The large mammal fauna of the Pleistocene site Schöningen 13II
The levels Schö 13II-1, 13II-2 and 13II-3

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Cover image: Skeleton of *Equus mosbachensis* (Von Reichenau, 1915)
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1. Introduction

In the German town of Schöningen archaeological excavations have taken place in a lignite mine since 1983. This research has been conducted on a large scale and has yielded many interesting and diverse finds from different time periods, the oldest of which date to the Palaeolithic. The most striking finds were done from 1995 onwards, when eight wooden spears were found at the site Schöningen 13II that appeared to be about 400.000 years old. The spears have been dated to the newly defined Reinsdorf Interglacial and are accompanied by the butchered remains of large mammals, most of which are horses (Thieme 2005, 116, 118, 123). This thesis will focus on the Middle Pleistocene large mammal material found in the three older levels located directly underneath the spear horizon, in order to contribute to the completion of the archaeozoological understanding of the site.

The archaeological significance of this research is evident. Large mammals were essential for the subsistence of Palaeolithic man, as shown by the butchering marks on the bones of the mammals. The wooden spears encountered in level 4 of Schöningen 13II constitute the equipment with which the animals were hunted (Voormolen 2008, 126-128). Moreover, the behaviour of early hominids can be understood by gaining information on the environment with which they interacted. This investigation therefore partly deals with the interaction between hominids and large mammals in the Palaeolithic period and the ecological background in which the hominids operated. Additionally an attempt will be made to date the archaeological site Schöningen 13II on the basis of the large mammal compositions.

Thus, the main goals of this research are to get an overview of the compositions of large mammal species found in the levels 1, 2 and 3 of the site Schöningen 13II and to deduce palaeoecological, taphonomic and biostratigraphic information from these faunal and skeletal assemblages. This has been done by determining and analysing a sample of the large mammal bones from these levels. For completeness, this analysis has been combined with previous analysis on the levels by several researchers. The following research questions will be addressed:

- Which large mammal species are present in the levels Schöningen 13II-1, 13II-2 and 13II-3 and how do the faunal compositions of these levels compare to each other? What palaeoecological information can be discerned from these compositions?
- How do the faunal assemblages in Schöningen 13II-1, 13II-2 and 13II-3 compare to the assemblage found in Schöningen 13II-4?

- What are the taphonomic influences on the skeletal compositions and what kind of traces do the bones display?
- How do the faunal compositions of the Schöningen 13II levels compare to Schöningen 12B and other Middle Pleistocene sites in Europe? Can biostratigraphic conclusions be drawn from these comparisons?

In order to answer these questions the Schöningen locality will first be described in Chapter 2, as to clarify the context in which the large mammal bones have been found. Information will be given on the geography and geology of the Schöningen locality. In addition, dating and correlation problems will be discussed and an overview will be given of previous palaeoecological and archaeological research conducted at the Middle Pleistocene Schöningen sites. The mammalian taxa under consideration and their specific context within the Schöningen locality will be described as well. In Chapter 3 the amount of investigated bone material and the used methodology will be outlined. The large mammal remains will then be described in Chapter 4, in which information will be given on the skeletal elements and characteristics of each order, family, genus and species represented in the faunal assemblages. Chapter 5 presents and compares the faunal compositions of the Schöningen 13II levels to establish the palaeoecology during the Reinsdorf Interglacial. Taphonomic and hominid or carnivorous influences on the bone assemblages will be described to determine the preservation state of the material. In Chapter 6 the biostratigraphy of Schöningen 13II will be established by comparing the faunal compositions of the Schöningen 13II levels with the site Schöningen 12B and with other Middle Pleistocene sites in Europe. It is hoped that these comparisons can be used to date the Schöningen 13II site.

2. The Schöningen locality

Schöningen is a town located in the north of Germany, in the eastern part of the federal state Niedersachsen. The archaeological sites discovered there are situated in a lignite quarry, which used to be divided into a northern and a southern quarry spanning 6 km long and 1 km wide (fig. 1). The Eocene lignite has been exploited since 1978, thereby removing the overlying Quaternary find horizons. For this reason archaeological rescue excavations had to take place to study the archaeological heritage (Thieme 2007, 18, 20, 24; Urban 2007a, 417).

Thus, in 1982 archaeologists started to investigate the north-western part of the quarry, a small operation which yielded settlements of the Linear Pottery Culture. Since 1983 rescue excavations in Schöningen have taken place on a large scale, as up until now approximately 400.000 m² has been excavated from 15 archaeological sites. These sites yielded many finds dating from the Stone Age to the Iron Age. Since 1992 the archaeological excavations have focussed on the southern section of the lignite mine, in which Lower Palaeolithic sites were found. The most significant discoveries at Schöningen were done from 1995 onwards, when archaeologists found eight wooden throwing spears in association with stone tools and the remains of butchered horses. The spears appeared to be about 400.000 years old and are considered the oldest known complete hunting weapons. The skill and refinement applied in their production and use display the extraordinary capabilities of Palaeolithic man (Thieme 2005, 116; Thieme 2007, 23, 24, 26).

In this chapter the geology and the dating and correlation issues of the Schöningen sequence will be described. In addition, the previous palaeoecological and archaeological research conducted at Schöningen will be discussed, in order to get an understanding of the context of the analysed bone material.

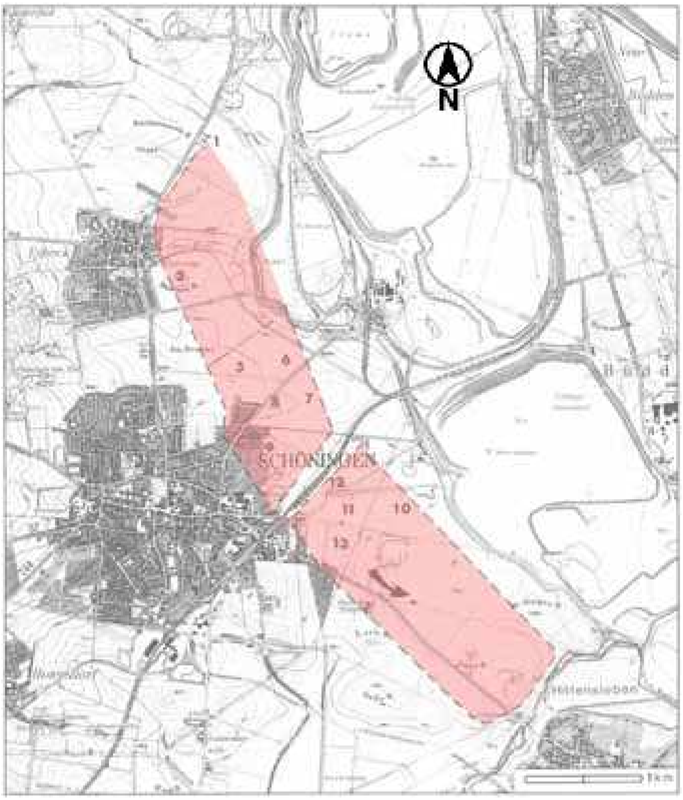


Figure 1. The northern and southern section of the Schöningen lignite mine, displaying the archaeologically examined area in pink. The location of the archaeological sites 1 to 13 are shown, with the exception of the sites 4 and 5 which are located outside of the mine (http://www.archaeologieportal.niedersachsen.de/schoeningen last visited on September 17, 2011).

2.1 Geology

The Schöningen lignite mine is located north of the Harz mountains and at the south-eastern margin of the Elm, a Triassic limestone ridge. The region is part of a halokinetic depression filled with Eocene limnic and marine sediments, which is situated in a salt dome between Stassfurt and Helmstedt. A complex sequence containing Quaternary sediments of Pleistocene and Holocene age is situated on top of these Tertiary deposits in the southern part of the lignite mine. The sequence covers the last 500.000 years (Thieme 2005, 116; Urban 2007a, 417, 419).

The oldest deposits of the Pleistocene sequence date from the Elsterian glaciation and are referred to as Schöningen 0. These deposits are overlain by six interglacial river channels which were formed in a northwest-southeast direction, parallel to the Stassfurt-Helmstedter salt dome (fig. 2). The erosional river channels are referred to as Schöningen I to VI and represent a series of interglacial and glacial cycles. Channels I to III are placed between the Elsterian and Saalian glaciations while the remaining channels IV to

VI overlie the Saalian deposits and thus cover the post-Saalian to Holocene period. Glacial tills have been deposited during the Elsterian and Saalian. These tills were transported by Fennoscandian glaciers, which entered the Schöningen area from the northeast. The land ice did not reach Schöningen during the last glaciation, the Weichselian (Thieme 1997, 808; Urban 2007a, 419).

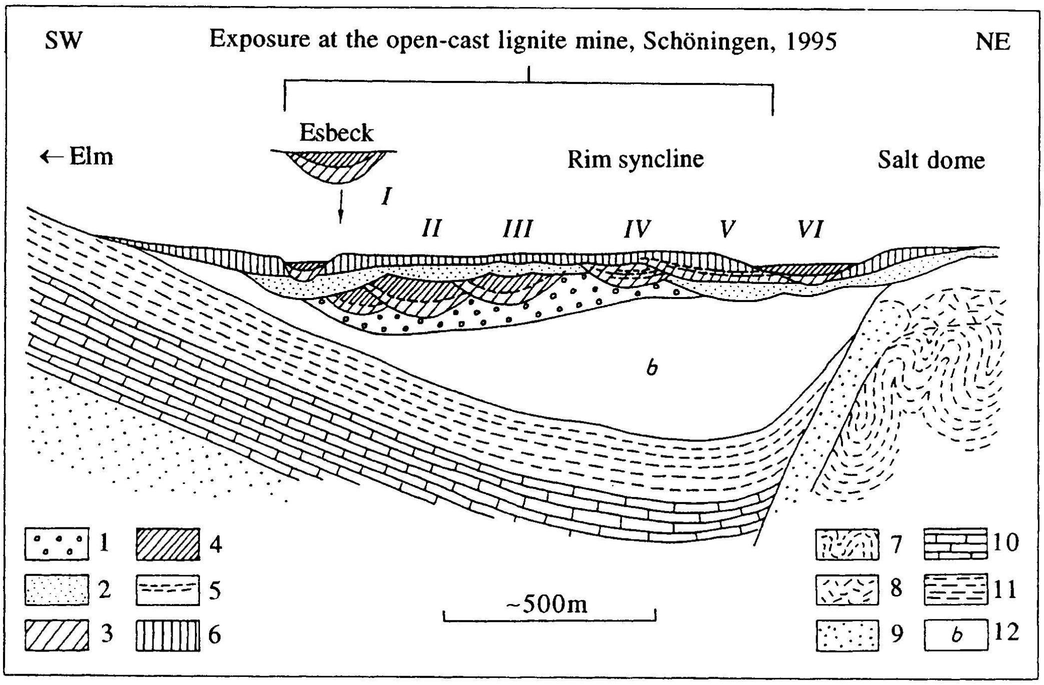


Figure 2. Schematic section through the Quaternary sedimentary sequence in the depression along the Stassfurt-Helmstedter salt dome, showing the channels I to VI.
Key: 1. Elsterian glacial deposits; 2. Saalian glacial deposits; 3. Lacustrine deposits; 4. Limnic telmatic sequences; 5. Soil complexes; 6. Loess deposits; 7. Evaporites; 8. Gypsum cap-rock; 9. Buntsandstein; 10. Triassic limestone (Muschelkalk); 11. Triassic deposits (Keuper); 12. Tertiary deposits (Thieme 1997, 808).

The Elsterian deposits of Schöningen 0 consist of ground moraines and glaciofluvial sands. On top of these lie two Elsterian tills, of which the younger is capped by rhythmites overlain by three interstadial layers. These layers are named Offleben 1 and Offleben 2, characterized by a boreal forest type, and Esbeck, characterized by an open-tundra steppe and continental climatic conditions (Mania 2007, 45; Urban 2007a, 419).

The Elsterian sequence is overlain by the Schöningen I channel, which contains limnic and telmatic sediments. This channel is dated to the late Holsteinian Interglacial on the basis of its palynological composition, as it contains *Abies* (fir), *Pinus* (pine), *Picea* (spruce), *Pterocarya* (wingnut) and *Azolla filiculoides* (water fern). The subsequent Buschhaus A Stadial is characterized by an increase of *Artemisia* (wormwood) and grasses indicating a cooling climate and the beginning of the Saalian. The stadial is followed by the Missaue I and II Interstadials characterized by the presence of *Pinus*, *Betula* (birch) and *Picea*. The next Buschhaus B Stadial contained a steppe with dwarf shrubs and is followed by Interstadial SU A, characterized by the dominant presence of *Pinus*. A burnt flint from a Late Elsterian fire place of *Homo erectus* situated underneath the Schöningen II channel gave a thermoluminescence (TL) date of 450 ± 40 kyr for Schöningen I (Urban 2007a, 419, 421).

The Schöningen II channel dates from the Reinsdorf Interglacial and the subsequent Fuhne cold stage. This newly defined interglacial has a different vegetational history than the preceding Holsteinian Interglacial and the following Schöningen Interglacial, represented in the Schöningen III channel (Thieme 2005, 118). The channel is filled with five levels of calcareous muds and peats, numbered 1 to 5. The oldest level at the bottom, Level II-1, dates from the climatic optimum of the Reinsdorf Interglacial. The following levels indicate a cold temperate climate. Level II-2 represents a stadial which marks the onset of climatic cooling, while Level II-3 represents an interstadial. The layer in which the famous wooden spears were found, Level II-4, comprises two stadials which are separated by an interstadial. Between Level II-4 and Level II-5 frost wedges occur within silty clays, marking the beginning of a periglacial environment (fig. 3). The carpological and palynological research on the Reinsdorf Interglacial point to a warm climatic forest steppe with dry regional conditions (see paragraph 2.3.1). Peat layers from this interglacial within Schöningen 12II-1 gave a Thorium/Uranium (Th/U) age of 320 kyr (Mania 2007, 56; Thieme 1997, 808; Urban 2007a, 421, 424, 425, 430). Together with Schöningen I, Schöningen II is the most significant channel, as both contain the Lower Palaeolithic sites 12 and 13 (fig. 4).

The Schöningen III channel represents the Schöningen Interglacial, which is correlated with the Dömnitz Interglacial (Thieme 2005, 118). It contains sediments composed of silty muds and peat, cross-cutting the Schöningen II channel. The pollen assemblages point to a warm (sub)continental climate with abundant *Pinus* and *Tilia* (linden) and some *Quercus* (oak). High percentages of *Alnus* (alder) were found as well, suggesting swampy conditions. The Schöningen Interglacial is followed by the Elm A Stadial, characterized by an increase in herbs, grasses, *Artemisia* and Ericales. This is succeeded by the Büddenstedt I and II Interstadials, which are temperate periods characterized by *Pinus-Betula* forests. These interstadials are separated by the Elm B Stadial. The Büddenstedt II Interstadial is followed by the Elm C Stadial, a cold phase characterized by an increase in herbs and *Betula*. The Schöningen III channel is covered with glaciofluvial till and sands of the Saalian (Drenthe) ice advance. On the basis of its peat the Schöningen Interglacial has been dated to an uncorrected Th/U age of 180 and 227 kyr (Urban 2007a, 430, 431).

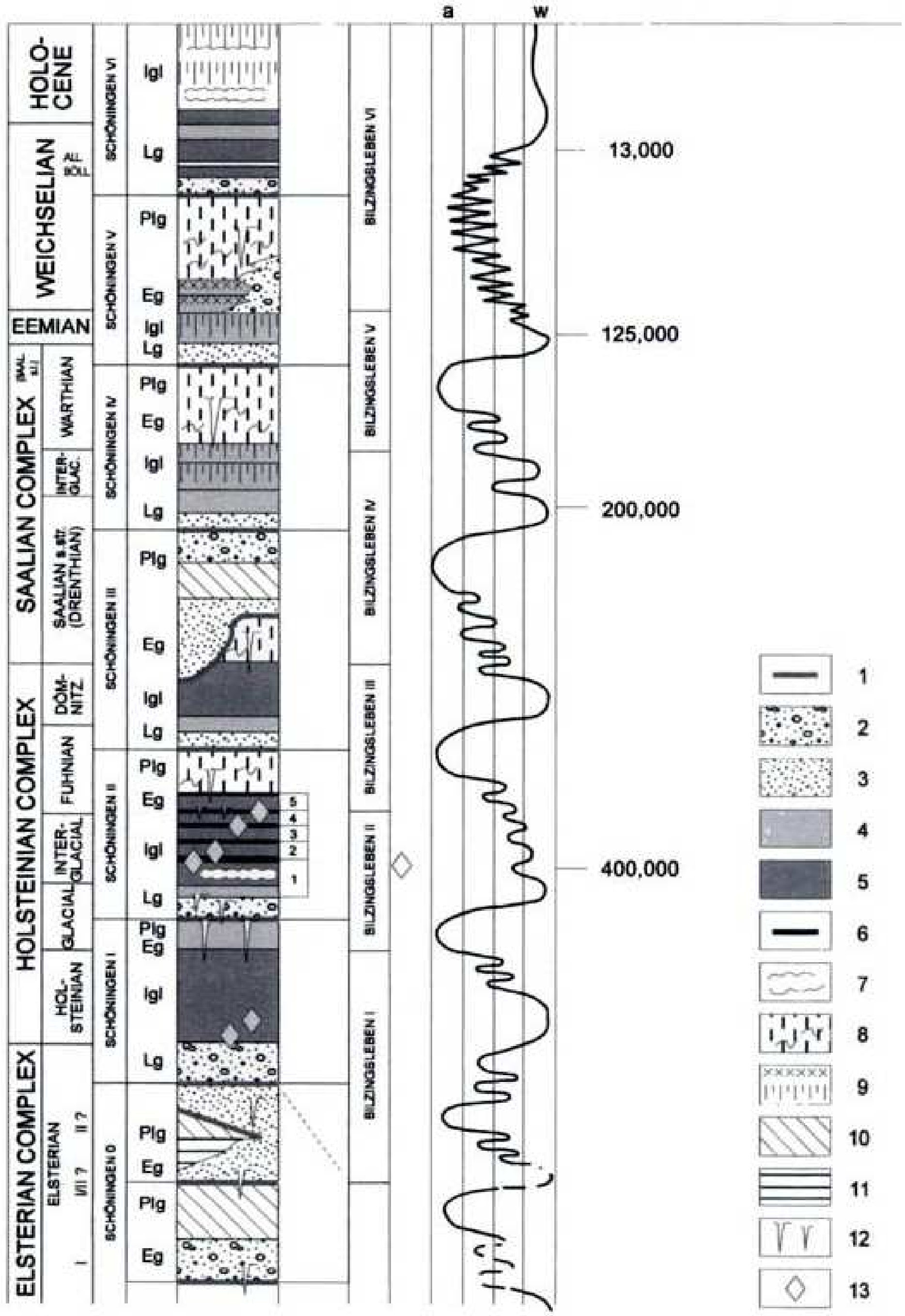


Figure 3. Scheme of the stratigraphic sequence through the Schöningen deposits. It covers the period from the Middle Pleistocene to the Holocene. The Schöningen 0-VI sequence is correlated with the climatic cycles of Bilzingsleben.

Key: 1. Denudation horizon; 2. Gravel sands; 3. Sands; 4. Lacustrine deposits; 5. Limnic organogenic sediments; 6. Peat; 7. Travertine; 8. Loess; 9. Soils and humic zones; 10. Ground moraines; 11. Laminated clay deposits; 12. Periglacial structures; 13. Lower Palaeolithic find horizons. Lg: Late glacial; Plg: Pleniglacial; Eg: Early glacial; Igl: Interglacial; 1-5: sequence within the Reinsdorf Interglacial; a: arctic; w: warm-temperate (Thieme 2005, 117).

The Schöningen IV channel is composed of a pedocomplex which is developed in alluvial loess. The channel eroded into the Saalian glacial sediments and holds two pseudogleyic layers, possibly indicative of one or more periglacial phases in between the two major ice advances of the Saalian glaciation. It contains vegetation suggesting the presence of a tundra environment (Urban 2007a, 432).

The Schöningen V channel is dated to the Eemian Interglacial and is composed of travertine and peat layers. These layers contain a high percentage of *Abies* during a period when the vegetation was characterized by a *Pinus-Picea-Abies* composition. The Th/U age of the Eemian peat layers is 132 ± 17 kyr. Schöningen V is overlain by the youngest channel of the Pleistocene sequence, Schöningen VI, which is composed of Late Weichselian and Holocene sediments and soils and braided river deposits of the present-day Missaue river (Urban 2007a, 432).

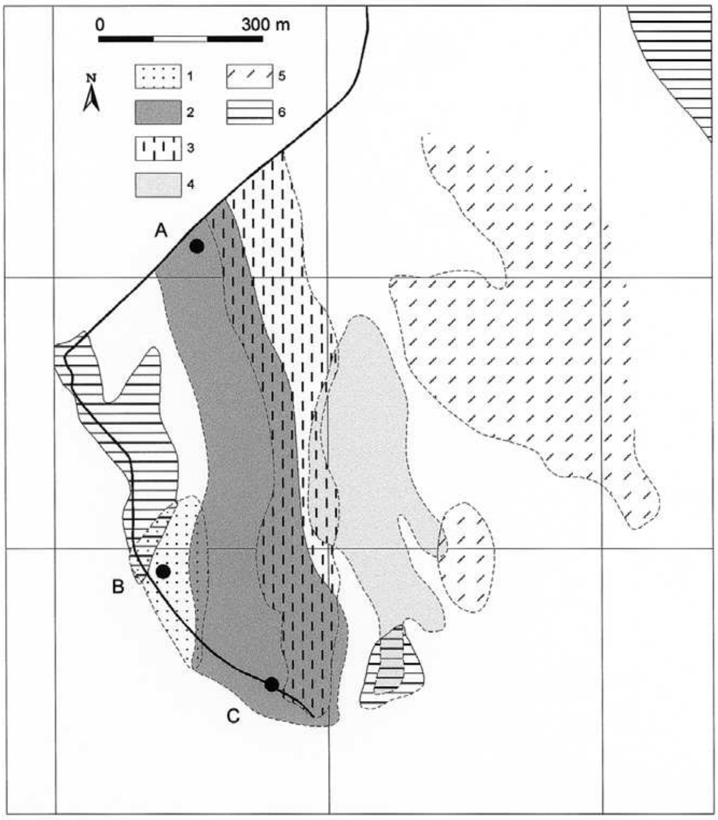


Figure 4. Course of the six Pleistocene and Holocene channels in a 1 km² area in the southern part of the Schöningen open-cast mine. Key: 1. Schöningen I; 2. Schöningen II; 3. Schöningen III; 4. Schöningen IV; 5. Schöningen V; 6. Schöningen VI. A: Schöningen 12; B: Schöningen 13I; C: Schöningen 13II. The solid line in the north and southwest is the border of the open-cast mine in the area (Thieme 2005, 119).

2.2 Dating and correlation problems

Several problems have arisen considering the age of the Schöningen sequence and its correlation with other Middle Pleistocene sequences. These issues will be outlined in this paragraph.

2.2.1 Schöningen and the Marine Isotope Stages

Attempts have been made to correlate the Middle Pleistocene sequence at Schöningen with the chronology of the Marine Isotope Stages (MIS). This chronological framework is based on the stable isotope variations within marine sequences, which point to variations in oxygen isotope values and hence in climatic fluctuations. The odd numbers within the MIS subdivision system represent warm stages and the even numbers represent cold stages. Since the establishment of the chronology of the marine record it has been a challenge to correlate the known terrestrial interglacial and glacial periods with the corresponding MIS (Geyh and Müller 2005, 1861; Jöris and Baales 2003, 282, 283).

Traditionally the Eemian Interglacial has been correlated with MIS 5e, whilst the Holsteinian Interglacial has been correlated with MIS 11 and the Elsterian glaciation with MIS 12 (Sarnthein *et al.* 1986, 293-295). However, recently the correlation of the Holsteinian with MIS 11 has been questioned. On the basis of palynological data and Th/U dates of fen peat the Holsteinian is said to correlate with MIS 9 and the Elsterian with MIS 10 (Geyh and Müller 2005, 1870, 1871; Meijer and Cleveringa 2009, 326, 335, 339). This correlation is again refuted by Nitychoruk *et al*., who stress that the Th/U absolute dating method is not conclusive because of its dating limit and its unreliability; the same dating method has placed the Holsteinian in MIS 7, 9 11 or 13. In addition, it is argued that the Holsteinian Interglacial shows convincing palynological resemblance to the Praclaux Interglacial, which is dated to MIS 11 (Nitychoruk *et al*. 2006, 2680).

Thus, the correlation of the terrestrial sequences with the marine record is not straightforward, which also became apparent when researchers tried to correlate the Schöningen sequence with the Marine Isotope Stages. According to the MIS data, three warm temperate periods occur between the Elsterian and the Saalian glacials. When the correlation of the Holsteinian with MIS 11 and the Eemian with MIS 5e is maintained, two pre-Saalian warm temperate isotope stages remain, MIS 9 and MIS 7. In the case of the Schöningen sequence, this would mean that the Schöningen I channel on top of the Elsterian deposits should correlate with the Holsteinian, MIS 11. The Schöningen II channel, the Reinsdorf Interglacial, should then correlate with MIS 9 and the Schöningen III channel, the Schöningen or Dömnitz Interglacial, must be equated with MIS 7 (Urban 1995, 184).

However, other researchers state that this correlation is erroneous. Some argue that the Reinsdorf Interglacial must be dated to MIS 11 and has a Holsteinian age, whereas the Schöningen Interglacial should be dated to MIS 9 (Mania and Thieme 2007, 218-220; Schreve and Bridgland 2002, 369, 370). Jöris and Baales (2003) have established a correlation of the Reinsdorf Interglacial with MIS 9e and the Schöningen Interglacial with MIS 9a instead of MIS 7 (fig. 5).

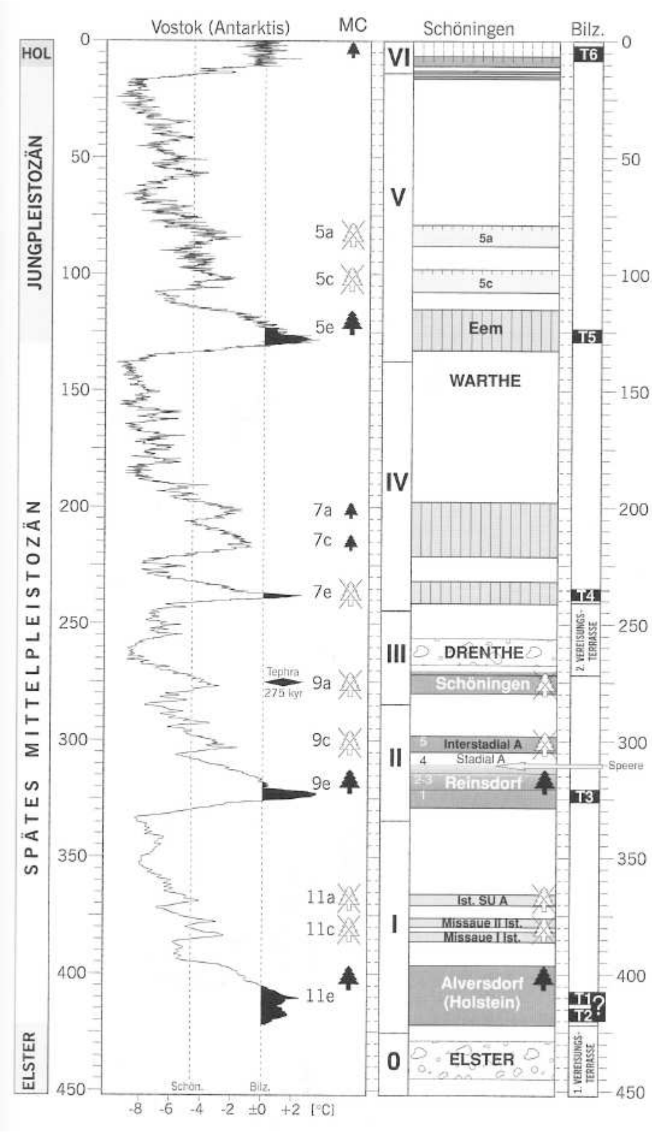


Figure 5. Correlation of the Schöningen sequence with the Marine Oxygen Isotope Substage chronology (Jöris and Baales 2003, 285).

