Life Between The Ice: Reconstructing the Paleolithic Interglacial Environment of Schöningen 12 II-4 to Explore Botanical Resource Exploitation by Hominins

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Chapter 1: Introduction

During the Lower Paleolithic, the European continent experienced an 'ice age' consisting of glacial periods and more temperate inter-glacial periods (Szymanek & Julien, 2018). Amid these climatic changes, hominins lived off of the land and left traces of their activities behind for archaeologists to uncover. The Paleolithic site of Schöningen in Germany, shown in Figure 1, has received a lot of attention since the discovery of wooden hunting spears situated near to a mass grave of butchered horse skeletons (Thieme, 1997). In addition to these finds, the excavations at Schöningen also provided archaeologists with many other artifacts, including stone tools, botanical, and faunal remains (Thieme, 2007). Extensive research has been conducted on the site since the start of excavation in 1982 to try and understand the various clues left behind by the hominins (Serangeli et al., 2015).

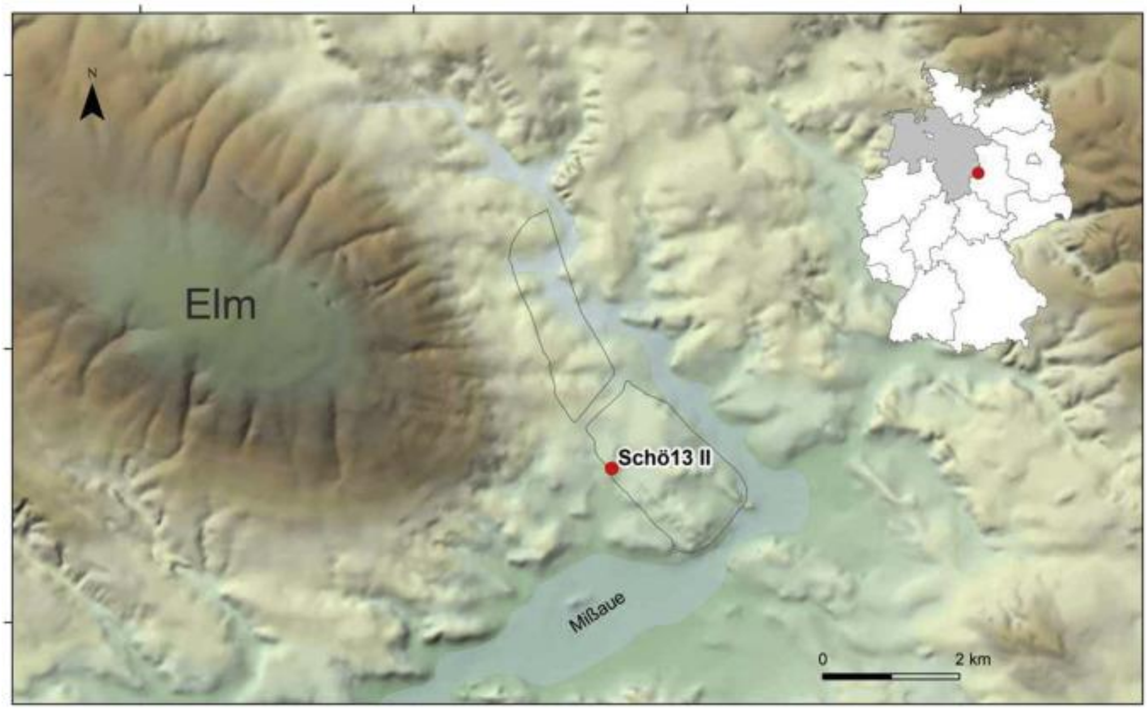

Figure 2: This figure shows the archeological site Schöningen 13 II and provides the location of Schöningen within Germany. Graphic by Utz Böhner, DEM by Dirk Fabian.

This thesis project will build upon the research that has been conducted surrounding the Paleolithic site in order to provide a greater understanding of the vegetation and environment through the study of botanical macro-fossils collected at Schöningen 12 II-4. The data will also be used to explore the potential opportunities for plant exploitation that would have been available to the hominins in the area. This thesis will focus on the different plants present at Schöningen 12 II-4 and use the characteristics of each species to determine potential uses the plants may have had for the hominins. Present understanding of human plant interactions is extremely limited, and this project aims to bring to light the possibilities of plant exploitation that may have occurred alongside hunting at this famous site.

1.1 Research Aims

This thesis aims to fill a gap in current research surrounding the environmental conditions in Schöningen 12 II-4 during one of the Pleistocene interglacial periods. An additional aim of this project explores hominin plant exploitation possibilities. Two research questions were created to guide the research of this project. The two main research questions were formulated as follows:

1. What were the vegetation and environment like at Schöningen 12 II-4?
2. What can an ethnobotanical analysis of the plant macro-fossils found at Schöningen 12 II-4 tell us about hominin subsistence strategies and raw plant material processing opportunities?

