cyperaceae Artemisia Rumex acet. Plantago lanc. Cerealea	0.1	4.2 6.2 2.0 3.7 1.2 78 0.5 — 4.7 1.2 — 0.2	15 19 1.1 2.4 1.1 40 0.7 2.8 19 0.6 0.2	14 19 1.5 4.4 0.5 39 	18 13 0.9 4.1 0.5 40 0.5 18 10 0.5 0.9 0.5	0.2	0.4	0.1 		17 7.9 0.4 6.6 2.8 36 4.1 18 0.1 4.6 0.1
Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae Cyperaceae Artemisia Rumex acet Plantago lanc.	0.1 	4.2 6.2 2.0 3.7 1.2 78 0.5 — 4.7 1.2 — 0.2	15 19 1.1 2.4 1.1 40 0.7 2.8 19 0.6 0.2	14 19 1.5 4.4 0.5 39 	18 13 0.9 4.1 0.5 40 0.5 — 18 10 0.5 0.9	0.2 	0.4	0.1 	0.2	17 7.9 0.4 6.6 2.8 36 4.1 18 0.1 4.6 0.1

Table A (continued)

			IABLI	E A (CC	minue	4)				
	60a	60b	61a	61b	62	63	64a	64b	64c	64d
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	20.7	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	. 0.0	0.2								
Σ Α.Ρ	351.5	554	100	70.5	209.5	660.5	131.5	140	162	165
Destruction D.b		49	46	65	46	71	101.0			
				1 00	1.0					
	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
Betula	21 2.6	9.5	19	6.1	9.2	11 9 7	11 12	8.5	15 12	20
Pinus	2.6	2.6	4.9	6.1 5.2	4.4	9.7	12	7.8	12	41
Pinus	2.6 0.3	2.6 0.1					12 0.2	7.8 0.7	12 1.0	
Pinus Salix Juniperus	2.6 0.3 0.1	2.6 0.1 0.1	4.9 0.1	5.2	4.4 0.4	9.7 0.2	12 0.2 0.1	7.8 0.7 0.2	12	41 1.3
Pinus	2.6 0.3 0.1	2.6 0.1	4.9 0.1	5.2	4.4 0.4 —	9.7	12 0.2	7.8 0.7 0.2	12 1.0 —	41
Pinus	2.6 0.3 0.1	2.6 0.1 0.1 0.1	4.9 0.1 — 0.1	5.2	4.4 0.4 —	9.7 0.2 — 0.8	12 0.2 0.1 0.2	7.8 0.7 0.2	12 1.0 —	41 1.3 — 0.4
Pinus Salix Juniperus Populus Viburnum Corylus	2.6 0.3 0.1 — 43	2.6 0.1 0.1 0.1 -	4.9 0.1 — 0.1 — 19	5.2	4.4 0.4 — — 8.5	9.7 0.2 — 0.8 — 25	12 0.2 0.1 0.2 — 20	7.8 0.7 0.2 — — —	12 1.0 — — — — 15	41 1.3 — 0.4 — 14
Pinus Salix Juniperus Populus Viburnum Corylus. Quercus	2.6 0.3 0.1 — 43 10	2.6 0.1 0.1 0.1 - 14 19	4.9 0.1 — 0.1 — 19 27	5.2	4.4 0.4 	9.7 0.2 — 0.8 — 25 18	12 0.2 0.1 0.2 — 20 19	7.8 0.7 0.2 — — — — 15 7.1	12 1.0 — — — 15 6.1	41 1.3 — 0.4 — 14 2.1
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus	2.6 0.3 0.1 43 10 2.7	2.6 0.1 0.1 0.1 14 19 3.1	4.9 0.1 — 0.1 — 19 27 3.7	5.2 ————————————————————————————————————	4.4 0.4 - 8.5 5.9 2.9	9.7 0.2 — 0.8 — 25 18 1.1	12 0.2 0.1 0.2 — 20 19 0.8	7.8 0.7 0.2 	12 1.0 — — — 15 6.1 1.0	41 1.3 — 0.4 — 14
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia	2.6 0.3 0.1 	2.6 0.1 0.1 0.1 14 19 3.1 4.6	4.9 0.1 — 0.1 — 19 27 3.7 7.0	5.2 — 25 2.8 — 4.7	4.4 0.4 	9.7 0.2 — 0.8 — 25 18 1.1 2.9	12 0.2 0.1 0.2 	7.8 0.7 0.2 	12 1.0 — — 15 6.1 1.0 2.0	41 1.3 — 0.4 — 14 2.1 —
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus	2.6 0.3 0.1 43 10 2.7 5.1 1.1	2.6 0.1 0.1 0.1 	4.9 0.1 0.1 19 27 3.7 7.0 1.8	5.2 	4.4 0.4 	9.7 0.2 — 0.8 — 25 18 1.1 2.9 4.2	12 0.2 0.1 0.2 	7.8 0.7 0.2 15 7.1 0.2 0.9 1.7	12 1.0 — — 15 6.1 1.0 2.0 0.5	41 1.3
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus	2.6 0.3 0.1 	2.6 0.1 0.1 0.1 14 19 3.1 4.6 1.2	4.9 0.1 	5.2 — — 25 2.8 — 4.7	4.4 0.4 	9.7 0.2 — 0.8 — 25 18 1.1 2.9	12 0.2 0.1 0.2 	7.8 0.7 0.2 	12 1.0 	41 1.3 — 0.4 — 14 2.1 —
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera	2.6 0.3 0.1 43 10 2.7 5.1 1.1	2.6 0.1 0.1 0.1 	4.9 0.1 0.1 19 27 3.7 7.0 1.8	5.2 	4.4 0.4 	9.7 0.2 	12 0.2 0.1 0.2 	7.8 0.7 0.2 15 7.1 0.2 0.9 1.7	12 1.0 — — 15 6.1 1.0 2.0 0.5	41 1.3
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum	2.6 0.3 0.1 	2.6 0.1 0.1 0.1 14 19 3.1 4.6 1.2	4.9 0.1 	5.2 	4.4 0.4 	9.7 0.2 	12 0.2 0.1 0.2 	7.8 0.7 0.2 15 7.1 0.2 0.9 1.7	12 1.0 	41 1.3
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus	2.6 0.3 0.1 43 10 2.7 5.1 1.1 14 0.2	2.6 0.1 0.1 	4.9 0.1 	5.2 	4.4 0.4 	9.7 0.2 	12 0.2 0.1 0.2 	7.8 0.7 0.2 	12 1.0 ———————————————————————————————————	41 1.3 0.4 14 2.1 1.0 21
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna	2.6 0.3 0.1 	2.6 0.1 0.1 0.1 14 19 3.1 4.6 1.2 45 0.1 —	4.9 0.1 	5.2 	4.4 0.4 	9.7 0.2 	12 0.2 0.1 0.2 	7.8 0.7 0.2 	12 1.0 	41 1.3 0.4 14 2.1 1.0 21 0.8
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae	2.6 0.3 0.1 	2.6 0.1 0.1 0.1 14 19 3.1 4.6 1.2 45 0.1 0.2 1.3	4.9 0.1 	5.2 	4.4 0.4 	9.7 0.2 	12 0.2 0.1 0.2 	7.8 0.7 0.2 	12 1.0 	41 1.3 0.4 14 2.1 1.0 21 0.8 4.4
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae Cyperaceae	2.6 0.3 0.1 	2.6 0.1 0.1 0.1 14 19 3.1 4.6 1.2 45 0.1 — 0.2 1.3 2.9	4.9 0.1 	5.2 	4.4 0.4 	9.7 0.2 	12 0.2 0.1 0.2 	7.8 0.7 0.2 15 7.1 0.2 0.9 1.7 57 	12 1.0 	41 1.3
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae Cyperaceae Artemisia	2.6 0.3 0.1 	2.6 0.1 0.1 0.1 14 19 3.1 4.6 1.2 45 0.1 - 0.2 1.3 2.9 -	4.9 0.1 	5.2 	4.4 0.4 	9.7 0.2 	12 0.2 0.1 0.2 	7.8 0.7 0.2 15 7.1 0.2 0.9 1.7 57 	12 1.0 	11.3
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae Cyperaceae Artemisia Rumex acet	2.6 0.3 0.1 	2.6 0.1 0.1 0.1 14 19 3.1 4.6 1.2 45 0.1 — 0.2 1.3 2.9 — 0.1	4.9 0.1 0.1 19 27 3.7 7.0 1.8 18 0.5 0.2 0.7 7.5 0.2 5.4	5.2 	4.4 0.4 	9.7 0.2 	12 0.2 0.1 0.2 	7.8 0.7 0.2 	12 1.0 	11.3
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae Cyperaceae Artemisia Rumex acet Plantago lanc.	2.6 0.3 0.1	2.6 0.1 0.1 0.1 14 19 3.1 4.6 1.2 45 0.1 - 0.2 1.3 2.9 - 0.1 0.2	4.9 0.1 0.1 19 27 3.7 7.0 1.8 18 0.5 0.2 0.7 7.5 0.2 5.4 0.2	5.2 	4.4 0.4 	9.7 0.2 	12 0.2 0.1 0.2 	7.8 0.7 0.2 	12 1.0 	11.3
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae Cyperaceae Artemisia Rumex acet Plantago lanc Cerealea	2.6 0.3 0.1	2.6 0.1 0.1 0.1 14 19 3.1 4.6 1.2 45 0.1 - 0.2 1.3 2.9 - 0.1 0.2 -	4.9 0.1 0.1 19 27 3.7 7.0 1.8 18 0.5 0.2 0.7 7.5 0.2 5.4 0.2	5.2	4.4 0.4 	9.7 0.2 	12 0.2 0.1 0.2 	7.8 0.7 0.2 	12 1.0 	11.3
Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae Cyperaceae Artemisia Rumex acet. Plantago lanc.	2.6 0.3 0.1	2.6 0.1 0.1 0.1 14 19 3.1 4.6 1.2 45 0.1 - 0.2 1.3 2.9 - 0.1 0.2	4.9 0.1 0.1 19 27 3.7 7.0 1.8 18 0.5 0.2 0.7 7.5 0.2 5.4 0.2	5.2 	4.4 0.4 	9.7 0.2 	12 0.2 0.1 0.2 	7.8 0.7 0.2 	12 1.0 	11.3

Rumex acet.

Plantago lanc.....

Cerealea.....

 $\Sigma\,\mathrm{A.P.}\,\ldots\ldots\ldots$

Destruction D.b....

72a

72b

73a

Hb

Table A (continued). 73b

74

75

76

79

Ha

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
Σ Α.Ρ	58.5	142	121.5	182	108.5	445	131	955	2518	2525
Destruction D.b	_		86	90				47	7.8	7.9
	_							47	7.8	
	IIc	IIIa			IVb	IVc	Va	47 Vb	7.8 Vc	
	IIc 5.5	111a 6.5	86	90	IVb 6.3	IVc 6.7	Va 6.6			7.9
Destruction D.b			86 IIIb	90 IVa		1		Vb	Vc	7.9 VIa
Betula	5.5	6.5	86 HHb 7.6	90 IVa 7.2	6.3	6.7	6.6	Vb 7.2	Vc 5.6	7.9 VIa 9.8
Betula	5.5 7.5	6.5 3.8	86 IIIb 7.6 4.4	90 IVa 7.2 4.3	6.3 3.6	6.7 4.3	6.6 4.0	Vb 7.2 3.8	Vc 5.6 3.1	7.9 VIa 9.8
Betula	5.5 7.5 0.2	6.5 3.8 0.1	86 IIIb 7.6 4.4	90 IVa 7.2 4.3	6.3 3.6 0.6	6.7 4.3 0.6	6.6 4.0 0.2	7.2 3.8 0.5	Vc 5.6 3.1 0.7	7.9 VIa 9.8
Betula	5.5 7.5 0.2	6.5 3.8 0.1	7.6 4.4 0.2	90 IVa 7.2 4.3 0.7	6.3 3.6 0.6 0.1	6.7 4.3 0.6 0.1	6.6 4.0 0.2 0.1	7.2 3.8 0.5 0.1	5.6 3.1 0.7 0.2	7.9 VIa 9.8
Betula	5.5 7.5 0.2 — 0.3	6.5 3.8 0.1	7.6 4.4 0.2 - 0.1	90 IVa 7.2 4.3 0.7 — 0.1	6.3 3.6 0.6 0.1	6.7 4.3 0.6 0.1	6.6 4.0 0.2 0.1 0.1	7.2 3.8 0.5 0.1 0.1	5.6 3.1 0.7 0.2 0.1	7.9 VIa 9.8
Betula	5.5 7.5 0.2 — 0.3	6.5 3.8 0.1 0.1	7.6 4.4 0.2 0.1	90 IVa 7.2 4.3 0.7 — 0.1	6.3 3.6 0.6 0.1 0.1	6.7 4.3 0.6 0.1 0.1	6.6 4.0 0.2 0.1 0.1	7.2 3.8 0.5 0.1 0.1	Vc 5.6 3.1 0.7 0.2 0.1	7.9 VIa 9.8 4.8
Betula	5.5 7.5 0.2 — 0.3 —	6.5 3.8 0.1 0.1	7.6 4.4 0.2 - 0.1 - 33	90 IVa 7.2 4.3 0.7 - 0.1 - 38	6.3 3.6 0.6 0.1 0.1 40	6.7 4.3 0.6 0.1 0.1 -	6.6 4.0 0.2 0.1 0.1 41	7.2 3.8 0.5 0.1 0.1 0.1 38	5.6 3.1 0.7 0.2 0.1 —	7.9 VIa 9.8 4.8
Betula	5.5 7.5 0.2 — 0.3 — 19 15	6.5 3.8 0.1 0.1 32 12	7.6 4.4 0.2 0.1 33 14	90 IVa 7.2 4.3 0.7 - 0.1 - 38 13	6.3 3.6 0.6 0.1 0.1 40 13	6.7 4.3 0.6 0.1 0.1 - 38 15	6.6 4.0 0.2 0.1 0.1 41 12	7.2 3.8 0.5 0.1 0.1 0.1 38 13	Vc 5.6 3.1 0.7 0.2 0.1 — 42 12	7.9 VIa 9.8 4.8
Betula	5.5 7.5 0.2 — 0.3 — 19 15 3.0	6.5 3.8 0.1 0.1 32 12 0.4	7.6 4.4 0.2 0.1 33 14 2.1	90 IVa 7.2 4.3 0.7 - 0.1 - 38 13 1.3	6.3 3.6 0.6 0.1 0.1 40 13 2.2	6.7 4.3 0.6 0.1 0.1 - 38 15 1.9	6.6 4.0 0.2 0.1 0.1 41 12 1.2	Vb 7.2 3.8 0.5 0.1 0.1 0.1 38 13 2.4	Vc 5.6 3.1 0.7 0.2 0.1 42 12 2.3	7.9 VIa 9.8 4.8
Betula	5.5 7.5 0.2 — 0.3 — 19 15 3.0 4.7	6.5 3.8 0.1 0.1 32 12 0.4 3.9	111b 7.6 4.4 0.2 0.1 33 14 2.1 3.2	90 IVa 7.2 4.3 0.7 - 0.1 - 38 13 1.3 1.5	6.3 3.6 0.6 0.1 0.1 40 13 2.2 1.2	6.7 4.3 0.6 0.1 0.1 - 38 15 1.9 1.1	6.6 4.0 0.2 0.1 0.1 	Vb 7.2 3.8 0.5 0.1 0.1 0.1 38 13 2.4 1.2	Vc 5.6 3.1 0.7 0.2 0.1 42 12 2.3 0.7	7.9 VIa 9.8 4.8
Betula Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus	5.5 7.5 0.2 — 0.3 — 19 15 3.0 4.7 6.5	6.5 3.8 0.1 	111b 7.6 4.4 0.2 	90 IVa 7.2 4.3 0.7 - 0.1 - 38 13 1.3 1.5 1.0	6.3 3.6 0.6 0.1 0.1 	6.7 4.3 0.6 0.1 0.1 - 38 15 1.9 1.1 0.9	6.6 4.0 0.2 0.1 0.1 	Vb 7.2 3.8 0.5 0.1 0.1 0.1 38 13 2.4 1.2 1.1	Vc 5.6 3.1 0.7 0.2 0.1 42 12 2.3 0.7 0.9	7.9 VIa 9.8 4.8
Betula Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus	5.5 7.5 0.2 — 0.3 — 19 15 3.0 4.7 6.5	6.5 3.8 0.1 0.1 32 12 0.4 3.9 4.5 37	111b 7.6 4.4 0.2 - 0.1 - 33 14 2.1 3.2 4.6 30	90 IVa 7.2 4.3 0.7 0.1 38 13 1.3 1.5 1.0 33	6.3 3.6 0.6 0.1 0.1 40 13 2.2 1.2 0.9 32	6.7 4.3 0.6 0.1 0.1 - 38 15 1.9 1.1 0.9	6.6 4.0 0.2 0.1 0.1 	7.2 3.8 0.5 0.1 0.1 0.1 38 13 2.4 1.2 1.1 33	Vc 5.6 3.1 0.7 0.2 0.1 42 12 2.3 0.7 0.9 33	7.9 VIa 9.8 4.8 32 10 0.6 0.6 0.6 42
Betula Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera	5.5 7.5 0.2 — 0.3 — 19 15 3.0 4.7 6.5 38 0.3	6.5 3.8 0.1 0.1 32 12 0.4 3.9 4.5 37	111b 7.6 4.4 0.2 0.1 33 14 2.1 3.2 4.6 30 0.1	90 IVa 7.2 4.3 0.7 - 0.1 - 38 13 1.3 1.5 1.0 33 0.1	6.3 3.6 0.6 0.1 0.1 40 13 2.2 1.2 0.9 32 0.1	6.7 4.3 0.6 0.1 0.1 - 38 15 1.9 1.1 0.9	6.6 4.0 0.2 0.1 0.1 	7.2 3.8 0.5 0.1 0.1 0.1 38 13 2.4 1.2 1.1 33	Vc 5.6 3.1 0.7 0.2 0.1 42 12 2.3 0.7 0.9 33	7.9 VIa 9.8 4.8 32 10 0.6 0.6 0.6 42
Betula Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum	5.5 7.5 0.2 — 0.3 — 19 15 3.0 4.7 6.5 38 0.3	6.5 3.8 0.1 0.1 32 12 0.4 3.9 4.5 37	111b 7.6 4.4 0.2 0.1 33 14 2.1 3.2 4.6 30 0.1	90 IVa 7.2 4.3 0.7 0.1 38 13 1.5 1.0 33 0.1	6.3 3.6 0.6 0.1 0.1 40 13 2.2 1.2 0.9 32 0.1	6.7 4.3 0.6 0.1 0.1 38 15 1.9 1.1 0.9	6.6 4.0 0.2 0.1 0.1 41 12 1.2 0.8 0.9 34	7.2 3.8 0.5 0.1 0.1 0.1 38 13 2.4 1.2 1.1 33	Vc 5.6 3.1 0.7 0.2 0.1 42 12 2.3 0.7 0.9 33 0.1	7.9 VIa 9.8 4.8
Betula Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus	5.5 7.5 0.2 — 0.3 — 19 15 3.0 4.7 6.5 38 0.3 0.1	6.5 3.8 0.1 0.1 32 12 0.4 3.9 4.5 37	111b 7.6 4.4 0.2 - 0.1 - 33 14 2.1 3.2 4.6 30 0.1	90 IVa 7.2 4.3 0.7 0.1 38 13 1.5 1.0 33 0.1 0.1	6.3 3.6 0.6 0.1 0.1 40 13 2.2 1.2 0.9 32 0.1 0.1	6.7 4.3 0.6 0.1 0.1 38 15 1.9 1.1 0.9 31	6.6 4.0 0.2 0.1 0.1 41 12 1.2 0.8 0.9 34	7.2 3.8 0.5 0.1 0.1 0.1 38 13 2.4 1.2 1.1 33 0.1	Vc 5.6 3.1 0.7 0.2 0.1 42 12 2.3 0.7 0.9 33 0.1 0.1	7.9 VIa 9.8 4.8
Betula Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna	5.5 7.5 0.2 — 0.3 — 19 15 3.0 4.7 6.5 38 0.1 — 0.1	6.5 3.8 0.1 0.1 32 12 0.4 3.9 4.5 37	86	90 IVa 7.2 4.3 0.7 0.1 38 13 1.3 1.5 1.0 33 0.1 0.1 0.3	6.3 3.6 0.6 0.1 0.1 40 13 2.2 1.2 0.9 32 0.1 0.1	6.7 4.3 0.6 0.1 0.1 38 15 1.9 1.1 0.9 31	6.6 4.0 0.2 0.1 0.1 41 12 1.2 0.8 0.9 34	7.2 3.8 0.5 0.1 0.1 38 13 2.4 1.2 1.1 33 0.1 0.2	Vc 5.6 3.1 0.7 0.2 0.1 42 12 2.3 0.7 0.9 33 0.1 0.1 0.1	7.9 VIa 9.8 4.8 32 10 0.6 0.6 0.6 42
Betula Pinus Salix Juniperus Populus Viburnum Corylus Quercus Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae	5.5 7.5 0.2 0.3 19 15 3.0 4.7 6.5 38 0.3 0.1 0.1 8.6	6.5 3.8 0.1 0.1 32 12 0.4 3.9 4.5 37 0.1 2.3	86	90 IVa 7.2 4.3 0.7 - 0.1 - 38 13 1.5 1.0 33 0.1 - 0.1 0.3 2.7	6.3 3.6 0.6 0.1 0.1 	6.7 4.3 0.6 0.1 0.1 38 15 1.9 1.1 0.9 31 0.2 0.2 3.5	6.6 4.0 0.2 0.1 0.1 	Vb 7.2 3.8 0.5 0.1 0.1 38 13 2.4 1.2 1.1 33 0.1 0.2 3.9	Vc 5.6 3.1 0.7 0.2 0.1 42 12 2.3 0.7 0.9 33 0.1 0.1 3.6	7.9 VIa 9.8 4.8 32 10 0.6 0.6 42 0.2 0.6