The issue became even more complex when Dutch researchers found evidence for a new interglacial between the Schöningen Interglacial and the Saalian glaciation, which has been called the Oostermeer Interglacial. The researchers established a scheme wherein the Elsterian is correlated with MIS 10, the Holsteinian or Maastricht-Belvédère Interglacial with MIS 9 and the newly defined Oostermeer Interglacial with MIS 7 (Meijer and Cleveringa 2009, 326, 342). When equating this so-called short-chronology scheme with the long-chronology scheme whereby the Elsterian is dated to MIS 12, the Holsteinian must then be dated to MIS 11 together with the Reinsdorf Interglacial, and the Maastricht-Belvédère Interglacial as well as the Schöningen Interglacial should be dated to MIS 9 (Schreve and Bridgland 2002, 369). However, according to Urban (2007a) the vegetation of the Reinsdorf Interglacial differs profoundly from the previous Holsteinian Interglacial and the following Schöningen Interglacial. The Reinsdorf Interglacial must therefore be attributed to a warm oxygen isotope stage rather than a warm oxygen isotope substage (Urban 1995, 184; Urban 2007a, 434-436). But when the Reinsdorf Interglacial is indeed correlated with MIS 9, there is no warm oxygen isotope stage left for the Oostermeer Interglacial.

The correlation of the Schöningen sequence with the Marine Isotope Stages has therefore been a subject of much debate and still remains unresolved. It is hoped that the biostratigraphic data from the mammalian remains of Schöningen can provide a contribution to this discussion (see Chapter 6).

2.2.2 Schöningen and Bilzingsleben

Besides dating problems, correlation problems between Schöningen and other Middle Pleistocene sites have occurred as well. For instance, the sequence at Schöningen has been compared with the terrace-travertine sequence at Bilzingsleben, a town situated southeast from Schöningen. A correlation has been established between both sequences (fig. 3). It is assumed that Bilzingsleben I correlates with Schöningen I, Bilzingsleben II with Schöningen II, and Bilzingsleben III with Schöningen III (Thieme 2005, 118).

However, according to Musil (2002) and Jechorek (2000) this correlation is incorrect. Musil argues that the horses found in level Schöningen 13II-4 are phylogenetically younger than the horses of Bilzingsleben II (Musil 2002). Jechorek analysed pollen assemblages from level Schöningen 13II-1, the climatic optimum. She found that the palaeovegetation was influenced by a strong subcontinental climate with the presence of *Acer tataricum* (tatarian maple), which is absent in the climatic optimum of Bilzingsleben II. The palaeovegetation of Bilzingsleben II is characterized by the presence of a *Buxo-Quercetum* (box-tree and oak) and a *Buxo-Syringetum* (box-tree and lilac) flora (Jechorek 2000; Mania 2007, 54; Thieme 2005, 118).

But in spite of these vegetational differences, it is still argued that the interglacial maxima of Bilzingsleben II and Schöningen 13II-1 are contemporaneous. Both sites do have specific vegetational elements in common and both show the influence of a strong subcontinental climate. In addition, the same mean annual temperatures and mean annual rainfall have been established for Bilzingsleben II and Schöningen 13II-1. The temperatures of the climatic optimum were a few degrees higher than today (Mania 2007, 55).

In order to establish whether Bilzingsleben II is indeed contemporaneous with Schöningen 13II-1 the large mammal compositions of both sites have been compared in paragraph 6.4.1.2.

2.3 Previous palaeoecological and archaeological research

The Middle Pleistocene sites Schöningen 12B, Schöningen 13I and Schöningen 13II were encountered in the southern part of the Schöningen lignite mine (fig. 4). These sites have been investigated since 1992 (Thieme 2005, 116). Research has focused on the palaeoecological background of the sites and is still in progress as of today. This paragraph mainly deals with the flora and fauna present at the site Schöningen 13II and their significance for environmental, climatological and biostratigraphic matters. In addition, the presence of hominids at Schöningen and their interaction with the surrounding flora and fauna will be described.

2.3.1 Palaeobotany

The palaeobotanical research on the Reinsdorf Interglacial at the Schöningen II channel was carried out by B. Urban (2007a, 2007b) and H. Jechorek (2000). Urban conducted the palynological analysis whereas Jechorek identified the carpological remains. They found that the sequence at Schöningen II contains many herbs and grasses during forested periods, which indicates the presence of warm and dry forest steppes (Urban 2007a, 423, 424).

Level II-1 comprises the climatic optimum of the Reinsdorf Interglacial. The plant micro- and macrofossils in this level indicate strong subcontinental influences (Urban 2007b, 70). The vegetation succession is characterized by a *Quercetum mixtum* (mixed oak) phase with *Azolla filiculoides* (water fern), followed by *Corylus-Alnus* (hazel-alder) and *Carpinus-Picea-Abies* (hornbeam-spruce-fir) phases and a *Pinus*-Ericaceae (pine-heath) zone (Urban 2007a, 424, 425). The carpological remains indicate the presence of open deciduous forests with mesophilous and thermophilous trees, including *Acer tataricum* (Tartarian maple), *Fraxinus excelsior* (ash), *Crataegus monogyna* (hawthorn) and *Berberis vulgaris* (barberry). The annual temperatures of the Reinsdorf Interglacial were slightly higher than today, as shown by the presence of *Linum austriacum* (Asian flax). High summer temperatures were necessary to sustain the thermophilous water plants present, including *Salvinia natans* (floating fern) and *Hydrocharis morsus-ranae* (frogbit). The occurrence of an exotic *Ranunculus* species point to swampy conditions. Other plant elements such as *Zannichellia palustris* (horned pondweed) and *Rumex maritimus* (golden dock) indicate saline environments (Jechorek 2000; Jechorek *et al*. 2007, 93, 94). During the end of the interglacial the pine-birch forest opened and grasses, herbs and Ericales became more abundant (Urban 2007a, 424, 425).

Level II-2 is referred to as Reinsdorf Stadial A. The level displays a decrease in tree pollen and an increase in grasses, herbs and shrubs, marking the onset of climatic cooling. Level II-3 displays interstadial conditions and is referred to as Reinsdorf Interstadial A. *Pinus, Betula*, *Picea* and *Alnus* dominated the vegetation, whereas trees indicating a warm climate were absent. Grasses and herbs still occurred, indicating an open forest steppe vegetation (Urban 2007a, 425; Urban 2007b, 70).

Level II-4 consists of two stadials separated by an interstadial. Reinsdorf Stadial B is found in level II-4a and shows mostly herbs indicative of a cold steppe. Reinsdorf Interstadial B is found in level II-4b and represents cold and dry conditions with a *Pinus-Betula* forest and the rare occurrence of *Picea* (spruce). However, the wooden spears that were made out of spruce were found in level II-4b as well. This implies that the spears were transported from dispersed stands of spruce distant from the site (Urban 2007a, 425, 430). Many plant macrofossils indicating a cold climate could be identified, including *Arctostaphylus uva-ursi* (bearberry), *Frangula alnus* (alder buckthorn) and *Pinus sylvestris* (Scots pine) (Jechorek 2000). Grasses and herbs dominated the vegetation between level II-4c (Reinsdorf Stadial C) and level II-5, in which frost wedges occur. This indicates a periglacial environment and the end of the Schöningen II channel (Urban 2007a, 430; Urban 2007b, 71).

2.3.2 Molluscs

The molluscs found at Schöningen 13II have been analysed by D. Mania and mainly comprise snails and mussels. In level Schöningen II-1 molluscan species indicative of wet environments have been found, indicating the presence of shores and lakes. However, the molluscan fauna is mainly represented by thermophilous species confined to forested environments. These species include natives still in existence today, like *Helicodonta obvoluta* (cheese snail), *Helix pomatia* (Burgundy snail) and *Cepaea hortensis* (white-lipped snail). Exotic species have been found as well, which are nowadays found in Southern Europe. These include the large snails *Helicigona (Drobacia) banatica* and *Aegopis verticillus* and the smaller species *Pagodulina pagodula* and *Vitrea subrimata*, indicating higher mean temperatures than today. Additionally species occurring in open or steppe environments were encountered, indicating a strong subcontinental climate. These include *Pupilla muscorum* and *Truncatellina claustralis,* an exotic species nowadays occurring in the Mediterranean. Thus, these findings are in accordance with the palaeobotanical analysis of Schöningen II-1 (Mania 2007, 100-102).

Far fewer molluscan species were encountered in the following levels. Molluscs from the cold phases were not preserved, which is why only the molluscan fauna of the warm phases could be reconstructed. In Schöningen II-2 and Schöningen II-3 thermophilous forest snails still occur, indicating that the continental climate continued to affect the following phases. Especially in Schöningen II-4 the molluscan fauna is dominated by cold tolerant steppe species, which favour dry conditions. They include *Vertigo pygmaea, Pupilla muscorum* and *Helicopsis striata*. Interestingly enough some of the present forest snails in this level have a broad ecological tolerance and can also survive in open landscapes and cold temperate, boreal biotopes (e.g. species such as *Bradybaena fruticum* and *Arianta arbustorum*). Species favouring moist and swampy environments are present as well. In general the molluscan fauna of Schöningen II-2 to Schöningen II-4 thus indicate a cooler climate, which is again in accordance with the palaeobotanical record (Mania 2007, 103, 104).

2.3.3 Fish, amphibians and reptiles

Remains of fish, amphibians and reptiles at Schöningen 13II are not abundant. The fish species encountered in level Schöningen 13II-1 include *Esox lucius* (pike), *Perca fluviatilis* (perch) and *Rutilus rutilus* (common roach). Schöningen 13II-2 contains fish species indicating shallow waters with rich vegetation and muddy soils. The increasing occurrence of *Tinca tinca* (tench) and *Carassius carassius* (Crucian carp) in this level indicate that the water became more eutrophic. Small cyprinids are well represented and include *Alburnus alburnus* (common bleak) and *Gobio gobio* (gudgeon). In Schöningen 13II-2 *Lota lota* (burbot) indicates the presence of flowing water, as does *Cottus gobio* (bullhead) in Schöningen 13II-4. Level Schöningen 13II-4 yielded abundant remains of *Pungitius pungitius* (nine-spined stickleback), which may indicate a cooling of the climate (Böhme 2007, 108, 109).

Amphibians and reptiles are highly dependent on the temperature because they are cold-blooded. They are thus good indicators of microclimates and the character and development of terrestrial and aquatic biotopes. However, the species found in Schöningen have a broad ecological tolerance. These include *Rana temporaria* (common frog) and *Bufo bufo* (common toad), which are indicative of forest in an aquatic environment. This is also indicated by the presence of *Anguis fragilis* (slow worm) in Schöningen 13II-2. In addition, *Pelobates fuscus* (garlic toad) and *Lacerta agilis* (sand lizard) were found in Schöningen 13II-2, indicating open forest steppes. *Emys orbicularis* (European pond turtle) was encountered in Schöningen 13II-1 and 13II-2 and points to high summer temperatures and waters that are rich in vegetation. The presence of *Rana arvalis* (moor frog), *Lacerta vivipara* (common lizard) and *Vipera berus* (common adder) in Schöningen 13II-2 indicate the existence of bog areas with cold moist microclimates. Typical thermophilous species have not been encountered in Schöningen 13II (Böhme 2007, 109, 110).

2.3.4 Small mammal fauna

Schöningen 13II yielded the remains of small mammals from the orders Insectivora and Rodentia. The order Insectivora comprises four shrew species, including *Sorex minutus* (pygmy shrew), a species corresponding in size and morphology with *Sorex araneus* (common shrew), a species closely related to *Neomys fodiens* (water shrew) and a larger extinct shrew species. In addition, a humerus of *Talpa europaea* (mole) was found. Desman species are relatively abundant and are related to the modern species *Desmana moschata*, which nowadays occurs in Russia. The species also show characteristics of *Desmana thermalis* and therefore represent the evolution from the Early Pleistocene *Desmana thermalis* to the modern *Desmana moschata*. The presence of desman species indicates semi-aquatic conditions (Van Kolfschoten 2007, 112-114).

Species from the order Rodentia are most abundant in Schöningen 13II. Typical forest-dwelling species are present, including *Apodemus sylvaticus* (wood mouse) and *Clethrionomys glareolus* (bank vole). The extinct large beaver *Trogontherium cuvieri* and the modern beaver *Castor fiber* are both represented. Together with the presence of *Arvicola terrestris* (water vole) they indicate the presence of semi-aquatic environments. Other voles are present as well. *Microtus oeconomus* (tundra vole) prefers a moist biotope with dense vegetation growth. *Microtus arvalis* (common vole) and *Microtus agrestis* (field vole) tend to avoid dense forests and prefer an open biotope. Species indicating an open steppe environment with dry conditions include *Microtus gregalis* (narrow-headed vole) and *Lemmus lemmus* (Norway lemming). Both species had a broad distribution area during the Pleistocene, whereas nowadays they are only found in arctic biotopes (Van Kolfschoten 2007, 113, 114). The evidence from small mammals therefore supports the presence of a forest steppe during the Reinsdorf Interglacial.

Arvicola terrestris dominates the small mammal assemblage and could be used for biostratigraphic purposes. The European Early and Middle Pleistocene *Arvicola* species display a development in the enamel thickness of their first lower molars. In order to establish the ratio between the anterior and posterior width of the enamel "walls" an enamel thickness quotient index (S.D.Q.) was devised. The S.D.Q. values from Schöningen 12 and Schöningen 13II-1 have been determined and appeared to be in accordance with the S.D.Q. values of *Arvicola* remains at Bilzingsleben and Neede, a

Holsteinian site in the Netherlands. Additionally it could be established that the S.D.Q. values appear to decrease between Schöningen 13II-1 and Schöningen 13II-4, a trend which has also been observed in other sites in Germany and the Netherlands (Van Kolfschoten 2007, 115).

2.3.5 Large mammal fauna

Since 1992 large mammal remains have been excavated from the Middle Pleistocene sites at Schöningen, most of which date from the Reinsdorf Interglacial (Van Kolfschoten *et al*. 2007, 76). The mammalian remains were analysed by several researchers. Van Zijderveld and Kirkels (1996) investigated the large mammals from Schöningen 12B, whereas Van Kolfschoten (2007) conducted the research on the fauna of Schöningen 13I. Van Asperen (2004) and Voormolen (2008) analysed the material from level Schöningen 13II-4. Matze (2010) investigated the large mammal composition of Schöningen 13II-1 to 13II-4. Her analysis of Schöningen 13II-1 to 13II-3 will be combined with the analysis of this thesis and will therefore be discussed in Chapter 5.

The Schöningen 12B site is dated to the Reinsdorf Interglacial and yielded the typical interglacial species *Sus scrofa* (wild boar) and *Capreolus capreolus* (roe deer). In addition, *Ursus spelaeus* (cave bear), *Ursus thibetanus* (Asian black bear), *Panthera leo* (lion), *Equus mosbachensis* (Mosbach horse), *Stephanorhinus kirchbergensis* (forest rhino), *Cervus elaphus* (red deer) and *Bos primigenius* (aurochs) could be identified (Van Zijderveld and Kirkels 1996). In order to establish whether Schöningen 12B is contemporaneous with Schöningen 13II, the faunal compositions of both sites have been compared in paragraph 6.3.1.

The site Schöningen 13I is the oldest of the Middle Pleistocene sites and most likely dates to the Holsteinian Interglacial. Only four species were found there, including *Mammuthus trogontherii* (steppe mammoth), *Equus* sp., *Cervus elaphus* and *Bison priscus* (steppe bison). These species indicate a cool or cold climate and the presence of open landscapes (Van Kolfschoten *et al*. 2007, 76, 79).

Level Schöningen 13II-4, in which the wooden spears were found, mainly yielded the butchered remains of *Equus mosbachensis*. Other species occurring in this level include *Canis lupus* (wolf), *Vulpes vulpes* (red fox), *Mustela erminea* (ermine), *Mustela nivalis* (weasel), *Stephanorhinus kirchbergensis, Stephanorhinus hemitoechus* (steppe rhino), *Cervus elaphus, Bos primigenius* and *Bison priscus* (Van Asperen 2004; Voormolen 2008). In paragraph 5.1.4 this faunal composition has been compared with the older levels Schöningen 13II-1 to 13II-3.

2.3.6 Hominids

So far no hominid remains have been found at the Middle Pleistocene Schöningen lakeshore sites. However, evidence for human occupation at Schöningen has been established by the presence of artefacts and butchering traces on large mammal bones.

The oldest evidence for human occupation was encountered at the site Schöningen 13I, which dates to the Holsteinian Interglacial. The site was discovered in 1994 and yielded flint tools, flakes and burnt flint in association with large mammal remains (Thieme 2005, 118, 119).

In 1992 the site Schöningen 12 was excavated, which is dated to the Reinsdorf Interglacial. The site yielded flint artefacts and four wooden implements. These wooden tools comprise worked branches of *Abies alba* (common silver fir), which have a diagonal groove cut into one end. They could therefore have functioned as cleft hafts for holding flint tools or sharpening flakes (Thieme 2005, 119, 120). The implements were again found in association with numerous large mammal bones, some of which display traces of cutmarks and intentional fracturing to obtain the marrow (Thieme 2007, 198).

The site Schöningen 13II has been excavated since 1994 and was situated on the shore of a shallow lake (Thieme 2005, 120). The oldest level Schöningen 13II-1 did not yield any convincing artefacts, although the large mammal bones in this level display cutmarks and intentional fracturing. Schöningen 13II-1 is dated to the climatic optimum of the Reinsdorf Interglacial and is assumed to correlate with Schöningen 12. This would therefore imply that the humans were present in Schöningen during the start of the Reinsdorf Interglacial (Thieme 2007, 124).

Level Schöningen 13II-2 again yielded large mammal remains and flint artefacts, including a scraper and a retouched piece of debris. Additionally a few charred remains of wood were found, proving the use of fire during the Early Palaeolithic. In level Schöningen 13II-3 retouched pieces of flint debris and charred wood remains were encountered as well (Thieme 2007, 124, 125).

The most significant archaeological finds of Schöningen were situated in level Schöningen 13II-4. This level contained over 25.000 faunal remains, most of which originate from *Equus mosbachensis*. Many bones display cutmarks and intentional fracturing, indicating that the animals were killed and butchered. The flint artefacts encountered comprise a few points, many retouched scrapers and pieces of debris from retouching. No waste material was found, suggesting that the hominids brought the flint tools to the site where they were reworked or resharpened. Bone retouchers are present as well (Thieme 2005, 121).

In 1994 the first wooden implement was discovered. It was made out of the stem of a small spruce (*Picea* sp.), from which the branches were carefully removed. Both ends of the tool were sharpened to a point. The size and shape of the tool has led to believe that it functioned as a wooden throwing stick (Thieme 2005, 123). The most spectacular finds were done from 1995 until 1999, when eight wooden spears were found among the remains of large mammals (fig. 6). All spears are made of *Picea* sp. (spruce), except for one spear which is made of *Pinus* sp. (pine). The spears display a high degree of standardization. The tips are all made from the hardest part of the tree, whilst the surface of the spears are carefully worked and polished. In addition, the spears are well-balanced with the maximum thickness and weight near the tip, making them suitable for long-distance throwing. It therefore appears that they had been used to hunt horse populations, as evidenced by the remains of at least twenty butchered horses found in association with the spears (Thieme 2005, 123, 125, 128). The horse bones originate from mares, studs and foals, which suggests that an entire herd was killed within a single event. The hominid traces on the bones indicate that the horses were exploited for their meat, hides and marrow (Thieme 2005, 130).

Figure 6. One of the wooden spears found in level Schöningen 13II-4, discovered in 1995. The spear is surrounded by skeletal remains of large mammals, including a horse skull on the right (Thieme 2005, 124).

The presence of at least four possible hearth structures in Schöningen 13II-4 has been established as well. In the vicinity of these structures another wooden stick made of spruce was found, which displays carbonisation traces and polishing from extensive use. This implement possibly functioned as a spit to roast or smoke pieces of meat (Thieme 2005, 125, 126).

The wooden spears and the other artefacts were attributed to *Homo erectus* and they have re-initiated the hunter versus scavenger debate. It has usually been assumed that only modern humans were capable of hunting big game animals, whereas *Homo erectus* mainly relied on scavenging and opportunistic hunting of small animals. The evidence found at Schöningen refutes this view. *Homo erectus* instead appears to have been a sophisticated hunter and was able to organise, coordinate and execute the hunt on large mammals by using advanced long-distance weaponry (Thieme 2005, 129).

2.4 The Schöningen 13II mammalian taxa under consideration

Thousands of animal bone fragments have been discovered in Schöningen 13II-1 to 13II-5, most of which came from level Schöningen 13II-4 (Van Kolfschoten *et al*. 2007, 84). For this thesis part of the large mammal bones found in Schöningen 13II-1, 13II-2 and 13II-3 has been investigated (see paragraph 3.1). The analysed taxa represent the families Canidae, Elephantidae, Equidae, Rhinocerotidae, Suidae, Cervidae, and Bovidae. A few fragments are referred representatives of the suborder Caniformia; these bones can not be determined to genus or species level.

3. Material and methodology

3.1 Material

The author has examined the bone material from the suborder Caniformia and the families Canidae, Elephantidae, Equidae, Suidae and Bovidae. The faunal remains that have been analysed consist of 239 bone fragments (table 1). Of these, 138 bones are determinable to family, genus or species level. Unfortunately, 101 bone fragments can not be determined due to their fragmentary state, or because they lack features. These bones have been categorized under "large mammal". Costae and vertebrae are in many cases not identifiable to species level.

Part of the animal bone assemblages from Schöningen 13II-1, 13II-2 and 13II-3 had already been investigated by L. Matze in her Master thesis. The 88 bones from these levels that she determined to species level have been included in the analyses of this research (Matze 2010). A few bones of the family Mustelidae from Schöningen 13II-3 were determined by E. van Asperen in her Master thesis and have been included as well (Van Asperen 2004). The Rhinocerotidae bones were separately analysed by T. Boxmeer and the Cervidae bones were examined by E. den Engelsman. The material they studied from the levels under investigation have been described in Chapter 4 and will also be included in the analyses of this thesis (Boxmeer 2011; Den Engelsman 2011).

Altogether 496 bone fragments from Schöningen 13II-1, 13II-2 and 13II-3 have been analysed, of which 395 fragments could be determined to family, genus or species level (table 1). These bones will be used in the establishment of the Minimum Number of Individuals, whereas the large mammal material will only be included in the charts of the Number of Individual Specimens (Chapter 5).

Table 1. The Number of Individual Specimens (NISP) per family from Schö 13II-1, 13II-2 and 13II-3, analysed by different researchers.

	NISP author	NISP Matze	NISP Van Asperen	NISP Boxmeer	NISP Den Engelsman	Total NISP per family
Suborder Caniformia	7	2				9
Family Canidae	1					1
Family Mustelidae			4			4
Family Elephantidae	5	11				16
Family Equidae	81	8				89
Family Rhinocerotidae		42		83		125
Family Suidae	5	4				9
Family Cervidae		12			82	94
Family Bovidae	39	9				48
Large Mammal	101					101
Total NISP per researcher	239	88	4	83	82	496

3.2 Methodology

The Pleistocene bone material has been compared with the bones of modern species of the comparative collection of the Leiden University. Although these bones are not identical due to differences in size and morphology, it has still been possible to determine the Pleistocene bones to order, family, genus or species level. The bone material has been documented in lists including the quadrant, find number, taxon and skeletal element. Hominid and animal traces on the bones, such as cutmarks or gnawing marks, are described and documented as well. These lists have been incorporated in a database, after which the data of each separate level has been analysed.

The Schöningen levels are denoted with a specific code in the database, for example "Schö 13II-1". The "Schö" is an abbreviation of the Schöningen complex itself, whereas the 13 indicates the number of the archaeological site within this complex. The Roman number II denotes the channel of which the site is part of, whereas the 1, 2 or 3 stands for the particular deposition levels. These codes will be used in this thesis to refer to a specific level. In addition, each bone has received a unique findnumber, which will be used in this thesis to refer to a specific element. These elements can be found in the database through that findnumber.

The abbreviations sin. (sinister) and dex. (dexter) are used to denote respectively the left and right side of a skeletal element. Prox. (proximal) and dist. (distal) are the abbreviations used to denote the specific part of the bone. The dental elements of upper jaws are denoted with a capital character, whereas the dental elements of lower jaws are denoted with a small character.

Unfortunately, it has not been possible to take measurements of the skeletal elements of the families determined by the author. Some of the bones can therefore not be determined to species level and evolutionary trends can not be discerned. However, the measurements of T. Boxmeer (2011) and E. den Engelsman (2011) have been incorporated in this thesis. Boxmeer was able to determine some of the dental elements of the Rhinocerotidae family to species level on the basis of morphological characteristics and size measurements using data presented by Van der Made (2010). Den Engelsman was able to determine most of the Cervidae bones to species level on the basis of morphological characteristics and measurements presented by Heintz (1970).

4. Description of the large mammal remains

In this chapter the large mammal remains from the levels Schöningen 13II-1, 13II-2 and 13II-3 will be described. For each species a list of material has been provided. The taxonomic description presents data on the variety of species and skeletal elements present, as well as the condition of the material. Information will also be given on morphological characteristics of each species, in particular the teeth and feet. In addition, per species a description will be given of the specific biotopes they inhabited.

4.1 Order Carnivora

The order Carnivora comprises a number of families e.g. Canidae, Mustelidae, Felidae and Hyaenidae. These are predators with generally strong, curved canines and secodont molars for the consumption of meat. Carnivores possess four to five digits per foot (Guérin and Patou-Mathis 1996, 155).

4.1.1 Family Canidae

4.1.1.1 *Canis lupus* (Linnaeus, 1758)

Canis lupus, the wolf, is a dog-like carnivore appearing in the Middle Pleistocene. The species has a wide ecological tolerance, as it can adapt to different environments. Therefore the wolf is not a good climatic indicator. Its diet consists of large mammals such as deer, but it also feeds on rodents (Guérin and Patou-Mathis 1996, 158; Kurtén 1968, 110).

Material:

Schöningen 13II-2: vertebra lumbalis (14841).

Description and remarks:

A well preserved vertebra lumbalis (14841) from Schö 13II-2 can be assigned to a wolf, based on size and morphological characteristics (fig. 7). No cutmarks or gnawing traces are present on this element.

Figure 7. Vertebra lumbalis (14841) of *Canis lupus* from Schö 13II-2. Lateral view. Scale bar in cm. Photo by author.

4.1.2 Suborder Caniformia

4.1.2.1 Caniformia gen. et sp. indet.

Material:

Schöningen 13II-1: dentes indet., sin. (12694); canine fragment (16320).