Previous research has yielded environmental data surrounding other Schöningen sites and layers. However a botanical analysis from Schöningen 12 II-4 has previously not been undertaken. This thesis hopes to provide this information to create a more comprehensive understanding of Schöningen and the context surrounding the hominins present in the landscape approximately 300,000 years ago. Plant macro-fossils extracted from Schöningen 12 II-4 form the basis for the environmental reconstruction and give insight into the interglacial landscape in central Germany.

Plant exploitation by hominins has previously been suggested as a reason for hominin presence in Schöningen (Bigga et al., 2015). This thesis aims to support the claim that hominins were exploiting plants as well as animals at Schöningen through an ethnobotanical analysis of the taxa available in and around the lake.

Chapter 2: Background

2.1 A Brief Introduction to the Pleistocene During the Central European Lower Paleolithic

The Lower Paleolithic period in Europe spans from roughly 1 million years ago until about 300,000 years ago and corresponds to Marine Isotope Stages (MIS) 29 to 9 (Szymanek & Julien, 2018, p. 56). This period is further divided into the late Early Pleistocene (MIS 29-19), early Middle Pleistocene (MIS 19-12), and mid-Middle Pleistocene (MIS 11-9), the last of which will be the focus of this thesis (Bridgland et al., 2006; Burdukiewicz, 2009; Szymanek & Julien, 2018). During this time, Central Europe underwent a series of glacial periods and corresponding interglacial periods that were significantly warmer as a result of the oscillations of glaciers from Scandinavia (Szymanek & Julien, 2018). Three separate periods of glaciation occurred in Pleistocene Europe: the Elsterian, roughly taking place during MIS 12; the Saalian, lasting approximately from MIS 6 until MIS 8; and the Weichselian, taking place from MIS 2 until MIS 4 (Ehlers & Gibbard, 2007). The Pleistocene glacial maximum saw ice farther south than 40 ° north and farther eastwards than 110 ° east (Ehlers & Gibbard, 2007, p. 12). The maximum extent of each glacial period can be seen in Figure 2.

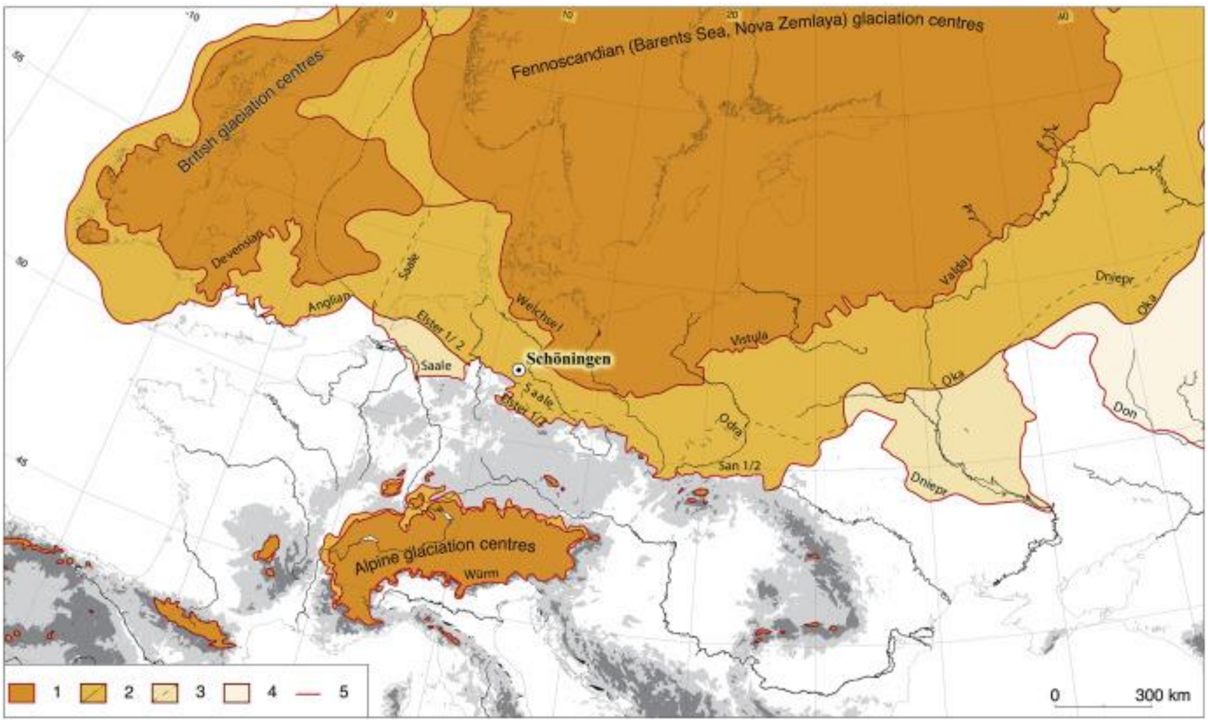

Figure 3: This figure shows the maximum extent of glaciation during Elsterian, Saalian, and Weichselian. Picture from Conard et al. (2015), modified from the image by van Gijssel (2006).

