Late Weichselian Record of Saiga (*Saiga tatarica* (L.)) from Denmark and its Indications of Glacial History and Environment

by Kim Aaris-Sørensen, Kaj Strand Petersen** and Mogens Bo Henriksen****

Abstract: The only fossil of saiga antelope (*Saiga tatarica* (L.)) from Scandinavia and in addition the northernmost record of the species in western Europe has been AMS-dated to c. 14,000 ^{14}C years BP. The specimen, a left horn core with attached portions of frontal, parietal and temporal bones, was found in 1924 embedded in till near Boltinggaards Skov on the Danish island of Funen (Fyn). As the skull fractures appear abrasive and the furrows of the horn core are marked and distinct the fragment is not supposed to have been transported very far. Recent geological investigations in the region compared with a sediment sample taken from the saiga specimen indicate that the fossil was taken up by the Young Baltic Ice somewhere southeast of the locality. As the AMS-dating antedates this gletscher advance it must be assumed that the Young Baltic Ice advanced and retreated over Denmark framed within the saiga AMS-dating of c. 14,000 BP and the development of the first stage of the Baltic Ice Lake around 13,000 BP. Saigas are highly adapted to dry steppe-grassland and their expansion into southern Scandinavia around 14,000 BP is therefore remarkable. It implies that the retreat of the Main Ice prior to the Young Baltic readvance must have been as extensive in time and space as to allow the reestablishment of a steppe biom. The Danish saiga record fits into a well known Late Weichselian saiga invasion into western Europe. However, the date of 14,000 BP query the two apparently separated occurrences, one around 15,000–14,500 BP and a younger one around 12,500 BP, previously mentioned in the literature.
Keywords: Saiga; Late Weichselian; palaeoenvironment; glacial history; South Scandinavia.

Introduction

In 1924 the left part of a skull and horn core of a saiga antelope (*Saiga tatarica* (L.)) was found in connection with a well digging at Boltinggaards Skov near Ringe on the island of Funen (Fyn) (Fig.1). This is still the only record of saiga in Scandinavia and it still represents the northernmost distribution of the species in western Europe. The specimen was handed over to the local museum in Ringe and five years later identified by Magnus Degerbøl during his visit there (Degerbøl 1932).

As the skull fragment was discovered in the depth of 13 m in what was characterized as „moraine clay" it was supposed to be on a secondary position redeposited by glacial movements. According to the view held of that time on the glacial history of southern Scandinavia Degerbøl (1932) argued that the saiga

* Kim Aaris-Sørensen, Zoological Museum, University of Copenhagen, Universitetsparken 15, DK-2100 Copenhagen Ø.