0.1

0.9

0.1

1541.5

7.1

0.3

0.1

709

0.1

2498.5

6.7

0.1

0.8

0.1

1.2

3506

0.2

0.7

2.3

3334

0.2

0.9

0.1

3293.5

1.7

0.1

0.8

0.1

1.1

3375

0.1

0.5

0.1

3321.5

1.7

0,1

0.9

3472

4.2

1.2

0.2

482

224			TABLE	A (con	ntinued	D.				111.1
	VIa	VIc	IX	Xa	Xb	Xc	XA	XI	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			
Σ Α.Ρ	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									
Quercus	32	32	26	36	45	16	17	15	21	20
	17	14	26 19	4.3	45 8.1	10	11	15 9.8	21 19	20 17
Fraxinus	17 2.9	14 2.6	19 1.6	4.3 0.2	8.1 0.7		11 2.5			
	17	14 2.6 0.8	19 1.6 1.6	4.3 0.2 0.9	8.1 0.7 0.7	10	11 2.5 2.7	9.8	19	17
Fraxinus	17 2.9 1.3 1.1	14 2.6	19 1.6 1.6 2.3	4.3 0.2	8.1 0.7	10 2.3	11 2.5	9.8 1.7	19 5.5	17 6.7
Fraxinus Tilia	17 2.9 1.3	14 2.6 0.8	19 1.6 1.6	4.3 0.2 0.9	8.1 0.7 0.7	10 2.3 1.0	11 2.5 2.7	9.8 1.7 2.0	19 5.5 2.2	17 6.7 2.6
Fraxinus Tilia Ulmus	17 2.9 1.3 1.1	14 2.6 0.8 0.8	19 1.6 1.6 2.3	4.3 0.2 0.9 0.2	8.1 0.7 0.7 0.5	10 2.3 1.0 0.6	11 2.5 2.7 1.2	9.8 1.7 2.0 1.4	19 5.5 2.2 0.4	17 6.7 2.6 1.3
Fraxinus	17 2.9 1.3 1.1	14 2.6 0.8 0.8 33	19 1.6 1.6 2.3	4.3 0.2 0.9 0.2	8.1 0.7 0.7 0.5	10 2.3 1.0 0.6	11 2.5 2.7 1.2	9.8 1.7 2.0 1.4 56	19 5.5 2.2 0.4	17 6.7 2.6 1.3 39
Fraxinus Tilia Ulmus Alnus Hedera	17 2.9 1.3 1.1	14 2.6 0.8 0.8 33	19 1.6 1.6 2.3	4.3 0.2 0.9 0.2 52	8.1 0.7 0.7 0.5 39	10 2.3 1.0 0.6 61	11 2.5 2.7 1.2	9.8 1.7 2.0 1.4 56 0.1	19 5.5 2.2 0.4 39	17 6.7 2.6 1.3 39
Fraxinus Tilia Ulmus Alnus Hedera Viscum	17 2.9 1.3 1.1 30 —	14 2.6 0.8 0.8 33 0.1	19 1.6 1.6 2.3 33	4.3 0.2 0.9 0.2 52 —	8.1 0.7 0.7 0.5 39	10 2.3 1.0 0.6 61	11 2.5 2.7 1.2 53	9.8 1.7 2.0 1.4 56 0.1 0.1	19 5.5 2.2 0.4 39 — 0.2	17 6.7 2.6 1.3 39
Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae	17 2.9 1.3 1.1 30 — 0.2 0.1 5.4	14 2.6 0.8 0.8 33 0.1 — 1.0 — 9.8	19 1.6 1.6 2.3 33 ————————————————————————————————	4.3 0.2 0.9 0.2 52 — — — 1.9	8.1 0.7 0.7 0.5 39	10 2.3 1.0 0.6 61 	11 2.5 2.7 1.2 53 — 0.3 — 6.1	9.8 1.7 2.0 1.4 56 0.1 0.1 0.9 — 5.1	19 5.5 2.2 0.4 39 0.2 0.3	17 6.7 2.6 1.3 39 0.2 —
Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae Cyperaceae	17 2.9 1.3 1.1 30 — 0.2 0.1 5.4 4.7	14 2.6 0.8 0.8 33 0.1 — 1.0 — 9.8	19 1.6 1.6 2.3 33	4.3 0.2 0.9 0.2 52 — — 1.9 2.8	8.1 0.7 0.7 0.5 39	10 2.3 1.0 0.6 61 ——————————————————————————————————	11 2.5 2.7 1.2 53 — 0.3	9.8 1.7 2.0 1.4 56 0.1 0.1 0.9	19 5.5 2.2 0.4 39 0.2 0.3 0.6	17 6.7 2.6 1.3 39 0.2 — — 0.2
Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae	17 2.9 1.3 1.1 30 — 0.2 0.1 5.4	14 2.6 0.8 0.8 33 0.1 — 1.0 — 9.8	19 1.6 1.6 2.3 33 ————————————————————————————————	4.3 0.2 0.9 0.2 52 — — — 1.9	8.1 0.7 0.7 0.5 39 	10 2.3 1.0 0.6 61 	11 2.5 2.7 1.2 53 — 0.3 — 6.1	9.8 1.7 2.0 1.4 56 0.1 0.1 0.9 — 5.1	19 5.5 2.2 0.4 39 	17 6.7 2.6 1.3 39 0.2 — 0.2 14
Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae Cyperaceae Artemisia Rumex acet	17 2.9 1.3 1.1 30 — 0.2 0.1 5.4 4.7	14 2.6 0.8 0.8 33 0.1 — 1.0 — 9.8	19 1.6 1.6 2.3 33 ————————————————————————————————	4.3 0.2 0.9 0.2 52 — — 1.9 2.8	8.1 0.7 0.7 0.5 39 	10 2.3 1.0 0.6 61 	11 2.5 2.7 1.2 53 — 0.3 — 6.1	9.8 1.7 2.0 1.4 56 0.1 0.1 0.9 — 5.1 7.6	19 5.5 2.2 0.4 39 	17 6.7 2.6 1.3 39 0.2 — 0.2 14 0.6
Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae Cyperaceae Artemisia	17 2.9 1.3 1.1 30 — 0.2 0.1 5.4 4.7 0.7 0.2 1.5	14 2.6 0.8 0.8 33 0.1 — 1.0 — 9.8 12 0.3 0.7 1.1	19 1.6 1.6 2.3 33 ————————————————————————————————	4.3 0.2 0.9 0.2 52 — — 1.9 2.8	8.1 0.7 0.7 0.5 39 	10 2.3 1.0 0.6 61 — 0.1 3.0 2.0 0.2 0.5 0.4	11 2.5 2.7 1.2 53 — 0.3 — 6.1 12	9.8 1.7 2.0 1.4 56 0.1 0.1 0.9 — 5.1 7.6 0.6	19 5.5 2.2 0.4 39 	17 6.7 2.6 1.3 39 0.2 — 0.2 14 0.6 1.3 0.6 1.0
Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae Cyperaceae Artemisia Rumex acet Plantago lanc. Cerealea	17 2.9 1.3 1.1 30 0.2 0.1 5.4 4.7 0.7 0.2 1.5 0.2	14 2.6 0.8 0.8 33 0.1 — 1.0 — 9.8 12 0.3 0.7 1.1 0.3	19 1.6 1.6 2.3 33 	4.3 0.2 0.9 0.2 52 — 1.9 2.8 0.2	8.1 0.7 0.7 0.5 39 	10 2.3 1.0 0.6 61 — 0.1 3.0 2.0 0.2 0.5 0.4 0.1	11 2.5 2.7 1.2 53 — 0.3 — 6.1 12 1.8 0.3	9.8 1.7 2.0 1.4 56 0.1 0.9 5.1 7.6 0.6 0.1 0.8	19 5.5 2.2 0.4 39 	17 6.7 2.6 1.3 39 0.2 — 0.2 14 0.6 1.3 0.6 1.0
Fraxinus Tilia Ulmus Alnus Hedera Viscum Fagus Calluna Gramineae Cyperaceae Artemisia Rumex acet Plantago lanc.	17 2.9 1.3 1.1 30 — 0.2 0.1 5.4 4.7 0.7 0.2 1.5	14 2.6 0.8 0.8 33 0.1 — 1.0 — 9.8 12 0.3 0.7 1.1	19 1.6 1.6 2.3 33 	4.3 0.2 0.9 0.2 52 — 1.9 2.8 0.2 — 1.3	8.1 0.7 0.7 0.5 39 	10 2.3 1.0 0.6 61 — 0.1 3.0 2.0 0.2 0.5 0.4	11 2.5 2.7 1.2 53 — 0.3 — 6.1 12 1.8 0.3	9.8 1.7 2.0 1.4 56 0.1 0.1 0.9 — 5.1 7.6 0.6 0.1	19 5.5 2.2 0.4 39 	17 6.7 2.6 1.3 39 0.2 — 0.2 14 0.6 1.3 0.6 1.0

Table A (continued).

	XXc	XXI	XXII	XXIII	XXIV	XXV	XXVI	XXVII	XXVII b	XXVIII
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									
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	
$\Sigma \ \mathrm{A.P.} \ \dots \dots$	742.5	239	320	116	158.5	410.5	356.5	1456	1343.5	350
Destruction D.b	14							5.0	7.2	

	XXVIII b	XXX	XXXII	XXXII	XXXII	XXXII	XXXIII		
Betula	13	15	12	8.0	7.0	5.3	6.9		
Pinus	4.0	18	9.0	7.8	8.5	5.3	7.6		
Salix			12	15	8.0	13	0.3		
Juniperus						0.1			
Populus			0.1	0.2	0.2				
Viburnum			0.6	1.1	1.6	1.5			
Corylus	38	15	13	8.9	13	12	30		
Quercus	6.2	13	14	19	18	18	1.0		
Fraxinus	0.3		0.7	0.5	0.6	0.6			
Tilia	0.9	3.7	0.3	0.4	0.2	0.2	1.4		
Ulmus	0.9		0.2	0.2	0.5	0.7	0.3		
Alnus	36	35	29	35	37	39	53		
Hedera			_	0.1					
Viscum									
Fagus	_		8.1	3.6	7.1	5.8			
Calluna	_		1.1	0.9	0.5	0.7			
Gramineae	0.9	126	118	83	69	55	2.1		
Cyperaceae	0.6	135	34	27	23	27	0.7		
Artemisia	1.2		4.3	4.0	4.6	4.7	_		
Rumex acet	-	5.6	16	7.5	7.2	4.3			
Plantago lanc	0.6	11	7.2	7.1	4.9	5.8	0.3		
Cerealea	_	3.7	1.0	1.0	1.4	1.9			
$\Sigma \; \mathrm{A.P.} \; \ldots \ldots$	326	54	1154	1065	1399.5	1135	291		
$Destruction\ D.b.\dots.$		_	34	28	18	25	_		

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SPERMATOPH YTA	2 2 2 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	9 8 J D D D D D D D D D D D D D D D D D D	1	15 16 17 18 18 18 19 19 19 19 19	4 4 <th> </th> <th></th> <th></th> <th></th> <th></th>					
Aceraceae Acer sp										
Alismataceae Alisma sp										
Aquifoliaceae Ilex aquifolium L										
Araliaceae Hedera Helix L Betulaceae				1 1 1		1 1 1 2 3 3 2		1 2 1 6 1 1 + 1	2 7 8 1 4 2 1 1 2 1	
Alnus glutinosa (L.) Gaertn	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	2 3 1 42 744 541 583 417 271 312	8 5 669 637 386 6 65 99 562 593 532 5	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	2 2 15 49 15 4 3 46 7 286 377 60 134 177 54 113 46 417 264 555 14	64 2 27 7 2 93 471 1348 313 215 7 52 100 142 205 76 22 130 144 16 94 4	79 86 333 142 266 194 245 189 35 27 30 237 39 64 43 47 131 94 329 142 85 198 9 6 8 52 5 3	58 57 127 530 218 315 329 329 185 100 17 26 47 52 2 9 188 112 230 121 118 49 58 97 13 7 80 202	102 149 137 46 117 251 210 221 221 239 194 101 216 112 128 68	714 498 494 175 810 322 474 303 247 256 40 114 592 698 19 333 374 511 437 437 437 437 438 43
Campanulaceae Campanula sp							21			
Jasione montana L Cannabaceae Humulus Lupulus L			1 6 2 3	4 2 2 3 2	1 2 2 2 2 2 2 1 9 8	1 1 5 2 1				
Caprifoliaceae Lonicera Periclymenum L										
Sambucus nigra L					4 2 ?5 28 8	25 1				$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
Caryophyllaceae Caryophyllaceae sp Cerastium-type	2		5				$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		+ 1	
Melandrium-type										
Chenopodiaceae sp	7	1 4	1 1 1	6 1 3	1			2 4 1 1 1 3 1 4 1	2 2 1 5 3 1 1 4 2 3 2 15	5 30 28 1 3 5 5 3 7 9 4 1 15 13 11 12
Cistaceae Helianthemum sp Compositae	1 8									
Liguliflorae Liguliflorae sp	1	3	1 1 2	1 1	1 1 2 1	1 2 1 1 1				2 1 6 1 5 3 2 1 1 4 8 9 15 24 15 12
Tubuliflorae Tubuliflorae sp	1 1	3 2 1 1		3 10 1 3 1 14 1 3 3	1 1 7 3 3 9 3 2 6 11 4 2 1 1	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	50 42 39 2 8 48 59 47 38 72 65 4 2 2 2 5 1 1 1 12 11 7 5 12 8 11 7 7 6 5	4 5 5 17 7 5 5 1 2 2 3 2 2 3 1 92 61 77 51 3 11 5 2 2 11 5 7 8 4 4 40 34 50 42 56 53
Artemisia sp	5 9 45 1 2									
Carpinus Betulus L			<th> <th>260 458 243 187 191 205 401 87 1908 719 2155 455</th><th>1023 378 938 1490 3 45 239 111 17 81 2</th><th> <th>33 29 384 164 231 275 219 88 60 65 18 30 82 221</th><th> <th>3 3 3 1 6 6 6 5 9 5 197 519 482 198 212 101 125 165 126 144 60 102 435 318 8 151 94 179 133</th></th></th></th>	<th>260 458 243 187 191 205 401 87 1908 719 2155 455</th> <th>1023 378 938 1490 3 45 239 111 17 81 2</th> <th> <th>33 29 384 164 231 275 219 88 60 65 18 30 82 221</th><th> <th>3 3 3 1 6 6 6 5 9 5 197 519 482 198 212 101 125 165 126 144 60 102 435 318 8 151 94 179 133</th></th></th>	260 458 243 187 191 205 401 87 1908 719 2155 455	1023 378 938 1490 3 45 239 111 17 81 2	<th>33 29 384 164 231 275 219 88 60 65 18 30 82 221</th> <th> <th>3 3 3 1 6 6 6 5 9 5 197 519 482 198 212 101 125 165 126 144 60 102 435 318 8 151 94 179 133</th></th>	33 29 384 164 231 275 219 88 60 65 18 30 82 221	<th>3 3 3 1 6 6 6 5 9 5 197 519 482 198 212 101 125 165 126 144 60 102 435 318 8 151 94 179 133</th>	3 3 3 1 6 6 6 5 9 5 197 519 482 198 212 101 125 165 126 144 60 102 435 318 8 151 94 179 133
Crassulaceae Sedum sp			1							
Cruciferae sp			10 1 2		1 1		$\begin{array}{c c c c c c c c c c c c c c c c c c c $			4 2 3 1 1 1 1 2 1 3 20 11 14 10
Gupressaceae Juniperus communis L Cyperaceae	4 40 36 16	19 2 3 2 22	1 2 5	3 1 2 3	1 2 3 2 2					
Cyperaceae sp	47 116 311 17 16 17	20 401 56 87 69 96 262	674 392 95 36 151 37 64 79 39 1	64 42 6 38 59 131 36 28 180 28 74 19 	49	63 48 24 13 83 14 54 30 5 105 1 	18 22 26 49 215 190 125 51 59 39 57 177 13 23	33 45 60 34 92 564 614 91 86 103 25 40 13 100 10	$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	49 77 181 4 27 71 64 10 4 6 45 12 97 145 73 396 290 326 307
Cladium Mariscus (L.) R. Br Dipsacaceae Succisa pratensis Moench			38 15 17 13	16 1 . 8 55 . 3 7 1 2 24 15	25 10 15 15 45 57 1					
Elaeagnaceae Hippophaë rhamnoides L										
Empetraceae Empetrum sp	7 12 x 1 1	1 17 1 5	1							
Ericaceae Ericaceae sp	59	15	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	1	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		$egin{array}{c c c c c c c c c c c c c c c c c c c $	<th></th> <th>$\begin{array}{c ccccccccccccccccccccccccccccccccccc$</th>		$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$
Calluna vulgaris (L.) Hull										
Mercurialis perennis L Fagaceae										
Fagus silvatica LQuercus sp	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	1 1 4 9 10 7 11 98 4 5 1	25 4 12 12 37 296 79 25 105 3	39 28 63 123 244 62 54 77 6 9 75 123 10 16	29 20 92 228 335 199 208 41 24 10 9 16 76 17	7 389 405 374 85 217 458 449 497 392 423 411 130 173 179 178 145	4 15 2 8 2 23 13 93 38 99 66 133 270 206 36 139 68 83 146 108 137 18 75 152 98 7 164 207 252 207
Gentianaceae Gentiana pneumonanthe-type Geraniaceae							1			
Geranium spGramineae										
Gramineae sp Cerealea	58 81 131 32 21 55	41 123 189 343 103 72 52	138 39 60 11 30 15 36 32 11	39 87 14 148 134 93 34 26 195 1 155 29	90 137 20 39 66 130 3 8 60 12 16 15	25 79 21 11 12 5 38 19 15 3	39 39 41 198 205 19 28 49 12 6 32 35 21 20	30 32 13 15 9 28 22 112 112 21 7 14 10 49	2 127 159 215 15 93 93 123 115 73 127 125 44 23 23 21 62 62 62 62 62 62 62	48 86 140 3 39 37 43 112 84 76 11 35 354 322 68 1348 869 947 606
Cerealea sp										3 5 1 1 24 14 1 9 5 14 11 1 3 6 5 11
Glyceria sp										
Hypericum sp										
Myriophyllum alterniflorum L	3 9 27 1 3 2	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	1			?1				
Myriophyllum Verticiliatum L Hippuridaceae Hippuris sp Iridaceae										
Iris Pseudacorus L						1				
Juncaceae sp										
Juncaginaceae Triglochin sp						1				