The Paleolithic period produced many changes within the European landscape as flora and fauna adjusted to the fluctuating levels of ice. As the climate changed, both plants and animals experienced growth and shrinking of their geographical range, and while this period birthed the emergence of many new species it also marked a period of extinction for many others (Magri & Palombo, 2013). The first hominins entered Northern Eurasia for the first time approximately 1 million years ago, the beginning of the Pleistocene period, and archaeological evidence places hominins in Central Europe as early as 600,000 years ago (Burdukiewicz, 2009). By 450,000 years ago, hominins had already reached Central Germany (Burdukiewicz, 2009).

2.2 Understanding the Complex Site Schöningen

The Pleistocene site Schöningen is situated in the German state of Lower Saxony, to the north of the Harz mountain range. Hominin activity in Schöningen dates to approximately 300,000 years ago (Burdukiewicz, 2009). The initial excavations at Schöningen, which began in 1982, were originally rescue archaeology excavations due to open-cast lignite mining in the area (Serangeli et al., 2015). The nearby mining operations uncovered Pleistocene and Holocene sedimentary deposits that were approximately 45 meters thick which included Elsterian, Saalian, and Weichselian glacial sedimentary deposits as well as Holstein, Reinsdorf, and Schöningen interglacial sedimentary deposits (Conard et al., 2015; Urban et al., 2011; Urban and Bigga, 2015). The mining company agreed to preserve an area of 3,900 m^2 for research purposes, and as a result a team led by German archaeologist Hartmut Thieme began excavating at Schöningen (Conard et al., 2015).

At least two separate Pleistocene sites exist within Schöningen and can be seen in Figure 3. The sites are labeled as Schöningen 12 and Schöningen 13, with Schöningen 12 being located approximately 800 meters to the north of Schöningen 13 (Julien et al., 2015). Within the two Pleistocene sites, numerous sections and layers have been excavated. The notation for describing different locales within Schöningen is as follows: site number, section within site, and layer within section. For example, Schöningen 13 II-4 (the 'Spear Horizon') is found at Schöningen site number 13 in section II at layer number 4. Some layers have been additionally subdivided. When this is the case a letter will follow the layer number, for example Schöningen 12 II-4c. Open cast mining operations from 2008 until 2009 have completely removed all Pleistocene layers of Schöningen 12 II. As a result the site of Schöningen 12 II effectively does not exist anymore (Serangeli et al., 2015).

Both Schöningen sites have been dated to MIS 9, approximately 300,000 ka BP, using lithographic and biostratigraphic evidence from uranium series dates (Sierralta et al., 2017) and luminescence ages (Richter & Krbetschek, 2015). The sites correspond with the late Lower Paleolithic and the late Middle Pleistocene periods (Conard et al., 2015).

The site contains an abundance of lacustrine sedimentary deposits, showing evidence for a Paleolithic lake in the vicinity. Different researchers have contested the origins of these lacustrine deposits. Elsner (1987) originally wrote that the lacustrine deposits resulted from a kettle-lake as the Elsterian glacial deposits melted revealing sediments containing dead-ice (Elsner, 1987). Another researcher, Mania (1995), argued that the lacustrine deposits formed as subsurface salts dissolved and fluvial channels experienced incisions and infilling over three separate phases (Mania, 1995). Finally, in a paper by Lang et al. (2012), the authors argued that the lake, of up to 2.5 kilometers long, 300-400 meters wide and 6-7.5 meters deep, was formed sub glacially during the Elsterian as sediment filled a tunnel-valley before deglaciation (Lang et al., 2012). The Lacustrine deposits are important to note because the lake and potentially changing water levels created a waterlogged environment which provided optimal conditions for preserving organic matter and other archaeological artifacts.

Within Schöningen there have been three different sites identified with strong cultural layers: Schöningen 12 B, levels 1 and 2; Schöningen 13 I – 1; and Schöningen 13 II-4 (Bigga et al., 2015). Other locations within Schöningen have yielded archaeological finds, however in much more isolated contexts (Serangeli & Conard, 2015, p. 289). The isolated nature of the other finds has been interpreted as objects that were unintentionally discarded whilst the hominins were passing through the area. However the lack of finds in some locales could also be attributed to the rescue nature of certain portions of the excavation (Julien et al. 2015; Serangeli & Conard, 2015). Both levels 1 and 2 of Schöningen 12B yielded similar finds, which can be summarized by various stone tools, botanical and faunal remains, and 4 fir (*Albies alba)* branches which were proposed as bases for stone tools (Thieme, 2007). The assemblage at Schöningen 13 I – 1 included various flint tools, flakes, and faunal remains of different steppe species (Thieme, 1997, 2007). Schöningen 13 II-4, also referred to as the 'Spear Horizon' contains some of the most famous finds from the site. The Schöningen 13 II-4 assemblage includes multiple wooden spears, large quantities of animal bones with cut marks, and large quantities of flint tools and flakes (Thieme, 1997, 2000, 2005, 2007).