** Kaj Strand Petersen, Geological Survey of Denmark and Greenland, Thoravej 8, DK-2400 Copenhagen NV.

*** Mogens Bo Henriksen, Odense Bys Museer, Overgade 48–50, DK-5000 Odense C.

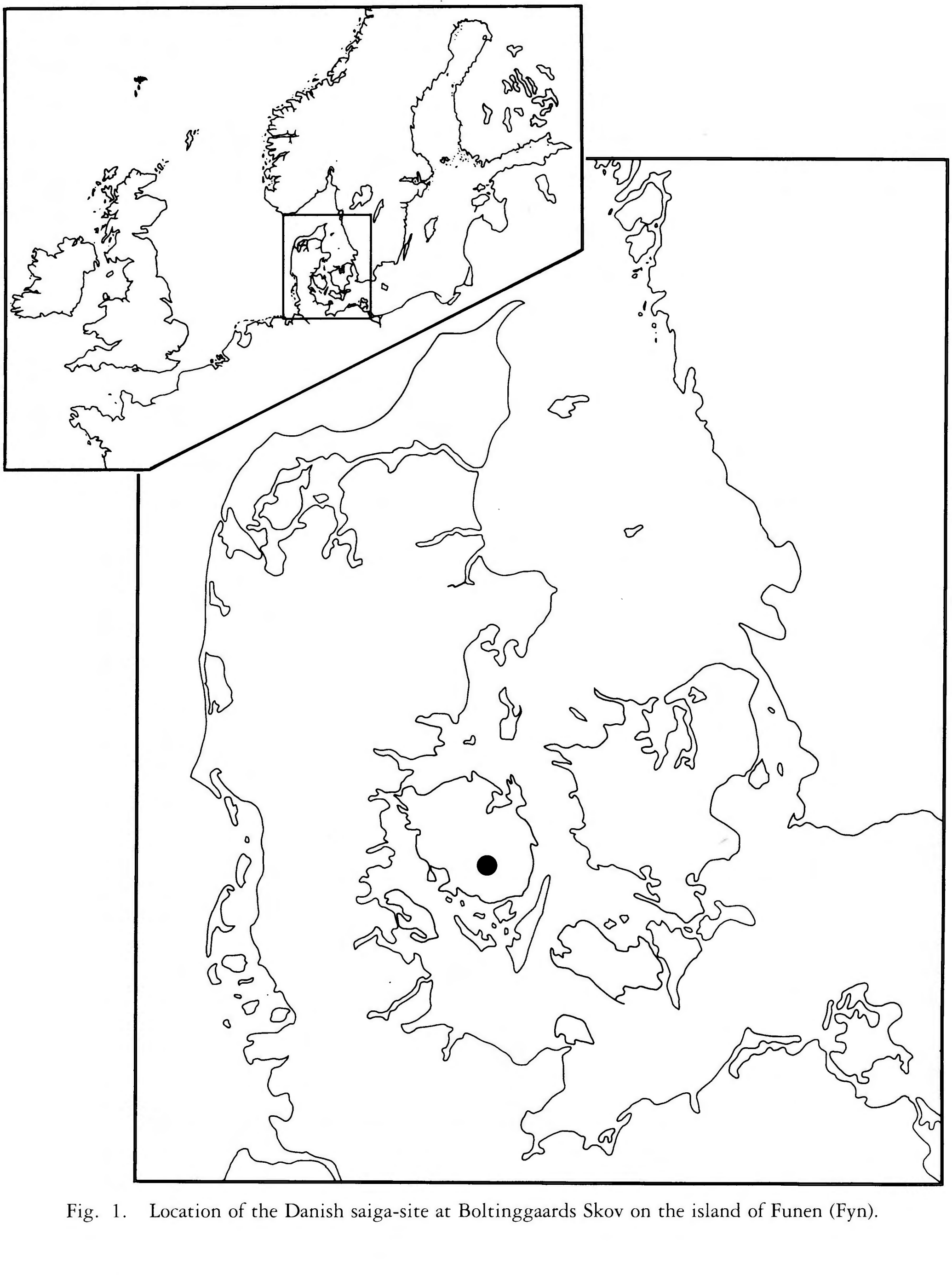

Fig. 1. Location of the Danish saiga-site at Boltinggaards Skov on the island of Funen (Fyn).

should date to the Eemian. Present day recognition of long ice free periods in southern Scandinavia during the Weichselian led Aaris-Sørensen *et al.* (1990) to propose a Middle Weichselian origin of the saiga specimen from Funen. This was in agreement with the already demonstrated large mammal fauna of this period proved by several ^{14}C-dates of other herbivores as *Mammuthus primigenius, Megaloceros giganteus, Rangifer tarandus* and *Bison priscus.*

However, the Late Pleistocene distribution of saiga in Eurasia and North America and especially the repeated immigration waves reported into western Europe during Late Weichselian (Kahlke 1992) made a more precise and reliable dating of the Danish specimen desirable. Neither the old assumption of an Eemian age nor the more recent proposal of a Middle Weichselian age seemed to fit into the overall picture of the history of the European saiga. So it was decided to try to have the specimen dated by an AMS ^{14}C-analysis. In addition it seemed obvious that a radiometric dating might turn out to be an important contribution to the discussion of the history of the last glaciation in South Scandinavia.