Schöningen 13II-3: 4 dentes indet. (14466, 14468, 14479, 14482); vertebra lumbalis (12782).

Description and remarks:

The canine (16320) from Schö 13II-1 might belong to a marten species (Mustelidae, *Martes* sp.) and is shown in fig. 8. The teeth discovered in Schö 13II-1 and Schö 13II-3 can not be assigned to specific carnivore species, but probably originate from the suborder Caniformia, the dog-like species. No Felidae or cat-like species have been found yet in the Schöningen 13II levels (Matze, 2010).

Figure 8. Fragment of a canine (16320) of a small carnivore from Schö 13II-1. Scale bar 1 cm. Photo by author.

4.2 Order Proboscidea

The order Proboscidea comprises the extinct families Mastodontidae (or Mammutidae), Gomphotheriidae and Elephantidae, the last of which includes the genera *Elephas* and *Mammuthus* (Guérin and Patou-Mathis 1996, 144-149). The family Elephantidae was the most common during the Pleistocene (Kurtén 1968, 130).

Elephantidae are characterized by their large tusks and high-crowned molars. They possess five digits on each foot, of which the middle third is the strongest. Digits one and two consist of two phalanges, the other digits have three phalanges (Guérin and Patou-Mathis 1996, 141, 142).

4.2.1 Family Elephantidae

4.2.1.1 Elephantidae gen. et sp. indet.

The Elephantidae species occurring in Europe during the Middle Pleistocene include *Elephas antiquus* and *Mammuthus* species. The straight-tusked elephant *Elephas antiquus* (Falconer and Cautley, 1847) first appeared in Europe during the Cromerian. It was a typical interglacial species occurring in temperate parklands and forests. During glacials the species would retreat to Mediterranean areas. It became extinct during the Weichselian (Kurtén 1968, 134, 135).

The mammoth, *Mammuthus* sp., was adapted to steppe and tundra environments, unlike *Elephas antiquus*. Its hypsodont teeth possessed tightly compressed lamellae, necessary for the consumption of siliceous grass (Kurtén 1968, 130, 131). Thus, the elephant remains under consideration here could either originate from a forest-dwelling or a steppe-dwelling species.

Material:

Schöningen 13II-1: 3 indet. fragments (12626, 12627, 12642); dist. epiphyseal fragment of a humerus, sin. (12646); middle shaft fragment of a humerus, dex. (12641).

Description and remarks:

The Elephantidae material is very fragmented and severely weathered. Because of the unusually large size and thickness of the bones, it has still been possible to determine the material as from an elephant species. It can not be established whether the bones originate from *Mammuthus* sp. or from *Elephas antiquus*.

4.3 Order Perissodactyla

The order Perissodactyla, or the odd-toed ungulates, consists of the families Tapiridae, Equidae and Rhinocerotidae. Unlike the Artiodactyla, the number of toes of the Perissodactyla is generally odd and the axis of the foot follows the third or central toe (Kurtén 1968, 139).

The Rhinocerotidae are among the most primitive Perissodactyla. They are characterized by their one or two nasal horns and lophodont molars. They possess three digits per foot (Guérin and Patou-Mathis 1996, 111, 112, 114). Their large and robust bones are generally well preserved (Kurtén 1968, 140).

The Equidae are characterized by their lophoselenodont hypsodont dentition, allowing them to consume grasses. They possess one digit per foot, the middle third digit (Guérin and Patou-Mathis 1996, 121, 123).

4.3.1 Family Equidae

The family Equidae has been divided into three different groups, comprising the caballoid or true horses, the stenonid horses or the zebra's and the asinid horses, the asses. This separation is based on specific differences in the dental morphology of these three groups (fig. 9). According to Smit (1996), the upper molars of caballoid horses possess a relatively long protocone in comparison with the upper molars of stenonid and asinid horses. The lower molars of caballoid horses have a U-shaped double knot, which tends to be V-shaped on the lower molars of the other equids. The vestibular groove on the lower molars of caballoid horses and asinid horses is rather shallow in comparison with the deep groove of the stenonid horses (Smit 1996, 53-55).

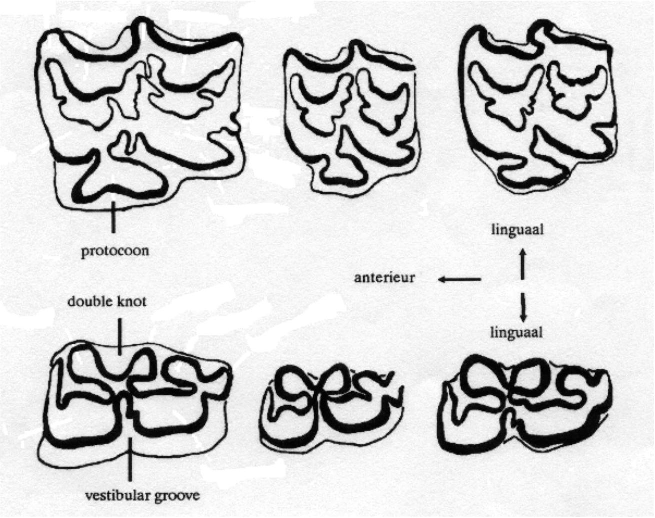


Figure 9. Morphological differences between the molars of caballoid, stenonid and asinid horses. Upper three molars from left to right: M1 of a caballoid horse, M1 of a stenonid horse and M1 of an asinid horse. Lower three molars from left to right: m1 of a caballoid horse, m1 of a stenonid horse and m1 of an asinid horse (Smit 1996, 55).

According to Eisenmann (1991a) the caballoid horses can be divided into three types. A type I horse is characterized by robust metapodials and small teeth with shorter protocones on the third and fourth premolars than on the first and second molars. Horses of type I are found in temperate climates and include species such as *Equus taubachensis* and *Equus germanicus*. A type II horse is characterized by relatively long protocones on the third and fourth premolars and generally shorter protocones on the first and second molars. Its muzzle is short and large. The horses of this type prefer a cold climate, with the exception of a horse found in Weimar-Ehringsdorf which preferred a temperate climate. Examples of a type II horse are *Equus chosaricus* and *Equus arcelini*. A type III horse possesses relatively short protocones on the third and fourth premolars, which are even shorter on the first and second molars. The horses of type III are found in cold climates and include the species *Equus mosbachensis, Equus achenheimensis* and *Equus steinheimensis* (Eisenmann 1991a, 749, 750, 752, 753).

The skeletal elements of Equidae are quite distinctive and therefore easy to determine. The Equidae bones are easily distinguishable from the bones of Rhinocerotidae, as these differ greatly in morphological characteristics. In addition, Equidae bones are more slender than the broad, robust Rhinocerotidae elements. The Equidae elements are morphologically distinct from the bones of the Artiodactyla, especially concerning dental elements and feet. Equidae bones are generally broader and shorter than Cervidae bones.

However, the long bones of Equidae, such as tibia and humerus, can be similar in size to the long bones of Bovidae. They are still distinguishable on the basis of morphological characteristics.

4.3.1.1 *Equus mosbachensis* (Von Reichenau, 1915)

Equus mosbachensis, the Mosbach horse, was a caballoid horse of relatively large size. The species occurred during the Middle Pleistocene period. According to Eisenmann (1991a) *Equus mosbachensis* was a type III horse with a long and narrow muzzle and long metapodials with primitive proportions. Type III horses are often found in cool or cold steppe environments with open forests (Eisenmann 1991a, 752, 753).

Material:

Schöningen 13II-1: middle fragment of a scapula, sin. (16807); dist. fragment of a humerus, sin. (12650); dist. epiphyseal fragment of a humerus, dex. (12638); dist. shaft fragment of a radius, sin. (16815); prox. shaft fragment of an ulna (15357); pelvis ilium fragment (16806); dist. epiphyseal fragment of a femur, dex. (12645); prox. epiphyseal fragment of a femur, dex. (12643); 2 patella, dex. (16916, 16077); 2 refitted astragalus fragments (15665, 16284).

Schöningen 13II-2: cranium fragment, palatum (685); cranium fragment (15980); cranium fragment, maxilla (651); 3 refitted mandibula fragments (661, 662, 663); 4 mandibula fragments (652, 665, 667, 12603); mandibula fragment with p2, sin. (12551); dentes indet. (14839); molar indet. (12563); 3 upper molars (14837, 12559, 12557); i3, dex. (12549); I2, dex. (12560); I3, dex. (14827); I3, dex. and molar indet. (14838); P2, sin. (701); 2 p4, sin. (12552, 668); 2 p4, dex. (12556, 12574); m1, sin. (660); m1, dex. (659); m2, sin. (14844); m3, sin. (14843); m3, dex. (655); os hyoideum (12533); 2 scapula, sin. (669, 631); dist. epiphyseal fragment of a humerus, dex. (14861); dist. epiphyseal fragment of a humerus (12528); os carpi intermedium, dex. (15506); shaft of a tibia with missing unfused epiphyses, sin. (16006); dist. epiphysis of a tibia, sin. (12527); 2 refitted proximal epiphyseal tibia fragments, sin. (16025, 16026); phalanx I (16001); phalanx II (15999); phalanx III (16002).

Schöningen 13II-3: fragment of a cranium, premaxillare (15540); 2 fragments of mandibles (15526, 14427); 2 I2, dex. (12746, 15550); p2, sin. (734); p3, dex. (15528); p3, sin. (15525); p4, sin. (804); fragment of a vertebra lumbalis (15518); articular part of a costa (12752); dist. shaft fragment of a humerus, dex. (15548); middle shaft fragment of a radius and ulna, dex. (724); 2 os carpi intermedium, dex. (727, 15520); os carpale tertium, dex. (775); metacarpale II without dist. part, dex. (17774); prox. epiphyseal fragment of a metacarpale IV, sin. (16734); 2 metacarpus, dex. (721, 728); prox. shaft fragment of a tibia, sin. (15542); astragalus, sin. (15547); prox. part of a metatarsale II, sin. (15532); prox. shaft fragment of a metatarsus, dex. (16737); phalanx I, dex. (725); phalanx II, dex. (726); 2 phalanx II (15519, 15523); sesamoideum (16647).

Description and remarks:

The skeletal elements have been compared with the bones of the modern *Equus caballus*, with which they corresponded in size and morphology. The material of Schö 13II-1 mainly consists of small fragments that are still determinable. The material shows little cracks from weathering. The Schö 13II-2 material is well preserved and consists of both fragmented and complete elements. The bones found in Schö 13II-3 are generally less well preserved than the bones from Schö 13II-2. However, they mostly consist of almost complete or complete elements, allowing a rather exact identification.

Generally the material is fairly complete. In Schö 13II-2 and Schö 13II-3 the material mainly consists of individual dental elements, which are entirely absent in Schö 13II-1. A mandibula fragment from Schö 13II-2 contains a fourth premolar (12551). Long bones are very abundant in all levels, in particular the elements humerus, radius and tibia. Compact bones are less well represented than long bones, but still often encountered.

Figure 10. Tibia diaphysis with missing unfused epiphyses, sin. (16006) of a juvenile *Equus mosbachensis* from Schö 13II-2. Anterior view. Scale bar in cm. Photo by author.

Adult horses dominate the assemblage. All of the bones have completely fused epiphyses, with the exception of one element. A left tibia diaphysis (16006) from Schö 13II-2 is missing both proximal and distal epiphyses, which had not been fused yet (fig. 10). This element therefore represents a juvenile horse. Two refitted left proximal epiphyseal fragments of a tibia (16025 and 16026) and a left distal epiphysis of a tibia (12527) are present in Schö 13II-2 as well, which may have associated with the tibia diaphysis.

Level Schö 13II-1 has yielded several fragments that can be refitted. A right proximal epiphyseal fragment (12645) and a right distal epiphyseal fragment (12643) both belong to a femur. The femur fragments probably associate with each other, as they correspond in size and weathering stage. Two astragalus fragments (15565 and 16284) can be refitted. Two right patella have been encountered, indicating the presence of at least two individuals in level Schö 13II-1.

Most of the Equidae material comes from Schö 13II-2. A well preserved cranium fragment with visible alveolar sockets for the incisors has been found in this level (fig. 11). Three mandibula fragments (661, 662, 663) can be refitted. Phalanx I (16001), phalanx II (15999) and phalanx III (16002) can be rearticulated and appear to have belonged to a hind limb (fig. 12).

Figure 11. Cranium fragment (685) of *Equus mosbachensis* from Schö 13II-2. Top view. Scale bar in cm. Photo by author.

Figure 12. Phalanges I, II and III (16001, 15999, 16002), belonging to a hind limb of *Equus mosbachensis* from Schö 13II-2. Anterior view. Scale bar in cm. Photo by author.

Level Schö 13II-2 has yielded two left scapulae and the dental elements present originate from minimally two individuals.

Schö 13II-3 has yielded a phalanx I (725) and a phalanx II (726), which most probably originate from one individual. A fragment of a premaxillare (15540) could perhaps have belonged to a stallion, as it may contain an alveolar socket for a canine. The dental elements and the presence of two right metacarpi indicate the existence of at least two individuals in Schö 13II-3.

The uniform large size of the bones and the caballoid morphology of the dental elements indicates that all of the material should be assigned to *Equus mosbachensis* (fig. 13, compare with fig. 9). This has also been indicated by Matze (2010) for part of the assemblage she investigated.

Figure 13. m1, dex. (659) of *Equus mosbachensis* from Schö 13II-2. The U-shaped double knot and shallow vestibular groove are typical characteristics of a caballoid species. Scale bar in cm. Photo by author.

The material is not assigned to the much smaller stenonid horse *Equus hydruntinus*, which also appeared during the Middle Pleistocene. Stenonid and asinid horses are generally confined to warm and dry environments. Given that caballoid horses are able to live in colder environments as well, one can assume that the material belongs to a caballoid horse species (Forsten 1996, 162; Smit 1996, 54).

Equus mosbachensis is the only equid species that has been found yet on the Schöningen site, as concluded by Matze (2010), Van Asperen (2004) and Van Zijderveld (1995). They have based their conclusion on the measurements of the greatest length of the horse elements found in Schöningen 12B and Schöningen 13II (table 2a). These measurements have been compared with the measurements made by Eisenmann (1991b) of different horse species, including the fossil horses *Equus mosbachensis* and *Equus germanicus* as well as the modern horses *Equus hemionus onager* and *Equus przewalskii* (table 2b). From the measurements it appears that the skeletal elements of *Equus mosbachensis* are longer than the elements of the other horses. The Schöningen horse elements appear to be almost identical in length to the elements of *Equus mosbachensis*, although the Schöningen elements are somewhat smaller (compare table 2a and table 2b). More specific measurements of the metapodials and phalanges ensured that the Schöningen horse material could be assigned to *Equus mosbachensis*. It is thus very likely that the newly analysed horse material for this thesis originates from *Equus mosbachensis* as well.

Table 2a. Measurements in mm of the greatest length of the long bones and first anterior (an.) phalanges and the greatest width of the third phalanges of the horse species from the assemblages of Schöningen 12B (Van Zijderveld 1995, 29-30), Schöningen 13II-3 (Matze 2010) and Schöningen 13II-4 (measurements of the metacarpus and first phalanges from combined data of Van Asperen (2004) and Matze (2010)). The many elements found in Schöningen 13II-4 display a large size variation, especially the metapodials and phalanges. Therefore, the minimum and maximum measurements have been added for Schö 13II-4.

	Schö 12B		Schö 13II-3		Schö 13II-4		Schö 13II-4	
Element	**n**	**mean**	**n**	**mean**	**n**	**mean**	**min**	**max**
Humerus	-	-	-	-	2	325,0	325	325
Femur	-	-	-	-	3	451,7	450	455
Radius	-	-	-	-	-	-	-	-
Tibia	-	-	-	-	2	402,5	400	405
Metacarpus	1	262,3	1	256,0	8	250,1	236	264
Metatarsus	2	296,4	-	-	7	300,0	290	330
Phalanx I an.	4	94,2	-	-	-	-	-	-
Phalanx I	-	-	-	-	18	92,4	83,7	99
Phalanx III	-	-	-	-	6	88,4	79,1	95,2

Table 2b. Measurements in mm of the greatest length of the long bones and first anterior (an.) and posterior (po.) phalanges and the greatest width of the third phalanges of various horse species (Eisenmann 1991b, 26).

	Equus mosbachensis		*Equus germanicus*		*Equus hemionus onager*		*Equus przewalskii*	
Element	**n**	**mean**	**n**	**mean**	**n**	**mean**	**n**	**mean**
Humerus	4	322,8	5	278,3	10	242,0	14	260,0
Femur	2	458,0	3	384,2	9	329,0	14	355,7
Radius	6	382,2	13	326,8	10	295,0	13	309,0
Tibia	6	401,7	6	343,6	10	313,0	14	321,7
Metacarpus	39	261,0	16	221,6	16	212,0	36	215,5
Metatarsus	42	308,5	14	267,9	16	247,5	36	256,6
Phalanx I an.	11	98,6	27	85,7	15	76,5	23	78,1
Phalanx I po.	14	95,6	24	83,2	15	71,2	23	73,8
Phalanx III	1	87,0	17	84,8	12	54,3	20	70,8

4.3.2 Family Rhinocerotidae

The bones of the family Rhinocerotidae are easily determinable. The skeletal elements are much larger and more robust than the elements of the other species present in Schöningen, with the exception of the Elephantidae species. In addition, the distinct morphology of the teeth and feet can not be confused with any other animal.

Determining the exact rhino species is much more difficult. Boxmeer (2011) has been able to determine the dental material of the Rhinocerotidae family to species level by measuring the elements according to Van der Made (2010) (fig. 14). These measurements have been compared with the biometric data of the dental elements of different Rhinocerotidae species provided by Guérin (1980).

Boxmeer has established the presence of *Stephanorhinus kirchbergensis* and *Stephanorhinus hemitoechus*. The dental elements of these species can be differentiated from each other on the basis of size and morphological characteristics. In general, it can be stated that *Stephanorhinus kirchbergensis* is larger in size than *Stephanorhinus hemitoechus*. However, the size variations of both species do display some overlap, which is why morphological differences between the dental elements need to be established as well. According to Van der Made (2010) the enamel of *S. kirchbergensis* is thin and smooth, whereas the enamel of *S. hemitoechus* is thick and rugose. In addition, the patterns on the occlusal surface of the dental elements are different for both species (Van der Made 2010, 451-453).

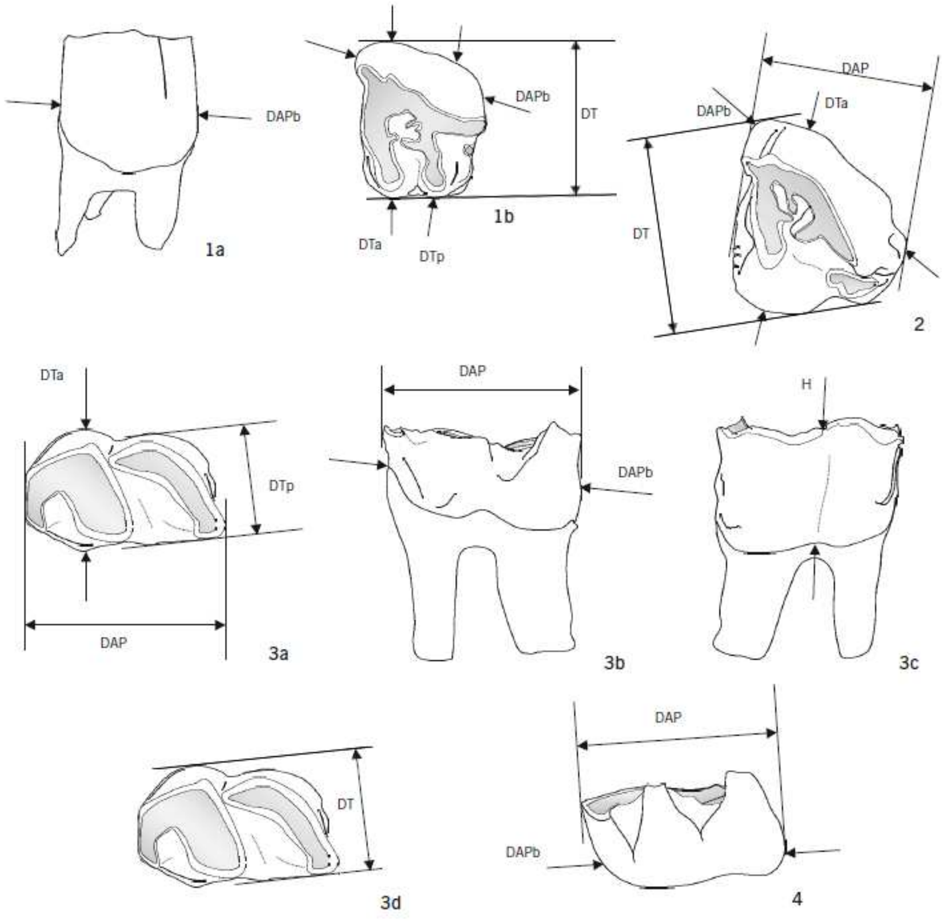


Figure 14. Methodology of measuring the dental elements of the Rhinocerotidae family.
Key: 1: P3; 2: M3; 3: m1; 4: m3.
Abbreviations: DAP: Antero-Posterior Diameter; DAPb: Maximum DAP measured on the buccal side; DT: Transverse Diameter; DTa: The maximum DT of the anterior lobe of the tooth; DTp: The maximum DT of the posterior lobe of the tooth; H: height (Van der Made 2010, 439).

4.3.2.1 *Stephanorhinus kirchbergensis* (Jäger, 1839)

Stephanorhinus kirchbergensis, the forest rhino, made its first appearance during the early Middle Pleistocene. Unlike the steppe rhino it possessed low-crowned molars and a high head posture, enabling it to consume bushes and twigs. It was a typical interglacial species confined to bushed environments and open forests. The species became extinct during the end of the Pleistocene (Guérin and Patou-Mathis 1996, 117).

In spite of the fact that forest and steppe rhinoceroses did not share the same biotope, they sometimes occurred simultaneously. Generally, when the forest rhino is abundant in an assemblage the steppe rhino is scarce, and vice versa. This perhaps indicates that both species were able to adapt to a different environment, at least to a certain degree (Kurtén 1968, 142).

Material:

Schöningen 13II-1: d1, dex. (16827).

Schöningen 13II-3: m2, sin. (14426); m3, sin. (14421); 2 m3, dex. (14422, 14429).

Measurements:

Table 3. Measurements in mm of the dental elements of *Stephanorhinus kirchbergensis* according to Van der Made (2010) (After Boxmeer 2011, 40, 41).

Location	FindNr.	Element	DAP	DT	DTa	DTp	H
Schö 13II-1	16827	d1, dex.	20.6	12.6	12.7	11.2	-
Schö 13II-3	14426	m2, sin.	53.6	38.5	32.6	34.2	35.4
Schö 13II-3	14421	m3, sin.	63.2	38.3	34.9	35.9	36.8
Schö 13II-3	14422	m3, dex.	59.7	35.3	34	33.9	28.5
Schö 13II-3	14429	m3, dex.	61.0	37.1	>33.1	35.4	35.7

Description and remarks:

A few dental elements have been assigned to *Stephanorhinus kirchbergensis* on the basis of morphological characteristics and measurements (table 3). The metric values of the (pre)molars fall within the range of *Stephanorhinus kirchbergensis*, as determined by Guérin (1980). The dental elements are too large to have belonged to *S. hemitoechus* and possess a dental pattern on the occlusal surface characteristic of *S. kirchbergensis*. The enamel of the elements is smooth instead of rugose, which is typical for *S. kirchbergensis* (Boxmeer 2011, 29, 31).

Schö 13II-1 contains one deciduous lower first premolar (16827) from the right side, originating from a juvenile individual. Four well preserved lower molars of *Stephanorhinus kirchbergensis* have been encountered in Schö 13II-3. The posterior wear facet of a lower second molar (14426) and the anterior wear facet of a lower third molar (14421) from the left side fit very well and associate with each other (Boxmeer 2011, 29). The presence of two lower third molars from the right side (14422 and 14429) point to the presence of at least two individuals in this level.

4.3.2.2 *Stephanorhinus hemitoechus* (Falconer, 1868)

Stephanorhinus hemitoechus, also known as the steppe rhino, appeared in Europe during the Holsteinian Interglacial. The species had subhypsodont molars and a low head posture. Thus, it was adapted to consume abrasive steppe grasses and confined to temperate open grasslands. The steppe rhino was not able to adapt to cold environments, as its remains have never been encountered in tundra's. During the end of the Pleistocene the rhino disappeared (Guérin and Patou-Mathis 1996, 117, 119; Kurtén 1968, 143).

Material:

Schöningen 13II-1: associating P3, P4, M1, M2 and M3, sin. (15340, 15379 and 15377, 15360, 15382, 15376); m3, dex. (14611); upper dentes (16803).

Measurements:

Table 4. Measurements in mm of the dental elements of *Stephanorhinus hemitoechus* according to Van der Made (2010) (After Boxmeer 2011, 40).

Location	FindNr.	Element	DAP	DAPb	DT	DTa	DTp	H
Schö 13II-1	15340	P3, sin.	38.2	-	47.1	47.1	46.9	-
Schö 13II-1	15379	P4, sin.	48.1	-	52.9	<56.4	49.1	-
Schö 13II-1	15360	M1, sin.	54.6	-	55.3	54.3	52.1	-
Schö 13II-1	15382	M2, sin.	51.1	-	59.3	-	-	-
Schö 13II-1	15376	M3, sin.	49.3	55.5	-	50.1	-	-
Schö 13II-1	14611	m3, dex.	55	-	26.7	26.7	26.2	27.5

Description and remarks:

Several well preserved (pre)molars from Schö 13II-1 can be assigned to *Stephanorhinus hemitoechus* on the basis of morphological characteristics and measurements (table 4). The metrics of the (pre)molars fall within the range of *S. hemitoechus* as determined by Guérin (1980) and the elements are smaller than the (pre)molars of *S. kirchbergensis*. In addition, the enamel is rugose instead of smooth, a typical characteristic of *S. hemitoechus*. The morphology of the occlusal surface of the (pre)molars mainly corresponds with the morphology of *S. hemitoechus* (Boxmeer 2011, 36, 37, 39).

The dental elements are from the left upper jaw of one adult individual, as they are similar in size and the wear facets of the elements fit each other well (fig. 15 and fig. 16, table 4). Another lower third molar from the right side (14611) may belong to the same individual, although this can not be confirmed. One of the dental elements (16803) can not be determined. Thus, at least one individual is present in Schö 13II-1.

Figure 15. M2, sin. (15382) of *Stephanorhinus hemitoechus* from Schö 13II-1. Occlusal view. Scale bar in cm. Photo T. Boxmeer.

Figure 16. M3, sin. (15376) of *Stephanorhinus hemitoechus* from Schö 13II-1. Occlusal view. Scale bar in cm. Photo T. Boxmeer.

4.3.2.3 *Stephanorhinus* sp.