							<u> </u>	1 1 1						1 1				· ·		1 1 1		1 1 1	1 1 1							1 1 1		1 1							TABLE	B (continued).
						g Q 0 p	g q q	g g	д	a 2 a	o 7 0	д	0	рв	a	q	a q	g Q g	g	g .	д д в д	ದ	5 Q 0 7	0	a	д в д	o a q	ದ	b c la	l lb	g c g	یا د ع	в д	c II a	XIII a XIII b XVII	VIII IX a	X X X	VIX KVI	CVIII)	XXIII CXIII C
	1 1 1 1 1 1 1 2 2 a 2 2 b	2 3 2 5 c	5 d d d d d d d d d d d d d d d d d d d	101 111 11 112	13.8	15 15 15 15	16	18 22 8	54 23	26 26 25	2 2 26	3 30 58 70	35 35	36 36 37	39 39	1 46	40 40 1	0 22 00	57 57 57	90 00 0	61 60 60 60 61 61 61 61 61 61 61 61 61 61 61 61 61	64 63	40 40 2	66 65 64	67	70 71 71	73 73	75 79 111	= = =			> > 1	× ×	X X X		× × ×	2 2 2	8 8 8	8 8 8 8	8 8 8
Scheuchzeriaceae									+																															
Scheuchzeria palustris L Scrophulariaceae																																								
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Melampyrum spOdontites-type																																	1							
Solanaceae Solanum Dulcamara L			2									. 1														7 1		1	1 3		2 1			3	1	2 2			1 6	4 4 2
Sparganiaceae Sparganium-type	12 20 27 1	1 3 7	11 6 1	1 24 1 4	2 3 10 2	20 14 15 28	8 1 3	2 1	0 6 4	1 54 2	41 51	9 11 1	6	2 5	4 37	2 2 1	2 7	2	2 3 5 13	3 6 1	1	2 2 1	1		4 1	6 6	1	1 47	32 41 2	11 70 9	98 101 57	85 65 2	3	4 9 15	8 23 1	17 5 11		1 29	28 2 37	14 24 6
Taxaceae																						1														1				2 3
Taxus baccata L Tiliaceae								3					1 4				20 102 3	34 13	9 9 12 16	6		27	7 10 9 1	6	86			28 48	28	51 3	39 35 28	40 25			3			5 4	2 4	4 3 2
Tilia sp								.:		20		. 1 7	:	22 53 3	47 2 1	0 2		15		. 88 27 4	15 13	9		. 46 54	33	38 5 8	30 57	119	111 117	49		33	33 53	54 13 13	21 12	14 16 17	17 16 20	18	15	
Typhaceae Турha latifolia L	. 5 5 5	1 3 6 5	2 7	7 183 14 1	8	2 2 2 2	1 1	4	. 1 1	3	2 7 1 .		1	21 29	4	1	1 2	1 2	7 2 2 19	9 23 1.		36			4 7	4 1 1	2 1	10	24 9 1	1 18 1	13 20 22	16 22 22	18 19	18 16 13	11 114	4 1	1	4	3 10	11 8 4
Ulmaceae Ulmus sp	1 1 1	1 2 1	1	3 3	1 1	10 13 7	9 28 2 1	2 2 1	0 33	1 3 2	1 3	3 2 9 17	17 140	18 58 14	92 15 3	39 1	23 152 4	41 5 6	1 1 1 1	1 46 22 1	9 3 2 1	4 18 2	2 6 3	3 10 14	22 47 4	48 10 2	5 10 20	19 40 167	149 163 32	71 34 3	31 29 32	38 30 37	21 50	30 10 13	18 12 2	8 7 12	3 8 3	2 3 24	20 2	2 7 8
Umbelliferae	. 4 2 10 2 1	2 1 1 7	4 4	4 28 6 2		1 1	1 3	3	1	10 1	5 7	1 1 2 3	7 3	1 6	2 3	1 3	1	8 2 6	3 7 10 19	9 16 16 1	1 5	1 20 1	1 3 5	1 7 1	3 1	1 7 2	1	2 84	86 50 9	12 123 11	15 102 93	202 207 5	6	7 11	2 6 2	14 14 14	2 2	1 11	12 1 61	50 78 42
Umbelliferae sp	. 4 2 10 2 1		1 1			1 2 1	2 1 1	4 1	. 2 1	1 1	2 1	4 4 ?1	4	4 4	2	. 3	1	9 9 1 .	2	2 3 8	8 1 2	1 24 1	1	. 1 1	4 4	2 144 19	9 1	3 5	6 9	1 3	5 3 2	12 8 7	11 9	4 62 61	10 12	19 6 6	1 11 5			51 38 40
Urtica sp Valerianaceae	1		1 2	2 2	1													1											1				1						21	40
Valeriana sp															00 00		24	24 45 4		. 100		20 405			25 10	00 10 0	0 00	40 04					1				. 1	1	2	3 4
a.i.d. (ad indeterminabile destructum)	3		39 13 14 3 4 3 2 .	$\begin{bmatrix} 2 & 2 & 2 & 2 \\ 1 & 1 & 1 \end{bmatrix}$	5 13 20	$\begin{array}{c ccccc} \cdot \cdot & 1 & 1 & 1 \\ \cdot \cdot & 5 & 2 & \cdot \end{array}$. 70 5 12 . 13 . 4	10 9 1	5 18 . 3 5	1 7 58 1 8	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	5 5 5 15 3	$\begin{bmatrix} 37 & 7 & 44 \\ 4 & 3 & 1 \end{bmatrix}$	93 39 .	1	$\begin{bmatrix} 31 & 4 & 3 \\ \dots & 3 & 3 \end{bmatrix}$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	11 14 21 25	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	33 105 66 5 1	06 36 47 3	. 59 3 . 8 1	35 40 6	68 43 24 7 4 3	$ \begin{array}{c ccccc} 2 & 23 & 60 \\ 1 & 5 & 2 \end{array} $	13 34 12 17 2	$ \begin{array}{c ccccc} 7 & 5 & 2 \\ 2 & 1 & 1 \end{array} $	5 8	4 9 6 5 4 4	$ \begin{array}{c ccccc} 10 & 9 & 14 \\ 4 & 5 & 1 \end{array} $	$\begin{bmatrix} 2 & \dots \\ 2 & \dots \end{bmatrix}$	7 41 42 1 7 4	16 15 14 4 3 1	11 49 51 1 4	21 9 22 9 5 6	40 19 8 3 1 5	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	67 42 43 13 18 6
a.i.p. (ad indeterminabile plicatum)	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	1 7	1 5	2 . 1 2		2 1 .			. 1 1		1 1	1	27	1	2 2 .			3 4 .	. 1 1 1	1 1 .	1	200 5 1005 5 020	0.5004 000 000		1	1		3 1	1		3 1	1 1	1	1	1 1		4 1 1	9 2	1 6	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
Σ Spermatophyta	. 314.5 622 1966.5 1114.5 996	<u> 1614 1224.5 1929 1380 17</u>	724 1020.5 795 986	6 2012.5 1583 1337	129 735.5 334 240	$\frac{105}{100} = \frac{2817}{100} = \frac{2299.5}{100} = \frac{236}{100}$	1 710 115.5 1180	$-\frac{ 1206 }{ 1973.5 }\frac{ 1973.5 }{ 257}$	6 2925 1001.5 2	$\frac{75}{}$ $\frac{ 1361.5 359}{}$ $\frac{ 105}{}$	57.5 1511 538 83	9 952 1092 732	482.5 3390 154	3537.5 808	2389 980 1379	9.5 2013 231.5	310 1712 204	45 500.5 709 290	0.5 520 744 880.	7.5 2579 1009.5 98	9 719 199 141	300.5 1095.5 259.	9.5 224 289 28	1002.5 1250	1470 1854 194	45 1079 741.5 6	42 201.5 310	1190 3174.53	202 3156.5 782	1792.5 4216 405	04 4033.5 3916 4	4199.5 4184 1739	1868.5 1820.5 172	720 1901 1506.5	1982 2113.5 498 1	1511.5 826 1083 1	$\frac{1016}{}$ $\frac{809}{}$ $\frac{915.5}{}$ $\frac{27}{}$	$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	$\frac{141}{274} \begin{vmatrix} 274 & 4029 & 31 \end{vmatrix}$	185 3650.5 2813
PTERIDOPHYTA																																								
Equisetaceae Equisetum sp	. 6 112 306 6	4 1 128	7 33 8 9	6 2 25 5		1 1 .	. 8 5	5 5	1 1	10	7 23 19	5 2 10			2			.								2 2	3		1				1 1	1		1 2			1	
Lycopodiaceae				1																. 2	2					1														1
Lycopodium sp Lycopodium clavatum-type																														1			1							
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Polypodiaceae	130 55 57	75 80 25 253 2	208 104 479	2 57 443 143	10 435 9	43 104 60 3	7 48 9 232	180 588	34 26 12 c	ecc 99 174	65 101 108 26	6 280 1534 35	144 229 25	57 440 66	258 228 8	9 21 7	28 163 31	11 81 29 11	5 71 70 1442	2 154 209 34	3 71 31 53	3 6888 145	5 298 376 31	4 48 134 1	1044 289 39	94 106 156	95 26 1216	10 286 1245	804 1301 c	334 204 163	32 153 159	216 418 839	426 407 56	669 147 241	226 429 241	31 50 63	12 9 17	85 10 547	328 50 684 4	415 565 353
Dryopteris-type	58 58	70 00 20 200 2	160	147				284									9	91		7 1 1 .	2	810 73	73 9	0 1	390 173 27 2 4	76 6 3	260	1 427	186 313			1 435	35	352	67	1 4	2 2 2	40 242	1 89	
Polypodium vulgare L Pteridium aquilinum (L.) Kuhn	$egin{array}{c c c c c c c c c c c c c c c c c c c $			1		1 1	1 4	2 4	1	1	1	3 2 9	6 12	1 7	8 1 .	. 4	4 1	11 1 4 .	. 1 1 1	1 4 2	6 4 1 1		. 1 6	1 6 1	5 5 1	13	1 3	4 1 13	5 11 2	3 11 1	13 18	14 19 5	6 11	5 8	12 8 2	5 3 5	7 11 8	3 4 10	3 9	5 1 7
Thelypteris Dryopteris (L.) Slosson	. 6 22 43 5 6	10 2 1	9 1 .	. 4 12 4	1	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	187 599	1 ·· · · · · · · · · · · · · · · · · ·	1 109 174	72 126 128 27	5 284 1554 35	150 241 25	58 447 66	269 229 9	0 25 8	28 167 32	23 82 33 11	5 72 71 1443	3 162 213 35	1 75 34 54	5 6889 145	5 299 382 313	5 55 135 1	1051 299 41	15 108 161	98 27 1220	14 296 1259	810 1312 2	338 216 173	73 167 179	231 437 844	433 422 57	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	238 439 243	36 55 74	21 22 27	88 14 557	33 51 696 4	22 572 365
Σ Pteridophyta	. 12 136 483 66 63	09 83 133 233 2	137 400 10.	00 101 100	11 100 0	TO THE T	230																															11 007	300 4	
BRYOPHYTA																																								
Sphagnum sp	3 8 4 2		2 2	3 11 2	2 2	1	. 1 1	1 2			1 1		2		1	10		3 2	1 1		1	1	1 2 :	2	2 6	4 2 1	1	5 5	1	1	5		1	2	5	1 3	1	3	3	3 2 3
Σ Bryophyta	3 8 4 2	3 3 6 2	2 2	3 11 2	2	1	. 1 1	1 2			1 1	8 22 1	2		1	. 10		3 2	1 1		1	1	1 2	2		4 2 1	1	5	1	1	5			2	5	1 3	1	3	3	3 2 3
THALLOPHYTA																																								
Botryococcaceae Botryococcus Braunii Kütz	. 12 45 155 3 9	12 7 121 6	16 4 3	2 15 13	1 10	5 7 6	8	1 7	1 5	9	19 13	4 5 1 7	5	1	7	7 85 3	1 .	2 .			1	2			4			9 26	23 79 20	29 14 22	2 13 17	31 41 5	7 5	6 1	3 3	5 4		102	61	2 1 1
Characeae (cf. p. 182	69	38	r																									3	19	r		r	rrr	r	r r				35	
Characeae sp. (oospores)			26 7 7	0 10 911 10		13 21 6 1	1	24	8 8	20 1	15 20 2	4 6 3	11	3 3	2 1	0 5	5 8 1	17 18			6			2	5	1	1	1 5103 6	656 4070 cc	1107 289 439	2 360 571 1	1316 298 52	61 131 2	29 10 6	34 91 1	562 185 109	1 0	nn 000	84	
Pediastrum sp	. c r-c 1368 6 2	4 16 3813 10 1195	30 7 7	70		10 21 0 1		21		1								5								1 1		1750 1	540 981	350 70 109	9 128 172	351 103 27	101 2		01 01 1	288	1 2	rr 262 2		1 1
Tilletia sphagni	1	16 22 2024 16	52 11 11	1 19 226 31	1 2 12	18 28 12 1	9	1 31	29 13	29 1	34 33 2	8 11 4 7	16	4 3	2 8	7 90 3	5 9 1	17 20 .			7	2		2	9	2 1	1 1	10 5129 6	679 4149 20	1136 303 454	4 373 588 1	1347 339 57	68 136 3	35 11 6	37 94 1	567 185 202	1 2	364	<u></u> 2	3 1 2
Σ Thallophyta	. 12 45 1523 9 12	23 3934 10	11 11	10 220 31		12 1								45																10					3. 3. 1	100 202		304	2	
Ceratophyllum-hair	14 7	14 9	5 r						2			1 27		17														r	$\begin{array}{c cccc} r & r & \dots \\ r & r & c \end{array}$	r		r	c r	r	1 1	r 1				
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LITERATURE

Abbreviations

Aarb. = Aarbøger for nordisk Oldkyndighed og Historie. København.

D.G.U. = Danmarks Geologiske Undersøgelse (Bulletin of the Geological Survey of Den-

mark). København.

O.V.S.F. — Oversigt Kongelige Videnskabernes Selskabs Forhandlinger. København.

Z. Tierzücht = Zeitschrift für Tierzüchtung und Züchtungsbiologie. Hamburg.

V.M. – Videnskabelige Meddelelser fra Dansk naturhistorisk Forening. København.

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230

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HANS JØRGEN HANSEN

ELECTRON-MICROSCOPICAL STUDIES ON THE ULTRASTRUCTURES OF SOME PERFORATE CALCITIC RADIATE AND GRANULATE FORAMINIFERA

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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

The 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 & Cifelli (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.

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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 analdit, 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 Å was found (pl. 2, fig. 1). The striation is orientated in two directions cutting each other at an angle of about 30° .

According to Reimer (1967) the resolution power of a collodium replica should at its best be about 60 Å. 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 μ . 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. 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 a raldit 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 replicate pseudoreplica 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 $5\,^{0}/_{0}$ HCl. When the specimen was dissolved the replica was pulled off and washed in distilled water.

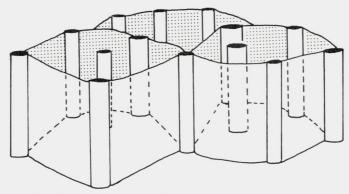


Fig. 1. Generalized model of the relation between the organic membranes enveloping the crystal units and the organic pore-tubes.

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 å 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 μ . 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 Å 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 Hansen (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 & Schneidermann (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 $20{\text -}30~\mu$ in length while their width is about $3{\text -}5~\mu$. 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 μ (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 μ . 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 (1968 c), 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 & Schneidermann (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 Argell (1967).

РЕЗЮМЕ

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.