Dating

A sample of 1,6 g of bone was taken from the interior of the skull and submitted for ^{14}C-dating. The pretreatment was done at the ^{14}C Laboratory of the Geological Survey of Denmark and Greenland and the National Museum, Copenhagen. The obtained collagen fraction was used for two datings both performed at the AMS ^{14}C Dating Laboratory, Institute of Physics and Astronomy, University of Aarhus. The two dates are very similar with a weighted average of 13,930 ± 110 BP in conventional ^{14}C years. The two dates and their callibrated values are shown in Table 1.

Table 1. AMS ^{14}C dates of *Saiga tatarica*, Boltinggaards Skov, Funen.

Sample no	^{14}C age BP, conv. ^{14}C years	Calibrated age ±1 stdv.	^{13}C(‰) PDB
K-6137 AAR-1456	13,880±140	14,700 BC BC 14,890–14,500	-20.8*
K-6137 AAR-1977	14,040±200	14,890 BC BC 15,140–14,630	-18.7**

The calculated ^{14}C ages have been corrected for fractionation so as to refere the result to be equivalent with the standard ^{13}C value of -25‰ (wood). Calibrated ages in calendar years have been obtained from the calibration tables in Radiocarbon vol. 35,1993.
* Measured in the Copenhagen Lab.
** Measured in the Aarhus Lab.

Osteology and Taphonomy

The saiga specimen from Boltinggaards Skov consists of the major part of the left frontal bone with the horn core, a part of the parietal bone and a small corner of the temporal bone. The frontal bone has been broken along the orbital margin, about 1 cm in front of the supraorbital foramen and separated from its right side fellow partly along the suture and partly by an irregular fracture crossing over to the parietal bone. The horn core has been broken approximately 4 cm from the tip (Fig. 2). Estimated from the size the horn core represents an adult male which has been carrying fully grown horns (older than 20 months) (Sokolov 1974).

The colour and patina of the fractures show that they are all old and not caused by the well digging and the discovery in 1924. It is notable that the fractures are not rounded but all appear abrasive as well as the furrows and grooves of the horn core are marked and distinct. Therefore, the fragment is not supposed to have been transported very far after it was broken off the rest of the skull/skeleton. By the discovery the whole specimen was covered by a thin layer of clayey sediment and this clay is still present in

Fig. 2. The saiga specimen from Boltinggaards Skov. Top left and right: frontal and lateral view. Bottom left and right: caudal and medial view. (Photo: Geert Brovad, ZMUC).

furrows and cavities. A sample of the clay, which was taken by Degerbøl in 1930, has been kept in the archives of the Geological Survey and has lately been analysed for loss on ignition and lime content.

No fossils earlier than Pleistocene have been recorded of *Saiga* and the Pleistocene remains are confined to Late Middle Pleistocene and Late Pleistocene. The Late Middle Pleistocene fossils have been found in Europe and Asia while the Late Pleistocene saiga remains have been recorded from the entire Holarctic with the widest distribution during the last glaciation going from England to the Canadian Northwest Territories.

Kahlke (1990 & 1992) has compared the skull remains of saigas from Late Middle Pleistocene with those of Late Pleistocene and Recent times and lumped them into two different morphotypes. The old less advanced morphotype, „the Bottrop-type" (named after a Saalian specimen found at the Rhein-Herne-Kanal near Bottrop, Westfalia) differs from the young „Pahren-type" (named after a Weichselian specimen found near Pahren, Thuringia) by having 1) Greater distance between the bases of the horn cores; 2) Greater angle of divergence of the shafts of the horn cores; 3) More gracile horn cores; 4) Slightly stronger caudal inclination of the horn cores; 5) Increasingly steep rise of the horn cores in transverse view.

The Danish specimen being only the left horn core eludes analysis of the distance between the two horn cores or the angle of divergence between them. However, looking at the morphology of the horn core itself it obviously cannot be described as gracile. It is clearly more massive and robust as in the young Pahren-type. This is confirmed by measurements (Table 2) and by visual comparison with five recent saigas from the collection of the Zoological Museum, University of Copenhagen (ZMUC). This again is in agreement with the Late Weichselian date reported in this paper.