Material:
Schöningen 13II-1: molar indet. (16211); upper molar, sin. (16826); P4, dex. (16833); 2 M2, sin. (16338, 16825); M2, dex. (16836); M3, sin. (14648); 2 refitted atlas fragments (14642, 14643); scapula fragment, sin. (15431); middle shaft fragment of a humerus, dex. (16817); radius without prox. part, sin. (15336); ulna with missing unfused epiphysis, sin. (16302); os carpi radiale, dex. (15334); os carpi intermedium, dex. (15347); os carpi ulnare, dex. (15425); os carpi accessorium, dex. (14690); os carpale quartum, sin. (15387); dist. epiphysis of a metacarpale II, dex. (16229); metacarpale IV without dist. part, sin. (15335); metacarpale IV, dex. (16106); metacarpus without dist. part, dex. (15371); patella, sin. (15349); 2 prox. epiphyseal tibia fragments (15370, 15439); middle shaft fragment of a tibia, sin. (12652); astragalus, dex. (16220); os tarsale quartum, dex. (16222); prox. epiphysis of a metatarsale II, sin. (15666); dist. epiphysis of a metatarsale IV, dex. (15343); metatarsus, sin. (15438); 2 phalanx I (16305, 15393); 2 phalanx I, sin. (16314, 16108); phalanx I, dex. (16203); phalanx II, sin. (15375); 4 phalanx II (16296, 16306, 15365, 15344); phalanx III, dex. (16230).
Schöningen 13II-2: 2 molars, indet. (17172, 15504); costa fragment (16024); humerus, sin. (16025); prox. epiphysis of a metatarsale II, sin. (16780).
Schöningen 13II-3: 7 (pre)molar fragments, indet. (14425, 14433, 14485, 16705, 16651, 16721, 735); 2 molar fragments, sin. (16724, 16738); middle shaft fragment of a humerus, sin. (16701); humerus with missing unfused prox. epiphysis, dex. (14834); os carpi accessorium, sin. (837); metacarpale II without dist. part, sin. (822); metacarpale IV without dist. part, sin. (825); middle shaft fragment of a metacarpale IV, dex. (824); tibia, sin. (776); astragalus, sin. (14519); calcaneum, sin. (12745); os tarsi centrale, dex. (16715); os tarsale tertium, sin. (14490); metatarsale II without dist. part, dex. (16707); metatarsus without dist. part, sin. (14486); 2 phalanx I (838, 16747); phalanx II, sin. (764).

Description and remarks:
The material corresponds in size and morphology with Pleistocene Rhinocerotidae bones. Most of the Rhinocerotidae material can not be assigned to a particular species, because the differentiation between the species mainly relies on the dental elements. The other elements are more difficult to identify to species level.

The Rhinocerotidae material of all levels is well preserved, as is generally the case for these large and robust bones (Kurtén 1968, 140). Unfortunately, the dental elements are either too fragmented or lack features to identify them to species level. The material mainly consists of dental elements and compact bones. Long bones are encountered as well, whereas costae and vertebrae are underrepresented. Cranium and femur fragments are entirely absent. Sternum, sacrum and pelvis remains have not been encountered as well.

The assemblage consists mainly of adults, with the exception of two elements originating from juveniles. A left ulna (16302) from Schö 13II-1 is missing its unfused epiphysis. In Schö 13II-3 a right humerus (14834) has been found, which is missing its proximal unfused epiphysis.

Level Schö 13II-1 has yielded the most *Stephanorhinus* sp. material. At least two individuals are present in this level, represented by the occurrence of two upper second molars from the left side (16338 and 16825). Two atlas fragments (14642 and 14643) can be refitted.

The material from level Schö 13II-2 is scarce. Only a few *Stephanorhinus* sp. elements are found in this level, which belong to at least one individual.

As shown, level Schö 13II-3 has yielded a humerus with a missing unfused epiphysis from a juvenile individual. All of the other elements present are fully fused. Thus, at least two individuals are present in Schö 13II-3.

4.4 Order Artiodactyla

The order Artiodactyla, or the even-toed ungulates, includes the families Camelidae, Giraffidae, Hippopotamidae, Bovidae, Cervidae and Suidae. These groups are called even-toed ungulates, because the number of toes is even and the axis of the foot passes through the third and fourth toes. The first toe is generally absent, whereas the second and fifth toes are only present in primitive species (Guérin and Patou-Mathis 1996, 33; Kurtén 1968, 153).

The Suidae and Hippopotamidae are among the more primitive artiodactyls, as they possess four metapodials and four digits per foot. The third and fourth digits are much larger and stronger than the reduced second and fifth digits. The primitive artiodactyls are also characterized by their brachyodont and bunodont teeth, which are necessary for an omnivorous diet (Guérin and Patou-Mathis 1996, 33, 34, 37).

The Bovidae and Cervidae are among the more evolved artiodactyls. Their second and fifth digits have disappeared and therefore only their third and fourth digits are functional. The third and fourth metapodials are fused. The Cervidae are characterized by their temporary antlers, whereas the Bovidae possess permanent horns. Both Cervidae and Bovidae have selenodont teeth for their herbivorous diet. The more low-crowned, brachyodont teeth of Cervidae confines them to woodland areas. The Bovidae possess more hypsodont teeth for the consumption of grass, confining them to open environments (Guérin and Patou-Mathis 1996, 33, 34, 37; Kurtén 1968, 167).

4.4.1 Family Suidae

The Suidae bones are not difficult to determine, due to their distinct size and morphology. The material can be differentiated from other Artiodactyla, as the bones are much smaller and shorter than the Bovidae and Cervidae bones. The Suidae material is similar in size to the bones of *Capreolus capreolus*, but the Suidae bones are robust, whereas the *Capreolus capreolus* material is slender in appearance.

4.4.1.1 *Sus scrofa* (Linnaeus, 1758)

Sus scrofa, the wild boar, appeared in Europe during the Middle Pleistocene (Guérin and Patou-Mathis 1996, 43). It is an omnivorous species, as it feeds on both plants and small animals, including amphibians and reptiles. Wild boar is a typical interglacial and interstadial forest species, as it can not survive strong winters. They are unable to withstand thick snow covers because of their short legs. Frost makes it impossible for them to search for food on the ground, on which they highly depend (Kurtén 1968, 154).

Material:

Schöningen 13II-1: radius, sin. (16829); ulna, sin. (16828); os carpi intermedium, sin. (16831); phalanx I, dex. (16819); phalanx I, sin. (16810).

Description and remarks:

The skeletal elements have been compared with the bones of modern *Sus domesticus*, with which they correspond in size and morphology. The material is very well preserved, as all the elements are complete and hardly display cracking or flaking. The bones of *Sus scrofa* are only present in Schö 13II-1 and probably originate from one individual. Both of the first phalanges (16819, 16810) look very similar in size, shape and weathering stage, whereas the radius (16829) and ulna (16828) can be refitted (fig. 17). The individual is an adult, which can be discerned from the epiphyseal fusion of the radius, ulna and phalanges.

Figure 17. Radius and ulna, sin. (16829 and 16828) of *Sus scrofa* from Schö 13II-1. Lateral view. Scale bar in cm. Photo by author.

4.4.2 Family Cervidae

The Cervidae bone material is generally well determinable. The Cervidae bones are longer and slender than the large and robust bone material of the Bovidae and Equidae and the robust, small bone material of the Suidae. Den Engelsman (2011) has indicated the presence of the Cervidae species *Cervus elaphus, Megaloceros giganteus* and *Capreolus capreolus.* These species can be distinguished from each other on the basis of the size of the skeletal elements. *Megaloceros giganteus* is the largest species, *Cervus elaphus* is medium-sized and *Capreolus capreolus* is the smallest species.

The identification of the Cervidae species is mainly based on their antlers. The species under consideration have characteristic antlers which can be easily distinguished from each other (fig. 18). The differences between the antlers will be outlined in more detail in the following descriptions of the Cervidae species. The terminology of Lister (1990) has been used to describe the antlers of *Cervus elaphus* (fig. 19).

A typical characteristic of antlers is that they are shed each year by the male, after which a new set is grown. As the deer gets older, these antlers will increase in size and complexity, developing more tines. When the antlers have reached their maximum growth, they will remain in that state during maturity, until they reduce in size when the animal reaches its old age (Lister 1996, 123).

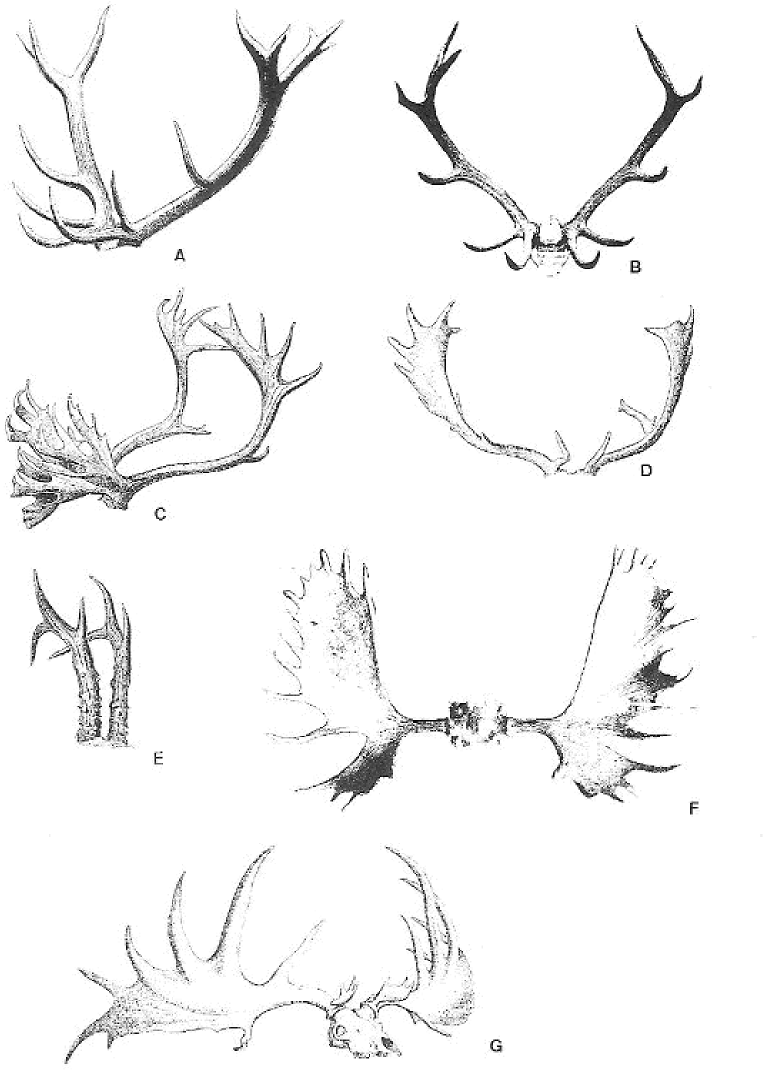


Figure 18. Antlers of the different Cervidae species.
A: *Cervus elaphus*; B: *Cervus elaphus*; C: *Rangifer tarandus*; D: *Dama dama*; E: *Capreolus capreolus*; F: *Alces alces*; G: *Megaloceros giganteus* (Guérin and Patou-Mathis 1996, 54).

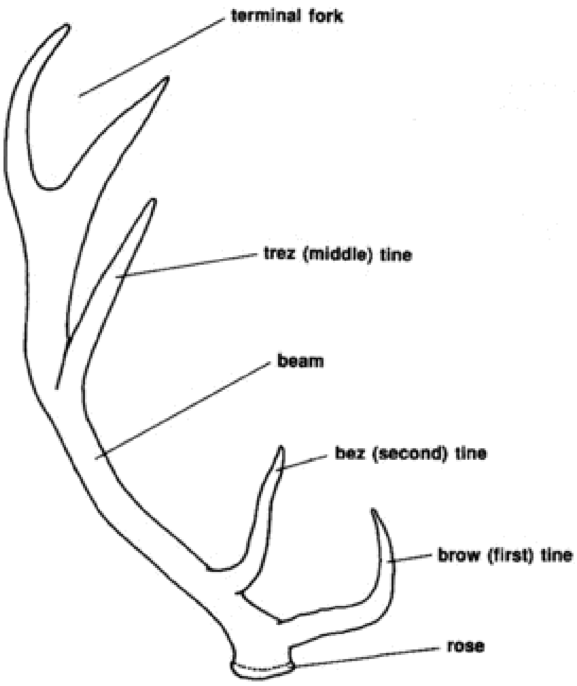


Figure 19. Terminology of the antlers of *Cervus elaphus* (Lister 1990, 178).

The dental and skeletal elements of the Cervidae species have been measured according to Heintz (1970) (fig. 20 and fig. 21).

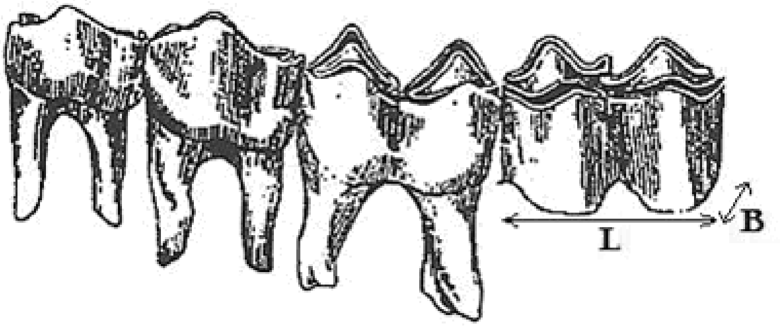


Figure 20. Measurements of the dental elements of the Cervidae (modified after Heintz 1970).

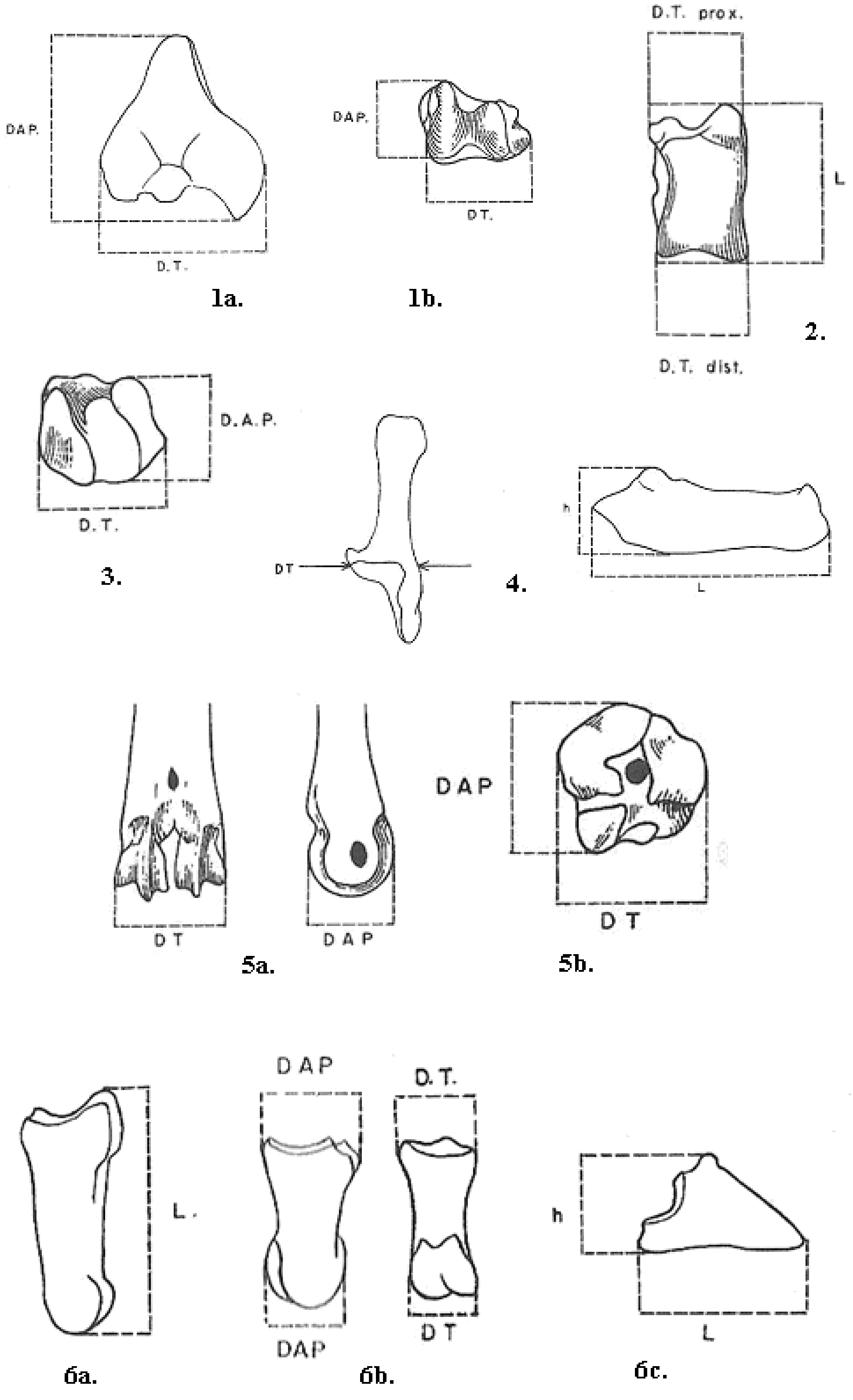


Figure 21. Measurements of the different skeletal elements of the Cervidae.

Key: 1a. proximal tibia; 1b. distal tibia; 2. astragalus; 3. proximal cubo-naviculare; 4. calcaneum; 5a. distal metatarsus; 5b. proximal metatarsus; 6a. phalanx I; 6b. phalanx II; 6c. phalanx III.

Abbreviations: DAP: Antero-Posterior Diameter; DT: Transverse Diameter (width); L: length; h: height (after Heintz 1970, 43, 44).

4.4.2.1 *Cervus elaphus* (Linnaeus, 1758)

Cervus elaphus, the red deer, appeared in its present form during the Middle Pleistocene. Its antlers have a pearly surface and carry several tines, the amount of which depends on the age of the animal (see paragraph 4.4.2 and fig. 19). It is a common cervid of medium to large size, and it is able to cover large distances. It prefers a temperate climate without permafrost and inhabits deciduous and pine forests in valleys and mountainous areas. Among its diet are hard fruits, leaves, a variety of plants and bark (Guérin and Patou-Mathis 1996, 53, 55; Kurtén 1968, 163).

Material:

Schöningen 13II-1: 2 refitted parts of a trez (middle) tine (519, 536); 2 tine fragments.

Schöningen 13II-2: antler fragment, terminal fork (15511); M3, sin. (12513); vertebra cervicalis fragment (16004); vertebra thoracicae fragment (12547); 2 vertebra lumbalis (12521, 15978); vertebra fragment (12543); sacrum fragment (16028); shaft fragment of a humerus with missing unfused dist. epiphysis, dex. (15998); dist. epiphyseal fragment of a tibia, dex. (694); tibia, dex. (12522); tibia, sin. (12545); calcaneum fragment, sin. (16021); 2 metatarsus, sin. (616, 15509); metatarsus, dex. (12520); 2 phalanx I with missing unfused epiphyses (12523, 12577); 3 phalanx II with missing unfused epiphyses (615, 14831, 15758).

Schöningen 13II-3: antler fragment (12669); p2, sin. (16636); 2 P3, dex. (12683, 12684); P3, sin. (12685); m2, dex.; M2, sin. (12687); M3, dex. (12680); M3, sin. (12672); vertebra lumbalis (15553); dist. epiphyseal fragment of a metacarpus, dex.; astragalus (823); calcaneum fragment, dex. (15972); 2 phalanx I with missing unfused epiphyses (810); 2 phalanx II with missing unfused epiphyses (746, 15529); tarsal fragment, dex. (754).

Measurements:

Table 5. Measurements in mm of the dental elements of *Cervus elaphus* according to Heintz (1970) (After Den Engelsman 2011, 26).

Location	FindNr.	Element	Width	Length
Schö 13II-2	12513	M3, sin.	24.50	19.97
Schö 13II-3	12685	P3, sin.	17.74	13.66
Schö 13II-3	12683	P3, dex.	16.84	15.25
Schö 13II-3	12684	P3, dex.	18.55	13.44
Schö 13II-3	-	m2, dex.	14.92	22.35
Schö 13II-3	12687	M2, sin.	21.04	18.66
Schö 13II-3	12680	M3, dex.	22.56	22.00
Schö 13II-3	12672	M3, sin.	23.43	20.99

Table 6. Measurements in mm of the skeletal elements of *Cervus elaphus* according to Heintz (1970) (After Den Engelsman 2011, 27, 28).

Location	FindNr.	Element	DTprox	DTdist	DAPprox	DAPdist	L
Schö 13II-2	12522	tibia, dex.	-	55.70	-	41.44	390.00
Schö 13II-2	616	metatars., sin.	45.64	48.65	50.61	33.05	330.00
Schö 13II-2	12520	metatars.,dex	49.98	54.41	49.94	33.16	320.00
Schö 13II-2	15509	metatars., sin.	41.33	46.30	41.64	31.11	290.00
Schö 13II-2	12523	phalanx I	27.38	24.54	33.67	22.15	67.94
Schö 13II-2	14831	phalanx II	23.78	17.86	27.50	25.74	45.59
Schö 13II-2	615	phalanx II	26.35	21.63	30.84	28.90	50.39
Schö 13II-2	15758	phalanx II	25.71	21.50	33.40	30.99	46.94
Schö 13II-3	823	astragalus	43.60	39.70	-	-	63.37
Schö 13II-3	-	phalanx I	26.66	28.06	35.61	26.22	58.78
Schö 13II-3	15229	phalanx II	24.02	18.59	28.63	24.46	44.21
Location	**FindNr.**	**Element**	**DT**	**DAP**	**L**	**H**	
Schö 13II-3	15972	calcan.,dex.	42.17	-	127.63	50.00	
Schö 13II-3	754	tarsal, dex.	47.29	38.94	-	-	

Description and remarks:

The material has been compared with the remains of modern *Cervus elaphus*, with which it corresponds in morphology and measurements (table 5 and table 6). *Cervus elaphus* can be distinguished from the other present cervids on the basis of its medium-sized antlers and skeletal elements. These are smaller than *Megaloceros giganteus* and larger than

Capreolus capreolus. *Cervus elaphus* has characteristic antlers with a pearly surface, consisting of several tines (fig. 18 and fig. 19). The antlers are thus well distinguishable from the small antlers of *Capreolus capreolus* and the large, broad antlers of *Megaloceros giganteus.*

The Schö 13II-1 material is fragmented, but well preserved. Level Schö 13II-2 has yielded material that is quite well preserved, with fragmented as well as complete skeletal elements. The material of Schö 13II-3 is severely fragmented and badly preserved. However, the elements are still determinable.

The material is fairly complete. Dental elements and vertebrae are often encountered and antler fragments are present in all levels. Long bones and compact bones are quite abundant and metacarpus and metatarsus elements are well represented. The assemblage has not yielded any femur, radius, ulna or pelvis fragments.

Relatively many elements with unfused epiphyses are present in both Schö 13II-2 and Schö 13II-3, thus indicating the presence of juvenile animals. Schö 13II-2 has yielded a right humerus (15998) without the unfused distal epiphysis (fig. 22). Two first phalanges (12523 and 12577) and three second phalanges (615, 14831 and 15758) are missing the unfused epiphyses. The same is the case for two first phalanges (810) and two second phalanges (746 and 15529), found in level Schö 13II-3. Full-grown elements are present as well, indicating that both adult and juvenile animals are equally represented in Schö 13II-2 and Schö 13II-3.

Figure 22. Distal shaft fragment of a humerus, dex. (15998) of a juvenile *Cervus elaphus* from Schö 13II-2. The unfused distal epiphysis is missing. Anterior view. Scale bar in cm. Photo by author.

The material of Schö 13II-1 only consists of a few antler fragments, of which two parts of a trez (middle) tine (519 and 536) can be refitted. The fragments may have originated from one individual. Schö 13II-2 has yielded a fragment of a terminal fork (fig. 23).

Figure 23. Antler fragment (15511) of *Cervus elaphus* from Schö 13II-2. Scale bar in cm. Photo by author.

Two left metatarsi (616 and 15509) and one right metatarsus (12520) from Schö 13II-2 are complete and well preserved, one of which is displayed in fig. 24. These point to the presence of at least two adult individuals. Several phalanges with unfused epiphyses have been found, which indicates that at least one juvenile animal is present as well. Level Schö 13II-3 has yielded two upper third premolars from the right side (12683 and 12684), indicating the presence of two individuals. Whether the unfused phalanges originate from another individual is unclear.

Figure 24. Complete metatarsus, sin. (15509) of *Cervus elaphus* from Schö 13II-2. Posterior view. Scale bar in cm. Photo by author.

4.4.2.2 *Megaloceros giganteus* (Blumenbach, 1803)

Megaloceros giganteus, the giant deer or Irish elk, made its first appearance during the Holsteinian Interglacial. It was a huge species with antlers that were formed like a palm, carrying several tines on its rim (fig. 18). They grew in lateral direction and could reach a width of 4 metres (Kurtén 1968, 165). The giant deer possessed a thickened mandibula. It could tolerate low temperatures, but preferred a temperate, humid and moderately cold climate. *Megaloceros giganteus* lived in open forests or on the borders of dense forests, which it could not enter due to its large antlers. During the end of the Pleistocene the species became extinct (Guérin and Patou-Mathis 1996, 62).

Material:

Schöningen 13II-1: M2, sin.; antler fragment (16915).

Schöningen 13II-2: phalanx I (696).

Schöningen 13II-3: prox. epiphyseal fragment of an ulna, sin. (15546); metatarsus without dist. part, dex.; phalanx I (15535); 2 phalanx II (15536); phalanx III (16740).

Measurements:

Table 7. Measurements in mm of the dental element of *Megaloceros giganteus* according to Heintz (1970) (After Den Engelsman 2011, 31).

Location	FindNr.	Element	Width	Length
Schö 13II-1	-	M2, sin.	25.73	22.97

Table 8. Measurements in mm of the skeletal elements of *Megaloceros giganteus* according to Heintz (1970) (After Den Engelsman 2011, 31, 32).

Location	FindNr.	Element	DTprox	DTdist	DAPprox	DAPdist	L	H
Schö 13II-2	696	phalanx I	34.34	33.71	36.83	24.20	77.84	-
Schö 13II-3	-	metatars.,dex	42.36	-	47.05	-	-	-
Schö 13II-3	15535	phalanx I	37.48	33.97	40.73	32.30	94.63	-
Schö 13II-3	15536	phalanx II	27.60	32.74	44.26	42.90	57.19	-
Schö 13II-3	16740	phalanx III	-	-	-	-	-	48.12

Description and remarks:

The dental and skeletal elements are larger in size than the elements of *Cervus elaphus* and *Capreolus capreolus* and have a slender appearance (table 7 and table 8). As such they have not been assigned to *Bos/Bison,* as the bones of the Bovidae are more robust. Thus, because of the relatively large size and slenderness of the elements they are assigned to *Megaloceros giganteus*.

The material from *Megaloceros giganteus* is scarce and not so well preserved. An antler fragment from Schö 13II-1 has a flat, broad structure, which can not have originated from the antlers of *Cervus elaphus* or *Capreolus capreolus*. The bone fragments mainly consist of phalanges. A first and second phalanx (15535 and 15536) from Schö 13II-3 look very similar in size and weathering stage, which perhaps indicates that these belong to the same individual (fig. 25 and fig. 26). The animals are all adults, as all of the elements are full-grown. Each level contains at least one individual.

Figure 25. Phalanx I (15535) of *Megaloceros giganteus* from Schö 13II-3. Anterior view. Scale bar in cm. Photo by author.

Figure 26. Phalanx II (15536) of *Megaloceros giganteus* from Schö 13II-3. Anterior view. Scale bar in cm. Photo by author.