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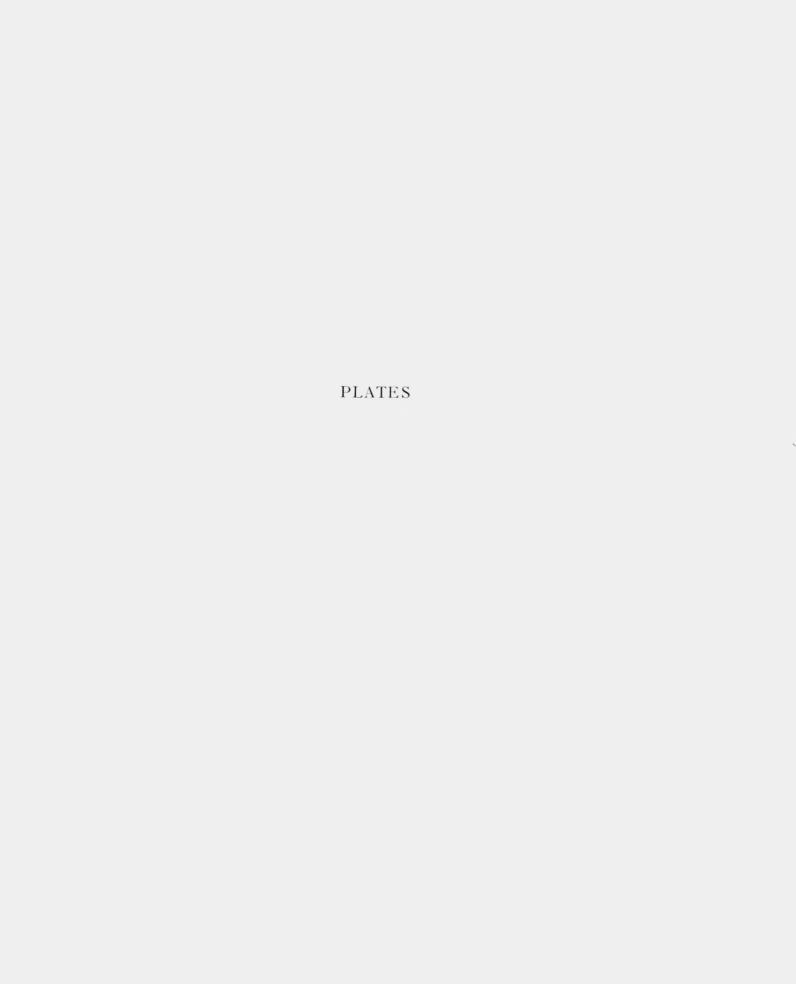


PLATE 1

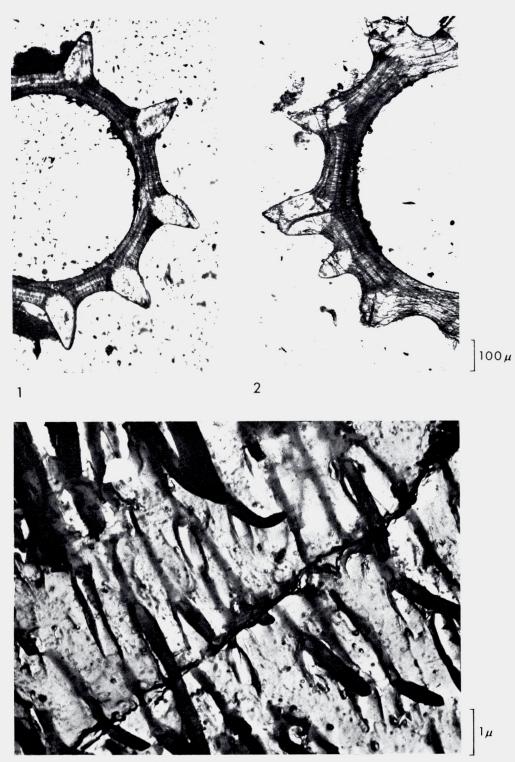
Figs. 1–2. Nodosaria latejugata Gümbel.

Transverse thin section of chambers 7 and 8 respectively, showing secondary lamination. 2 nicols parallel.

Fig. 3. Nodosaria latejugata Gümbel.

 $Carbon\ shadowed\ replica\ of\ etched\ transverse\ section\ showing\ the\ boundary\ between\ two\ secondary\ lamels\ with\ a\ sheet\ of\ organic\ material.\ TEM.$

PL. 1



2

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°) striae with a distance of $30{\text -}40$ Å 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.

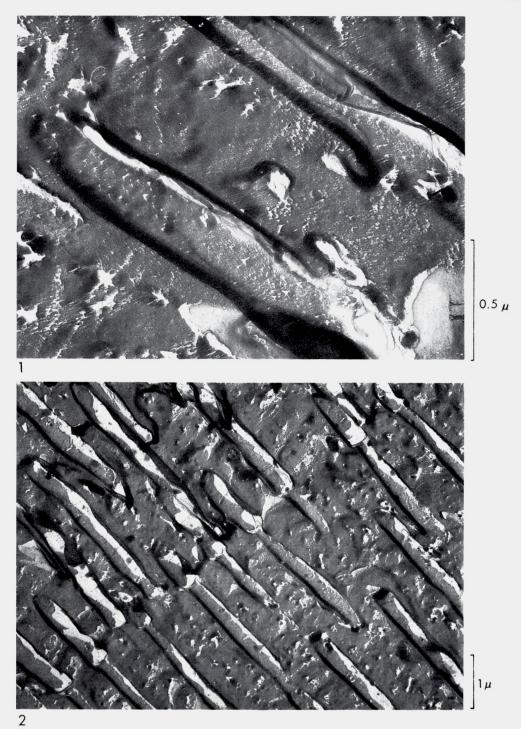
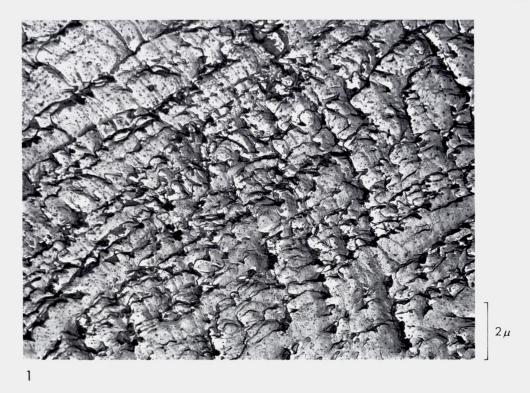


Plate 3

- 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.

Рг. 3





 1μ

2

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.



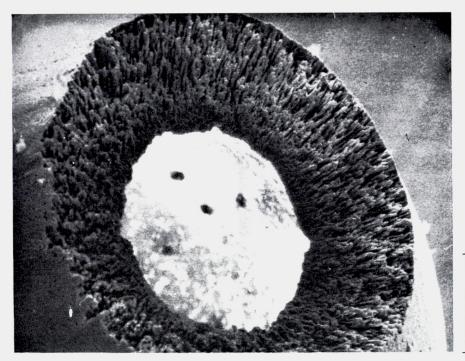
10μ

1

Plate 5

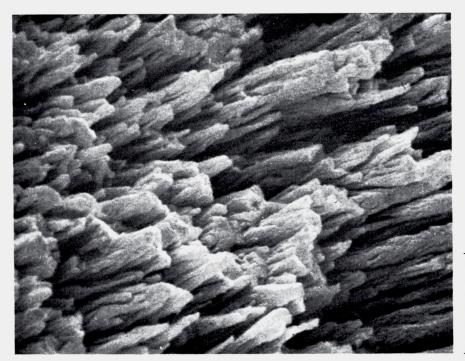
- Fig. 1. Nodosaria sp. Hvorslev, Denmark. Middle Oligocene.
 - Fractured and naturally corroded apertural part, showing the columnar nature of the calcite. SEM.
- Fig. 2. Detail of fig. 1. Columnar calcite crystals indicative of continuous growth with slight etch lines indicative of the cleavage rombohedron. *Note* that the crystals are uninterrupted, suggesting that no primary lamination is present. SEM.

Pl. 5



50μ

1



5μ

2

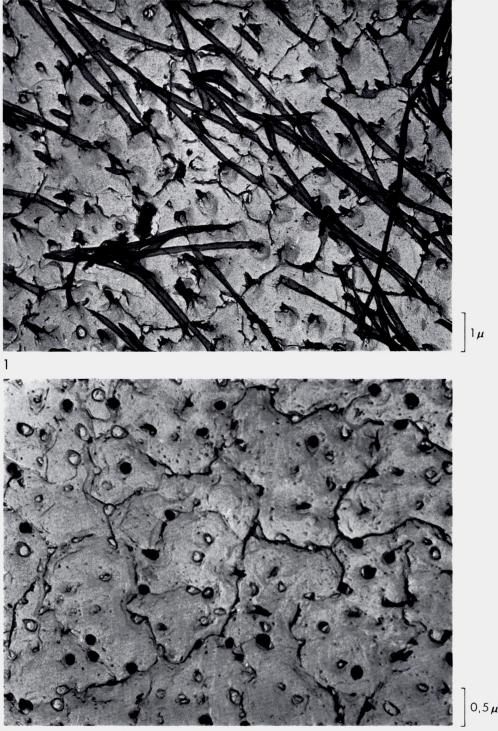
Plate 6

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.

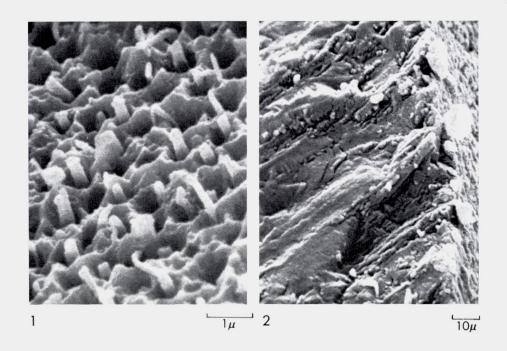


- Fig. 1. Nodosaria latejugata Gümbel.

 Slightly etched outer surface of chamber wall with pore-tubes etched free. SEM.
- Fig. 2. Nodosaria tatejugata 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.

PL. 7





5μ

- 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.

Pl. 8





5μ

Fig. 1. Polymorphina sp.

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.

PL. 9

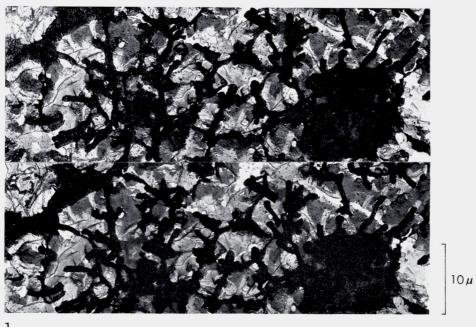




Fig. 1. Polymorphina sp.

Replica of etched inner surface shadowed with carbon showing pore-tubes and organic membranes. TEM.

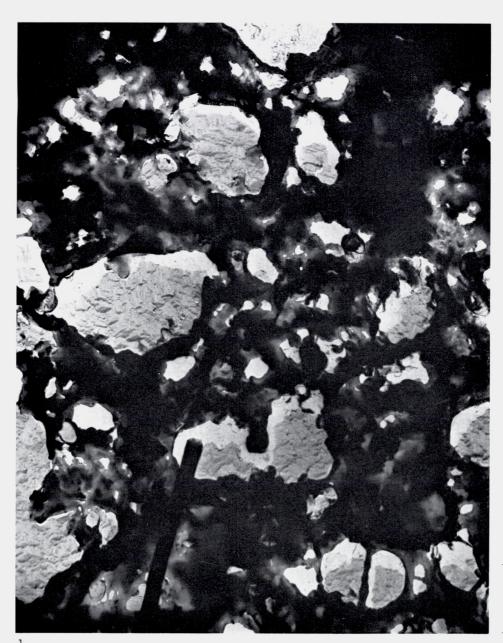


1μ

Fig. 1. Polymorphina sp.

One-stage carbon replica of etched surface showing organic membranes and crystal units. TEM.

PL. 11



2 μ

I

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.

Pl. 12



5μ



5μ

- 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.



1

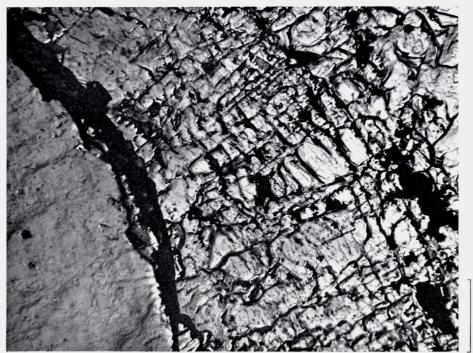


3μ

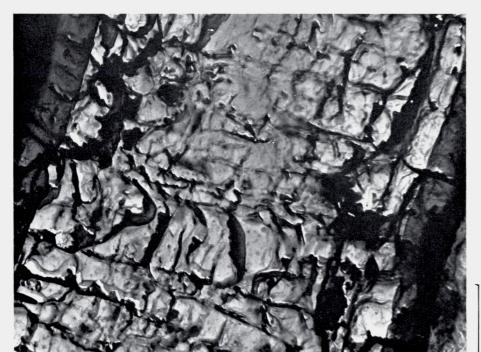
- Fig. 1. Bulimina midwayensis Cushman & Parker.

 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.

PL. 14



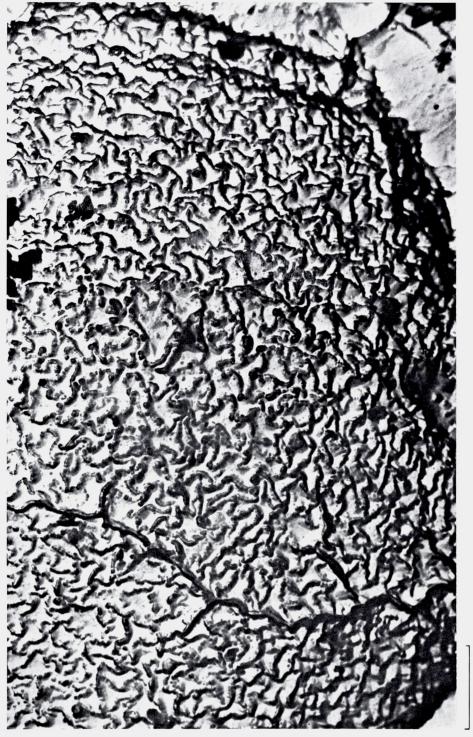
 5μ



3 μ

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.



5μ

Fig. 1. Bulimina midwayensis Cushman & Parker.

Second carbon shadowed replica of etched inner surface of the oldest-but-two chamber of megalo-spheric 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.

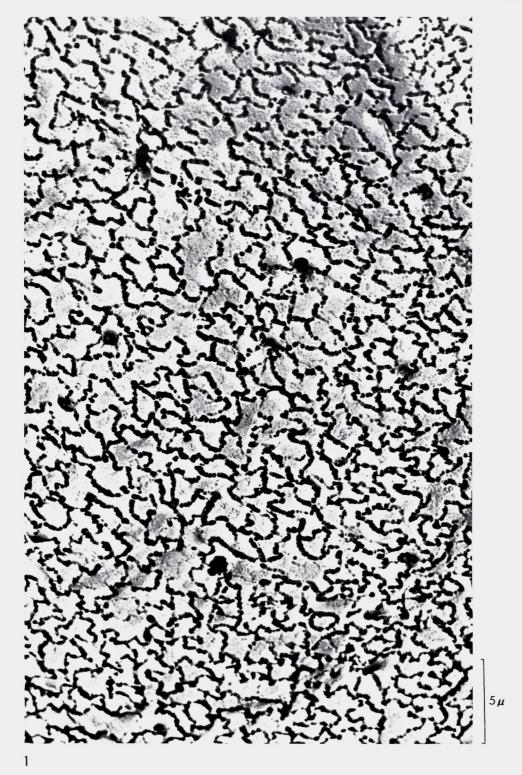


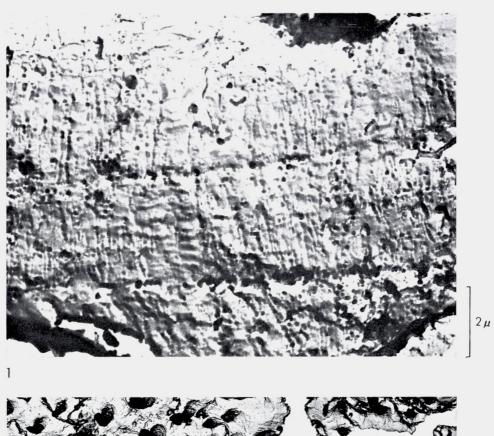
Fig. 1. Bulimina midwayensis Cushman & Parker.

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.

PL. 17





3,

Fig. 1. Bulimina marginata d'Orbigny.

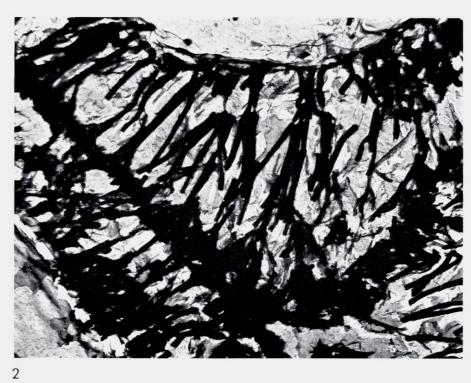
Replica-pseudoreplica of etched section of laminated wall of youngest-but-one chamber, showing concentration of organic material in the lamel boundary intimately connected with the pore-tubes. TEM.

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.

Pl. 18

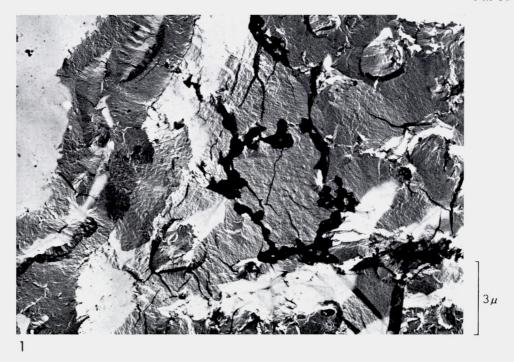




- Fig. 1. Melonis scaphum (Fichtel & Moll).
 - Replica-pseudoreplica of outer etched surface of central part of apertural face showing delimitation of a crystal unit by organic spongy material. TEM.
- Fig. 2. Melonis scaphum (Fichtel & Moll).

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.

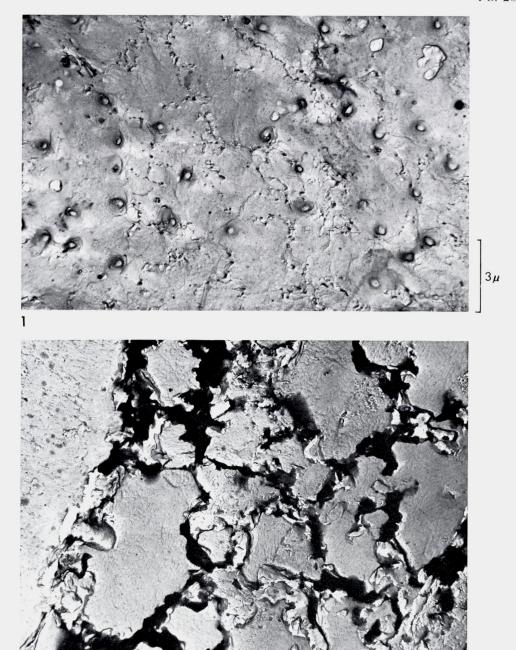
PL. 19





- 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.



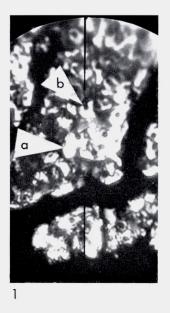
3μ

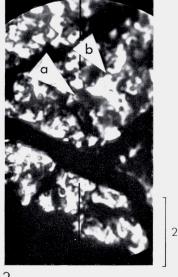
- Fig. 1. Melonis scaphum (Fichtel & Moll).