Table 2. Measurements of horn core of *Saiga tatarica*, Boltinggaards Skov, Funen compared with a recent Russian specimen and the Pahren- and Bottrop-morphotypes (Kahlke 1990:24).

Measurements in mm	Boltinggaards Skov Denmark *Late Weichselian*	„Sarepta-area" Between Don and Volga ZMUC CN 208 *Recent*	Pahren Thuringia *Weichselian*	Bottrop Westfalia *Saalian*
Greatest length of horn core (the furrowed part)	98.0 (+ c. 40.0)	142.0	144.0 (dex.)	134.1
Circumference at the base of the horn core	115.0	113.0	110.0	94.9 (dex.)
Greatest oro-aboral diameter at the base of the horn core	37.0	37.0	37.1	32.7 (dex)
Least latero-medial diameter at the base of the horn core	32.6	32.0	32.3	29.8 (dex.)

The anatomical features used for characterizing the two morphotypes have not at all been randomly chosen. They have to be confined to the skull and the horn cores as this is obviously the part of the male saiga skeleton which is most likely to survive the many taphonomic filters and finally to be discovered (see e.g.Harington 1981, Kahlke 1990). Apart from being the most resistant part of the skeleton it is also the most recognizable part. Other fragments of the saiga skeleton could easily be confused with those of *Capreolus, Rupicapra, Capra* and *Rangifer* depending of the state of preservation, the size of the fragments and the context.

Palaeoecology

The rather specific ecological requirements of the saiga make fossil remains of this species important tools in palaeoenvironmental reconstructions. Saigas are gregarious animals highly adapted to dry steppe-grassland. Here they feed mainly on grasses, Chenopodiacea, *Ephedra, Artemisia* and various herbs and here they can use speed to outdistance predators. The form and shape of the leg, foot and hoove plus the heavy loadings on the foot make the saiga well suited to firm substrates (Guthrie 1990, 262–263) and not boggy substrates as a moist tundra during summertime. They also avoid snow cover of more than 10 cm thickness, ice-crust formations and rugged country. Due to high fertility and mobility saigas can rapidly escape unfavourable environmental changes, restore the population and expand into new favourable habitats (Sokolov 1974).

Due to severe overhunting during the 19th century the range of the saiga became discontinuous resulting in only isolated patches spread over the Kalmyk and Kazakhstan steppe in the 1920s and 1930s. However, protection and conservation measures reversed the trend so that today the species has more or less regained its former (AD 1600–1800) distribution. It is now occuppying the steppe zone from the river Volga in west and as far east as to Mongolia and Sinkiang (Sokolov 1974, Corbet 1978).

Although the number of fossil saiga remains are rather few and the datings not always unambiguous it is possible to separate several immigration waves into Europe during the Saalian, Eemian and Weichselian (Delpech 1983, Kahlke 1992). Apart from a possible immigration into central Europe in Early Saalian the saiga only reaches central and western Europe in the late periods of respectively the Saalian and the Weichselian glaciations. In the Eemian, the Early and Middle Weichselian and the Holocene it does not expand further west than the eastern Europe and always east of the Carpathians.

The Late Weichselian expansion into Europe reaches Southwest France (Delpech 1983), Southeast France (Crégut-Bonnoure and Gagniere 1981, Crégut-Bonnoure 1992), South England (Currant 1987) and as far north as Denmark. The Pyrenees and the Alps probably acted as barriers against a migration further south and the retreating ice cap prevented further migration to the north.

Delpech (1983) demonstrated two apparently separated occurrences in Southwest France one around 15,000–14,500 BP and a younger one around 12,500 BP. Kahlke (1992) summarizing the rather few ^{14}C-dates of other late glacial saiga remains in Europe finds it likely that these two separated immigration waves are also documented in the rest of western Europe. At least no dates speak against it. The result of the AMS-dating of the Danish saiga specimen reported here falls inbetween the two postulated immigration waves. With a date of c. 14,000 BP it should either be interpreted as a very young member of the oldest immigration wave or as a first indication of a continuous occupation of saigas in late glacial Europe around 15,000–12,000 BP. We need more radiometric dates to decide on this.