4.4.2.3 *Capreolus capreolus* (Linnaeus, 1758)

Capreolus capreolus, the roe deer, appeared in Europe during the Middle Pleistocene and was much larger in size than the modern roe deer (Guérin and Patou-Mathis 1996, 57). The species has small antlers generally carrying three small tines (fig. 18). It has a preference for temperate woodlands with open patches and lives a more sedentary lifestyle than the red deer *Cervus elaphus*. The diet of the roe deer consists of fruits, fungi, leaves, grasses and twigs (Kurtén 1968, 166, 167). Its present form appeared during the Late Pleistocene (Guérin and Patou-Mathis 1996, 57).

Material:

Schöningen 13II-1: p4, sin.; m2, sin. (16847); phalanx I (16347); dist. epiphyseal fragment of a metapodium.

Schöningen 13II-2: 4 refitted antler fragments (15989, 15990, 15991, 15992); p4, sin.(683); M1, sin. (712); mandibula corpus with m1, m2 and m3, sin. (682).

Schöningen 13II-3: P4, sin.; dental indet.; humerus fragment, dex..

Measurements:

Table 9. Measurements in mm of the dental elements of *Capreolus capreolus* according to Heintz (1970) (After Den Engelsman 2011, 23).

Location	FindNr.	Element	Width	Length
Schö 13II-1	-	p4, sin.	6.61	8.98
Schö 13II-1	16847	m2, sin.	9.89	11.81
Schö 13II-2	683	p4, sin.	6.14	9.10
Schö 13II-2	712	M1, sin.	11.74	9.67
Schö 13II-2	682	m1, sin.	5.90	-
Schö 13II-2	682	m2, sin.	8.30	11.90
Schö 13II-2	682	m3, sin.	7.71	16.06
Schö 13II-3	-	P4, sin.	9.56	9.65

Table 10. Measurements in mm of the skeletal element of *Capreolus capreolus* according to Heintz (1970) (After Den Engelsman 2011, 23).

Location	FindNr.	Element	DTprox	DTdist	DAPprox	DAPdist	L
Schö 13II-1	16347	phalanx I	11.41	6.67	12.96	8.12	38.02

Description and remarks:

The material has been compared with the remains of modern *Capreolus capreolus*, with which it corresponds in size and morphology (table 9 and table 10). Because of its small-sized antlers and skeletal elements, *Capreolus capreolus* is easily distinguishable from the considerably larger cervids *Cervus elaphus* and *Megaloceros giganteus*. The bones of

Capreolus capreolus and *Sus scrofa* are similar in size and morphology, but the bones of *Capreolus capreolus* are more slender than the robust bones of *Sus scrofa*.

The material of Schö 13II-1 displays severe cracking and flaking. The Schö 13II-2 material is fragmented, but well preserved. Level Schö 13II-3 has yielded three fragments that are not so well preserved. Each level contains at least one individual. All of the bone material originates from adult animals and mainly consists of loose dental elements. However, a well preserved left mandibula fragment containing a first, second and third molar (682) has been found in level Schö 13II-2 (fig. 27).

Figure 27. Mandibula corpus with m1, m2 and m3, sin. (682) of *Capreolus capreolus* from Schö 13II-2. Buccal view. Scale bar in cm. Photo E. den Engelsman.

4.4.2.4 Cervidae gen. et sp. indet.

Material:

Schöningen 13II-1: antler fragment (16814); dentes indet.; 2 calcaneum (16349); carpal or tarsal (16221).

Schöningen 13II-2: tine fragment (16008); mandibula; middle fragment of a costa (16774); os carpi ulnare, dex. (14820); calcaneum (18140); fragment of a metacarpal/tarsal II or IV (689); 2 dist. epiphyseal fragments of a metacarpal/tarsal II or IV (690, 691).

Schöningen 13II-3: 4 antler fragments (16632, 12686, 16640, 16637); cranial fragment (12679); mandibula fragment (12679); fragment of a long bone (15545).

Description and remarks:
The material is very fragmented and lacks features to identify the actual species. The elements from Schö 13II-1 and 13II-2 are quite well preserved. The material found in Schö 13II-3 displays more cracking and flaking of the bones. Although it is unclear whether the remains originate from different species, the elements indicate the presence of at least one individual per level.

4.4.3 Family Bovidae

The Bovidae material is well distinguishable from the other species present at Schöningen. The bones of the Bovidae are very large and robust, unlike the slender and longer bones of the Cervidae. The Bovidae bones are similar in size to the bones of *Megaloceros giganteus,* which are therefore more difficult to distinguish. However, the bones of *Megaloceros giganteus* are generally more slender and longer than the robust bones of the Bovidae. The Bovidae bones are much larger than the medium-sized Suidae bones. The Bovidae material is similar in size to the bones of the Equidae, but the differences in morphology between Artiodactyla and Perissodactyla allows for a clear distinction between these two families.

4.4.3.1 Genus *Bos/Bison*

As already mentioned in Chapter 3, it has not been possible to determine the Bovidae material to species level. This material is therefore categorized under "*Bos/Bison*". According to previous research by Van Asperen (2004) and Matze (2010) it is likely that the material belongs to either *Bison priscus* or *Bos primigenius*.

Bison priscus (Bojanus, 1827), the steppe bison, made its first appearance in Europe during the Middle Pleistocene. The bison was quite large and its horns could span up to 120 cm, so that the species was unable to enter densely forested environments. It was therefore confined to steppes or areas with an open vegetation. The species is abundant in Pleistocene deposits, which has led to believe that steppe bisons migrated in herds on a seasonal basis, much like the modern American bison (*Bison bison*). During the Weichselian *Bison priscus* became extinct (Guérin and Patou-Mathis 1996, 70; Kurtén 1968, 185, 186).

Bos primigenius (Bojanus, 1827), the aurochs, appeared in Europe during the early Middle Pleistocene. The aurochs inhabited open woodlands as well as dense grasslands. It is found less frequently in Pleistocene deposits than the steppe bison, probably because it lived a more sedentary lifestyle. Humans drove the aurochs to extinction in 1628 (Guérin and Patou-Mathis 1996, 67; Kurtén 1968, 188).

Material:

Schöningen 13II-1: sacrum (16835); os carpale tertium, dex. (16051); prox. epiphyseal fragment of a tibia, dex. (16330).

Schöningen 13II-2: mandibula (12550); vertebra thoracicae (14817); 2 vertebra lumbalis (16017, 14816); middle shaft fragment of a radius, dex. (672); os carpale quartum, dex. (16776); middle shaft fragment of a metacarpus, sin. (692); 2 patella, dex. (15987, 16018); fibula, sin. (15982); astragalus, dex. (676); calcaneum, dex. (678); os tarsi centrale, dex. (679); os tarsi centrale, sin. (707); prox. epiphyseal fragment of a metatarsus, dex. (693); phalanx I, sin. (696); 2 metapodia fragments (690, 711).

Schöningen 13II-3: cranium occipitale, dex. (14418); 2 upper molars (14413, 14414); dentes indet., dex. (789); vertebra thoracicae processus (818); dist. epiphyseal fragment of a humerus, sin. (12698); radius and ulna, sin. (14501); os carpi radiale, dex. (15524); os carpi radiale, sin. (821); patella, sin. (16697); dist. shaft fragment of a tibia, sin. (16717); calcaneum without prox. part, sin. (14833); phalanx I, dex. (12677); phalanx I with missing unfused prox. epiphysis, dex. (14836); phalanx II, dex. (16691); 2 phalanx II fragments (836, 14835); 2 refitted phalanx III fragments (16729, 16652).

Description and remarks:

The *Bos/Bison* bones have been compared with the bones of modern *Bos taurus*, with which they correspond in size and morphology. Three well preserved and determinable bone fragments of *Bos/Bison* have been found in level Schö 13II-1. The Schö 13II-2 material is more abundant and mainly consists of complete or almost complete skeletal elements that are quite well preserved. The material of Schö 13II-3 consists of both fragmented and complete elements, but the bones are not so well preserved as the material from Schö 13II-2. Gnawing marks are present on the distal part of a radius from Schö 13II-2 (see paragraph 5.3.2 and fig. 32).

The material is not entirely complete. Cranial fragments and dental elements are underrepresented, whereas compact bones such as phalanges and carpals are abundant. Long bones are often encountered as well, especially tibia and radius fragments. There are no scapulae and femora present in the material. Costa bones are absent in the material, because these can not be determined to species level.

The bones originate from adult bovids, with the exception of one juvenile represented by a phalanx I with a missing unfused proximal epiphysis, encountered in Schö 13II-3 (fig. 28).

Figure 28. Phalanx I with missing unfused proximal epiphysis (14836) of a juvenile *Bos/Bison* from Schö 13II-3. Anterior view. Scale bar in cm. Photo by author.

The material from level Schö 13II-1 is scarce and originates from at least one individual. Two right patella have been found in Schö 13II-2, indicating the presence of at least two individuals in that level (fig. 29). Three elements of a right hind limb originate from one individual, as they can be rearticulated. It concerns a calcaneum (678), astragalus (676) and os tarsi centrale (679) from Schö 13II-2 (fig. 30).

Figure 29. Two patella, dex. (16018 and 15987) of *Bos/Bison* from Schö 13II-2. Anterior view. Scale bar in cm. Photo by author.

Figure 30. Calcaneum (678), astragalus (676) and os tarsi centrale (679), belonging to a right hind limb of *Bos/Bison* from Schö 13II-2. Anterior view. Scale bar in cm. Photo by author.

Two phalanx III fragments (16729, 16652) from Schö 13II-3 can be refitted. This level has also yielded a well preserved, almost complete radius and ulna (14501) of an adult bovid (fig. 31). All of the elements present in Schö 13II-3 are fused, with the exception of one unfused phalanx I. Thus, at least one adult and one juvenile individual are present in Schö 13II-3.

Figure 31. Radius and ulna, sin. (14501) of *Bos/Bison* from Schö 13II-3. Lateral view. Scale bar in cm. Photo by author.

4.5 Large and medium mammals

Unfortunately, 101 bone fragments can not be determined to order, family, genus or species level. These fragments can therefore only be categorized under "large mammal" or "medium mammal". Large mammals are mammals heavier than 44 kilograms and include the aforementioned orders of Proboscidea, Perissodactyla and Artiodactyla. Medium mammals include the species weighing less than 44 kilograms, such as the Carnivora species and the smaller Artiodactyla species *Sus scrofa* and *Capreolus capreolus*. Small mammals, such as rodents, are not included in this analysis and will therefore not be discussed.

A few bones originate from Artiodactyla species. They either belong to Bovidae or Cervidae species, as they are too large to have originated from *Sus scrofa*. However, as these bones can not be assigned to a particular family, they have not been included in the palaeoecological analyses of paragraph 5.1.

5. The faunal composition of the Schöningen 13II levels

In this chapter the assemblages from the levels Schö 13II-1, 13II-2 and 13II-3 will be analysed. These assemblages will also be compared with the faunal assemblage from level Schö 13II-4, which has been investigated by Van Asperen (2004) and Matze (2010). The palaeoecology will be reconstructed on the basis of the Minimum Number of Individuals (MNI) present in each level.

The Number of Individual Specimens (NISP) present in the levels Schö 13II-1 to 13II-3 will be used to establish the preservation state of the bone material. The representation of juvenile elements in these levels will be discussed as well. In addition, the presence of cutmarks and gnawing traces has been documented, in order to determine the influence of hominids and carnivores on the taphonomic state of the bone assemblages.

An overview of the total amount of investigated bone material so far is shown in table 11. It displays both the Number of Individual Specimens (NISP) and the Minimum Number of Individuals (MNI) from the levels Schö 13II-1 to 13II-4. For an overview of the bone material investigated exclusively for this thesis, one is referred to Appendix A.

5.1 Palaeoecology

The faunal assemblage of the Schöningen 13II levels can be indicative of the palaeoecology during the Reinsdorf Interglacial. The specific palaeoenvironmental requirements of the present species enable to make inferences on the climate and the presence of forested or steppe environments. Considering the extinct species, such as *Megaloceros giganteus*, these requirements are deduced from their anatomy and the palaeoenvironmental context they were found in. The palaeoenvironmental requirements of the species still in existence today are based on the tolerances and range limitations of their modern descendants.

However, it must be taken into account that the modern distribution of a species does not necessarily reflect the full range of conditions a species is able to live in. The habitat tolerances of species may also have altered over time, which is why it can not always be assumed that a lineage was always adapted to one particular environment. Similarly it should be noted that during the Quaternary certain environments with specific vegetational and faunal associations existed without a modern analogue (Lister 1992, 332, 333).

Table 11. The Number of Individual Specimens (NISP) and the Minimum Number of Individuals (MNI) of the species present in all Schöningen 13II levels. The asterisks denote the findings of the author plus the findings of Matze (2010). The 3 Mustelidae species from Schö 13II-3 have been determined by Van Asperen (2004). The data from Schö 13II-4 combines the findings of Van Asperen (2004) and Matze (2010) and is demarcated by a red line.

	Schö 13II-1 NISP	**Schö 13II-1 MNI**	**Schö 13II-2 NISP**	**Schö 13II-2 MNI**	**Schö 13II-3 NISP**	**Schö 13II-3 MNI**	**Schö 13II-4 NISP**	**Schö 13II-4 MNI**
ORDER CARNIVORA								
Family Canidae								
Canis lupus			1	1			1	1
Vulpes vulpes							1	1
Family Mustelidae								
Mustela erminea					1*	1	1	1
Mustela nivalis							1	1
Mustela sp.					1*	1	1	1
Martes sp.					2*	1		
Suborder Caniformia								
Caniformia gen. et sp. indet.	2	1	2*	1*	5	1		
ORDER PROBOSCIDEA								
Family Elephantidae								
Elephantidae gen. et sp. indet.	16*	1					1	1
ORDER PERISSODACTYLA								
Family Equidae								
Equus mosbachensis	11	2	41	2	35*	2	1024	19
Equus sp.			2*	1				
Family Rhinocerotidae								
Stephanorhinus kirchbergensis	1	1			4	2	1	1
Stephanorhinus hemitoechus	21*	2			1*	1	3	1
Stephanorhinus sp.	58*	2	5	1	35*	2	25	1
ORDER ARTIODACTYLA								
Family Suidae								
Sus scrofa	9*	1						
Family Cervidae								
Cervus elaphus	3	1	26*	3	21*	2	61	2
Megaloceros giganteus	2	1	1	1	6	1		
Capreolus capreolus	5*	1	4	1	3	1		
cf. *Capreolus capreolus*					1*	1		
Cervidae gen. et sp. indet.	5	1	10*	1	7	1	29	2
Family Bovidae								
Bos primigenius					3*	1	7	1
cf. *Bos primigenius*							7	2
Bison priscus					6*	1	19	2
cf. *Bison priscus*							1	1
Genus *Bos/Bison*	3	1	18	2	18	2	23	2

The Minimum Number of Individuals (MNI) is very low, making it impossible to gain information on the exact representation of each species during the Reinsdorf Interglacial (table 11). This has always been a problem for archaeozoologists, as not all animals preserve equally well and will be influenced by hominid activities, hibernation or hydrodynamic sorting. The remains will therefore never be representative of the actual faunal assemblage (Van Kolfschoten 1995, 80). In addition, the relative abundance of species can fluctuate greatly over short periods of time (Lister 1986, 322). However, the presence and absence of certain species per level can still be indicative of the palaeoecology.

5.1.1 Schöningen 13II-1

Order Carnivora
    Suborder Caniformia
        Caniformia gen. et sp. indet.
Order Proboscidea
    Family Elephantidae
        Elephantidae gen. et sp. indet.
Order Perissodactyla
    Family Equidae
        Equus mosbachensis (Von Reichenau, 1915)
    Family Rhinocerotidae
        Stephanorhinus hemitoechus (Falconer, 1868)
        Stephanorhinus sp.
Order Artiodactyla
    Family Suidae
        Sus scrofa (Linnaeus, 1758)
    Family Cervidae
        Cervus elaphus (Linnaeus, 1758)
        Megaloceros giganteus (Blumenbach, 1803)
        Capreolus capreolus (Linnaeus, 1758)
        Cervidae gen. et sp. indet.
    Family Bovidae
        Genus *Bos/Bison*

The faunal composition of Schö 13II-1 is very diverse and consists of typical interglacial species (table 11). Different Cervidae species and *Sus scrofa* are present, which are indicative of forested environments. *Sus scrofa* can not tolerate thick snow covers, which is why the presence of this species indicates a temperate climate. *Stephanorhinus kirchbergensis*, the forest rhino, is present as well. *Megaloceros giganteus* also indicates the presence of open forests, as it could not enter dense forests.

The steppe-dwelling species *Equus mosbachensis* and *Stephanorhinus hemitoechus* are relatively abundant in the assemblage. Together with the presence of *Bos/Bison*, they are indicative of steppe and open grassland environments. The Elephantidae material either originates from the steppe-dwelling *Mammuthus* sp. or the forest-dwelling species *Elephas antiquus*. It can therefore be stated that both forests and steppes were present to support the assemblage from Schö 13II-1. The environment may have consisted of forests with open patches.

5.1.2 Schöningen 13II-2

<u>Order Carnivora</u>
  Family Canidae
    Canis lupus (Linnaeus, 1758)
  Suborder Caniformia
    Caniformia gen. et sp. indet.
<u>Order Perissodactyla</u>
  Family Equidae
    Equus mosbachensis (Von Reichenau, 1915)
    Equus sp.
  Family Rhinocerotidae
    Stephanorhinus sp.
<u>Order Artiodactyla</u>
  Family Cervidae
    Cervus elaphus (Linnaeus, 1758)
    Megaloceros giganteus (Blumenbach, 1803)
    Capreolus capreolus (Linnaeus, 1758)
    Cervidae gen. et sp. indet.
  Family Bovidae
    Genus *Bos/Bison*

The faunal assemblage of Schö 13II-2 is less diverse than the assemblage of Schö 13II-1 (table 11). Elephantidae species and *Sus scrofa* are no longer present in this level. Still, the presence of *Capreolus capreolus* and the relative abundance of *Cervus elaphus* indicates the occurrence of forested environments.

The presence of *Equus mosbachensis* and *Bos/Bison* suggests the presence of steppe or grassland environments. The *Canis lupus* individual is unfortunately not indicative of a specific environment, as it can adapt to several biotopes. The ecology is therefore more or less the same as the ecology of Schö 13II-1.

5.1.3 Schöningen 13II-3

<u>Order Carnivora</u>
- Family Mustelidae
  - *Mustela erminea* (Linnaeus, 1758)
  - *Mustela* sp.
  - *Martes* sp.
- Suborder Caniformia
  - Caniformia gen. et sp. indet.

<u>Order Perissodactyla</u>
- Family Equidae
  - *Equus mosbachensis* (Von Reichenau, 1915)
- Family Rhinocerotidae
  - *Stephanorhinus kirchbergensis* (Jäger, 1839)
  - *Stephanorhinus hemitoechus* (Falconer, 1868)
  - *Stephanorhinus* sp.

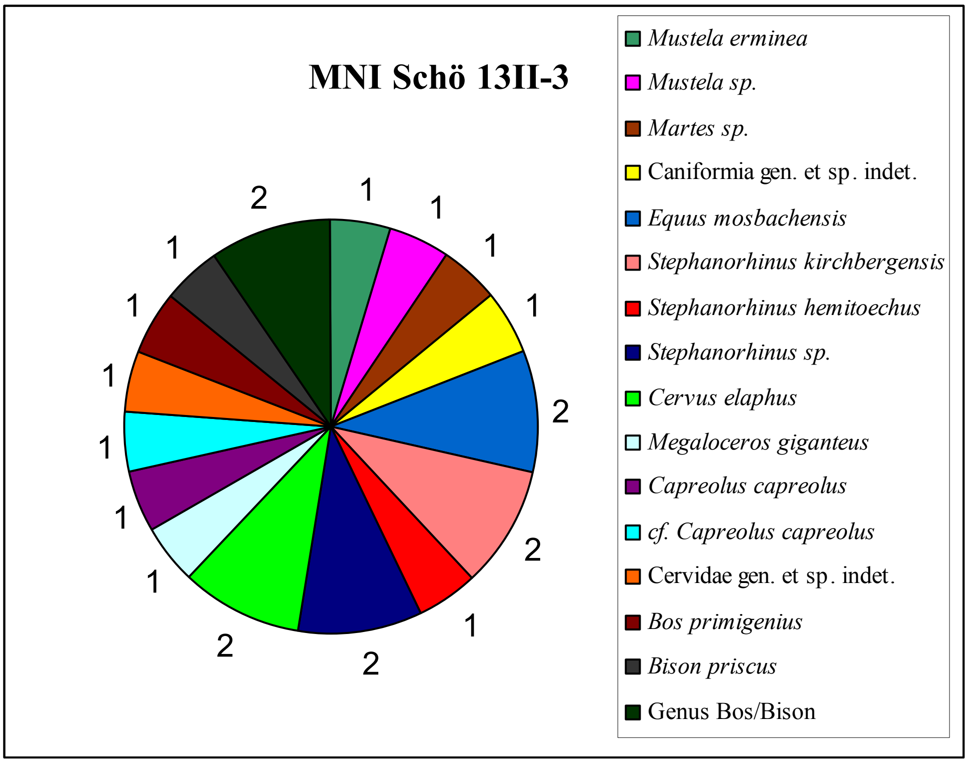
<u>Order Artiodactyla</u>
- Family Cervidae
  - *Cervus elaphus* (Linnaeus, 1758)
  - *Megaloceros giganteus* (Blumenbach, 1803)
  - *Capreolus capreolus* (Linnaeus, 1758)
  - cf. *Capreolus capreolus*
  - Cervidae gen. et sp. indet.
- Family Bovidae
  - *Bos primigenius* (Bojanus, 1827)
  - *Bison priscus* (Bojanus, 1827)
  - Genus *Bos/Bison*

The faunal composition of Schö 13II-3 is very diverse and consists of typical interglacial species (table 12). Three species of the family Mustelidae are present. *Mustela erminea*, the ermine, generally prefers a humid climate with the presence of forests (Guérin and Patou-Mathis 1996, 186). Another fragment of the genus *Mustela* could not be determined to species level. *Martes* sp. indicates the presence of temperate forests (Guérin and Patou-Mathis 1996, 190, 191).

All of the Cervidae species are still present in Schö 13II-3 and together with the occurrence of *Stephanorhinus kirchbergensis* they also indicate the presence of forested environments.

Stephanorhinus hemitoechus, the steppe rhino, occurs in this assemblage as well. Together with *Equus mosbachensis* and *Bison priscus* this species therefore indicates the presence of steppe environments. Unfortunately the steppe and forest rhino are both represented by one individual, so that it is unknown which of these species is dominant. The *Stephanorhinus* species can therefore not indicate the abundance of forests or steppes.

Table 12. The Minimum Number of Individuals per species found in Schö 13II-3. The chart includes the individuals determined by Van Asperen (2004) and Matze (2010) and excludes indeterminable bone fragments.



5.1.4 Comparison with Schöningen 13II-4

Order Carnivora
- Family Canidae
  - *Canis lupus* (Linnaeus, 1758)
  - *Vulpes vulpes* (Linnaeus, 1758)
- Family Mustelidae
  - *Mustela erminea* (Linnaeus, 1758)
  - *Mustela nivalis* (Linnaeus, 1766)
  - *Mustela* sp.

Order Proboscidea
- Family Elephantidae
  - Elephantidae gen. et sp. indet.

Order Perissodactyla
- Family Equidae
  - *Equus mosbachensis* (Von Reichenau, 1915)
- Family Rhinocerotidae
  - *Stephanorhinus kirchbergensis* (Jäger, 1839)
  - *Stephanorhinus hemitoechus* (Falconer, 1868)
  - *Stephanorhinus* sp.

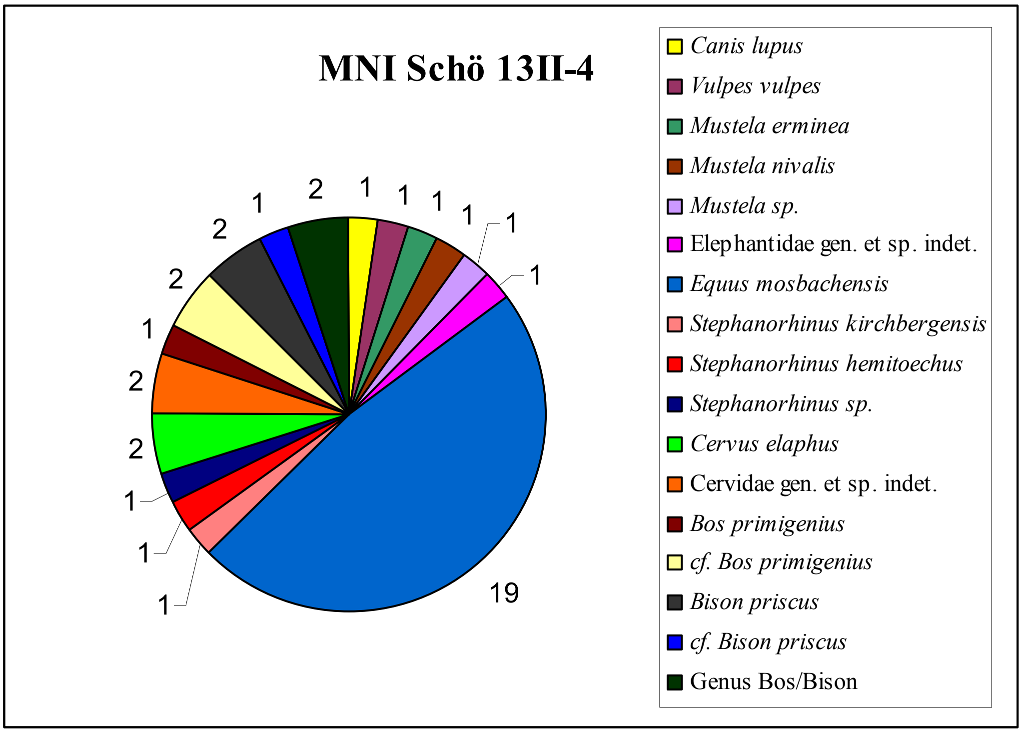
Order Artiodactyla
- Family Cervidae
  - *Cervus elaphus* (Linnaeus, 1758)
  - Cervidae gen. et sp. indet.
- Family Bovidae
  - *Bos primigenius* (Bojanus, 1827)
  - cf. *Bos primigenius*
  - *Bison priscus* (Bojanus, 1827)
  - cf. *Bison priscus*
  - Genus *Bos/Bison*

The faunal composition of Schö 13II-4 differs substantially from the composition of the other levels (table 13). Here, the overrepresentation of *Equus mosbachensis* becomes apparent. In Schö 13II-1 to Schö 13II-3 *Equus mosbachensis* is represented by at least two individuals, whereas at least 19 individuals are present in Schö 13II-4. The dominance of *Equus mosbachensis* does not automatically indicate the abundance of a steppe environment, as the assemblage is highly influenced by hominids. However, the presence of *Stephanorhinus hemitoechus* and *Bison priscus* and the combined absence of the typical temperate forest species *Sus scrofa* and *Capreolus capreolus* may point to the disappearance of forests and the beginning of a period with a dominance of steppes.

However, the presence of the species *Stephanorhinus kirchbergensis* and the ermine *Mustela erminea* indicate that forests must still have been present. *Cervus elaphus* and *Bos primigenius* can also be found in forested environments, although they have a higher environmental tolerance.