 Photomicrograph of central part of fractured apertural face. Crossed nicols.
- Fig. 2. Same as fig. 1. Specimen rotated 40° 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.

Pl. 21



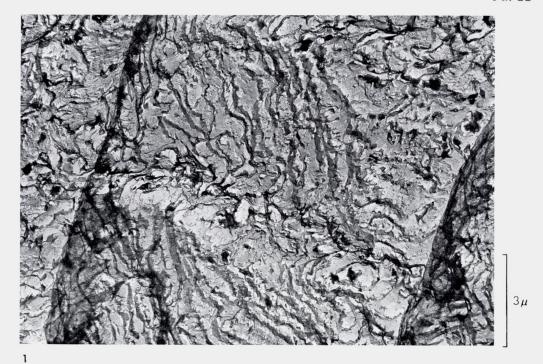


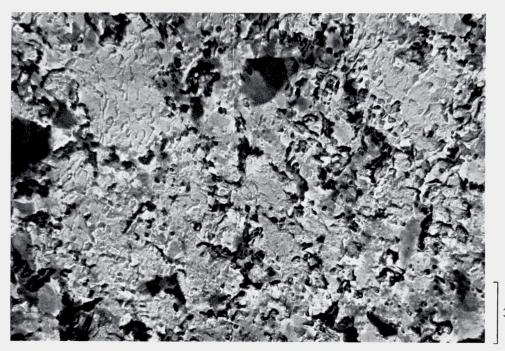
25μ



5,

- 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.

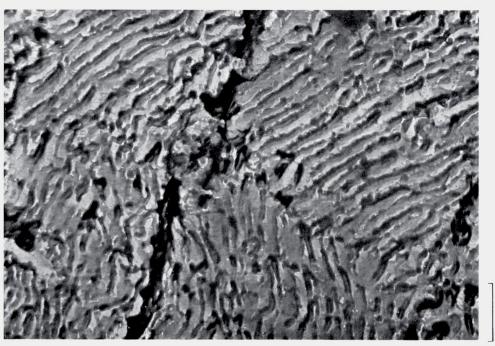




- Fig. 1. Heterolepa cf. subhaidingeri (Parr).
 - First two-stage replica of polished, etched section showing delicate organic membranes enveloping the small crystal plates constituting crystal units. A crystal unit boundary is seen running from bottom to top of the micrograph slightly right of center. 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.



1,5μ



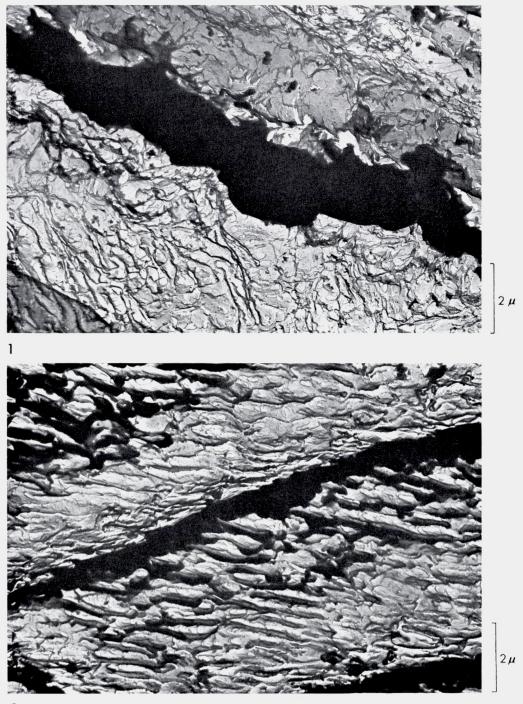
1,

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.

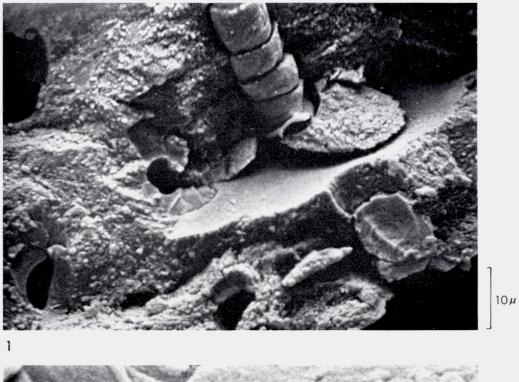


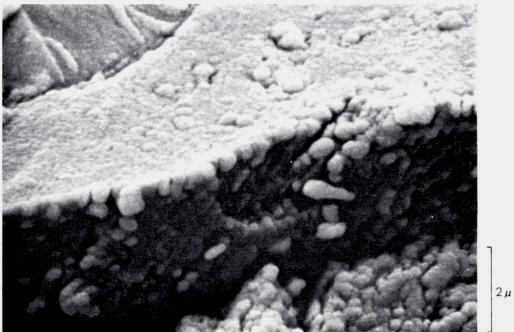
2

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.





2

Plate 26

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.



 2μ



 2μ

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FR. J. MATHIESEN

PALAEOBOTANICAL INVESTIGATIONS INTO SOME CORMOPHYTIC MACROFOSSILS FROM THE NEOGENE TERTIARY LIGNITES OF CENTRAL JUTLAND

PART II:

GYMNOSPERMS

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Kommissionær: Munksgaard København 1970

CONTENTS

		Page
II.	Gymnospermae	3
	Taxoxylon amentotaxoides n.sp	
	Saxegothaeoxylon miocenicum n.sp	
	Pinus palaeostrobus (C. v. Ettingshausen) O. Heer	13
	Pityosporites spp	14
	Pinuxylon sp. cf. P. paxii R. Kräusel	15
	Sciadopitys tertiaria P. Menzel	17
	Sciadopityoxylon wettsteinii K. A. Jurasky	
	Sequoia couttsiae O. Heer	22
	Sequoioxylon canadense (C. Schröter) nov. comb	26
	Sequoia langsdorfii (A. T. Brongniart) O. Heer	28
	Taxodioxylon gypsaceum (N. R. Göppert) R. Kräusel	30
	Taxodium dubium (K. von Sternberg) O. Heer	32
	Taxodioxylon taxodii W. Gothan	34
	Glyptostrobus europaeus (A. T. Brongniart) O. Heer	44
	Glyptostroboxylon tenerum (G. Kraus) N. Conwentz	50
	Cupressinoxylon callitroides n.sp	52
	Cupressinoxylon thujoides n.sp	57
	Cupressinoxylon bioloides (R. Prill) nov. comb	59
Sel	ected Bibliography	64

Synopsis

Remains of gymnosperms, which are copiously present in the Danish lignitic deposits, are referable to the recent families Cephalotaxaceae, Podocarpaceae, Abietaceae, Sciadopityaceae, Taxodiaeeae 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. sp.

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

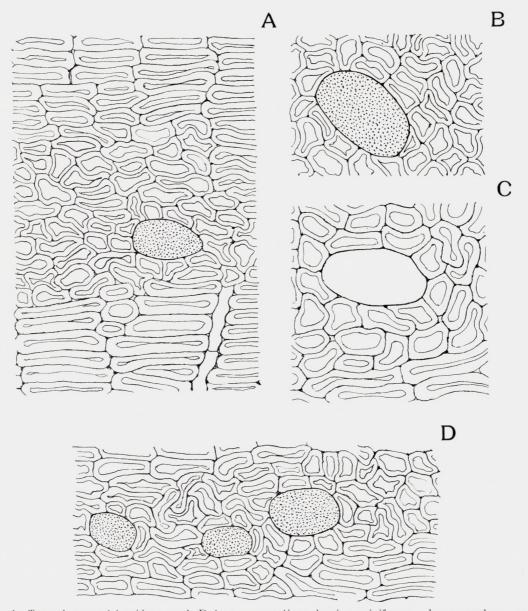


Fig. 1. $Taxoxylon\ amentotaxoides\ n.sp.\ A-D,$ transverse sections showing resiniferous xylem parenchyma and surrounding tracheids. ($\times 400$). Salten.

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

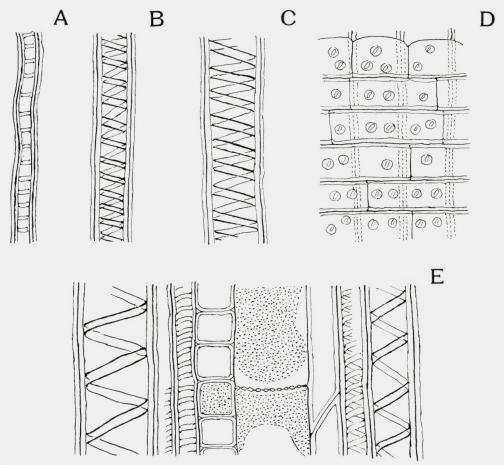


Fig. 2. Taxoxylon amentotaxoides n.sp. A-C, parts of tracheids in radial section and E, in tangential section, showing the annual or spiral thickenings of the wall. E also shows a part of a ray and the finely beaded wall separating two resiniferous xylem parenchyma elements. D, cross-field area. (×400). 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 16μ 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 6μ , 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 2μ) 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, occurring 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 bright-walled 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

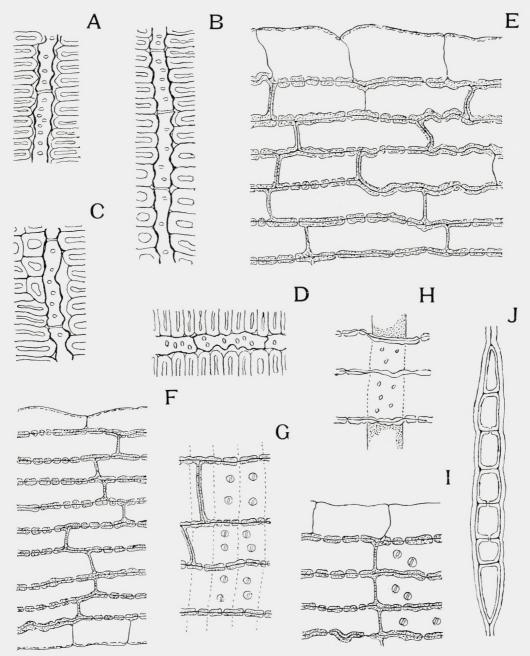


Fig. 3. Saxegothaeoxylon miocenicum n.sp. A–D, transverse sections of late wood showing ray cells running through groupes of tracheids with only slightly altered walls. E–I, parts of rays in radial section, H, showing the parts connecting the ray cells with the resiniferous xylem parenchyma. J, tangential 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 μ (4 to 8 μ). 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 μ 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 μ . The elements of the resiniferous parenchyma attain a length of 250 μ , 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 l.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. 6a to 8. G. de Saporta (1865 I) p. 74, Table III, figs. 1, A–C; Table IV, fig. 3A. 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 μ 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

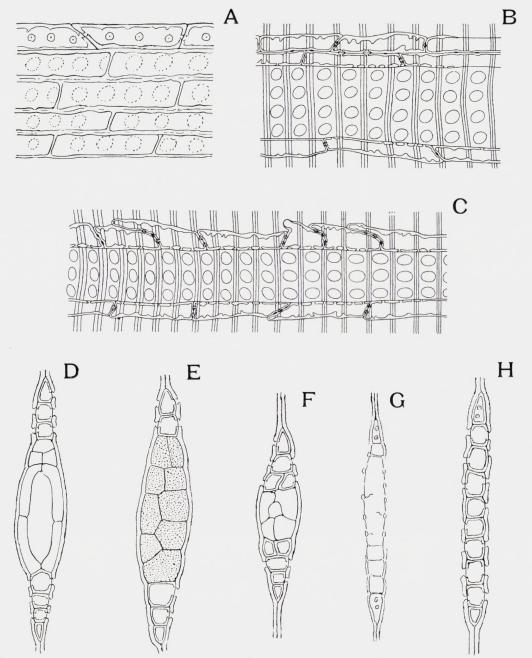


Fig. 4. Pinuxylon sp. cf. P. paxii R. Kräusel. A, B and C, radial sections. D–F, tangential sections of rays including resin ducts or coherent resiniferous parenchyma. G and H, simple rays; in the ray figured in G the tissue is partly dissolved. (B and $C\times 250$, A and $D-H\times 400$). Troldhede 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. Ødum 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 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.

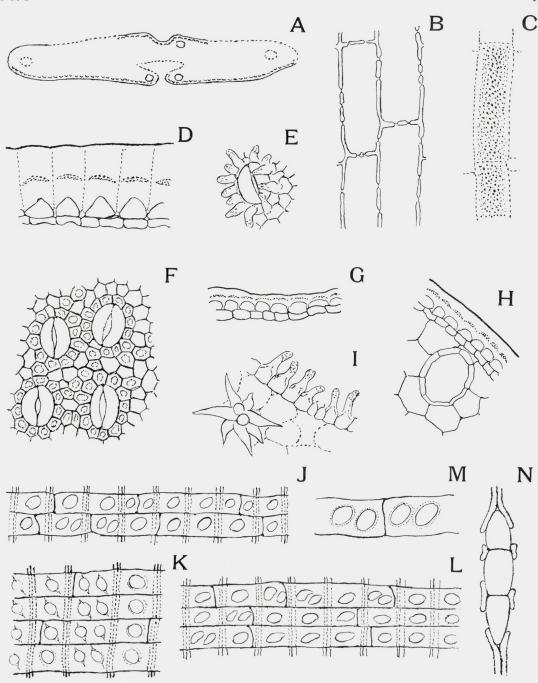
The thickness of the outer wall of the epidermis is apparent from the transverse sections (Fig. 5, D, G and H). The zone of small cavities is seen to form an arch about the middle of the wall. The side and inner walls of the cells normally appear in a state of dissolution in the preparations as well 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

Sciadopityoxylon wettsteinii K. A. Jurasky. J-M, radial sections and N, tangential section of rays (J-L \times 250, M and N \times 400). Troldhede.

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. (A \times 30, B-I \times 400). Grindsted.



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 thick-walled 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 $(10-12\ mm)$ 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.

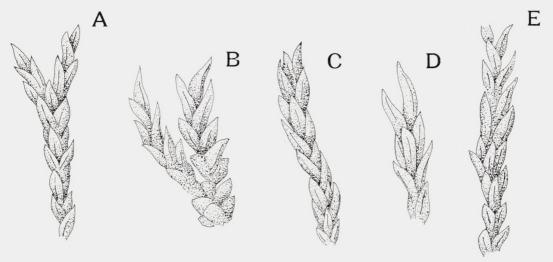


Fig. 6. Sequoia couttsiae O. Heer. Parts of foliage twigs (×2). Moselund, Mrs. E. Nordmann del.

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 $(60 \times 40 \text{ mm})$ 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 Sequoia-dendron 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. Buchholz (1939) the genus Sequoia St. Endlicher contains two types differing sufficiently to justify the division into two genera, Sequoia (sempervirens) and Sequoia-dendron (giganteum). Metasequoia seems most conveniently kept apart as a special genus. An adequate solution of this somewhat complicated question would probably

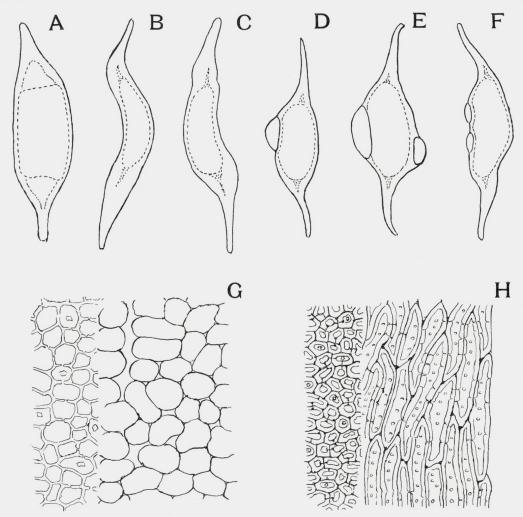


Fig. 7. A–F, transverse sections, drawn in outline, of seeds, A of Sequoia sempervirens (A. B. Lambert) St. Endlicher. B and C, Sequoiadendron giganteum (J.Lindley) J. T. Buchholz and D–F, Metasequoia glyptostroboides H. H. Hu and C. Cheng. G, exo- and mesotesta of S. giganteum and H, of S. couttsiae (Moselund). H is drawn from macerated material (A–F×20, G–H×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 retatements 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 1919b, p. 240) vereinigt werden muss") (Kräusel 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.

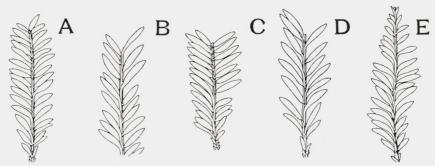


Fig. 8. Sequoia langsdorffii (A. T. Brongniart) O. Heer. Deciduous foliage twigs. Moselund.

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. 151b 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.

Transverse section. 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 crescent-shaped 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

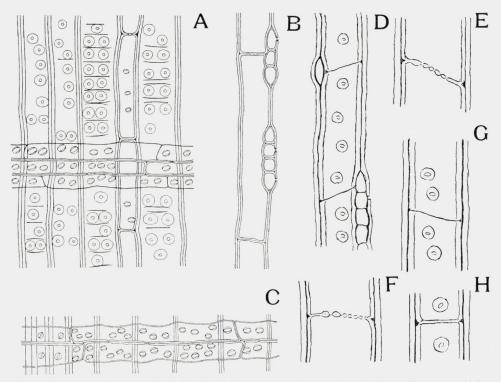


Fig. 9. Taxodioxylon gypsaceum (N. R. Göppert) R. Kräusel. A and C, radial and B, tangential section D, G and H, parts of strand tracheids. E and F, horizontal walls of resiniferous xylem parenchyma (A, B and $C \times 250$, D-H $\times 400$). Troldhede State Quarry.

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 (I. 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 Biol. Skr. Dan. Vid. Selsk. 17, no. 3.

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 40μ .

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

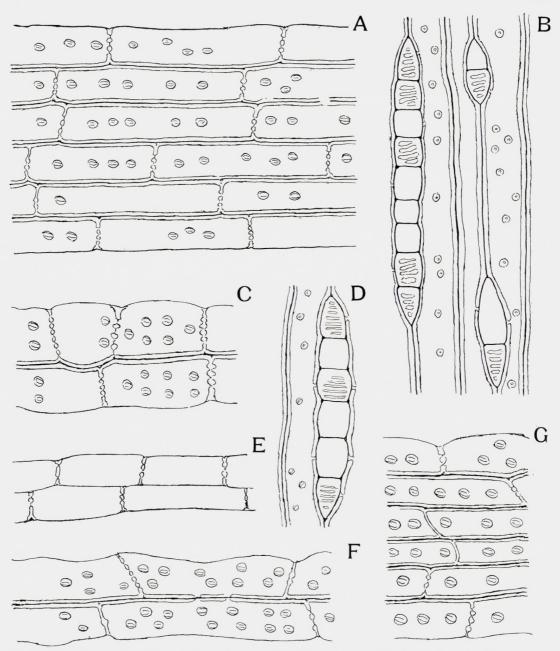


Fig. 10. $Taxodioxylon\ taxodii\ W.$ Gothan. A, C, E, F and G, selected parts of rays in which the pitting of the tangential walls is prominent. B and D, tangential view of rays of the same type. $(\times 400)$. Troldhede.