Nevertheless the occurrence of saiga in Europe during the Late Weichselian indicates a dry, continental steppe environment and its presence in southern Scandinavia during the time of deglaciation is interesting. The date of the Boltinggaards Skov specimen gives a maximum age of the glacial deposits in which it was found and at the same time it has some important implications for the glacial history and the palaeoenvironment of the area.

Glacial History

The nature of the sediment in which the fossil saiga occurred is important for the palaeogeographical and palaeoenvironmental interpretations. From the old description it appears that it was deeply embedded in till around 13 m below surface (Degerbøl 1932, 175). It is seen from the Geological map of Nyborg (Southeast Funen) (Madsen 1902) that within the southwestern part of this area the dominating surface deposit is a clayey till. However, at the time of the publication of the geological map, no further studies were undertaken from the area around Ringe. But recently, detailed studies have been conducted of till deposits from this region in connection with investigations of migration of nutrients, pesticides and heavy metals in fractured clayey till (Klint and Fredericia 1995).

The till in the area is decribed as sandy till with a thickness of up to 10–15 m overlaying meltwater sand. From the studies it appears that the Late Weichselian till belongs to the ice advance from southeast, the so called Young Baltic Ice and can be decribed as a lodgement till (op. cit., Fig. 5). Furthermore, analysis on fine gravel material show a Baltic origin.

Measurements on percent of loss on ignition and lime of the preserved sediment sample from the saiga give 2.55 % and 28 % respectively, which is within the magnitude of the till from the recent area of investigation (Klint pers. comm.). However, most important in the comparison between the fossil saiga sediment and the recent investigation is the fact that it can be excluded (in all probability) that the saiga was embedded in flow till. This means that the fossil has been taken up by the glacier somewhere to the southeast of the locality. So, the AMS-dating antedates the gletscher advance over southeastern Denmark to the East Jutland Borderzone formed by the Young Baltic Ice (Harder 1908).

Therefore we venture the assertion that the Young Baltic Ice advanced and retreated over Denmark framed within the saiga-AMS dating of c. 14,000 ^{14}C years BP and the development of the first stage of the Baltic Ice Lake around 13,000 BP (Björck 1995). However, this is not in accordance with the timing of the last deglaciation in the Kattegat region as given by Lagerlund and Houmark-Nielsen (1993). Here „the Young Baltic Ice reached its maximum extension in Denmark from southerly and southeasterly directions well before 14,200 BP“ (op.cit.,345). The only available dating of the East Jutland Borderzone based on a mammoth tusk from Rosmos in the Tirstrup sandur (13,240 +760/-690 BP (Aaris-Sørensen *et al.*1990)) has recently been questioned by some new AMS datings on the same material giving a much higher age (Pedersen and Petersen in press). However, the old dating lays well within the timing as deduced from the dating of the saiga.

Conclusions

Saiga antelopes immigrated into central and western Europe during the Late Weichselian reaching Southwest and Southeast France, South England and as far north as Denmark. The rather few saiga remains and even fewer datings have so far shown two apparently separated immigration waves one around 15,000–14,500 BP and a younger one around 12,500 BP. However, the AMS-dating of the Danish saiga to c. 14,000 BP query this assumption and could as well be a first indication of a continous occupation of saigas in late glacial Europe around 15,000–12,000 BP.

As the Danish saiga fossil was found embedded in a till belonging to the so called Young Baltic Ice, the AMS-dating antedates this ice advance. The advance and retreat of the Young Baltic Ice can then be framed within the saiga dating of 14,000 BP and the development of the first stage of the Baltic Ice Lake around 13,000 BP.