The 'Spear Horizon' brought widespread fame to Schöningen within the archaeological community specifically because of the impeccable preservation of the wooden spears, as wood from the Lower and Middle Paleolithic is extremely rare. Prior to the findings at Schöningen, only two other sites provided researchers with wooden artifacts from this period: a fragmented spear tip made from yew extracted from Clacton-on-Sea (Oakley et al., 1997); and complete yew spear excavated at Lehringen (Adam, 1951; Thieme & Veil, 1985). The discovery of multiple, well preserved, wooden spears at Schöningen was revolutionary for our understanding of hominin hunting, providing strong evidence to support claims of pre *Homo sapiens* hominin species possessing the capabilities to hunt large game through coordinated attacks (Conard et al., 2015).

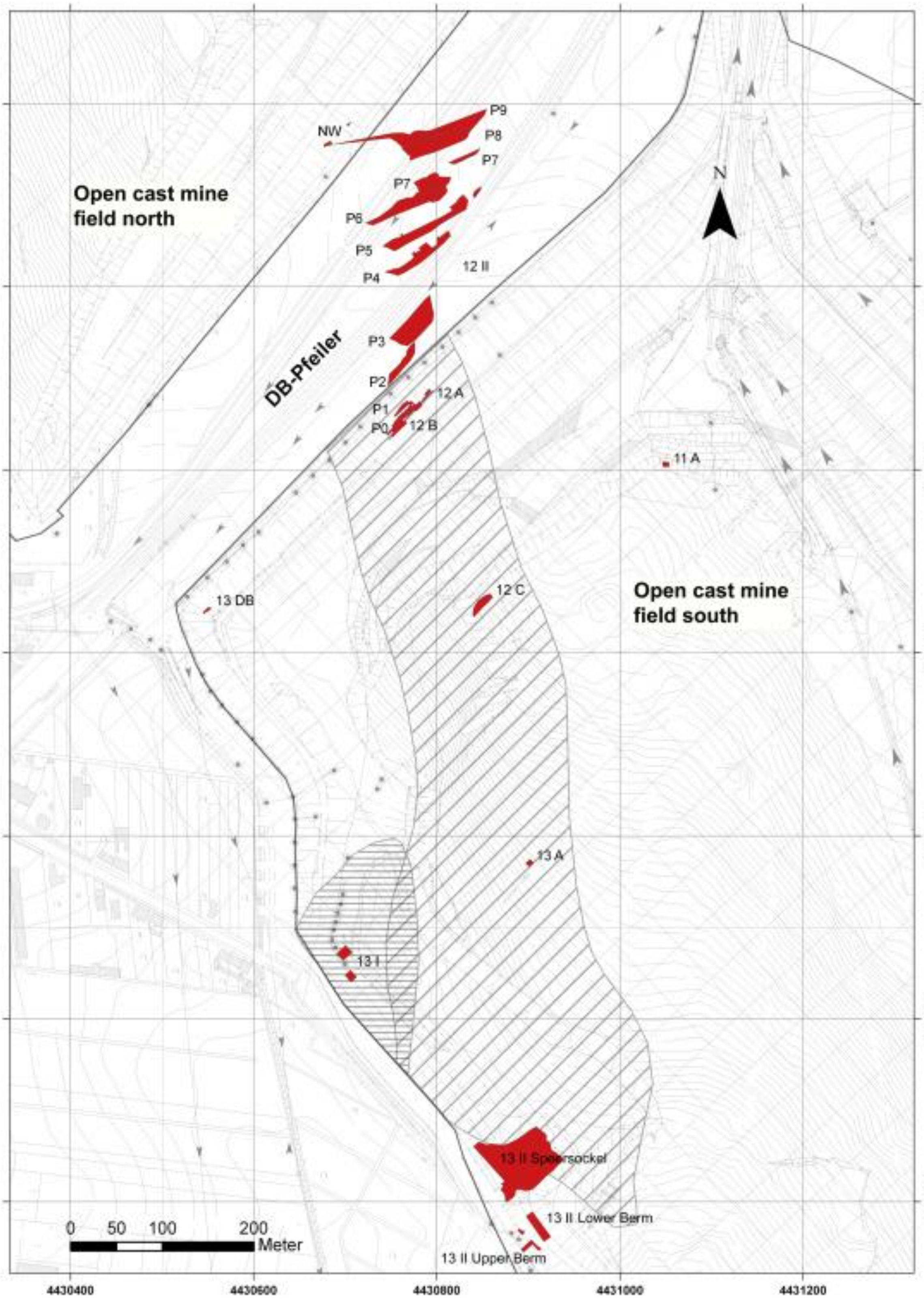

Figure 4: This figure shows a schematic drawing of the different Schöningen sites along with the open-cast mine. Drawing by Utz Böhner.