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 bead-like 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 ± 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-

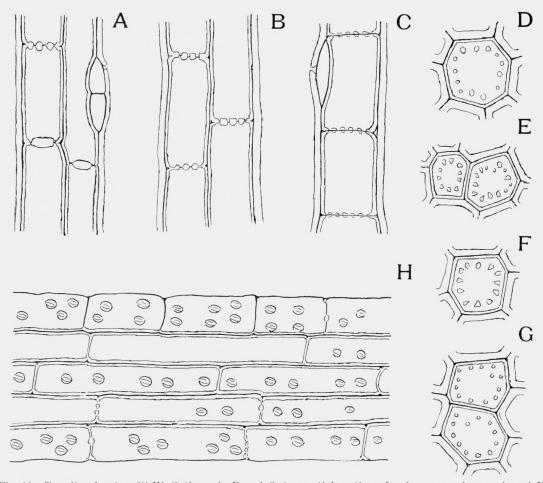


Fig. 11. Taxodioxylon taxodii W. Gothan. A, B and C, tangential section of xylem parenchyma; A and B show thick and highly pitted horizontal walls, C represents a type of thinner horizontal walls with a more bead-like pitting. D–G, horizontal walls of xylem parenchyma as they appear in transverse section. H, part of a ray with feebly developed pitting of the tangential walls. (×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 Cupressaeeae, 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-

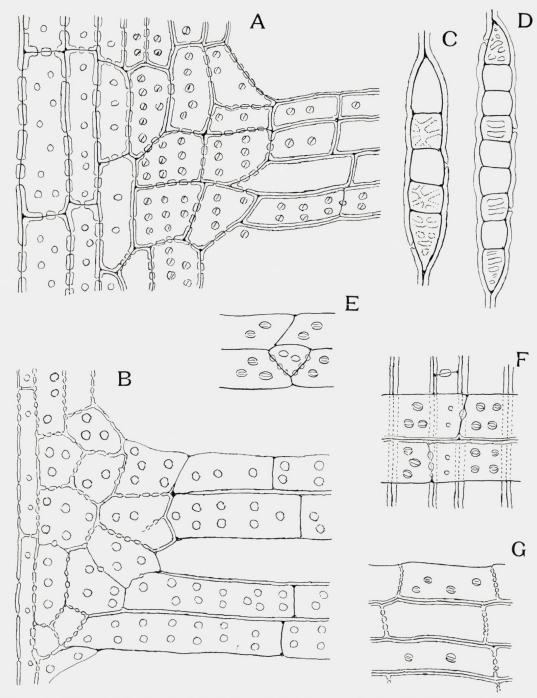


Fig. 12. $Taxodium\ distichum\ (L.)\ L.-G.$ Marie Richard. In A is shown the transition of the medullary parenchyma iuto the first fosmed tissure of the rays. B shows similar features in $Glyptostrobus\ pensilis\ A.$ B. Lambert. (A and B \times 400).

Taxodioxylon taxodii W. Gothan. C and D, tangential sections of rays and E-G radial sections; the tangential walls of the ray cells are strongly pitted in the parts selected for drawing. (C to $G \times 400$). 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 Schönfeld 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 μ . 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-

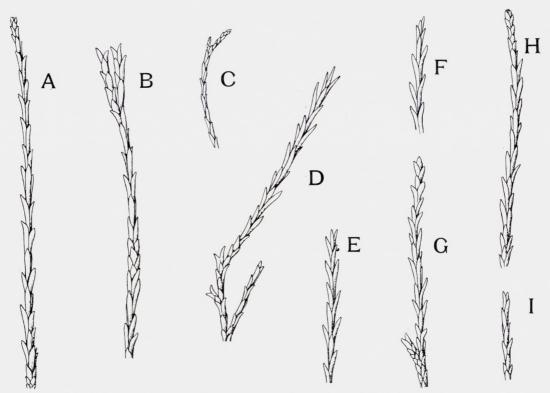


Fig. 13. Glyptostrobus europaeus (A. T. Brongniart) O. Heer. A-I, foliage twigs (×2). Moselund.

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

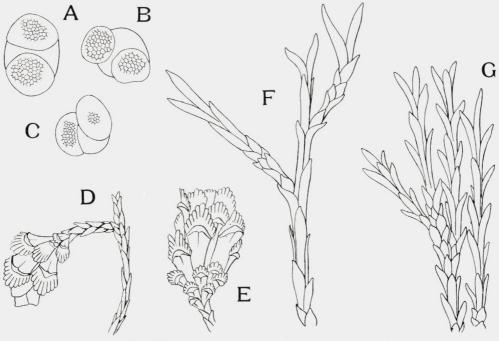


Fig. 14. A–C, pollen grains of the Pityosporites type (\times 250). Moselund. Glyptostrobus europaeus (A. T. Brongniart) O. Heer. D and E, cones drawn from casts, F and G, foliage twigs. (D–G \times 3). Moselund.

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).

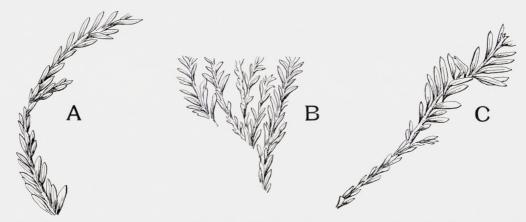


Fig. 15. Glyptostrobus europaeus (A. T. Brongniart) O. Heer. Foliage twigs showing dimorphous leaves ($\times 2$). Moselund. Mrs. E. Nordmann: del.

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

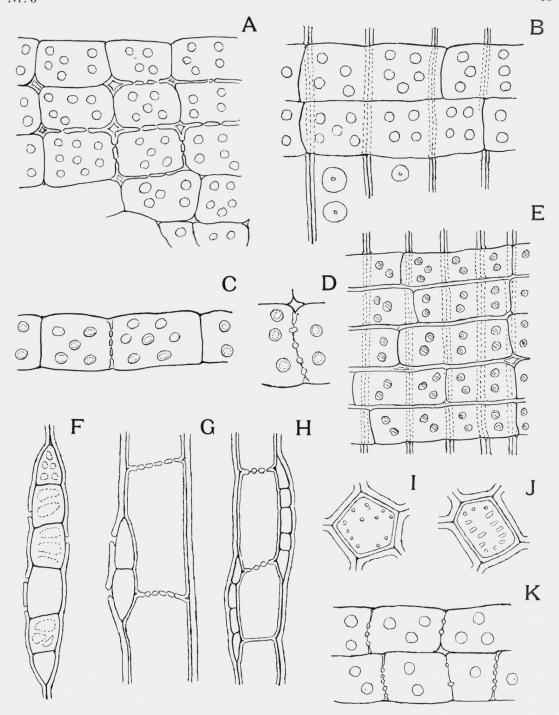


Fig. 16. Glyptostroboxylon tenerum. N. Conwentz (G. Kraus). A–E and K, radial sections of rays (E, cross-fields from the late wood type). F. tangential section of ray. G and H, xylem parenchyma in tangential section. I and J, transverse sections of xylem parenchyma, showing the pitting of the horizontal 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 transverse section 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 μ 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 μ) 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 μ 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 μ . 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 2μ 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 μ 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 μ) 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 uniscriate, 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 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 b, 43 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 development 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 unfortunately 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.

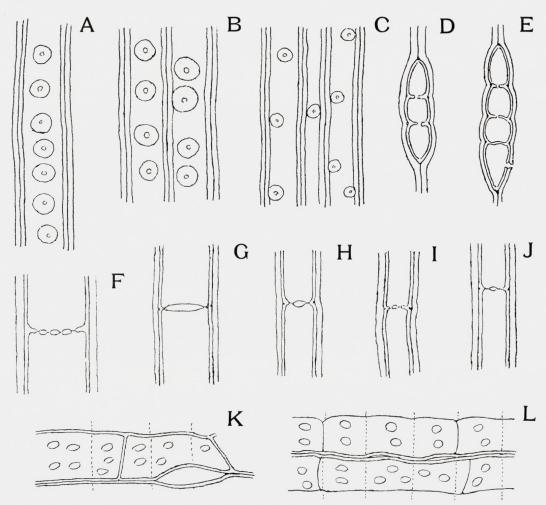


Fig. 17. Cupressinoxylon thujoides n.sp. A and B, parts of tracheids in radial, and C, in tangential section. D and E, rays in tangential view. F-J, transverse wall of xylem parenchyma showing variations in the mode of pitting. K and L cross-field pitting in the early wood. (×600). Troldhede State Quarry.

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 μ , 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 μ 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.

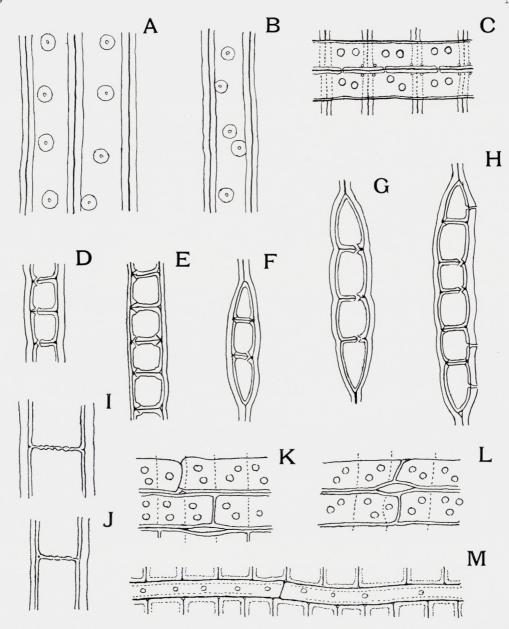


Fig. 18. Cupressinoxylon biotoides nov. comb. A and B, parts of tracheids in radial and tangential section. D-H, view of rays in tangential section; in all the figures the ruptures in the horizontal walls fo the ray cells are conspicuous. C, K and L, cross-field pitting; K and L also show indentures. 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 μ in diameter, aperture small. The tangential wall of the late wood tracheids with scattered bordered pits, measuring 5 to 9 μ 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 $5\times3\times2$ 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 μ with an extremely minute aperture measuring only 1.5 to 2 μ . 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 μ . 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

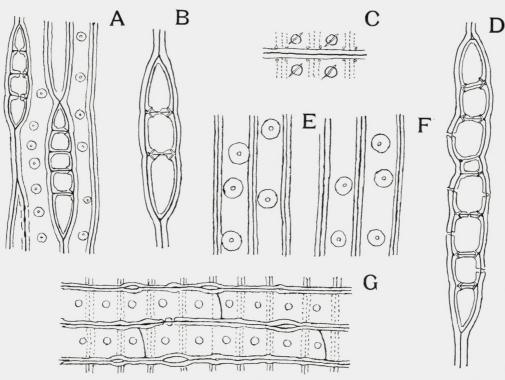


Fig. 19. Biota orientalis (L.) St. Endlicher. A, B and D, rays in tangential section. C and G, radial section of rays showing the cross-field pitting and in G indentures. E, radial and F, tangential sections of tracheides. (\times 600). Materiel from the Botanical Garden of the University, Copenhagen.

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 μ 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 (l.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 Thuia 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 5μ). 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.

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CORRIGENDA

PLATE II. radial sections. Read: longitudinal sections.

PLATE V. Pinus palaeostrobusoo. Heer. Read: Pinus palaeostrobus. O. Heer.

PLATE IX. (A and B \times 40, C and D \times 175). Read: (A and D \times 40, B \times 60 and C \times 175).

PLATE XI. langential. Read: tangential.

PLATE XII. langential. Read: tangential.

PLATE XIX. thisk. Read: thick.

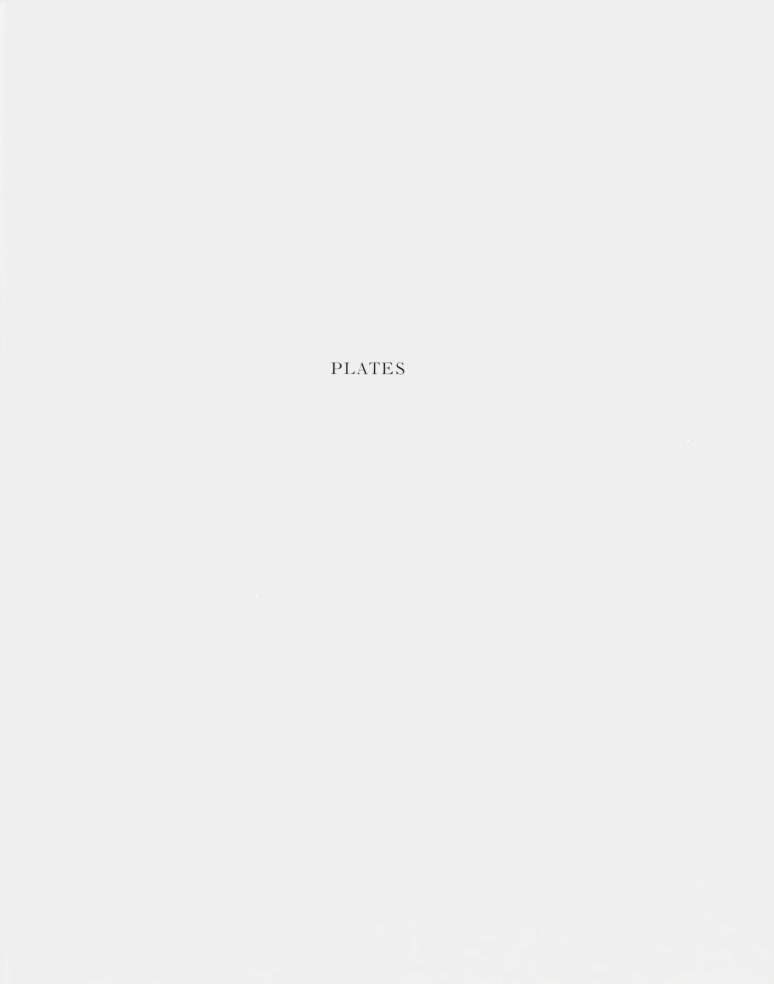
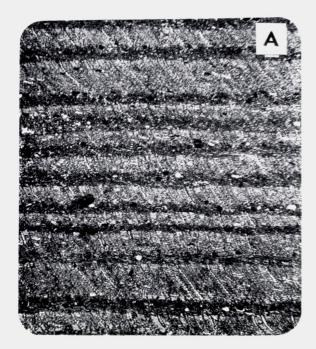
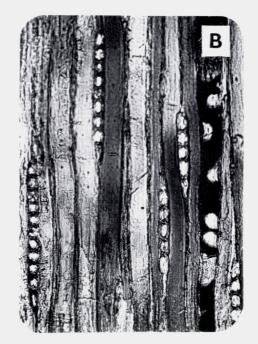


PLATE I

Taxoxylon amentotaxoides n.sp. A and C, transverse sections. B, tangential section. (A $\times 40$, B and C $\times 175$). Salten.





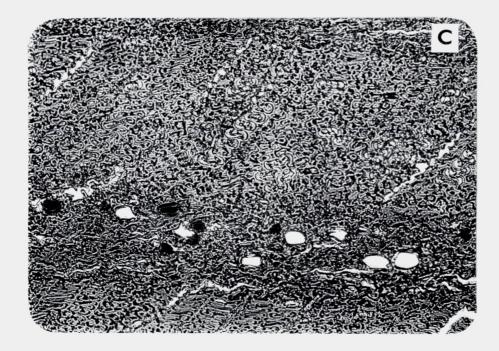
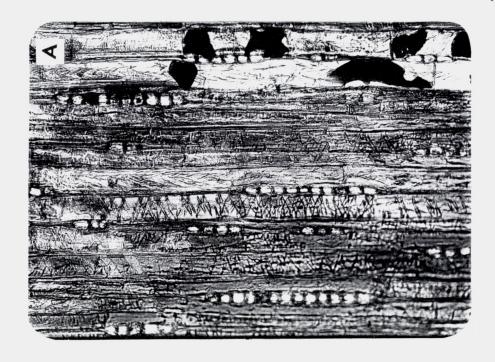
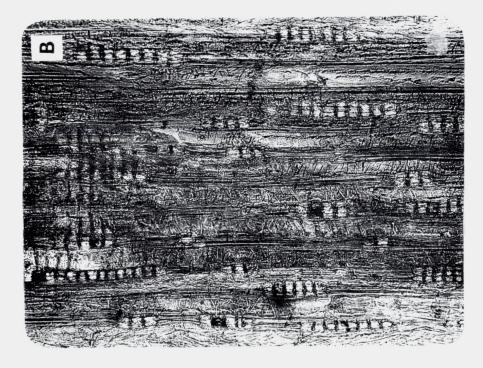


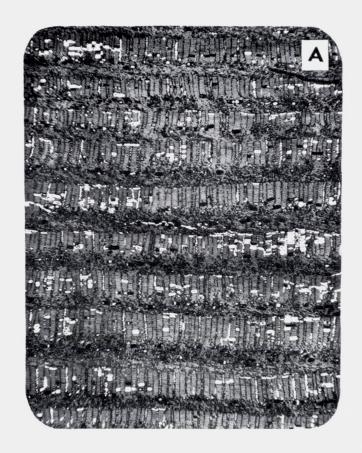
PLATE II

Taxoxylon amentotaxoides n.sp. A and B, radial sections showing the spiral thickenings of the tracheidal wall. ($\times 175$). Salten.









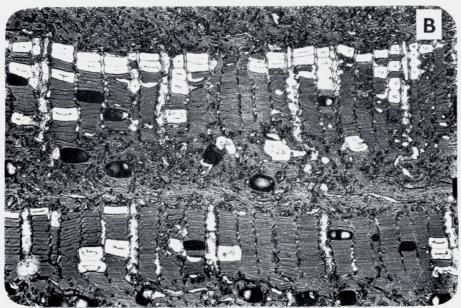
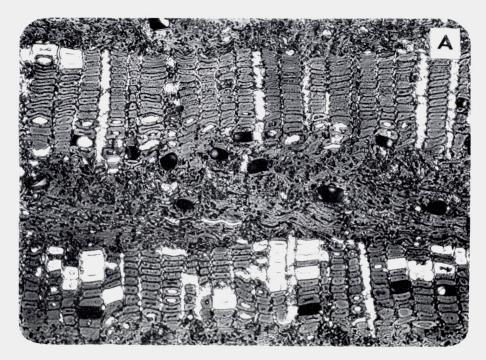


PLATE IV

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.