The rather specific ecological requirements of the saiga makes the Danish specimen an important tool in reconstructing the palaeoenvironment and in writing a glacial history. Being highly adapted to dry steppe-grassland its presence in southern Scandinavia around 14,000 BP is remarkable. It requires that the Main Ice retreated far enough and that the intervening time before the Young Baltic readvance lasted long enough for a steppe biom to be reestablished.

References

Aaris-Sørensen, K., Petersen, K. S. and Tauber, H., 1990: Danish finds of mammoth (*Mammuthus primigenius* (Blumenbach)). Stratigraphical position, dating and evidence of Late Pleistocene environment. Danmarks Geologiske Undersøgelse, Serie B, 14, 44 pp.

Björck, S., 1995: Late Weichselian to Early Holocene development of the Baltic Sea–with implications for coastal settlements in the southern Baltic region. In: Fischer, A. (ed.), Man and Sea in the Mesolithic, Oxbow Monograph 53, 23–34.

Corbet, G. B., 1978: The Mammals of the Palaearctic Region: a taxonomic review. British Museum (Natural History). Cornell University Press. Pp 314.

Crégut-Bonnoure, E., 1992: Dynamics of Bovid migration in Western Europe during the Middle and Late Pleistocene. Courier Forsch.-Inst. Senckenberg 153, 177–185.

Crégut-Bonnoure, E. and Gagnière, S., 1981: Sur la présence de *Saiga tatarica* (Mammalia, Artiodactyla) dans le dépot Pléistocène supérieur de la grotte de la Salpétrière à Remoulins (Gard, France). Nouv. Arch. Mus. Hist. nat. Lyon 19, 37–42.

Currant, A. P.. 1987: Late Pleistocene Saiga Antelope *Saiga tatarica* on Mendip. Proc. Univ. Bristol Spelaeol. Soc., 18(1), 74–80.

Degerbøl, M., 1932: Et Fund af Steppe-Antilope (*Saiga tatarica* (Pall.)) i Danmark. Meddelelser fra Dansk Geologisk Forening 8(2), 175–184.

Delpech, F., 1983: Les faunes du Paléolithique supérieur dans le sud-ouest de la France. Cahiers du Quaternaire 6, 1–453.

Guthrie, R. Dale, 1990: Frozen Fauna of the Mammoth Steppe. The Story of Blue Babe. The University of Chicago Press. Chicago and London. Pp 323.

Harder, P., 1908: En Østjydsk Israndslinje. Danmarks Geologiske Undersøgelse II. Række Nr. 19, 230 pp.

Harington, C. R., 1981: Pleistocene Saiga Antelopes in North America and their Paleoenvironmental Implications. In: Mahaney, W. C. (ed.), Quaternary Paleoclimate 193–225. Geo Books, University of East Anglia, Norwich, England.

Kahlke, R.-D., 1990: Der Saiga-Fund von Pahren. Ein Beitrag zur Kenntnis der paläarktischen Verbreitungsgeschichte der Gattung *Saiga* GRAY 1843 unter besonderer Berücksichtigung des Gebietes der DDR. Eiszeitalter u. Gegenwart 40, 20–37.

–, 1992: Repeated immigration of Saiga into Europe. Courier Forsch.-Inst. Senckenberg 153, 187–195.

Klint, K. E. and Fredericia, J., 1995: Sprækkeparametre i moræneler. Vand & Jord, Nr. 5, 2. årgang, oktober, 208–214.

Lagerlund, E. and Houmark-Nielsen, M., 1993: Timing and pattern of the last deglaciation in the Kattegat region, southwest Scandinavia. Boreas 22, 337–347.

Madsen, V., 1902: Beskrivelse til Geologisk Kort over Danmark. Kortbladet Nyborg. Danmarks Geologiske Undersøgelse I. Række Nr. 9, 182 pp.

Pedersen, S. A. S. and Petersen, K. S., in press: Djurslands Geologi. Danmarks og Grønlands geologiske undersøgelse.

Sokolov, V. E., 1974: *Saiga tatarica*. Mammalian Species 38, 1–4.