In comparison with the previous levels, carnivores are relatively abundant in the assemblage of Schö 13II-4. These are represented by *Canis lupus*, *Vulpes vulpes*, the aforementioned *Mustela erminea* and *Mustela nivalis*. With the exception of *Mustela erminea*, these species are not very good climatic indicators, as they can adapt to a variety of environments. Both the wolf *Canis lupus* and the weasel *Mustela nivalis* are found in many different biotopes (Guérin and Patou-Mathis 1996, 186). The red fox *Vulpes vulpes* may indicate a temperate climate and the presence of a forested environment. However, the fox has a high environmental and climatic tolerance, as it can also be found in steppes and deserts in cold or cool conditions (Guérin and Patou-Mathis 1996, 162; Kurtén 1968, 116).

Table 13. The Minimum Number of Individuals per species found in Schö 13II-4. The data was collected by Van Asperen (2004) and Matze (2010).



5.1.5 Conclusion

The faunal assemblages of the different levels indicate a climatic deterioration throughout the Reinsdorf Interglacial, which is in accordance with the palaeobotanical results (see paragraph 2.3.1). Schö 13II-1 was deposited during the climatic optimum, suggested by the typical interglacial species *Sus scrofa* and *Capreolus capreolus*. *Sus scrofa* is absent in all the other levels, whereas *Capreolus capreolus* is only absent in the youngest level, Schö 13II-4. This suggests that Schö 13II-4 was deposited during a colder climate with a steppe environment, which is indicated by the abundance of steppe species such as *Equus mosbachensis, Stephanorhinus hemitoechus* and *Bison priscus*. However, the presence of the species *Mustela erminea* and *Stephanorhinus kirchbergensis* in level Schö 13II-4 indicate the presence of forests, which is not in accordance with the palaeobotanical results (see paragraph 2.3.1). This anomaly either means that forests must have been present in Schö 13II-4, or that the present forest-adapted species had a higher environmental tolerance than previously thought.

5.2 Taphonomy

In order to investigate the taphonomic aspects, charts have been made of the Number of Individual Specimens per level. The bones have been divided in groups according to their place in the skeleton. The category "head" includes antler, cranium, mandibula, dentes and os hyoideum and the category "body" comprises vertebrae, costae, sternum, sacrum and pelvis. The category "front limb" comprises scapula, humerus, radius, ulna, metacarpus and carpals and the category "hind limb" includes femur, tibia, metatarsus, tarsals, calcaneum, astragalus and patella. The category "feet" comprises the phalanges. Sesamoidea are not included, because it is unknown whether these originate from the front limb or hind limb. An overview of the representation of all the skeletal elements per level is shown in Appendix B.

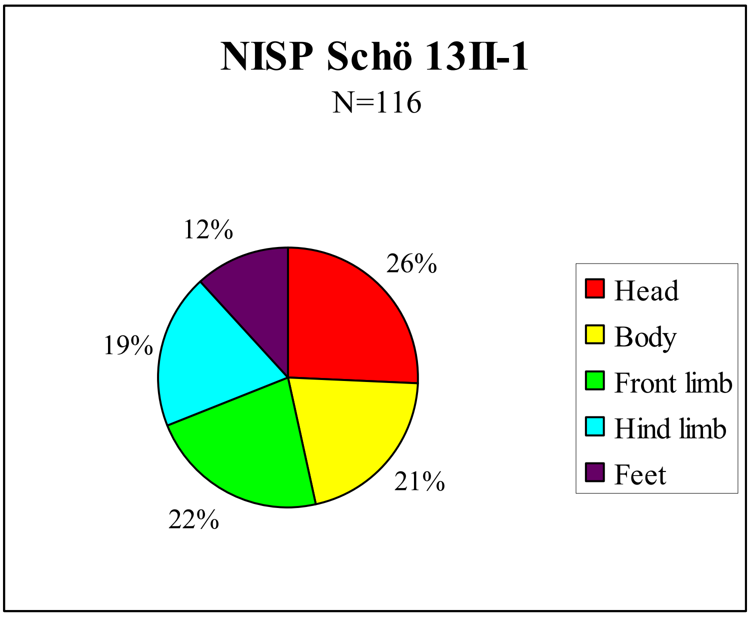
Large mammal material has been included in the charts as well. All vertebrae and costae can not be determined to species level and are therefore categorized under "large mammal". Obviously, the exclusion of these skeletal parts will give an incomplete overview of the elements that are preserved per level. In addition, the amount of juvenile elements present in the different Schöningen levels will be discussed.

The NISP only includes the material analysed for this thesis (Appendix A). The material of Matze (2010) has not been included in these charts, as she applied a different method than the author.

5.2.1 Schöningen 13II-1

The skeletal elements present in Schö 13II-1 are more or less equally divided into the different categories, with the exception of the feet (table 14). The elements mainly originate from the head, which is caused by the relative abundance of the dental elements. The category body mostly includes vertebrae fragments. Feet are less well represented than the other skeletal parts, probably because this category only includes the phalanges.

Table 14. The Number of Individual Specimens from Schö 13II-1, divided into the categories head, body, front limb, hind limb and feet. The bones categorized under "large mammal" have been included as well.



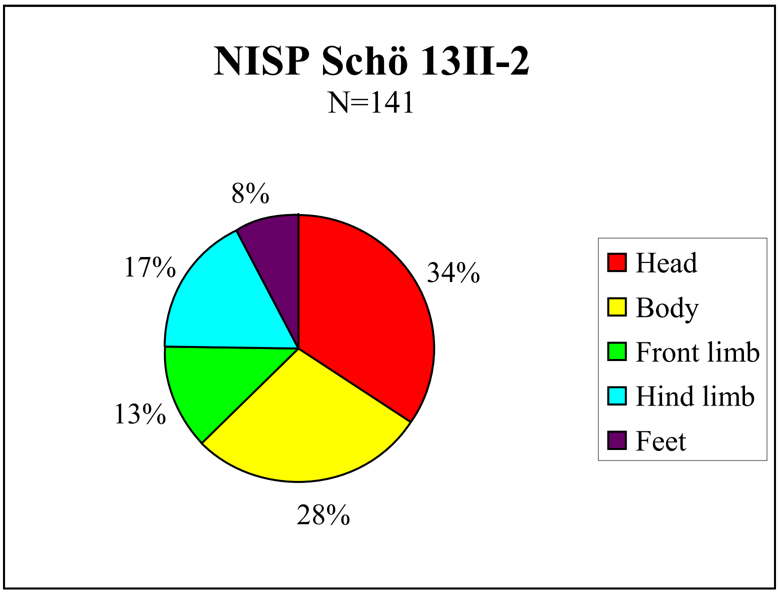
In total 6 of the 116 elements from Schö 13II-1 belong to juvenile animals. These include a deciduous first premolar from *Stephanorhinus kirchbergensis* and a left ulna with a missing unfused epiphysis from a *Stephanorhinus* species. In addition, four vertebrae originating from large mammals are missing their unfused epiphyses. Thus, elements from juvenile animals are represented by only 5.2% of the total assemblage from Schö 13II-1.

5.2.2 Schöningen 13II-2

The skeletal elements found in Schö 13II-2 display a different picture than the material from Schö 13II-1 (table 15). The number of elements from the head has gone up by 8% and the amount of elements from the body has gone up by 7%. The amount of bones from the front limb has gone down by 9%. The fact that the NISP of this chart is higher than the NISP of the chart from Schö 13II-1 can explain this phenomenon.

Up to 34% consists of head fragments, which can be explained by the relatively high amount of dental material and mandibula fragments present in this level. 28% of the material consists of body fragments, which is mainly caused by the high quantity of vertebrae and costae. The elements of the hind limb are mainly represented by tibia fragments. Again, the category feet is least represented, as is the case for Schö 13II-1.

Table 15. The Number of Individual Specimens from Schö 13II-2, divided into the categories head, body, front limb, hind limb and feet. The bones categorized under "large mammal" have been included as well.

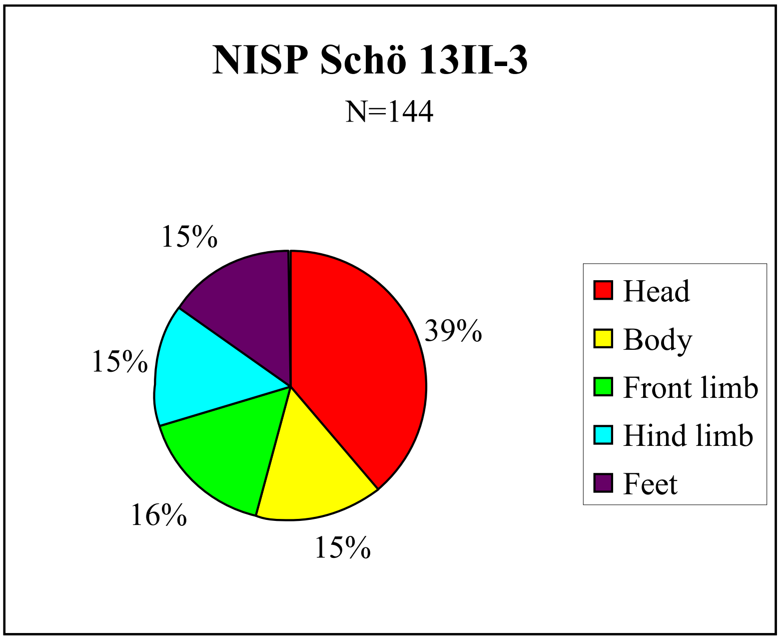


In total 13 of the 141 skeletal elements from Schö 13II-2 originate from juvenile animals. A left tibia shaft with missing unfused epiphyses originates from *Equus mosbachensis*. One proximal unfused epiphysis and one distal unfused epiphysis of a left tibia have been found in the same level and also belong to a juvenile *Equus mosbachensis*, although it is unclear whether these associate with the tibia shaft or with each other. Many elements from *Cervus elaphus* belong to juvenile individuals and include a right humerus without a distal epiphysis as well as two first phalanges and three second phalanges with missing unfused epiphyses. In addition, three vertebrae with unfused epiphyses and one femur with a missing unfused proximal epiphysis originate from large mammals. Thus, elements from juvenile animals are represented by 9.2% of the assemblage from level Schö 13II-2.

5.2.3 Schöningen 13II-3

The NISP from Schö 13II-3 clearly displays an overrepresentation of elements from the head, whereas the remaining categories are equally represented (table 16). This phenomenon is mainly caused by the high abundance of dental elements in this level.

Table 16. The Number of Individual Specimens from Schö 13II-3, divided into the categories head, body, front limb, hind limb and feet. The bones categorized under "large mammal" have been included as well.



In comparison with the chart of Schö 13II-2, the category head of Schö 13II-3 has remained more or less the same. The amount of elements from the body has gone down by 13%, whereas the category feet has gone up by 7%. The phalanges are thus relatively well represented in this level.

In total 8 skeletal elements of the 144 elements from Schö 13II-3 originate from juveniles. A right humerus with a missing unfused proximal epiphysis belongs to a *Stephanorhinus* species. Elements from juvenile individuals of *Cervus elaphus* include two first phalanges and two second phalanges with missing unfused epiphyses. In addition, one first phalanx with a missing unfused proximal epiphysis originates from a juvenile *Bos/Bison*. Juvenile large mammals are represented by a vertebra with an unfused cranial epiphysis and a humerus with an unfused proximal epiphysis. Elements from juvenile animals are therefore represented by merely 5.5% of the entire bone assemblage from Schö 13II-3.

5.2.4 Conclusion

The category "head" displays the highest percentage in all Schöningen 13II levels. This is caused by the dental elements, which are most abundant in each level as they preserve very well (Appendix B). However, it needs to be taken into account that the many dental elements present most likely belong to only a few individuals.

The relatively high number of dental material, vertebrae, costae and phalanges can be explained by the fact that these are more numerous in the skeleton than the limb bones, which are therefore less well represented (Appendix B). Thus, it can be stated that all skeletal parts are more or less equally represented in all levels, indicating that the material is well preserved.

The amount of juveniles in the material is relatively low in all levels. However, the presence of juvenile bones confirm the pristine preservation of the material.

5.3 Traces on the skeletal material

Both hominid and carnivore traces have been found on the analysed bone material. These will be described in the following paragraphs.

5.3.1 Hominid modification

As already mentioned, level Schö 13II-4 is famous for the numerous hominid traces found on the animal bones, confirming the presence of hominids. However, hominid modification on animal bones is far less abundant in the older levels Schö 13II-1, Schö 13II-2 and Schö 13II-3. Cutmarks have been encountered on two indeterminable bone fragments from unknown levels, which are not clear enough for photographic documentation. Unfortunately, the presence of cutmarks can not be firmly established on the determinable bone material.

Previously, Matze has shown the presence of cutmarks on a scapula of *Cervus elaphus* from Schö 13II-2. She has also found impact notches on a femur of *Equus mosbachensis* from Schö 13II-3 (Matze 2010, 75, 76). This proves that besides Equidae, Cervidae were butchered by the hominids as well.

5.3.2 Gnawing marks

Gnawing traces are present on a few bones. A moderately gnawed vertebra cervicalis fragment (15385) of a large mammal has been found in Schö 13II-1. The gnawing was caused by a rodent, as it displays small scores. The distal end of a radius diaphysis (672) of *Bos/Bison* from Schö 13II-2 also displays gnawing marks (fig. 32). These were possibly caused by a small rodent as well, as the diaphysis has not been destroyed by the gnawing. This is generally the case when larger carnivores chew on bones.

Figure 32. Gnawing traces on the distal part of a radius diaphysis, dex. (672) of *Bos/Bison* from Schö 13II-2. The gnawing marks were probably caused by a rodent. Posterior view. Scale bar in cm. Photos by author.

6. Biostratigraphy

The analysed large mammal assemblages can be used to investigate the biostratigraphy of Schöningen 13II. In order to do so, the principles and problems underlying biostratigraphic correlations will first be described. The faunal assemblages of the Schöningen 13II site will then be compared with other large mammal assemblages from Middle Pleistocene sites in Germany and Great Britain, to establish the contemporaneity of these sites.

6.1 Principles and problems of biostratigraphy

Biostratigraphy is a discipline focused on the establishment of the temporal ranges of individual taxa and palaeobiological assemblages, which are used to verify and correlate relative ages of rock strata (Palombo and Sardella 2007, 31). Large mammals are particularly useful biostratigraphic indicators, as they are subject to several processes like origination, extinction, migration and evolution. In addition, mammals are known for their drastic turnovers during climatic changes (Schreve 2001a, 1693; Von Koenigswald 2007, 445).

These turnovers are easily recognizable in the stratigraphic sequence and are related to the climatic tolerances of species. During the late Middle and Late Pleistocene interglacials a faunal assemblage dominated by *Elephas antiquus* prevailed, characterized by the presence of typical warm temperate species such as *Stephanorhinus kirchbergensis, Sus scrofa* and *Capreolus capreolus* (fig. 33). During cold stages the fauna was characterized by *Mammuthus* and *Coelodonta,* together with the presence of cold-adapted species like the reindeer *Rangifer tarandus* (Linnaeus, 1758) and the musk ox *Ovibos moschatus* (Zimmerman, 1780) (fig. 33). The *Mammuthus*-assemblage and the *Elephas*-assemblage exchanged during each climatic change, meaning that the new faunal assemblage invaded, whereas the previous assemblage became locally extinct. The faunal compositions were mainly affected by precipitation, as the cold stages were characterized by a continental climate, which were alternated by maritime-influenced warm stages (Von Koenigswald 2007, 445).

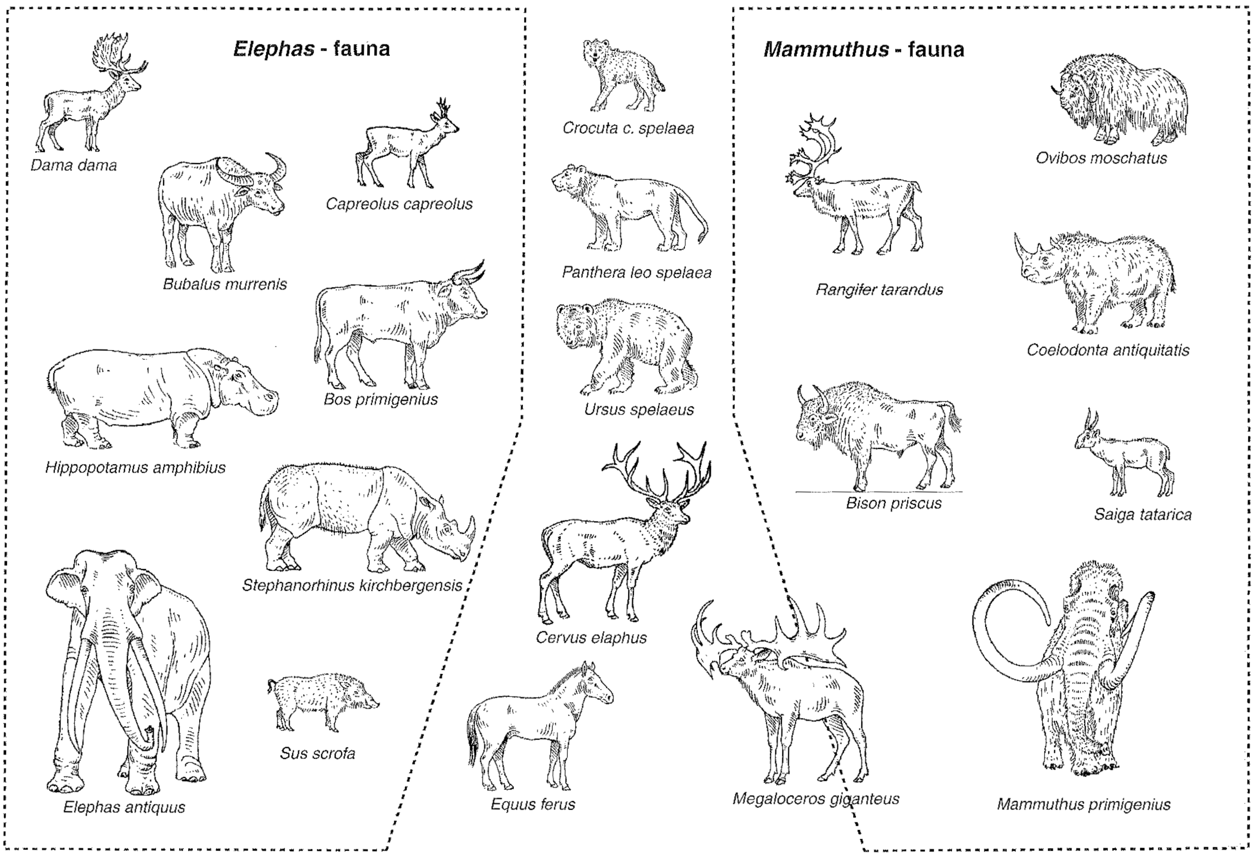


Figure 33. The interglacial *Elephas* faunal assemblage versus the glacial *Mammuthus* faunal assemblage. These assemblages occurred alternatively during the Middle Pleistocene in Central Europe. Some herbivores and several carnivores occurred during both glacial and interglacial periods (Von Koenigswald 2007, 446).

Thus, interglacial and glacial periods can be easily distinguished from each other on the basis of mammalian assemblages. Distinguishing different interglacial periods on the basis of faunal compositions is less straightforward, but still possible by studying the presence or absence of interglacial species in an assemblage as well as the evolutionary stages reached by specific mammals.

The presence or absence of certain species in an assemblage can provide useful information on the stratigraphic range and co-occurrence of specific taxa, which can be used to establish respectively range-zones and assemblage-zones. The stratigraphic range of a species is equated with its time of existence, starting with its origination or first appearance and ending with its extinction or last appearance. However, these are estimates which can always be modified by new finds (Lister 1986, 320). Origination is more difficult to establish than extinction as evolution from an ancestor can be gradual, which makes it difficult to differentiate between a species and its ancestor. Extinction on the other hand is easier to determine, because the timing of the disappearance of a lineage can be established on the basis of sites covering the range of the species. Whenever the species is present in a deposit, it automatically means that the deposit pre-dates the age of extinction of the species (Lister 1992, 329, 330).

However, the stratigraphic sequence of earliest and latest occurrences of mammalian remains does not always correspond with the temporal order of their actual first and last appearance in time, as stratigraphy is affected by factors such as discontinuities in sedimentation, environmental conditions and taphonomic and sampling biases (Palombo and Sardella 2007, 31). These factors also affect the actual absence of species in an assemblage. However, absence data of species will be more reliable when large amounts of remains have been excavated, when one or more species are also absent at other similar sites and when sites of different ages with different assemblages cover the same sedimentary contexts and palaeoenvironments (Lister 1992, 330).

The presence or absence of a species can also indicate distributional shifts in and out of the study area, which can be instigated by several naturally-caused factors such as natural barriers and vegetational, faunal or climatic changes. It should be noted here that a co-occurring mammalian assemblage is not a block of species migrating together. Instead, species migrate independently from each other and have different tolerances and responses to climatic and environmental change. New faunal combinations will emerge under the influence of physiological tolerances, climatic conditions and geographical, vegetational and faunal constrains (Lister 1992, 331; Palombo and Sardella 2007, 31).

Considering these phenomena, it is important to take four consequences into account. First, the region under consideration should be compared with other sites to understand the overall shifting of species. Second, the distributional shifts imply that faunal compositions could change rapidly and easily, meaning that immigration and emigration of a species in a certain region can be an important biostratigraphic marker. Third, immigration or emigration is not simultaneous in various areas, making it difficult to correlate migrational shifts. Fourth, it should be noted that a specific species or a species composition can be found repeatedly in a region, in response to environmental changes. However, there are still species combinations that only occurred in a particular time period, as specific environmental and geographical characteristics and constrains could lead to unique mammal assemblages never to occur again. Schreve (2001b) has therefore been able to determine that distinctive faunal assemblages were formed during each successive temperate period, enabling the formation of Mammal Assemblage-Zones (MAZ) with which different interglacials can be defined (Lister 1992, 331, 332; Schreve 2001b, 65).

Another important biostratigraphic tool is the evolutionary pattern of a species, which can be observed as anatomical changes such as an increase in body size. Evolutionary change is ideally easily detectable and genetically based. In addition, evolution can best be studied when the characters change gradually, unidirectionally and synchronously over a species geographical range, or when a new character appears at a given time period. However, evolution is a complex process and evolutionary patterns differ per species (Lister 1992, 333).

Increase or decrease of body size is a type of change that is easy to quantify, although it does not necessarily point to evolutionary change. Change in body size can also be affected by environmental conditions, natural selection as well as different adaptive forces. Body size variations can also be indicative of temperature change, as some mammals tend to grow larger as it gets colder. In any case, change in body size can be caused by several factors and is therefore not a reliable biostratigraphic marker (Lister 1992, 334).

A morphological change will be more reliable for biostratigraphic purposes when the trait in evolution is more complex and unique, as it will then be less reversible, less influenced by environmental factors and only to be observed in one time period. Examples of more complex characters are change in body proportions and localised morphological traits such as details of bone articulation, which are more likely to be genetically based and less likely to display repeated changes. Combinations of characters are more reliable and useful for biostratigraphic purposes than individual traits, as these are even less likely to be repeated (Lister 1992, 334, 335).

When studying evolutionary trends it is important to take a number of things into account. First, it is essential that substantial amounts of fossil remains are examined, as there exists morphological variation between individuals of a species. In this respect, it is important to consider variations in age and sex as well as geographical variations. It can therefore not be assumed that morphological differences within a single species in the fossil record automatically implies a difference in age. Second, evolutionary patterns are complex. Rates of change are not always gradual and unidirectional as is often assumed, but instead stasis, slow or rapid evolution can occur. In addition, evolutionary trends can be subject to morphological fluctuations and reversals (Lister 1992, 336, 339).

When using mammals for biostratigraphic purposes, it is in any case essential that the complex patterns of change in mammalian lineages and individual species are understood first. In addition, biostratigraphic conclusions should not be based on one isolated characteristic, but on as many lines of evidence as possible to be more reliable (Lister 1992, 341-343).

Boxmeer (2011), Matze (2010) and Van Asperen (2004) have made an attempt to establish the biostratigraphy of the Schöningen 13II site by measuring the size of large mammal bones. Their results have shown that size changes have taken place which might be indicative of the biostratigraphic position of the Schöningen 13II assemblages. Boxmeer and Matze have shown that the rhino species increase in size during the Reinsdorf Interglacial. The horses, however, display morphological change and a decrease in size, which has been established by Matze and Van Asperen.

As already mentioned, change in body size is not a reliable biostratigraphic indicator and does not necessarily point to evolutionary change. According to Boxmeer the size increase of the rhino species can indeed not be used for biostratigraphic purposes. According to Lacombat, *Stephanorhinus hemitoechus* has a stable average body size between MIS 11 and MIS 7, whereas *Stephanorhinus kirchbergensis* increases in size (Lacombat 2006, 2009). However, Boxmeer has observed a general size increase for *S. hemitoechus* between MIS 11 and MIS 7. In addition, the dental elements of *S. kirchbergensis* are larger in level Schö 13II-3 than in Schö 13II-4, which would imply that the elements decrease in size over time. These results are not in accordance with the general trends observed by Lacombat. Boxmeer has therefore concluded that the size variation most likely relates to sexual dimorphism and natural variation within the rhino populations (Boxmeer 2011, 48-51).

Matze and Van Asperen have observed a decrease in size of the long bones of the Schöningen horses. According to Eisenmann (1991a), the long bones of the horses decrease in size from 100.000 years BP onwards, but the results from Van Asperen and Matze show that this trend already started during the Middle Pleistocene. The morphological change observed in the metapodials and phalanges of the horses is more likely to be induced by evolution, but this could not be established. The dental elements of the horses display a decrease in size within Schöningen, but when compared with other Middle Pleistocene sites it appears that over time the elements display reversals and fluctuations in size. This trend has also been established by Eisenmann (1991a) who analysed horse teeth from the Pleistocene, but it is unknown whether it is caused by environmental factors, migration or evolution (Van Asperen 2004, 50, 51, 61-63).

For this research, only the faunal compositions of the Schöningen 13II site are used to establish a biostratigraphy. In order to do so, the faunal compositions of the Schöningen 13II levels have been compared with Schöningen 12B and with other Middle Pleistocene sites in Europe.

Table 17. Comparison of the Middle Pleistocene faunal assemblages from Schöningen 13II-1 to 13II-3 (research author, Van Asperen 2004 and Matze 2010), Schöningen 13II-4 (Van Asperen 2004 and Matze 2010), Schöningen 12B (Van Zijderveld and Kirkels 1996), Weimar-Ehringsdorf, Lower Travertine (Schäfer *et al.* 2007), Bilzingsleben II (Mania 1995), Barnham (Parfitt 1998), Hoxne, Stratum B (Stuart *et al.* 1993) and Swanscombe, Lower Loam (Stuart 1982).

	Schöningen 13II-1	**Schöningen 13II-2**	**Schöningen 13II-3**	**Schöningen 13II-4**	**Schöningen 12B**	**Weimar-Ehringsdorf (LT)**	**Bilzingsleben II**	**Barnham**	**Hoxne (Stratum B)**	**Swanscombe (LL)**
ORDER CARNIVORA										
Family Canidae										
Canis lupus		+		+		+	+			+
Vulpes vulpes				+		+				
Vulpes sp.							+			
Family Ursidae										
Ursus arctos						+				
Ursus spelaeus					+	+	+			+
Ursus thibetanus					+	+				
Ursus sp.								+	+	
Family Mustelidae										
Meles meles						+	+			
Meles sp.										
Mustela putorius								+		
Mustela erminea			+	+						
Mustela nivalis				+						
Mustela sp.			+	+						
Martes martes						+				+
Martes sp.			+				+			
Lutra lutra									+	
Lutra sp.							+			
Suborder Caniformia										
Caniformia gen. et sp. indet.	+	+	+							
Family Felidae										
Felis silvestris							+			+
Lynx lynx						+				
Panthera leo					+			+	+	+
Panthera leo spelaea							+			
Family Hyaenidae										
Crocuta crocuta						+				

Table 17 continued.