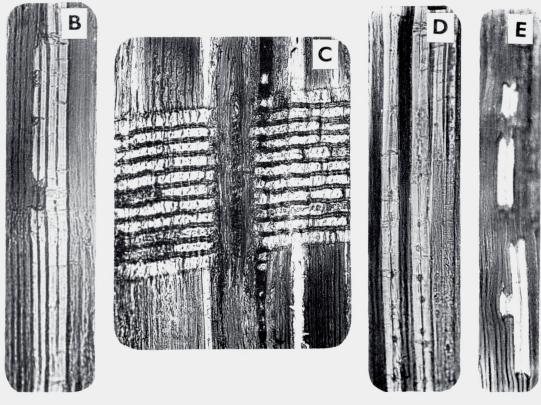
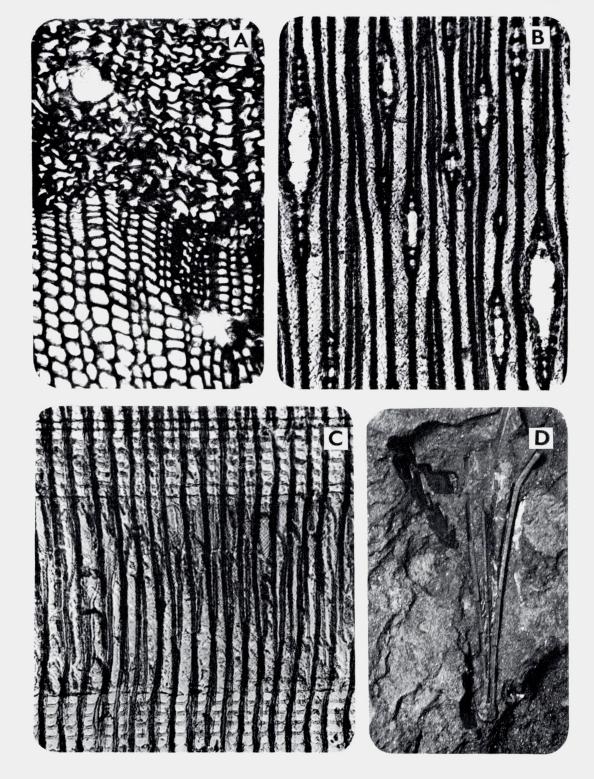
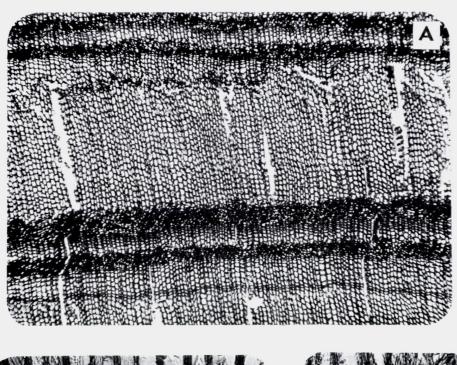
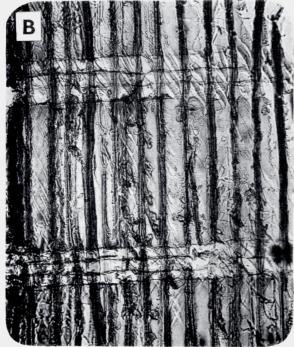


PLATE V



$\label{eq:platevi} P_{LATE} \ VI$ Sciadopityoxylon wettsteinii. K. A. Jurasky. A, transverse section. B, radial and C, tangential sections. (A $\times 40,\ B$ and C $\times 175$). Lystrupsminde.





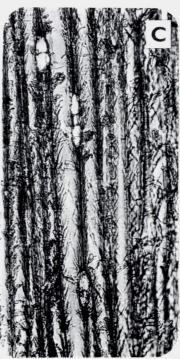


PLATE VII

Sequoia couttsiae. O. Heer. A, bunch of foliage twigs, two terminated by cones. B–D, cones, C, highly compressed. E–G, seeds $(A-G\times 3)$. Moselund. Glyptostrobus europaeus. H and I, seeds $(\times 3)$. Moselund.

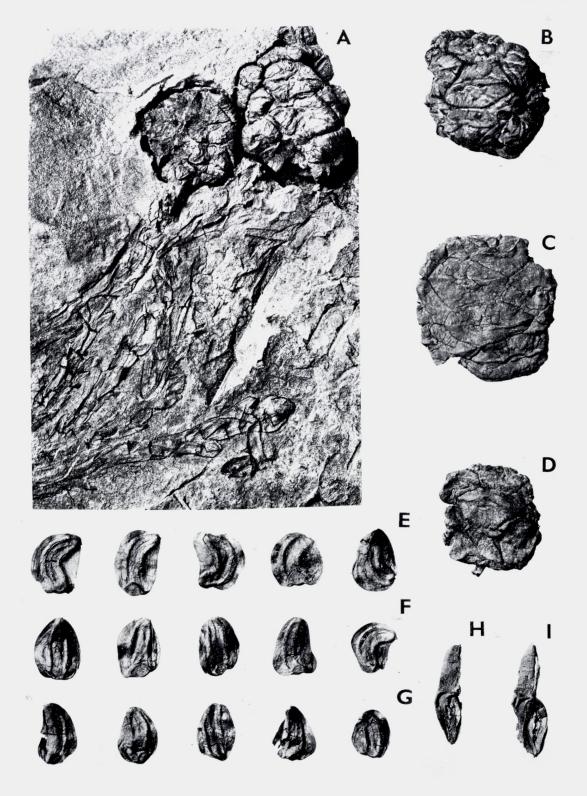


Plate VIII Sequoioxylon canadense (C. Schröter) nov. comb. A, transverse section. B, tangential section. C and D, radial sections. (×175). Torvig State Quarry.

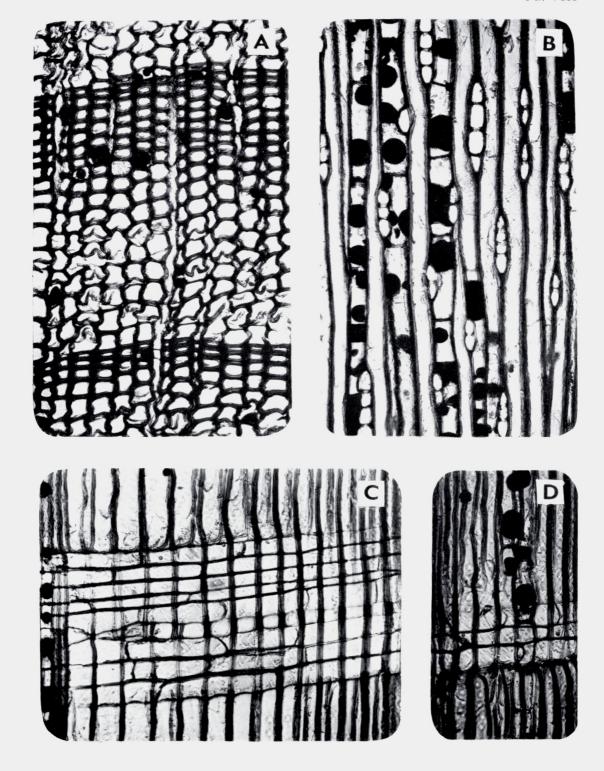
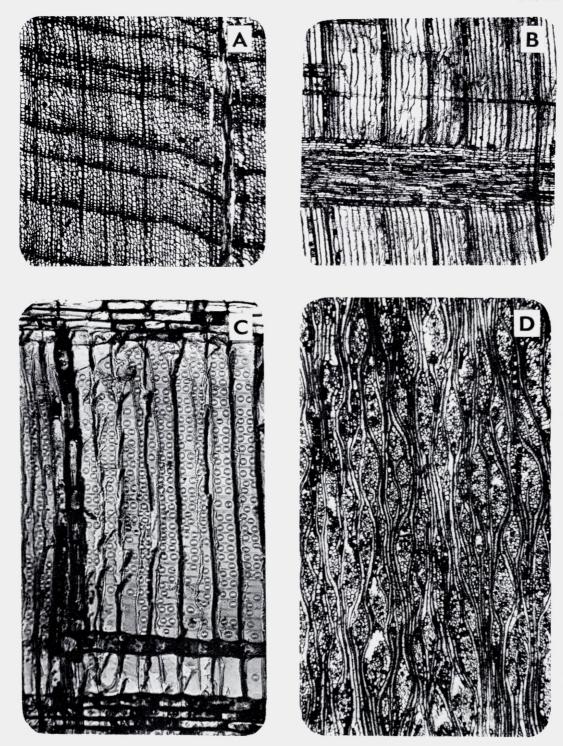


Plate IX. Sequoioxylon canadense (C. Schröter) nov. comb. Anomalously developed wood. A, transverse section. B and C, radial sections. D, tangential section. (A and B×40, C and D×175). Torvig State Quarry.





 $\label{eq:constraint} \emph{Sequoia langsdorffii.} \mbox{ (A. T. Brongniart) O. Heer. A-F, deciduous foliage twigs. G-K cones in transverse and longitudinal planes. (\times2). Moselund.}$

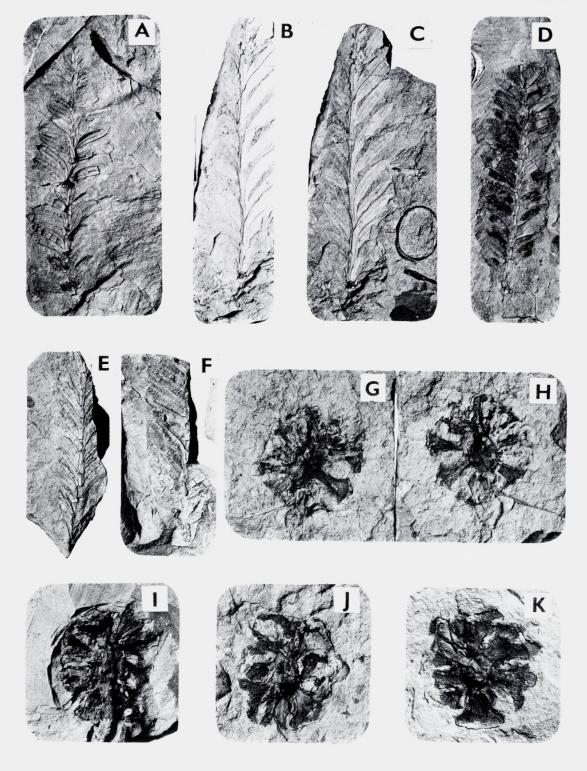


PLATE XI

 $\label{eq:continuous} \textit{Taxodioxylon gypsaceum} \ (\text{N. R. G\"{o}ppert}) \ \text{R. K\"{r}\"{a}usel. A, transverse and B, langential sections. C and D, radial sections. } (\times 175). \ \text{Troldhede State Quarry.}$

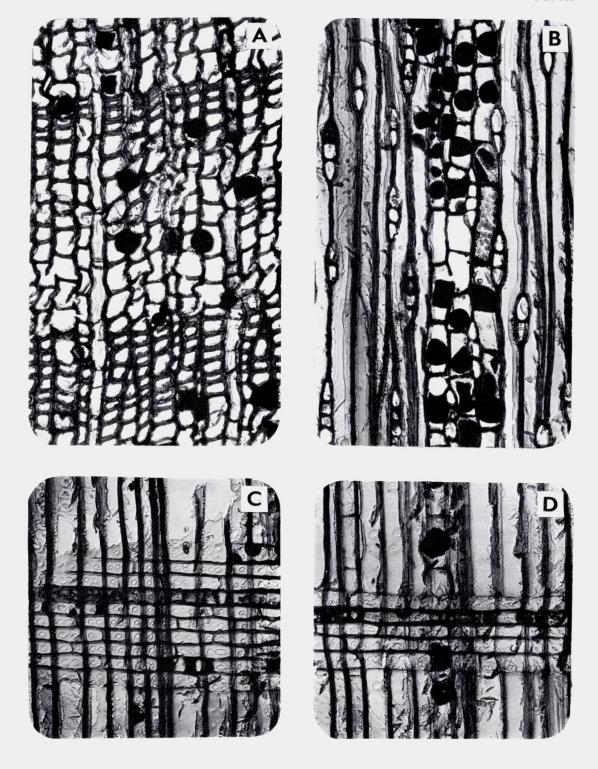
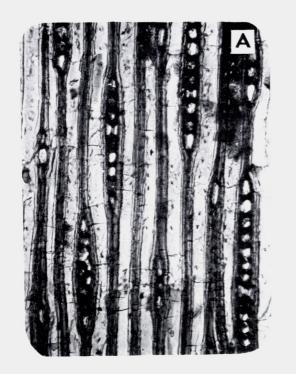


PLATE XII

 $\label{eq:continuous} \textit{Taxodioxylon gypsaceum} \ (\text{N. R. G\"{o}ppert}) \ \text{R. Kr\"{a}usel. A, langential section. B and C, radial sections.} \ (\text{B} \times 80, \text{A and C,} \times 175). \ \text{Troldhede State Quarry.}$





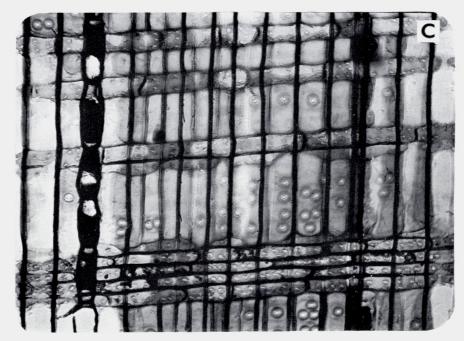
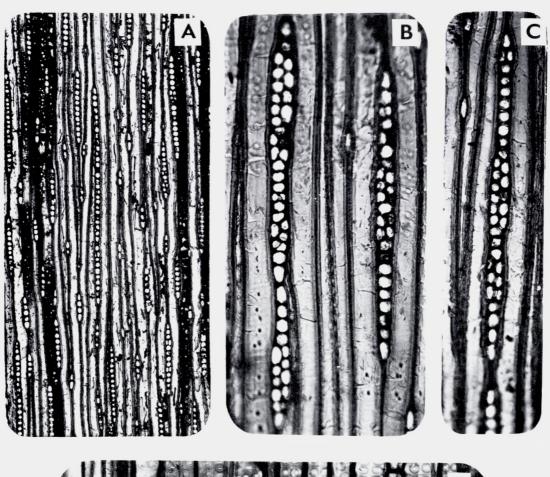


PLATE XIII

 $\label{eq:continuous} \begin{array}{lll} \textit{Taxodioxylon gypsaceum} \ \mbox{(N. R. G\"{o}ppert)}. \ \mbox{R. Kr\"{a}usel. A-C, tangential sections. D, radial section. (A <math display="inline">\times 40, \\ \mbox{B-D} \times 175). \ \mbox{Troldhede State Quarry.} \end{array}$



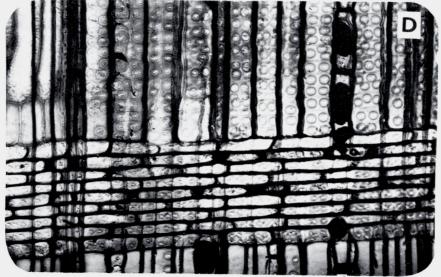


PLATE XIV $Taxodium\ dubium.\ (K.\ v.\ Sternberg\ 1838).\ O.\ Heer\ 1855.\ Deciduous\ foliage\ twigs.\ (\times 2).\ Moselund.$

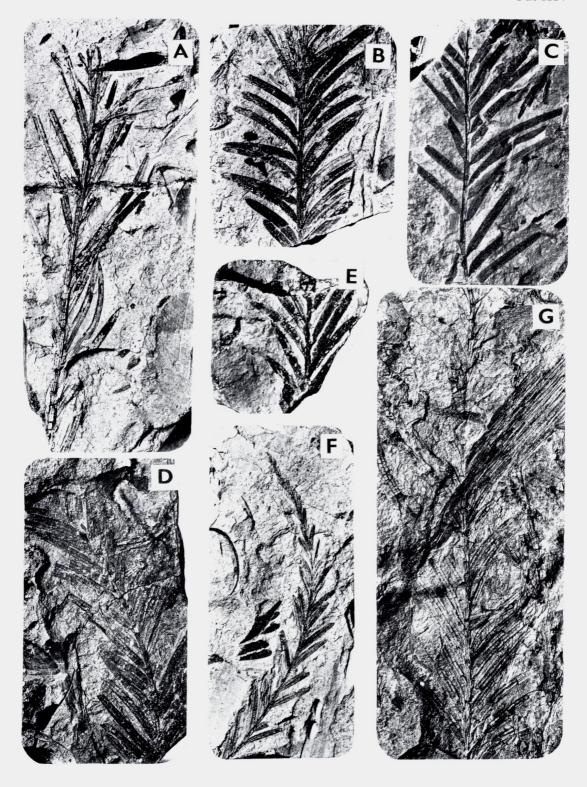


PLATE XV

 $\label{eq:constraint} \begin{tabular}{ll} \it Taxodium~dubium~(K.~v.~Sternberg).~O.~Heer.~A, cone~scales.~B-J, seeds.~(A \times 2,~B-J \times 4).~Silkeborg~Vesterskov.\\ K,~\it Glyptostrobus~europaeus~O.~Heer.~Foliage~twigs~carrying~cones~(\times 2).~Fasterholt. \end{tabular}$

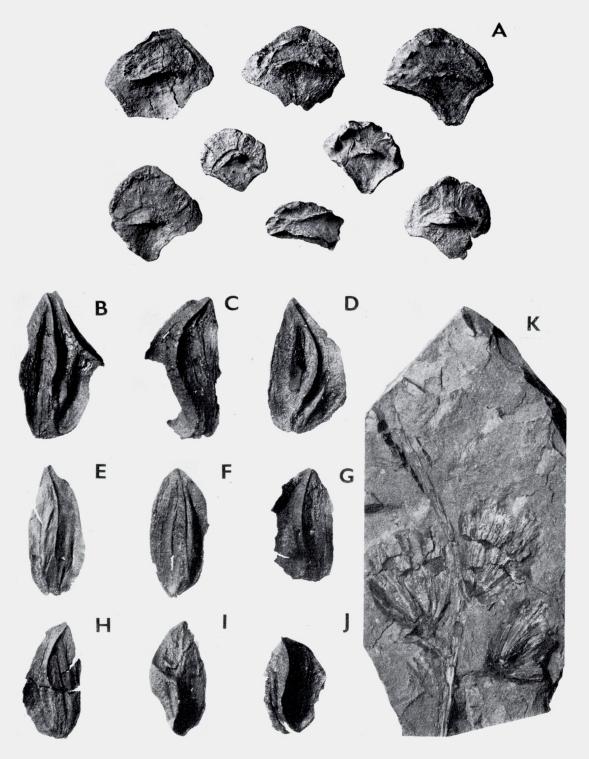
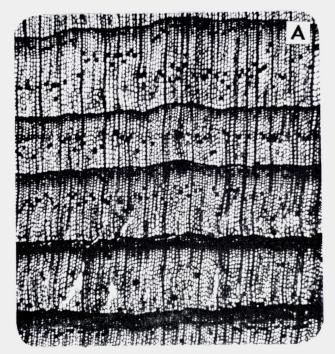
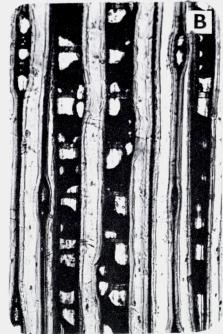
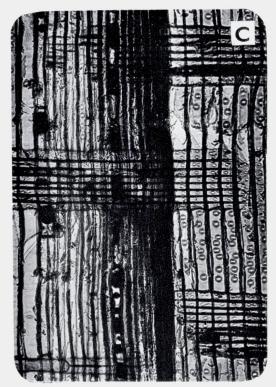