2.3 A Summary of Past Research at Schöningen 12 II-4

The focus of this thesis will be on Schöningen 12 II-4, a layer chronologically contemporaneous with the infamous Spear Horizon (Schöningen 13 II-4). Schöningen 12 II-4 and Schöningen 13 II-4 are also geographically near to each other, which is visualized well in Figure 4. Schöningen 12 II-4 was excavated as part of the rescue archaeology excavation (Julien et al., 2015). The soil composition included a layer of gray clay and a dark layer including high quantities of organic material (Julien et al., 2015). The excavations at Schöningen 12 II-4 yielded 23 stone artifacts which included 5 retouched lithium (Serangeli & Conard, 2015). Additionally, 569 bone specimens were retrieved, and 43 of these bones showed signs of scraping or cut marks. However, it is unclear whether these were human made alterations (Julien et al., 2015). Around 60 % of the bone assemblage was comprised of bovids, and aurochs were particularly prevalent (Julien et al., 2015).

Compared with other layers, Schöningen 12 II-4 does not boast as many material artifacts. However, the few artifacts uncovered confirm that hominins at least passed through the northern area of Schöningen. Limited research is available to describe the botanical remains recovered at Schöningen 12 II-4, however the layer is briefly mentioned (see Bigga et al., 2015).

Figure 5: A drawing showing the stratigraphy of Schöningen 13 II-4 and the DB Pfeiler containing Schöningen 12 II. 1: Holocene, 2: Weichselian glacial löss, 3: Saalian glaciation made of sand and gravel, 4: Schöningen 12 II, 5: Elsterian glacial deposits, 6: sand and lignite. Photos and drawing by Jordi Serangeli.

2.4 Ancient Diet

Studying ancient hominin diet is a difficult task for a number of reasons. Firstly, early hominin fossils are rare (Alemseged & Bobe, 2009). Secondly, the study of dietary adaptations includes many destructive methods which would damage the fossils (Alemseged & Bobe, 2009). With so few fossils to study, the risk of damaging a specimen is often too high. Additionally, another large issue with studying ancient hominin diet is that organic matter does not preserve well in many conditions (Alemseged & Bobe, 2009). This makes it difficult to find direct evidence of plant material that has been consumed. Lastly, there are issues with interpreting paleobotanical diets because there are inherent issues with basing knowledge about ancient diets on present diets (Alemseged & Bobe, 2009).

Despite the issues involved, there are studies that link hominins to a diet inclusive of plant material. Hominins from as early as *Australopithecus* have been suggested as following a hunter-gatherer diet (Paine et al., 2019). Early hominins were selective about both species and plant part in order to live seasonally with respect to the resources available to them (Paine et al., 2019, p. 2). It is important when thinking about early human diet to consider both the texture (hard, soft, etc.) and high or low levels of nutrition (Alemseged & Bobe, 2009, p. 181). These factors in addition to season, temperature, habitat and availability all influence the ways in which early humans interacted with plants in their diet (Henry et al., 2018). As omnivores, early humans surely ate plant material, but different factors may have played a role in determining how much of a particular hominins diet came from plants (Henry et al., 2018).

Chapter 3: Methods

The following section explores the methodology used for this thesis's research phase. In the first section of the Methods, the soil sampling strategy containing the plant macro-fossils (fruits and seeds) will be discussed. Issues with the sample will also be discussed here. After this the process of dry sieving the sample will be discussed. Following this will be a detailed description of the picking process. The next section will discuss the process of identifying and counting each macro-fossil. Finally, the process for taking the data and creating an environmental reconstruction and an ethnobotanical analysis will be discussed.

3.1 Sampling Methodology

The soil sample containing the plant macro-fossils used for this thesis project were obtained at the Schöningen 12 II site. The sample comes from level 4. Schöningen 12 II-4 is a level contemporary to Schöningen 13 II-4, which is also known as the 'Spear Horizon'. The sample was collected from the prehistoric lakeside that existed at Schöningen during the Pleistocene period. The lakeside was chosen because of the high quality of organic matter preservation due to the waterlogged conditions. The original intended use for this sample was to look for zoological remains. Organic material, including plant macro-fossils, were well preserved in this sample, which made its use appropriate for this thesis.