	Schöningen 13II-1	Schöningen 13II-2	Schöningen 13II-3	Schöningen 13II-4	Schöningen 12B	Weimar-Ehringsdorf (LT)	Bilzingsleben II	Barnham	Hoxne (Stratum B)	Swanscombe (LL)
ORDER PROBOSCIDEA										
Family Elephantidae										
Elephas antiquus						+	+	+		+
Elephantidae gen. et sp. indet.	+			+	+					
ORDER PERISSODACTYLA										
Family Equidae										
Equus mosbachensis	+	+	+	+	+					
Equus taubachensis						+				
Equus ferus									+	+
Equus sp.		+					+			
Family Rhinocerotidae										
Stephanorhinus kirchbergensis			+	+	+	+	+			+
Stephanorhinus hemitoechus	+		+	+		+	+			+
Stephanorhinus sp.	+	+	+	+				+	+	+
ORDER ARTIODACTYLA										
Family Suidae										
Sus scrofa	+				+	+	+	+		+
Family Cervidae										
Dama dama								+	+	+
Dama sp.						+	+			
Cervus elaphus	+	+	+	+	+	+	+	+	+	+
Megaloceros giganteus	+	+	+			+				
Capreolus capreolus	+	+	+		+	+			+	+
cf. *Capreolus capreolus*			+							
Capreolus sp.							+			
Alces latifrons						+				
Cervidae gen. et sp. indet.	+	+	+	+						
Family Bovidae										
Bos primigenius			+	+	+		+			+
cf. *Bos primigenius*				+						
Bison priscus			+	+		+	+			+
cf. *Bison priscus*				+						
Bubalus murrensis							+			
Genus *Bos/Bison*	+	+	+	+				+		

6.2 General comparison of the Middle Pleistocene sites

When comparing the different Middle Pleistocene sites, it appears that these more or less contain the same interglacial faunal assemblages (table 17). In comparison with the German and British sites, not many Carnivora species have been found within the Schöningen 13II site. Although some Canidae and Mustelidae species are present in the Schöningen 13II levels, the other Middle Pleistocene sites also contain species of the families Ursidae, Felidae and Hyaenidae.

Considering the Elephantidae species, it appears that *Elephas antiquus* is present in all of the Middle Pleistocene German and British sites, whereas it is absent in the Schöningen sites. However, it is likely that the indeterminate Elephantidae bone fragments found in the Schöningen sites also belong to *Elephas antiquus*, as this species is typical for interglacial periods (fig. 33).

The species from the order Perissodactyla are well represented in the Middle Pleistocene sites. Species from the family Equidae are present in all Middle Pleistocene sites, with the exception of Barnham. However, the Equidae remains originate from different species, making comparisons between the sites complicated. Rhinocerotidae species are present in all Middle Pleistocene sites and comprise the species *Stephanorhinus kirchbergensis* and *Stephanorhinus hemitoechus*.

The order Artiodactyla is another well represented group. *Sus scrofa* is present in all sites, with the exception of Hoxne. Cervidae species are quite abundant, with *Cervus elaphus* occurring in all sites. The fallow deer *Dama dama* and another *Dama* species are only absent in the Schöningen sites. The Bovidae species are well represented by *Bos primigenius* and *Bison priscus.* The water buffalo *Bubalus murrensis* has only been encountered in Bilzingsleben II.

6.3 Comparison within the Schöningen locality

6.3.1 Schöningen 12B

The Schöningen 12B site was discovered in 1992 and has yielded more than 1000 faunal remains. These are mostly fragmented due to human interference. Wolves and hyenas have left their gnawing traces on the bones as well. Ten different large mammal species have been found at the site (Van Kolfschoten *et al.* 2007, 83).

Both the Schöningen 13II levels and Schöningen 12B are dated to the Reinsdorf Interglacial. In order to establish which of the four Schöningen 13II levels is contemporaneous with the Schöningen 12B site, it is necessary to compare the faunal compositions from the Schöningen 13II levels with Schöningen 12B.

The faunal compositions of Schöningen 12B and the Schöningen 13II levels show differences as well as similarities. Schöningen 12B is very dissimilar to the Schöningen 13II levels concerning the Carnivora species. *Ursus spelaeus* (Rosenmüller and Heinroth, 1794), *Ursus thibetanus* (Cuvier, 1823) and *Panthera leo* (Linnaeus, 1758) are all present in Schöningen 12B and absent in the Schöningen 13II levels. On the contrary, the Carnivora species *Canis lupus, Vulpes vulpes, Mustela erminea, Mustela nivalis* and a *Martes* species are found in Schöningen 13II-2 to 13II-4 and do not appear in Schöningen 12B.

The Carnivora species at Schöningen 12B are typical interglacial species that made their appearance in Europe during the Middle Pleistocene. The cave bear *Ursus spelaeus* is often found in temperate forests, although it could also adapt to cold steppe environments. Like the cave bear, the Asiatic black bear *Ursus thibetanus* also indicates the presence of a temperate forest (Guérin and Patou-Mathis 1996, 174, 175, 179; Kurtén 1968, 123). The lion *Panthera leo* prefers an open environment with a temperate or cold temperate climate (Guérin and Patou-Mathis 1996, 208).

Both Schöningen 13II-1, Schöningen 13II-4 and Schöningen 12B contain indeterminate Elephantidae fragments. These most likely originate from *Elephas antiquus*, as this species has been encountered in the other Middle Pleistocene sites as well. The Perissodactyla species *Equus mosbachensis* occurs in Schöningen 12B and all Schöningen 13II levels. *Stephanorhinus kirchbergensis* occurs in Schöningen 12B as well as Schöningen 13II-3 and 13II-4, whereas *Stephanorhinus hemitoechus* is present in Schöningen 13II-1, 13II-3 and 13II-4 and absent in Schöningen 12B.

Not many Artiodactyla species have been found at Schöningen 12B. The species that are present also occur in the Schöningen 13II levels. *Sus scrofa* is present in Schöningen 13II-1 and Schöningen 12B. *Cervus elaphus* and *Capreolus capreolus* are also present at both sites, although *Capreolus capreolus* is absent in Schöningen 13II-4. *Megaloceros giganteus* is only present in Schöningen 13II-1 to 13II-3. *Bos primigenius* is found in Schöningen 12B and is definitely present in Schöningen 13II-3 and 13II-4. However, this species may also be present in the levels Schöningen 13II-1 and 13II-2, as the analysed bones from these levels have been categorized under "*Bos/Bison*".

Considering the fact that both warm temperate species *Capreolus capreolus* and *Sus scrofa* appear in Schöningen 13II-1 as well as in Schöningen 12B, it can be stated that these are contemporaneous. Like Schöningen 13II-1, Schöningen 12B belongs to the climatic optimum of the Reinsdorf Interglacial, when deciduous forests were dominant to sustain the aforementioned species. The presence of *Ursus spelaeus, Ursus thibetanus* and *Stephanorhinus kirchbergensis* in Schöningen 12B confirms this forested environment.

6.4 Comparison with German and British Middle Pleistocene sites

6.4.1 German sites

6.4.1.1 Weimar-Ehringsdorf

Weimar-Ehringsdorf is located in the German federal state of Thüringen. A travertine sequence was found there in the Ilm river valley, which dates to the Middle and the Late Pleistocene (Schäfer *et al.* 2007, 141). The sequence starts with early Saalian Ilm gravels, which are covered by floodplain muds. On top of the muds the travertine series are deposited. These are divided into the Lower Travertine, a middle section of muddy sediment called the Pariser Horizon, and the Upper Travertine, which is in itself divided into four travertine beds A to D, separated by three thin Pseudopariser layers of sandy humous travertine. The travertine sequence is covered by loessic loam deposits (Mania 1993, 26).

The Lower Travertine has yielded abundant remains of fossil flora and fauna, which are indicative of fully interglacial conditions. The palaeovegetation points to the presence of a mixed deciduous forest (Steiner 1993, 17). The molluscan fauna indicates the existence of different environments, such as dry grasslands and stagnant, shallow waters. The small and large mammals are indicative of the presence of open as well as forested and moist environments (Kahlke 1995, 735).

Besides floral and faunal remains, artefacts, hominid remains and hearths have been found as well. The association of bones of elephant, rhino and other large mammals with cutmarks, flint artefacts and hearths indicates that the hominids hunted these mammals, butchered them and cooked their remains (Steiner 1993, 18).

Based on the evolutionary stages reached by small and large mammals, it has been concluded that the Lower Travertine must be older than the Eemian travertine at Taubauch. The Lower Travertine is therefore dated to an intra-Saalian warm period (Schäfer *et al.* 2007, 143, 144, 146). According to Schreve and Bridgland (2002) Weimar-Ehringsdorf should be dated to MIS 7. They have observed a faunal turnover from a woodland fauna to an open grassland fauna at Weimar-Ehringsdorf, displaying the exact same pattern as observed in several sites in Britain dated to MIS 7 (Schreve and Bridgland 2002, 367, 368). This makes the Lower Travertine interesting for comparison with the Schöningen 13II levels, as the faunal assemblages of both sites might confirm their different age estimations.

The upper part of the Lower Travertine and the Pariser Horizon display an abrupt change into a colder climatic stage. The interglacial fauna slowly disappears, whereas a steppe-adapted fauna becomes increasingly abundant (Steiner 1993, 18). The environment of the following Upper Travertine consists of a steppe with bushes and patches of forests, while trees are not as abundant as in the Lower Travertine. The large mammal assemblage of the Upper Travertine is characterized by the woolly rhino *Coelodonta antiquitatis* (Blumenbach, 1799), the woolly mammoth *Mammuthus primigenius* (Blumenbach, 1799), and the steppe rhino *Stephanorhinus hemitoechus*. The presence of these species and the absence of *Elephas antiquus* points to an ongoing deterioration of the climate (Steiner 1993, 19). The Upper Travertine is covered by a layer containing a *Mammuthus*-fauna, indicative of a cold stage with a tundra environment. This layer dates to the Late Pleistocene (Mania 1993, 37; Steiner 1993, 19).

The large mammal assemblage found in the Lower Travertine at Weimar-Ehringsdorf is a typical *Elephas antiquus*-fauna (Steiner 1993, 17). Relatively many Carnivora species have been found, contrary to the Schöningen 13II levels. *Canis lupus* and *Vulpes vulpes* have been encountered at both Weimar-Ehringsdorf and Schöningen 13II-2 and 13II-4. Three Ursidae species, *Ursus arctos* (Linnaeus, 1758)*, Ursus thibetanus* and *Ursus spelaeus* are present at Weimar-Ehringsdorf. The brown bear *Ursus arctos* was a forest species like the other two bear species, although it could adapt to other environments as well (Guérin and Patou-Mathis 1996, 177). *Meles meles* (Linnaeus, 1758) and *Martes martes* (Linnaeus, 1758) have been found at Weimar-Ehringsdorf, whereas *Mustela* and *Martes* species have been encountered in Schöningen 13II-3 and 13II-4. The badger *Meles meles* prefers open forests, while the pine marten *Martes martes* is generally found in temperate pine forests (Guérin and Patou-Mathis 1996, 191, 193; Kurtén 1968, 94). *Lynx lynx* (Linnaeus, 1758) and *Crocuta crocuta* (Erxleben, 1777) are two other Carnivora species only to be found in Weimar-Ehringsdorf. The lynx *Lynx lynx* is a predator found in forested areas. The spotted hyena *Crocuta crocuta* suggests the presence of extensive open environments (Guérin and Patou-Mathis 1996, 213; Stuart and Lister 2001, 1685).

Elephas antiquus is present at Weimar-Ehringsdorf. The order Perissodactyla is represented at both Weimar-Ehringsdorf and the Schöningen 13II levels. *Equus mosbachensis* is found in all Schöningen 13II levels, whereas another smaller horse species is found in Weimar-Ehringsdorf, *Equus taubachensis* (Freudenberg, 1911). According to Eisenmann (1991a) *Equus taubachensis* was a large type I horse species, characterized by robust metapodials and small teeth with shorter protocones on the third and fourth premolars than on the first and second molars. *Equus taubachensis* indicates the presence of a temperate climate and open environments such as savannas and steppes (Eisenmann 1991a, 749, 750; Guérin and Patou-Mathis 1996, 126, 129; Kurtén 1968, 149, 150). Both *Stephanorhinus kirchbergensis* and *Stephanorhinus hemitoechus* are present at Weimar-Ehringsdorf and Schöningen 13II-1, 13II-3 and 13II-4.

The order Artiodactyla shows both similarities and differences between Weimar-Ehringsdorf and the Schöningen 13II levels. *Sus scrofa* and the Cervidae species *Cervus elaphus, Megaloceros giganteus* and *Capreolus capreolus* are found in both Weimar-Ehringsdorf and the Schöningen 13II levels, whereas a *Dama* species and *Alces latifrons* (Johnson, 1874) are only present at Weimar-Ehringsdorf. The *Dama* species indicates the presence of forested environments and parklands (Guérin and Patou-Mathis 1996, 56). The broad-fronted moose *Alces latifrons* was confined to open parkland or savanna environments, as it was unable to enter dense forests with its broad antlers (Kurtén 1968, 167, 168). *Bison priscus* is a Bovidae species that both Schöningen 13II-3, 13II-4 and Weimar-Ehringsdorf have in common, whereas *Bos primigenius* is absent at Weimar-Ehringsdorf.

The presence of *Crocuta crocuta*, *Ursus arctos* and *Alces latifrons* at Weimar-Ehringsdorf and their absence in the Schöningen 13II assemblages displays that the faunas are not contemporaneous. This is also confirmed by the different Equidae species present, although horses do tend to develop local forms (Von Koenigswald 2007, 449).

6.4.1.2 Bilzingsleben

Like Weimar-Ehringsdorf, Bilzingsleben is also situated in Thüringen in Central Germany. The Pleistocene site at Bilzingsleben is located in the Wipper river valley and consists of a sequence of six travertine terraces. These terraces are younger than the Elsterian, as they are positioned above an Elsterian ground moraine. The fourth terrace, Bilzingsleben IV, is correlated with the Saalian, whereas Bilzingsleben I to III consist of three valley floors displaying travertine sequences that are correlated with three Middle Pleistocene interglacials (Mania 1995, 739). Bilzingsleben I is correlated with the Holsteinian Interglacial, Bilzingsleben II with the Reinsdorf Interglacial and Bilzingsleben III with the Schöningen/Dömnitz Interglacial (see paragraph 2.3 and fig. 3). Thus, Bilzingsleben II is considered of the same age as the Schöningen 13II levels, which can perhaps be confirmed by comparing the faunal assemblages of these sites (Mania and Thieme 2007, 218, 219).

The faunal assemblage from Bilzingsleben II is indicative of a diverse ecology with rivers, lakes, open forests and grasslands. This diversity is also confirmed by the palaeovegetation. A warm temperate climate prevailed (Mania and Mania 2005, 99).

Besides the large mammal material, Bilzingsleben II has also yielded the Lower Palaeolithic material culture and remains of *Homo erectus*. A camp site was found with dwellings, food debris, workshops, activity zones and hearths (Mania 1990, 76-110). The large mammal bones are affected by hominid activities, as these have been made into artefacts or display butchering traces. All of the present species show these traces, meaning that all large mammals were hunted and butchered (Mania 1990, 180; Mania and Mania 2005, 108).

The site Bilzingsleben II contains more Carnivora species than the Schöningen 13II levels. In addition to *Canis lupus,* a *Vulpes* species and a *Martes* species, which are present in both Bilzingsleben II and the levels of Schöningen 13II, Bilzingsleben II also contains *Ursus spelaeus*, *Meles meles,* a *Lutra* species, *Felis silvestris* (Schreber, 1777) and *Panthera leo spelaea* (Goldfuss, 1810). The wild cat *Felis silvestris* appears in forested environments, but can also be found at the borders of open fields or bushed grasslands. It also occurs in humid environments with reed and riverine forests (Guérin and Patou-Mathis 1996, 214). The cave lion *Panthera leo spelaea* lives in open environments with a temperate or temperate cold climate and is often found in cave deposits (Guérin and Patou-Mathis 1996, 208; Kurtén 1968, 86). *Mustela* species are present in level Schöningen 13II-3 and 13II-4, whereas they are not encountered at Bilzingsleben II.

Elephas antiquus occurs in Bilzingsleben II as well. The *Equus* species present at Bilzingsleben II has been determined as *Equus mosbachensis-taubauchensis*. As is the case for the Schöningen 13II levels both *Stephanorhinus kirchbergensis* and *Stephanorhinus hemitoechus* are found in Bilzingsleben II.

The Artiodactyla species *Sus scrofa, Cervus elaphus, Bos primigenius* and *Bison priscus* are found at both Bilzingsleben II and the Schöningen 13II levels. A *Dama* species is only present at Bilzingsleben II. A *Capreolus* species at Bilzingsleben II can not be determined to species level. The presence of *Capreolus capreolus* and *Sus scrofa* in level Schöningen 13II-1 may indicate that this level is contemporaneous with Bilzingsleben II. Significant is the presence of the water buffalo *Bubalus murrensis* (Berckhemer, 1927) at Bilzingsleben II, a species that indicates the presence of open water during winter. The water buffalo needs open water to submerge in, so that it can escape from cold winds. The presence of open waters during winter indicates that winters were mild, which was caused by a maritime influence on the climate (Von Koenigswald 2007, 449, 452).

The large mammal assemblages from the levels of Schöningen 13II and Bilzingsleben II appear to be very similar. It is therefore highly likely that both sites are more or less contemporaneous. As shown in paragraph 2.2.2, Musil (2002) argues that level Schöningen 13II-4 is not contemporaneous with Bilzingsleben II, as the horses from Bilzingsleben are phylogenetically older than the horses from Schöningen 13II-4 (Thieme

2005, 118). Thus, the older Schöningen 13II-1 level can perhaps be paralleled with the Bilzingsleben II site, as both contain the warm temperate species *Sus scrofa* and a *Capreolus* species, indicating a climatic optimum. This is supported by the presence of *Bubalus murrensis* at Bilzingsleben II. In addition, it has been established that Schöningen 13II-1 and Bilzingsleben II have a similar climate as well as the same mean annual temperatures (Mania 2007, 55; see paragraph 2.2.2). The correlation of both sites can perhaps be more firmly established when the analysed horse bones from Schöningen 13II-1 are measured and compared with the size of the horse bones from Bilzingsleben II.

6.4.2 British Hoxnian sites

The British sites under consideration have been dated to the Hoxnian/Holsteinian on the basis of lithostratigraphic and palynological evidence. The Hoxnian Interglacial is considered the first temperate period after the Anglian/Elsterian glaciation in Britain (Schreve 2001a, 1694).

6.4.2.1 Barnham

Barnham is located in the county of Suffolk in England. A Middle Pleistocene sequence has been found there in an abandoned clay pit at East Farm. The sequence is underlain by a series of glacial deposits, correlated with the Anglian glaciation. A channel infill with silts, sands and clays cut through these deposits, of which the upper grey silts and sands have yielded a rich faunal assemblage. The composition of the vertebrate fauna displays changes suggesting a succession from a fluvial to a marsh environment. The large mammal fauna indicates the presence of mixed woodland and open grassland. The silts and sands get thinner at the margins of the channel and pass into grey silty sands, which cover coarse gravels. On top of the grey silty sands rests a dark brown clay unit. The sequence is covered by brown clays and silts (Ashton *et al.* 1994, 585-587).

At the margins of the channel artefacts have been found that are contemporary with the faunal assemblage. These artefacts consist of cores and flakes and have been found in three different excavated areas (Ashton *et al.* 1994, 587-589).

The faunal composition at Barnham is similar to the assemblage at Swanscombe. The site has therefore been correlated with MIS 11 (Ashton *et al.* 1994, 587).

The large mammal assemblage at Barnham is relatively poor compared to the other Middle Pleistocene sites. The Carnivora found there include an *Ursus* species, *Mustela putorius* (Linnaeus, 1758) and *Panthera leo*, which are all absent in the Schöningen 13II levels. The polecat *Mustela putorius* is found in mixed and deciduous woodland, marshland and well-vegetated river banks (Parfitt 1998, 140). *Elephas antiquus* is found at the site as well.

The Perissodactyla order is not well represented at Barnham. Only a *Stephanorhinus* species has been determined, which is why it is not possible to compare the species of the Perissodactyla order from the Schöningen 13II levels and Barnham.

Species from the Artiodactyla order that are found at both Barnham and the Schöningen 13II levels include *Sus scrofa, Cervus elaphus* and an unknown Bovidae species. *Dama dama* (Linnaeus, 1758) is only present at Barnham. The fallow deer *Dama dama* inhabits dense deciduous and coniferous forests as well as parklands (Guérin and Patou-Mathis 1996, 56).

The small faunal assemblage and the many indeterminate species at Barnham make it difficult to compare the site with the Schöningen 13II assemblages. Barnham and the Schöningen 13II levels do not share many of the same species, but the species found at both sites are not indicative of different time periods. The sites may therefore be contemporaneous in spite of the dissimilar faunal assemblages.

6.4.2.2 Hoxne

Hoxne is situated near the Barnham site in the county of Suffolk in England. The Pleistocene sequence discovered there is situated on top of an Anglian layer and constitutes the stratotype of the Hoxnian Interglacial. The sequence consists of a succession of sediments, defined as Strata G to A from bottom to top. These strata contain palaeoenvironmental evidence for a fluctuating climate (Ashton *et al*. 2008, 652, 653; Schreve 2001a, 1694).

The lowest deposition, Stratum G, is a glaciogenic unit consisting of chalk and flint-rich tills, which has been attributed to the Anglian stage (MIS 12). Stratum F consists of lacustrine clay containing pollen and beetles, which are indicative of an amelioration of the climate into interglacial conditions. The lake sediments from Stratum E contain pollen indicating the development of temperate deciduous forests. Stratum D is a peat horizon with pollen and beetle remains pointing to interglacial conditions. The lacustrine sands and silts in Stratum C contain pollen and beetle assemblages, which are suggestive of a very cold, continental climate. Stratum B is divided into Stratum B2, consisting of fluvial chalky gravel, and Stratum B1, consisting of fluvial sands, silts and clays. The faunal remains in Stratum B suggest a warm climate and mixed environments. The upper Stratum A consists of Stratum A2(iii), Stratum A2(ii), Stratum A2(i) and Stratum A1. Stratum A2(iii) consists of alluvial silt and contains a faunal assemblage indicative of a temperate climate. The remaining uppermost strata only contain mixed pollen. The ice-wedge frosts and periglacial structures in Stratum A2(i) and Stratum A1 indicate a return to cold conditions (Ashton *et al*. 2008, 657-660).

Stratum B will be compared with the Schöningen 13II assemblages, as this stratum yielded many large mammal remains indicating interglacial conditions. It is also said to correlate with level Schöningen 13II-4 (Ashton *et al*. 2008, 665). In addition, the vertebrate remains of Stratum B have been found in association with the lithic artefacts of a hominid culture, the Lower Industry. The artefacts consist of flint handaxes, cores and hammerstones (Wymer and Singer 1993, 74). The presence of cutmarks on the bones of in particular *Equus ferus* and *Cervus elaphus* suggests that humans dismembered the carcasses and filleted meat from these bones (Stopp 1993, 148; Stuart *et al.* 1993, 190, 191, 198).

The age of Stratum B is uncertain. Based on amino acid geochronology and biostratigraphy, it most likely correlates with an interstadial within the later part of MIS 11, although it could also date to a younger warm episode (Ashton *et al*. 2008, 660, 665, 666).

Hoxne Stratum B contains different Carnivora species compared to the Schöningen 13II assemblages. They include *Lutra lutra* (Linnaeus, 1758), *Panthera leo* and an *Ursus* species. The otter *Lutra lutra* feeds on fish and is thus a semi-aquatic animal, indicating the presence of water (Kurtén 1968, 107).

The Perissodactyla species at Hoxne are not abundant. *Equus mosbachensis* is absent at the Hoxne site. The horse species present at Hoxne is referred to as the Eurasian wild horse or tarpan *Equus ferus* (Boddaert, 1785). An unknown *Stephanorhinus* species has been identified at Hoxne.

The Artiodactyla order at Hoxne is represented by the Cervidae species *Cervus elaphus* and *Capreolus capreolus*, which are also present in the Schöningen 13II levels. *Dama dama* is only present at Hoxne, whereas *Sus scrofa* is absent there.

Thus, Hoxne and the levels of Schöningen 13II do not have many species in common. The only species that both sites share are *Capreolus capreolus* and *Cervus elaphus*. *Capreolus capreolus* is only absent in level Schöningen 13II-4, whereas *Cervus elaphus* is present in all of the Schöningen levels. Hoxne could therefore correlate with the levels Schöningen 13II-1, 13II-2 or 13II-3.

6.4.2.3 Swanscombe

Swanscombe is situated in the county of Kent in England. A fluviatile sequence has been found there in the Barnfield Pit, which lies in a 30 m high terrace of the Lower Thames river. Swanscombe is the type site for the Mammal Assemblage-Zone (MAZ) of the first post-Anglian interglacial, as determined by Schreve (2001a). The characteristic faunal assemblage at Swanscombe is determined by the presence and absence of particular species, most notably the presence of the large Clacton fallow deer *Dama dama clactoniana* (Falconer, 1868) and the cave bear *Ursus spelaeus* and the absence of the spotted hyena *Crocuta crocuta* and the hippopotamus, *Hippopotamus amphibius* (Linnaeus, 1758) (Schreve 2001a, 1695, 1696). In addition, the Swanscombe MAZ is characterized by the occurrence of specific large mammals that made their first appearance during the Hoxnian Interglacial. These mammals include *Stephanorhinus kirchbergensis*, *Stephanorhinus hemitoechus*, *Megaloceros giganteus* and *Bos primigenius* (Schreve and Bridgland 2002, 359, 360). These species have also been recorded in Schöningen 12B and the Schöningen 13II levels, which would confirm the Holsteinian age of the Schöningen material.

The fluviatile sequence of the Swanscombe site starts with the Basal Gravel, consisting of flint gravel in a brown, sandy-clay matrix which is considered as a solifluction deposit. It is overlain by the Lower Gravel, which consists of sandy gravel and contains a mammalian and molluscan fauna indicative of temperate conditions. The palynological evidence points to the presence of mixed oak forests with open grasslands. The layer also contains flint artefacts of the Clactonian culture type. The Lower Gravel is truncated by a channel infill of gravel in a shelly silty sand matrix, called the Midden Level. In this deposit mammalian remains have been found in association with Clactonian artefacts. On top of the Lower Gravel a channel is cut, which is infilled by the Lower Loam. The Lower Loam consists of clayey sands with thin lenses of white shell sand and it displays breaks in the sedimentation. Abundant faunal remains as well as artefacts have been found in this layer. The Lower Loam contains pollen indicative of late-temperate interglacial conditions. The upper part of the Lower Loam deposit is weathered and consists of a hard silty clay. On top of this so-called Weathered Lower Loam lies the Lower Middle Gravel, consisting of sandy gravel. This layer has yielded several thousand hand-axes and a molluscan fauna indicative of firmly established woodlands. The Lower Middle Gravel is separated from the following Upper Middle Gravel by an erosional boundary. The Upper Middle Gravel consists of sands with thin gravels and silty clays and has yielded three pieces of human skull. It also contains a mammalian and molluscan fauna suggesting a cooling of the climate. The deposit is cut by a channel with solifluction deposits and the so-called Upper Sand layer, which consists of sand with thin bands of clay with ice wedge casts, indicating periglacial conditions. This is overlain by the Upper Loam, which consists of a brown, sandy clay with bands of grey clay, containing pollen indicative of the presence of temperate woodlands. The overlying Upper Gravel consists of gravel in a sandy clay matrix, which turns into loose clayey silt with pebbles towards the top. It contains the remains of *Ovibos*, indicating cold conditions. The sequence ends with the Higher Loam, a clayey sand with pebbles (Ashton *et al.* 1995, 134-136; Bridgland 1994, 197, 198, 200, 202, 204, 205).