PLATE XVI

 $\label{eq:continuous} \textit{Taxodioxylon taxodii} \ \text{W. Gothan. Wood of the stem type. A, transverse section. B and D, tangential sections.} \\ \text{C, radial section. (A and D} \ \times 40, \ \text{B and C} \ \times 175). \ \text{Troldhede State Quarry.}$







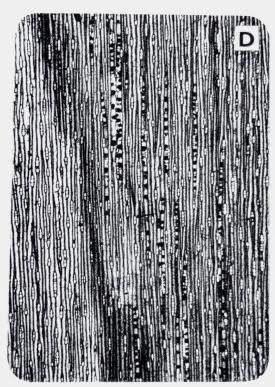


PLATE XVII

 $\label{eq:continuous} \begin{array}{lll} \textit{Taxodioxylon taxodii} \ \text{W. Gothan. Wood of the root type. A, transverse section. B, tangential section. (A and B \times 40). C, radial and D, tangential sections (\times 175). In C the slide is focused so as to show the schulpturing on the tangential ray cell walls. Troldhede State Quarry. \\ \end{array}$

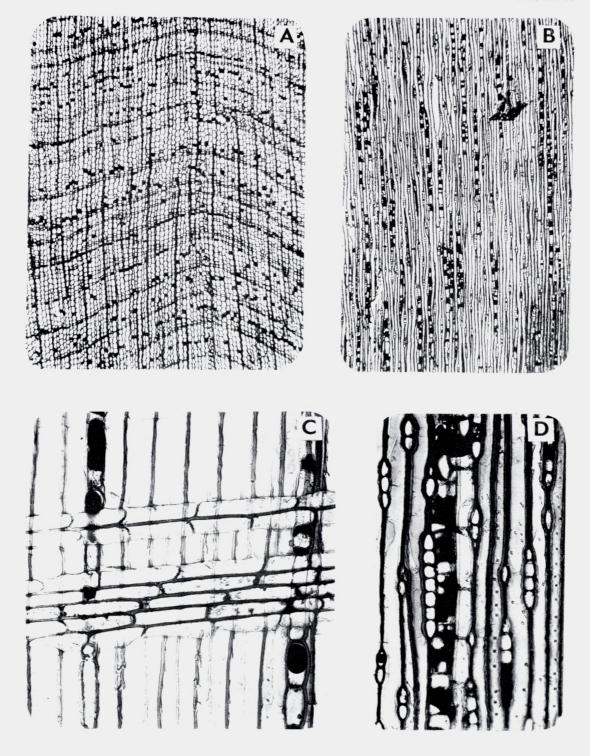


PLATE XVIII

 $\label{eq:compressed} \textit{Taxodioxylon taxodii} \ \text{W. Gothan. Wood of the compressed type. A, transverse section. B, tangential and C, radial sections (A <math display="inline">\times 40, \ \text{B} \ \text{and} \ \text{C} \times 175). \ \text{Troldhede State Quarry.}$

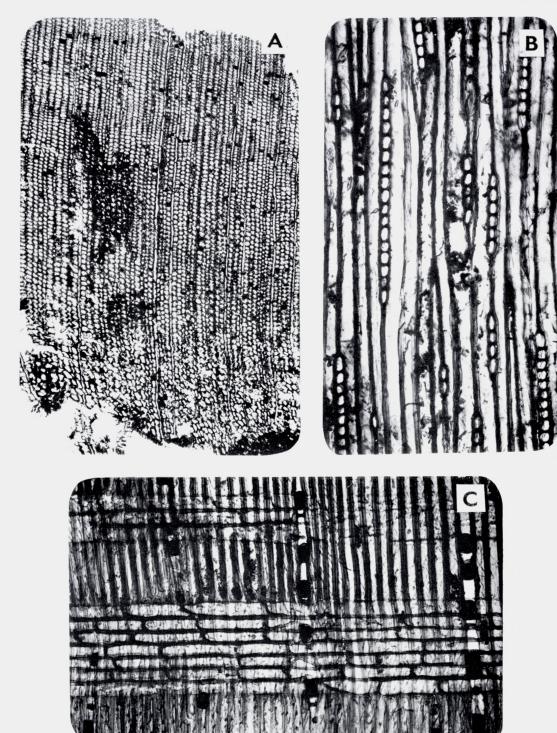


PLATE XIX

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.

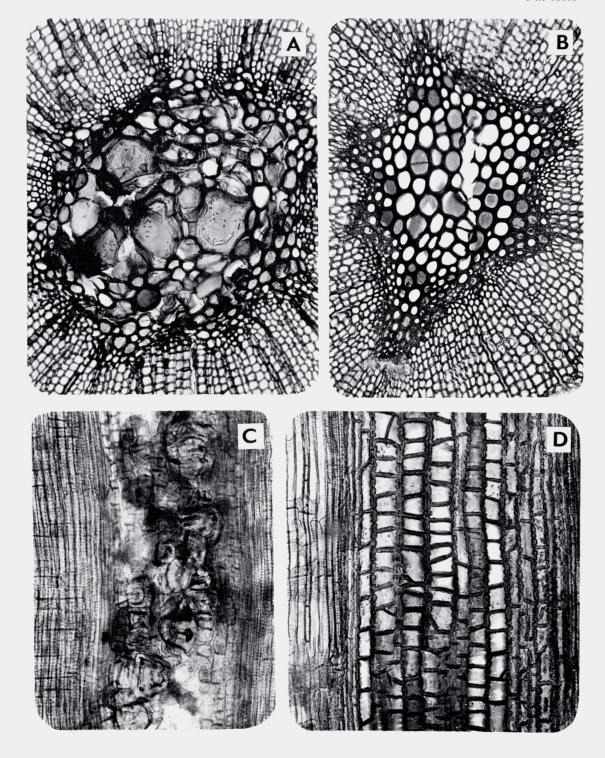
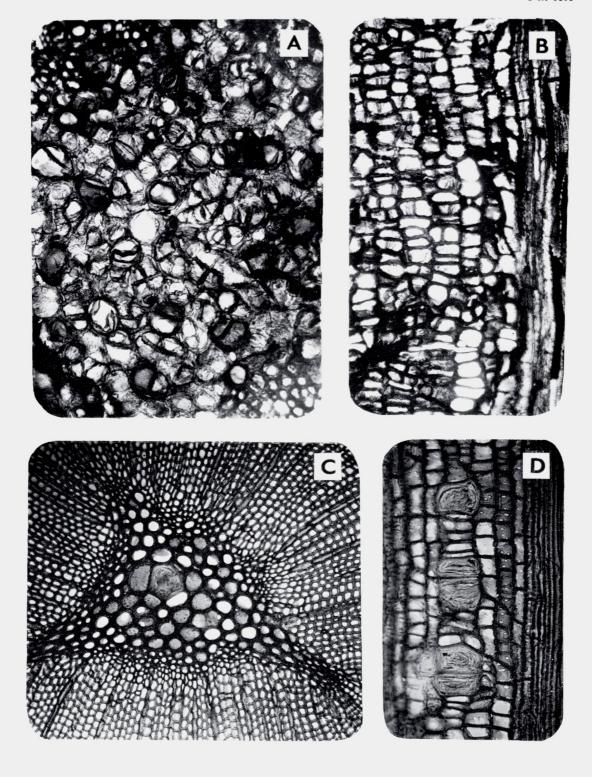


PLATE XX

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).



$\label{eq:plate_XXI} Plate ~XXI \\ \textit{Glyptostroboxylon tenerum} ~(G.~Kraus) ~N.~Conwentz. ~A, transverse section. ~(\times~40). ~B~~and ~C, radial sections. ~(\times175). ~Troldhede.$

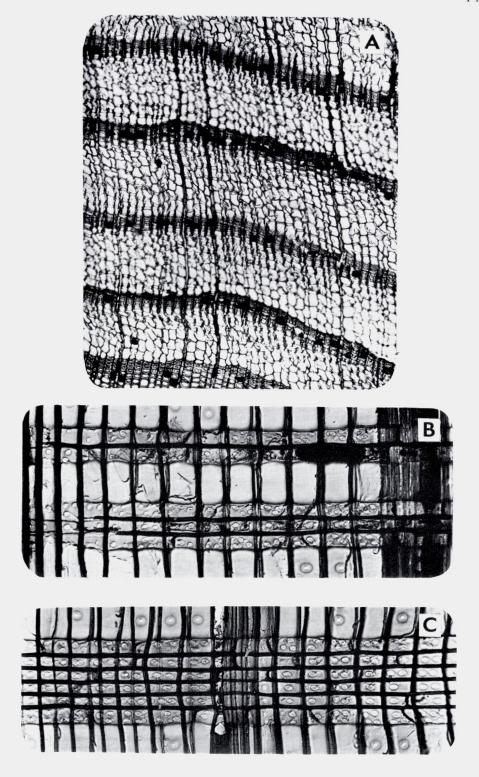
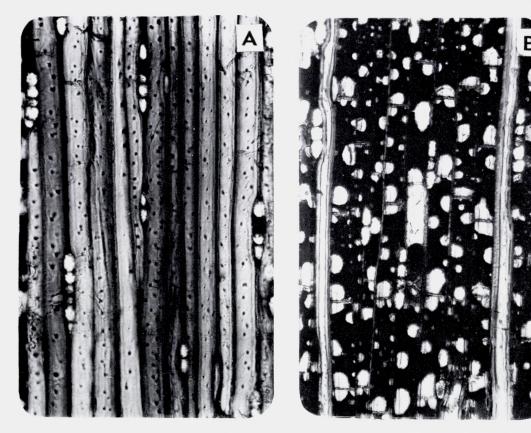


PLATE XXII Glyptostroboxylon tenerum (G. Kraus) N. Conwentz. A and B, tangential sections of late wood (×175). Troldhede. C, transverse section (×40) (from a quarry at Fiskbæk).



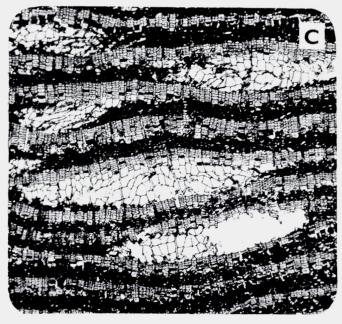


PLATE XXIII

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 C \times 175). Troldhede.

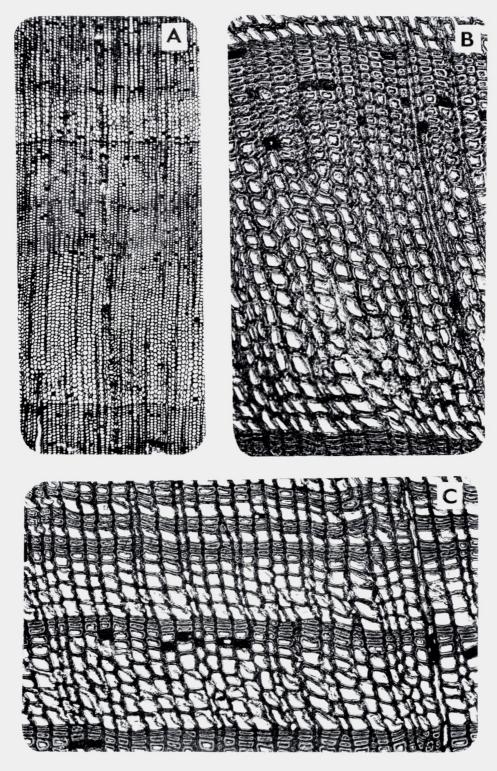
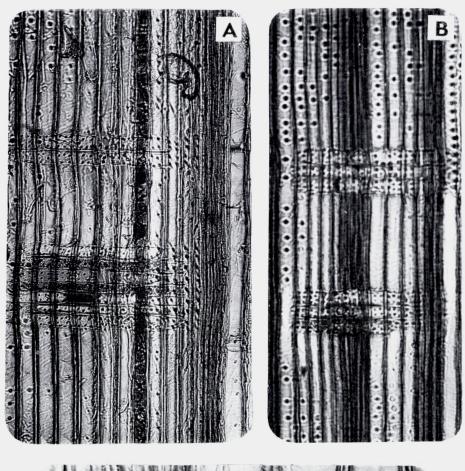
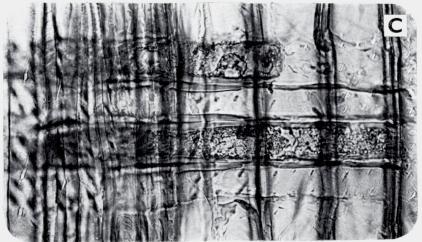


PLATE XXIV

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 B \times 175, C \times 600). Troldhede.





$P_{\rm LATE~XXV}$ Cupressinoxylon callitroides n.sp. Tangential sections of wood of the stem type A, and of the root type B. (×175). In A the spiral structure of the tracheidal wall is distinct, e.g. to the right in the photo. Troldhede.

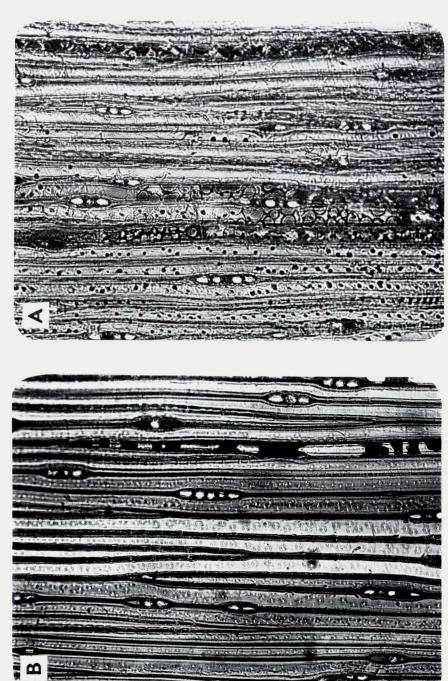
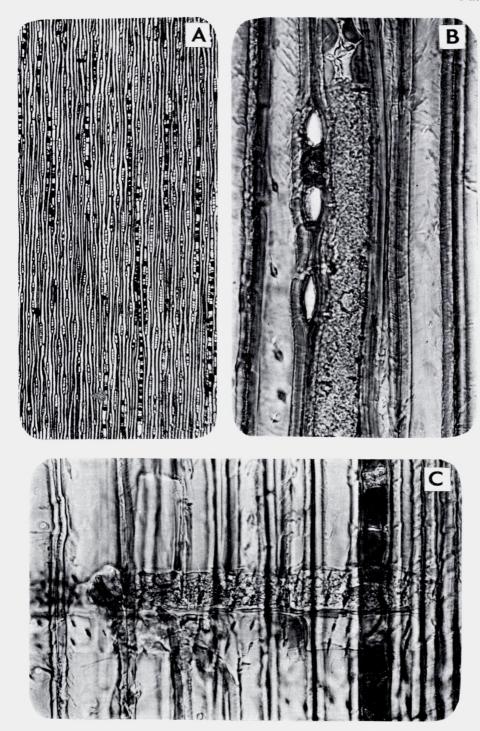


PLATE XXVI Cupressinoxylon callitroides n.sp. A, tangential section. B, tangential section showing the papillose inner surface of a tracheid. C, radial section, the ray cells are partly papillose (A $\times 40$, B and C $\times 600$). Troldhede.



$P_{LATE} \ XXVII$ Cupressinoxylon thujoides n.sp. A, transverse section. B, tangential and C, radial section. (A × 60, B and C × 175). Troldhede State Quarry.

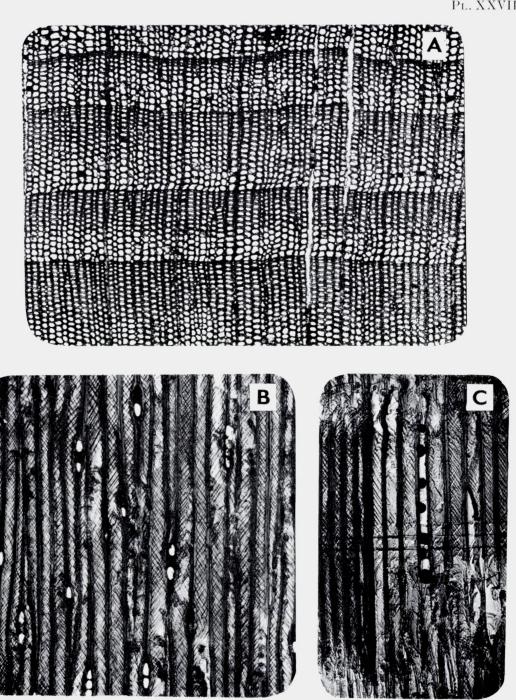
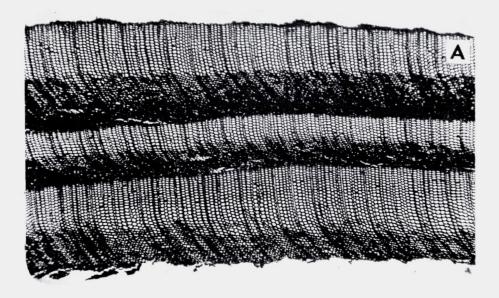
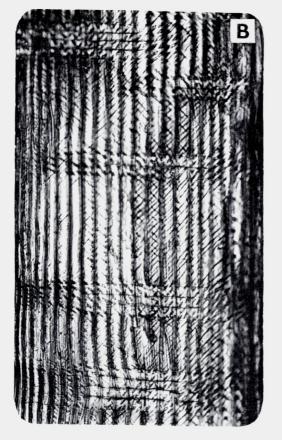
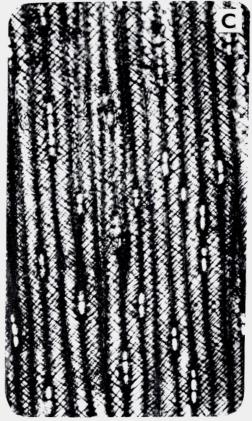


PLATE XXVIII

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. (A \times 60. B and C \times 175). Lystrupsminde.







Det Kongelige Danske Videnskabernes Selskab Biologiske Skrifter

Biol. Skr. Dan. Vid. Selsk.

	Bind 11 (kr. 162)	kr. ø
1.	FOGED, NIELS: Diatoms from Afghanistan. 1959	30
	EINARSON, LÁRUS, and TELFORD, IRA R.: Effect of Vitamin-E Deficiency on the Central Nervous System in Various Laboratory Animals. 1960	
	LARSEN, KAI: Cytological and Experimental Studies on the Flowering Plants of the Canary Islands. 1960	24
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