For this project, only a portion of the total amount of sediment was sampled for analysis. The amount was enough to give a fair representation of the total sample while keeping the workload manageable for the size of this project. Using the entire sample would have given a more comprehensive overview of all the taxa present. However, a smaller sample will still be sufficient for the aims of this thesis. The smaller sample was also most logical due to time constraints surrounding this thesis.

3.2 The Sieving Process

When preparing a sample for plant macro-fossil analysis, it must go through a sieving process to separate the fossils from the soil. The original intention of this sample was a zoological analysis, so the sample was dry sieved on site. The sample had already been dry sieved to 500 micrometers before this project began.

Sieving to 500 micrometers is atypical for a botanical analysis, which would normally sieve materials to a much smaller size. The standard in the Leiden University botanical laboratory is to sieve to 150 micrometers. Typically, a smaller sieve size is preferred because many plant macro-fossils are extremely small and can only be seen under a microscope. A larger sieve size has great implications for botanical analysis because it will include an overrepresentation of larger fossils and will exclude fossils smaller than 500 micrometers, as these fossils would have fallen through the sieve and would not have been collected.

Despite the larger sieve size, the sample contained many plant macro-fossils, which meant that it was still a viable sample for botanical analysis. The loss of smaller fossils will affect the data and create a bias for taxa that leave behind larger fossils. Due to the original sieving, this project will not include any data pertaining to fossils smaller than 500 micrometers. It will also not be possible to provide a pollen analysis for the same reason.

3.3 Picking Macro-fossils

The macro-fossils must be hand-picked from the sample after the sieving is complete. This is done under a microscope with tools. For this project, a Leica microscope was used with a magnification of 10 times. The tools used to pick the fossils included forceps, small paint brushes, Petrie dishes, beakers, and plastic collection tubes.

During the picking process, small quantities of the sample were placed into a lined Petrie dish. Under the microscope the sediment was scanned row for row in search of macro-fossils. When found, the individual macro-fossils were removed from the Petrie dish with forceps or a paintbrush and were placed into a plastic collection tube. For this thesis, only carpological macro-fossils (seeds and fruit) were picked. Fossilized wood was not included.

The primary tool used for picking was the paintbrush. A paintbrush was used due to the fragile nature of the fossils. Some larger fossils were extracted using forceps. Macro-fossils were pre-sorted based on morphology into collection tubes after being extracted from the sample. After the botanical fossils were removed, the excess sediment was placed into a beaker.

There were 8 collection tubes that contained the pre-sorted macro-fossils. The collection tubes were airtight. The samples were dry, which meant that they did not require any chemical treatment for preservation.

3.4 Macro-fossil Counting and Identification

After the picking process was finished, identification of the macro-fossils began. To identify the macro-fossils, they were separated based on morphology. Once the fossils were separated and grouped the morphology could be compared to reference collections and books to determine the type of fossil. Identifications were made to the species level when possible. However not all taxa could be identified past the genus level due to preservation of fossils. Fossils that could not be identified past the genus level use the abbreviation 'sp.' following the name of the genus. When the species cannot be confirmed 'cf.,' meaning confer, follows the genus, and precedes the species indicating that the species can be used as a reference and possible identification.

Notation of the plant part also took place during the identification process. Plant parts in this assemblage were categorized as: bud, fruit, nutlet, perianth, fruitstone, oospore, endocarp, or lid. Plant parts help identify the reproductive processes of the taxa in the assemblage.

In addition to identifying the type of fossils, each seed was counted. Whole fossils and fragmented fossils were counted separately from one another for each taxon. Fragmented fossils were defined as less than 75% of the fossil. Total numbers reported for all taxa exclude *Characeae sp.* fossils. The Characeae sp. fossils were not counted due to their prevalence in the sample, and Characeae sp. was intentionally excluded from the total to correct for overrepresentation to avoid a bias in the dataset.

3.5 Environmental Reconstruction

Once identifications were made for the taxa in the assemblage, literature was consulted to understand the specific ecological tolerances for each taxon. An analysis of the specific ecological tolerances of each taxon will be used to understand the general ecological conditions present at Schöningen 12 II-4. Information regarding soil type, salinity, temperature, rainfall, water levels, and water current, among other metrics, was collected for the environmental analysis. Taxa that could not be identified to species level, while still helpful, provide a much more limited amount of specific environmental information. These taxa will still be discussed when relevant information can be discerned.

The quantitative data will provide the prevalence of each species in the form of percentages of the total assemblage as well as the prevalence within each subgroup. While this can be helpful, care must be taken when examining these percentages, as certain species within the assemblage naturally yield more seeds than others and will subsequently produce higher amounts of fossils. As a result, these percentages should be viewed as a guide rather than a definitive count of each species found at Schöningen 12 II-4.