The temperate fauna found in the Lower Loam has been used for comparison with the faunal assemblages of Schöningen 13II. The Lower Loam deposit is dated to the Hoxnian and has been correlated with MIS 11. It is therefore considered to be contemporaneous with the Hoxne site (Schreve 2001a, 1694-1696).

The Lower Loam at Swanscombe has yielded relatively many Carnivora species. *Canis lupus* is present in Swanscombe and in Schöningen 13II-2 and 13II-4. The other Carnivora at Swanscombe are not found in the Schöningen 13II levels and include *Ursus spelaeus, Martes martes, Felis silvestris* and *Panthera leo*.

Both *Elephas antiquus* and *Equus ferus* are present in Swanscombe, as is the case for Hoxne. The Schöningen 13II levels and Swanscombe both contain the Rhinocertidae species *Stephanorhinus kirchbergensis* and *Stephanorhinus hemitoechus*.

The Artiodactyla species *Sus scrofa, Cervus elaphus, Capreolus capreolus, Bos primigenius* and *Bison priscus* appear in both Swanscombe and the Schöningen 13II levels. *Dama dama* is only present in Swanscombe, whereas *Megaloceros giganteus* only appears in Schöningen 13II-1 to 13II-3.

Thus, the Swanscombe site and the Schöningen 13II levels share many of the same species. The appearance of both warm temperate species *Sus scrofa* and *Capreolus capreolus* in level Schöningen 13II-1 and Swanscombe may indicate that these are contemporaneous.

6.5 Conclusion

It is difficult to place the Reinsdorf Interglacial in the Middle Pleistocene sequence based on the large mammal assemblages. Most of the analysed large mammals are very common throughout the Middle Pleistocene and the Schöningen 13II levels lack specific species that are indicative of a certain period in time. It is not possible to make a biostratigraphic differentiation on the limited differences between the faunal assemblages. However, it is certain that the Reinsdorf Interglacial is positioned between the Elsterian and the Saalian ice advance. The Schöningen 13II mammalian assemblages show close similarities with the assemblages from the German site Bilzingsleben II and the British Swanscombe site, which would therefore point to a Holsteinian age for Schöningen 13II. The faunal assemblages from Schöningen 13II and the assemblages from the British sites Barnham and Hoxne, which are also dated to MIS 11, do display some marked differences. These differences can, however, be explained by the geographical distance between the sites and are not necessarily caused by differences in age.

The Holsteinian age for the Schöningen 13II levels is also confirmed by the comparisons made by Schreve and Bridgland (2002). They have argued that the mammalian assemblages of Schöningen are very similar to Bilzingsleben II and Swanscombe and should therefore be dated to MIS 11. An alternative date has been proposed by Urban (2007a), who dated the Reinsdorf Interglacial to MIS 9 and the Schöningen Interglacial to MIS 7. However, the mammalian assemblages of the Reinsdorf Interglacial are not supportive of this date, as they do not resemble the Purfleet Mammal Assemblage-Zone dated to MIS 9. The Purfleet MAZ is characterized by the presence of the species *Crocuta crocuta* and *Ursus arctos*, which are both absent in the Schöningen 13II levels, Schöningen 13I and Schöningen 12B. Therefore, the Reinsdorf Interglacial is older than MIS 9 and should be dated to MIS 11 (Schreve and Bridgland 2002, 368, 369).

However, this conclusion must be treated with caution for two reasons. First, the absence of the two biostratigraphically significant species in all of the Middle Pleistocene Schöningen sites is of course not definite. The species can still be encountered during the progression of the research at Schöningen. Second, it should be noted that the conclusion is solely based on the data obtained from large mammal compositions. Mammalian assemblages can indicate interglacials and interstadials, but can also represent somewhat colder boreal periods or short temperate periods instead of actual interglacials. Tracing and reconstructing climatic change can not be based on faunal records alone because it gives less valuable conclusions about the course of the climate. The more reliable evidence from pollen analysis and small mammal remains must be added in order to convincingly date the Reinsdorf Interglacial to MIS 11 (Nitychoruk *et al.* 2006, 2679). The assignment of the Reinsdorf Interglacial to MIS 9 by Urban (2007a) can therefore not be excluded.

7. Summarizing conclusions and discussion

This thesis has focused on the Middle Pleistocene large mammal bones found in Schöningen, a town situated in the German federal state Niedersachsen. The mammalian remains were encountered in the archaeological site Schöningen 13II, which also yielded evidence for the presence of hominids. The site is dated to the Reinsdorf Interglacial.

The main goals of this research are to get an overview of the large mammal species present in the levels Schöningen 13II-1, 13II-2 and 13II-3 and to deduce palaeoecological, taphonomic and biostratigraphic information from these faunal and skeletal compositions. In specific, the following research questions have been addressed:

- Which large mammal species are present in the levels Schöningen 13II-1, 13II-2 and 13II-3 and how do the faunal compositions of these levels compare to each other? What palaeoecological information can be discerned from these compositions?
- How do the faunal assemblages in Schöningen 13II-1, 13II-2 and 13II-3 compare to the assemblage found in Schöningen 13II-4?
- What are the taphonomic influences on the skeletal compositions and what kind of traces do the bones display?
- How do the faunal compositions of the Schöningen 13II levels compare to Schöningen 12B and other Middle Pleistocene sites in Europe? Can biostratigraphic conclusions be drawn from these comparisons?

In order to provide answers to these questions, part of the large mammal bones found in Schöningen 13II-1, 13II-2 and 13II-3 has been analysed and determined. This analysis is combined with previous analyses on the levels by several researchers. In total 496 bones have been examined, of which 395 can be determined to family, genus or species level. Unfortunately, 101 bones can not be determined and are categorized under "large mammal". These indeterminate bones mainly include costae and vertebrae.

The used methodology has turned out to be very effective. The Pleistocene large mammal bones can be easily determined by comparing them to the bones of modern species. However, the bones of the Bovidae can not be determined to species level in this manner and are therefore categorized under "*Bos/Bison*". The incorporation of the bone material in the database has made it possible to quickly analyse the large mammal data of each separate level. T. Boxmeer (2011) and E. den Engelsman (2011) have examined the families Rhinocerotidae and Cervidae, and their measurements have been incorporated in this thesis.

The analysed taxa represent the suborder Caniformia and the families Canidae, Elephantidae, Equidae, Rhinocerotidae, Suidae, Cervidae, and Bovidae. The Caniformia and Elephantidae bones can not be determined to species level. The species that have been determined include the wolf *Canis lupus*, the Mosbach horse *Equus mosbachensis*, the forest rhino *Stephanorhinus kirchbergensis*, the steppe rhino *Stephanorhinus hemitoechus*, the wild boar *Sus scrofa*, the red deer *Cervus elaphus*, the giant deer *Megaloceros giganteus* and the roe deer *Capreolus capreolus.* The Bovidae family is represented by either the steppe bison *Bison priscus* or the aurochs *Bos primigenius*.

Previous research conducted by Van Asperen (2004) and Matze (2010) on the large mammal species from Schöningen 13II-1 to 13II-3 has been added to the analyses. Van Asperen has determined species of the family Mustelidae, comprising the ermine *Mustela erminea*, a *Mustela* species and a *Martes* species. The assemblages investigated by Matze contain the same species analysed by the author. She has additionally been able to distinguish the bones of the Bovidae species *Bos primigenius* and *Bison priscus*.

The large mammal compositions of the levels Schöningen 13II-1, 13II-2 and 13II-3 have been used to reconstruct the palaeoecology. The reconstruction is based on the specific palaeoenvironmental requirements of the present species. The Minimum Number of Individuals (MNI) has been counted to determine the representation of each species. Although in general the MNI has turned out to be low, the palaeoecology can still be established on the basis of the presence or absence of certain species.

Level Schöningen 13II-1 contains a typical interglacial fauna. The combined presence of *Stephanorhinus kirchbergensis, Sus scrofa* and *Capreolus capreolus* indicate the presence of forested environments and a warm temperate climate. Schöningen 13II-1 therefore represents the climatic optimum of the Reinsdorf Interglacial. The species *Equus mosbachensis*, *Stephanorhinus hemitoechus, Megaloceros giganteus* and *Bos/Bison* are indicative of open grasslands and steppes, so the environment most likely consisted of forests with open patches to sustain the present mammalian assemblage.

The faunal composition of Schöningen 13II-2 is less diverse than Schöningen 13II-1. The interglacial species *Sus scrofa* is absent in this level, which indicates that the climate has deteriorated. However, *Capreolus capreolus* is still present together with *Cervus elaphus*, suggesting the presence of forests. *Equus mosbachensis* and *Bos/Bison* are indicative of the presence of steppe and grassland environments. The ecology was therefore similar to the ecology of Schöningen 13II-1.

Level Schöningen 13II-3 contains a very diverse faunal assemblage. *Stephanorhinus kirchbergensis* and *Capreolus capreolus* are still present and together with the presence of the ermine *Mustela erminea* they indicate the presence of humid and temperate forests. The presence of *Equus mosbachensis, Stephanorhinus hemitoechus* and *Bison priscus* are indicative of steppe environments. Thus, the forest steppe environment was maintained throughout the levels Schöningen 13II-1 to 13II-3.

When comparing the levels Schöningen 13II-1 to 13II-3 with level Schöningen 13II-4 the differences are striking. The faunal assemblage from Schöningen 13II-4 is dominated by at least 19 individuals of *Equus mosbachensis*, whereas the previous levels contain at least two individuals of this species. This overrepresentation in combination with the cutmarks on the bones indicates that the horses were hunted and butchered by humans. The presence of *Equus mosbachensis* combined with the presence of *Stephanorhinus hemitoechus* and *Bison priscus* also indicates the presence of steppe environments. In addition, the interglacial species *Capreolus capreolus* is absent in Schöningen 13II-4, which may point to the disappearance of temperate forests and the beginning of a period with a dominance of cold steppe environments. However, the typical forest-adapted species *Mustela erminea* and *Stephanorhinus kirchbergensis* still appear in Schöningen 13II-4. Either patches of forests must have been present to sustain these species or they had a higher environmental tolerance than previously thought.

Thus, in general the large mammal fauna indicates a climatic deterioration throughout the Reinsdorf Interglacial, which is also suggested by palaeobotanical data. Schöningen 13II-1 represents the climatic optimum with the presence of forests with open patches, as indicated by the presence of *Sus scrofa* and *Capreolus capreolus*. The absence of *Sus scrofa* in the following levels and the absence of *Capreolus capreolus* in Schöningen 13II-4 indicates the gradual disappearance of temperate forests. The increase of cold-tolerant species adapted to steppe environments are indicative of the appearance of a cold steppe environment. Only the presence of *Mustela erminea* and *Stephanorhinus kirchbergensis* in Schöningen 13II-4 is not in accordance with the palaeobotanical results, as there were no forests present to sustain these species.

Considering the taphonomic state of the bones, it appears that the bone material is generally well preserved. The bones are often fragmented and show cracking or flaking of the surface, but they are well determinable. Other bones are complete and hardly display any signs of weathering. The degree of preservation of the bones differs per species. For instance, the large and robust bones of the Rhinocerotidae are better preserved than the slender, more breakable bones of the Cervidae.

In order to determine the representation of the skeletal elements from the head, body, front limb, hind limb and feet, the Number of Individual Specimens (NISP) per level has been calculated. The elements from the head are most abundant in all levels, which can be explained by the overrepresentation of dental elements. The relative underrepresentation of limb bones can be explained by the fact that these are not as numerous in the skeleton as, for instance, the vertebrae and phalanges. When taking these factors into account, it can be concluded that the skeletal elements are more or less equally represented in each level and are thus well preserved.

The low percentages of unfused skeletal elements and deciduous dental elements in each level indicates that juveniles are not abundant. However, the presence of bones from juvenile individuals again displays the pristine preservation of the material.

Unfortunately, the presence of cutmarks on the large mammal bones from Schöningen 13II-1, 13II-2 and 13II-3 can not convincingly be established. Two indeterminate bone fragments from unknown levels certainly contain cutmarks. In addition, Matze (2010) has determined the presence of cutmarks on a scapula of *Cervus elaphus* from Schöningen 13II-2. In any case it is certain that the bones from the oldest levels hardly contain any cutmarks compared to the bones from Schöningen 13II-4. The large mammal fauna from Schöningen 13II-1 to 13II-3 therefore appears to have derived from natural populations, which might occasionally have been hunted and butchered by hominids. This is confirmed by the equal representation of each species in the analysed levels, as opposed to the unnatural overrepresentation of *Equus mosbachensis* in Schöningen 13II-4.

In addition, two bones display gnawing marks caused by small rodents. These include a moderately gnawed cervical vertebra from Schöningen 13II-1 and a radius diaphysis of *Bos/Bison* from Schöningen 13II-2, with gnawing traces on the distal end.

In order to establish a biostratigraphy, the Schöningen 13II mammalian assemblages have been compared with the assemblages found in Schöningen 12B and other Middle Pleistocene sites in Germany and Great Britain. Level Schöningen 13II-1 and Schöningen 12B appear to be contemporaneous, as both contain the warm temperate species *Sus scrofa* and *Capreolus capreolus*. This implies that Schöningen 12B also dates to the climatic optimum of the Reinsdorf Interglacial.

The Schöningen 13II assemblages have been compared with the assemblage of Weimar-Ehringsdorf in Germany, a site dated to MIS 7. The sites do not have many species in common. The presence of *Crocuta crocuta*, *Ursus arctos* and *Alces latifrons* at Weimar-Ehringsdorf and their absence in the Schöningen 13II levels implies that these are not contemporaneous. Thus, the Schöningen 13II assemblages do not date to MIS 7.

The German site Bilzingsleben II is seen as a correlative of Schöningen II. When comparing the assemblage of Bilzingsleben II with the Schöningen 13II assemblages it appears that Bilzingsleben II mostly resembles level Schöningen 13II-1. Both contain *Sus* *scrofa* and a *Capreolus* species, perhaps indicating a contemporaneous climatic optimum. This is confirmed by the presence of the water buffalo *Bubalus murrensis* at Bilzingsleben II, which is a warm temperate species indicating mild winters.

The British archaeological site Barnham is dated to MIS 11 and has yielded a relatively poor mammalian assemblage. Most species encountered there are not found in the Schöningen 13II levels. However, the species found in both sites are not indicative of different time periods. Moreover, the observed differences are likely caused by the geographical distance between the sites. The sites may therefore be contemporaneous in spite of the dissimilar faunal assemblages.

Hoxne is another British site dated to MIS 11 and represents the stratotype of the Hoxnian/Holsteinian Interglacial. The site contains species like *Panthera leo* and *Dama dama*, which are absent in the Schöningen 13II levels. Both sites share the presence of *Capreolus capreolus* and *Cervus elaphus*. As is the case for Barnham, Hoxne can still be of the same age as Schöningen 13II, in spite of the fact that they do not have many species in common. Hoxne can correlate with either Schöningen 13II-1, 13II-2 or 13II-3.

The Lower Loam at the British site Swanscombe is dated to MIS 11 as well. It is the only British site that displays convincing similarities to the Schöningen 13II assemblages, as both share many of the same species. The appearance of both warm temperate species *Sus scrofa* and *Capreolus capreolus* in Schöningen 13II-1 and Swanscombe may indicate that these are contemporaneous.

Unfortunately, most of the analysed large mammals from the Schöningen 13II levels are very common throughout the Middle Pleistocene and the material lacks specific species that are indicative of a certain period in time. The mammalian compositions of the Reinsdorf Interglacial bear most resemblance to Bilzingsleben II and Swanscombe, attributed to MIS 11. This implies that the Schöningen 13II assemblages are Holsteinian in age and that the Reinsdorf Interglacial is not an actual interglacial, but a warm substage within the Holsteinian Interglacial. According to the Mammal Assemblage-Zones established by Schreve and Bridgland (2002), the absence of *Crocuta crocuta* and *Ursus arctos* in the Schöningen 13II levels implies that these must be older than MIS 9. Thus, the levels indeed most likely date to MIS 11. However, it should be noted that a biostratigraphy based solely on large mammal compositions is not very reliable. The interpretation of Urban (2007a), who dates the Reinsdorf Interglacial to MIS 9 on the basis of pollen analyses, can therefore not be excluded.

The results of this research have significant implications for the archaeological research in Schöningen. During the Reinsdorf Interglacial the hominids lived in a forest steppe environment, with which they effectively interacted. The large mammals were not hunted often during the start of this interglacial, the time of the climatic optimum. Perhaps there was little need to hunt big game, as the humidity and warm temperatures of the climate would have produced enough botanical food supply. But as the climate became increasingly colder, it may have become more necessary for the hominids to consume meat. They fabricated wooden spears that were made out of the surrounding trees. The spears were used to hunt the specific interglacial species that were available at that time, most notably *Equus mosbachensis*. The location at Schöningen was particularly suitable for the hominids to reside, as the lakeshore environment and the surrounding flora and fauna provided them with water and food. This interpretation therefore illustrates the need to investigate large mammal assemblages for the purpose of understanding hominid behaviour and dispersal.

Subsequent research on the Schöningen 13II assemblages and the other Middle Pleistocene Schöningen sites should focus on three important issues. First, the abnormal presence of the species *Mustela erminea* and *Stephanorhinus kirchbergensis* in level Schöningen 13II-4 should be investigated further. Both *Mustela erminea* and *Stephanorhinus kirchbergensis* are considered forest-adapted species, but the palaeovegetation of Schöningen 13II-4 indicates the presence of a cold steppe environment. Either both species were able to adapt to cold steppes, or forests must have been present to sustain them, which would imply that the climate was not as cold as the pollen analyses suggest. This discrepancy indicates that a reconsideration of the palaeoecological conditions is among the aspects to be discussed in the near future.

Second, the size changes of large mammals that took place during the Reinsdorf Interglacial should be clarified. Previous researchers found that the Schöningen horses decrease in size during the Reinsdorf Interglacial, whilst their bones display morphological change as well. The Schöningen rhinos display an increase in size. It is unclear whether these trends imply a fast evolutionary speed during the Reinsdorf Interglacial or whether they are induced by sexual dimorphism or environmental change. In addition, the size changes should be used for biostratigraphic correlation purposes. For example, the correlation of Bilzingsleben II with Schöningen 13II can perhaps be more firmly established in the future when the analysed horse bones from Schöningen 13II-1 are measured and compared with the size of the horse bones from Bilzingsleben II.

Third, it is important to combine all of the present palaeoecological evidence. Palaeobotanical and faunal data must not be investigated in isolation. A coherent story can only be established when all the evidence from Schöningen is combined. The age estimates of the Reinsdorf Interglacial are uncertain at present, but perhaps this problem can be solved in the future on the basis of united evidence.

Abstract

In the German town of Schöningen (Niedersachsen, Germany) several Middle Pleistocene sites have been found and excavated since 1992. These sites are named Schöningen 12B, Schöningen 13I and Schöningen 13II. The latter has been the focus of research since wooden spears of Palaeolithic man were found there among the remains of butchered horses. Schöningen 13II consists of five different levels named Schöningen 13II-1 to 13II-5, which are dated to the newly defined Reinsdorf Interglacial. For this thesis the large mammal remains found in the oldest levels Schöningen 13II-1, 13II-2 and 13II-3 have been determined and analysed.

The bones have been assigned to species of the suborder Caniformia, the wolf *Canis lupus*, species of the family Elephantidae, the Mosbach horse *Equus mosbachensis,* the forest rhino *Stephanorhinus kirchbergensis,* the steppe rhino *Stephanorhinus hemitoechus,* the wild boar *Sus scrofa,* the red deer *Cervus elaphus,* the giant deer *Megaloceros giganteus,* the roe deer *Capreolus capreolus* and species of the genus *Bos/Bison*, the bones of which belong to either the aurochs *Bos primigenius* or the steppe bison *Bison priscus*. The large mammal species of Schö 13II-1, 13II-2 and 13II-3 determined by previous researchers, have been added to the analyses for completeness. In addition to the aforementioned species, these researchers have determined species of the family Mustelidae, including the ermine *Mustela erminea*, a *Mustela* species and a *Martes* species, and species of the family Bovidae, including *Bos primigenius* and *Bison priscus*. The previously analysed faunal assemblage from level Schöningen 13II-4 has been added to the palaeoecological and biostratigraphic analyses as well.

The large mammals have been used to reconstruct the palaeoecology during the Reinsdorf Interglacial. The animals represent a warm temperate climate and the presence of a forest steppe environment in Schöningen 13II-1, the climatic optimum, with increasingly cooler conditions up to level Schöningen 13II-4, in which the wooden spears were encountered. These results are in accordance with the palaeobotanical data of the Schöningen 13II levels. Considering the taphonomic state of the bones it appears that these are very well preserved, whilst all skeletal elements are more or less equally represented. Unfortunately the presence of human cutmarks has been difficult to establish, only two indeterminate bone fragments certainly display cutmarks. The fauna therefore consisted of natural populations which might occasionally have been hunted and butchered by hominids. Gnawing traces of a rodent are present on a radius of *Bos/Bison*.

The mammalian compositions of the Schöningen 13II levels have been compared with those from other Middle Pleistocene sites in Germany and Great Britain. The Schöningen 13II compositions bear most resemblance to the faunal assemblages from

Bilzingsleben II and Swanscombe, attributed to MIS 11. It follows that according to the large mammal fauna the Reinsdorf Interglacial should be attributed to MIS 11 as well, and is thus of Holsteinian age.

Samenvatting

In de Duitse plaats Schöningen (Nedersaksen, Duitsland) zijn verscheidene Midden-Pleistocene vindplaatsen aangetroffen en opgegraven sinds 1992. Deze vindplaatsen zijn genaamd Schöningen 12B, Schöningen 13I en Schöningen 13II. Laatstgenoemde is de focus van onderzoek geweest, aangezien daar houten speren van de Paleolithische mens gevonden zijn te midden van de resten van geslachte paarden. Schöningen 13II bestaat uit vijf verschillende lagen genaamd Schöningen 13II-1 tot en met Schöningen 13II-5, welke gedateerd zijn tot het nieuw gedefinieerde Reinsdorf Interglaciaal. Voor deze scriptie zijn de grote zoogdierresten uit de oudste lagen Schöningen 13II-1, 13II-2 en 13II-3 gedetermineerd en geanalyseerd.

De botten zijn toegekend aan soorten van de onderorde Caniformia, de wolf *Canis lupus*, soorten van de familie Elephantidae, het Mosbach paard *Equus mosbachensis*, de bos-neushoorn *Stephanorhinus kirchbergensis*, de steppe-neushoorn *Stephanorhinus hemitoechus*, het wilde zwijn *Sus scrofa*, het edelhert *Cervus elaphus*, het reuzenhert *Megaloceros giganteus*, het ree *Capreolus capreolus* en soorten van het genus *Bos/Bison*, waarvan de botten behoren aan hetzij het oeros *Bos primigenius*, hetzij de steppenwisent *Bison priscus*. De grote zoogdiersoorten uit Schö 13II-1, 13II-2 en 13II-3 welke gedetermineerd zijn door voorgaande onderzoekers, zijn toegevoegd aan de analyses voor het totaalbeeld. Naast bovengenoemde soorten hebben deze onderzoekers ook soorten van de familie Mustelidae gedetermineerd, waaronder de hermelijn *Mustela erminea,* een *Mustela* soort en een *Martes* soort, en soorten van de familie Bovidae, waaronder *Bos primigenius* en *Bison priscus*. De eerder geanalyseerde dierlijke samenstelling uit de laag Schöningen 13II-4 is tevens toegevoegd voor de paleoecologische en biostratigrafische analyses.

De grote zoogdieren zijn ingezet bij de reconstructie van de paleoecologie gedurende het Reinsdorf Interglaciaal. De dieren vertegenwoordigen een warm gematigd klimaat en de aanwezigheid van een bos en steppe omgeving in Schöningen 13II-1, het klimaatoptimum, met toenemende koelere omstandigheden tot aan Schöningen 13II-4, waarin de houten speren zijn aangetroffen. Deze bevindingen stemmen overeen met de paleobotanische gegevens uit de Schöningen 13II lagen. Aangaande de tafonomische staat van de botten kan gesteld worden dat deze zeer goed bewaard zijn gebleven en alle skeletelementen zijn min of meer evenredig vertegenwoordigd. Helaas is de aanwezigheid van menselijke snijsporen moeilijk te bepalen, slechts van twee ondetermineerbare botfragmenten kan met zekerheid gesteld worden dat zij snijsporen bevatten. De fauna bestond dus waarschijnlijk uit natuurlijke populaties waar soms op gejaagd werd door hominiden voor de voedselvoorziening. Knaagsporen van een knaagdier zijn aanwezig op een radius van *Bos/Bison*.

De zoogdier samenstellingen van de Schöningen 13II lagen zijn vergeleken met de samenstellingen uit andere Midden-Pleistocene sites in Duitsland en Groot-Brittannië. De Schöningen 13II samenstellingen vertonen de meeste overeenstemming met de dierlijke assemblages uit Bilzingsleben II en Swanscombe, toegekend aan MIS 11. Hieruit volgt dat het Reinsdorf Interglaciaal volgens de grote zoogdier fauna ook uit MIS 11 en dus uit het Holstein dateert.

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Appendices

Appendix A: Table of the data collected by the author, Den Engelsman (2011) and Boxmeer (2011).

Appendix B: Graph of the NISP per skeletal element per level as determined by the author.

Appendix A: Table of the data collected by the author, Den Engelsman (2011) and Boxmeer (2011), displaying the Number of Individual Specimens (NISP) and Minimum Number of Individuals (MNI) of the Schöningen levels 13II-1, 13II-2 and 13II-3.

	Schö 13II-1 NISP	**Schö 13II-1 MNI**	**Schö 13II-2 NISP**	**Schö 13II-2 MNI**	**Schö 13II-3 NISP**	**Schö 13II-3 MNI**
ORDER CARNIVORA						
Family Canidae						
Canis lupus			1	1		
Caniformia gen. et sp. indet.	2	1			5	1
ORDER PROBOSCIDEA						
Elephantidae gen. et sp. indet.	5	1				
ORDER PERISSODACTYLA						
Family Equidae						
Equus mosbachensis	11	2	41	2	29	2
Family Rhinocerotidae						
Stephanorhinus kirchbergensis	1	1			4	2
Stephanorhinus hemitoechus	7	1				
Stephanorhinus sp.	41	2	5	1	25	2
ORDER ARTIODACTYLA						
Family Suidae						
Sus scrofa	5	1				
Family Cervidae						
Cervus elaphus	3	1	21	3	18	2
Megaloceros giganteus	2	1	1	1	6	1
Capreolus capreolus	4	1	4	1	3	1
Cervidae gen. et sp. indet.	5	1	8	1	7	1
Family Bovidae						
Genus *Bos/Bison*	3	1	18	2	18	2

Appendix B: Graph of the NISP per skeletal element per level as determined by the author.