3.6 Ethnobotanical Analysis

The method chosen for the ethnobotanical analysis of the assemblage was a literature review. Journals and books were consulted to determine known uses for the different taxa in the assemblage. Additional literature was consulted to determine whether there was archaeological evidence to support hominin use for these taxa. Literature about all geographical regions was consulted, but the archaeological context was limited to the late Lower Paleolithic. Literature pertaining to hominin dentition and subsistence strategies were particularly useful. The various types of literature used for this project will be helpful in determining whether the hominins may have been in Schöningen to collect plant-based resources in addition to hunting.

Chapter 4: Results

The results from the identification and counting of the macro botanical fossils from Schöningen 12 II-4 have been displayed in Table 1. Taxa have been divided into three separate ecological groups: waterside and damp ground, obligate aquatics, and unclassified. Taxa were listed in alphabetical order within their ecological grouping. Whole and fragmented fossils were included. However, when counting occurred these were separated from one another, and this choice is reflected in Table 1 through separate columns. Some taxa appear multiple times in Table 1. This is either because the assemblage contained different plant parts from the same species or varied species that could not be identified within the same genus. As a result, Table 1 also includes a classification of which plant part was fossilized. Six distinct types of plant parts were distinguished: bud, fruit, nutlet, perianth, fruitstone, oospore, endocarp, and lid.

There were 26 taxa identified to the genus or species level. Preservation of fossils was the most common reason taxa could not be identified to the species level. The total number of each taxon present in the assemblage can be calculated by adding the whole and fragmented numbers of each taxon together. The absolute number of fossils studied includes both partial and whole fossils. Certain species produce more seeds per plant and as such the absolute numbers may not be indicative of the whole numbers of plants present at the time of deposition. Interpretations of the data from Table 1 must keep this in mind to avoid misinterpreting the significance of certain taxa in the assemblage.

Non-botanical fossils were also present in the assemblage. These have not been included in Table 1 and were not counted. The fossils included: *Coleoptera* (elytrum), *Mollusca* (operculum and shell fragments), *Osteichthyes* (teeth and shell fragments), and *Ostracoda* (carapace). These fossils will not be discussed further in this project.

Taxon	Plant part	Whole Fossils	Partial
Waterside & damp ground			
Alnus glutinosa	bud	1	0
Bidens sp.	fruit	1	1
Eleocharis palustris	nutlet	1	0
Hippuris vulgaris	fruit	919	20
Persicaria cf. *hydropiper*	nutlet	6	0
Ranunculus sceleratus	fruit	798	865
Rumex maritimus	perianth	26	20
Schoenoplectus lacustris	nutlet	693	337
Sparganium erectum	fruitstone	19	3
Total		**2464**	**1246**
Obligate aquatic			
Characeae sp.	oospore	1000+*	1000+*
Groenlandia densa	endocarp	612	27
Myriophyllum spicatum	fruit	2	0
Myriophyllum sp.	fruit	45	5
Potamogeton alpinus	endocarp	522	0
Potamogeton crispus	endocarp	132	3
Potamogetonaceae sp.	endocarp	803	175
Potamogetonaceae sp.	lid	186	24
Ranunculus Sect. *Batrachium* sp	fruit	1645	167
Sparganium cf. *emersum*	fruitstone	7	0
Stuckenia pectinata	endocarp	1108	16
Zannichellia palustris	fruit	2365	732
Total (*without characeae)		**7427**	**1149**
Unclassified			
Carex sp.	trigonous nutlet	1982	521
Carex sp.	utricle	8	0
Chenopodium sp.	seed	4	0
Ranunculus sp.	seed	2	0
Viola sp.	seed	1	0
Total		1997	521
TOTAL		11888	2916

Table 1. Quantitative data showing the taxa present at Schöningen 12 II-4. Table by Emily Diana Stott.

4.1 Waterside and Damp Ground Taxa

Alnus glutinosa **(black alder)**

This tree typically grows in decently waterlogged soil with poor aeration along streams, standing water, or in alluvial lowlands (McVean, 1956). *Alnus glutinosa* often grows near to other plants of the same species and grows well in cultivated soil or soil shared with thin covering low vegetation (McVean, 1956). *A. glutinosa* has also been proven hearty in brackish water and areas of high salinity, though the growth of the plant is partially stunted (Dendievel et al., 2019). The Schöningen 12 II-4 assemblage contained 1 whole, fossilized bud from *Alnus glutinosa.* This makes up approximately 0.03 % of the waterside and damp ground taxa, and 0.007 % of the entire assemblage.

Alnus glutinosa has no known edible parts. However various parts of the plant have multitudinous medicinal and practical purposes. The dried bark of *Alnus glutinosa* serves as an alterative, astringent, cathartic, febrifuge, and a tonic (PFAF). Fresh bark can serve emetic purposes (PFAF). Additionally, a mixture of the inner bark and vinegar will produce a concoction that can be used to treat lice and skin problems and can also be used as a tooth cleaner (PFAF). Powdered bark and sticks can also be used to clean teeth (PFAF). Multiple assorted colors of ink can be derived from the bark and catskins of the *Alnus glutinosa* tree and the wood is durable for construction projects and additionally produces a nice charcoal (PFAF).

***Bidens* sp.**

This genus belongs to the *Asteraceae* family and is tolerable in tropical, subtropical, and temperate regions. Plants in the *Bidens* genus prefer mesophytic environments with rainfall between 1,000 and 1,500 millimeters per year (Budumajji & Solomon Raju, 2018). Plants in this genus tend to form colonies in open, hilly landscapes and experience no problems growing in nutrient deficient soils (Budumajji & Solomon Raju, 2018). Due to variability between species in this genus, no further ecological information can be derived. One whole fruit fossil and one partial fruit fossil were discovered in the Schoningen 12 II-4 sample. *Bidens* sp. accounts for 0.05 % of the waterside and damp ground taxa and makes up 0.014% of the total assemblage.

Plants in the *Bidens* genus offer a wide range of practical uses depending on the species. Many species offer leaves and shoots for eating and flowers for making tea (PFAF). The various species within *Bidens* also exhibit a wide range of medical properties such as antibacterial, styptic, and anti-inflammatory (PFAF). Without a species identification, it is difficult to know exactly what uses would have been possible from the *Bidens* found in Schöningen.

***Eleocharis palustris* (common spike rush)**

The plant *Eleocharis palustris* grows in very wet, waterlogged environments such as the riverbanks in freshwater marshes (Stančič, 2008). High levels of underground water that experience frequent oscillations of the water level are ideal conditions for *Eleocharis palustris* and the plant thrives best in nutrient-rich soil containing excessive amounts of calcium carbonate (Mertz, 2002; Philippi, 1998; Stančič, 2008). The Schöningen 12 II-4 sample contained one whole, fossilized nutlet from the *Eleocharis palustris* plant and no partial fossils. *Eleocharis palustris* makes up 0.03 % of the waterside and damp ground taxa, and 0.007 % of the entire assemblage.

The sap from *Eleocharis palustris* is edible. However there are no other known edible parts of the plant. There are no medicinal uses associated with *Eleocharis palustris*. However the plant can be used to make bedding and cushions (PFAF).

Hippuris vulgaris **(common mare's tail)**

Hippuris vulgaris grows in aquatic or waterlogged habitats such as lakes, marshes, rivers, and riversides (Cianfaglione et al., 2017; Tutin et al., 1968). The plant is a perennial herb that prefers shallow fresh waters (Cianfaglione et al., 2017). The Schöningen 12 II-4 assemblage contained 919 whole fossilized fruits and 20 partial fossilized fruits. *Hippuris vulgaris* is responsible for 24.77 % of the waterside and damp ground taxa, and 6.2 % of the total assemblage.

Leaves and shoots from *Hippuris vulgaris* can provide a food source either raw or cooked and can be made into soups (PFAF). Juice from the entire plant can be used medicinally as a vulnerary through ingestion or topical application (PFAF).

Persicaria **cf.** ***hydropiper*** **(water pepper)**

Persicaria hydropiper is a plant that prefers to grow in damp habitats with arable land and other similarly disturbed landscapes (Simmonds, 1945). This plant grows in various soil types but does not appear to do well in chalk, due to this species' water requirements (Brenchley, 1920). *Persicaria hydropiper* plants produce 1 seed per fruit. However this plant is known to give anywhere from 3 to 1,200 seeds at one time, many seeds per plant (Simmonds, 1945). While the *Persicara* in the Schöningen assemblage cannot be entirely confirmed as *P. hydropiper,* the *Persicara* fossils shared similar morphology to *P. hydropiper*. There were 6 whole, fossilized nutlets present in the Schöningen 12 II-4 sample, and 0 partial fossils present. This accounts for 0.16 % of all waterside and damp ground taxa, and 0.04 % of the total taxa present.

Due to the spicy flavor of this plant, it is often used as a spice for food (Ayaz et al., 2020). Furthermore, *Persicaria hydropiper* has many known medicinal uses. It can be used as an astringent, sedative, and an antiseptic; and additionally, can be used to treat respiratory illnesses, edema, and snake bites (Ayaz et al., 2020). Yellow dye can also be extracted from the plant and has been used to dye wool (Mitchell & Dean, 1978).

***Ranunculus sceleratus* (celery leaved buttercup)**

This species is an ephemeral plant that has two life cycles annually, one in the summer and again in the winter (Van der Toorn, 1980). *Ranunculus sceleratus* prefers to grow in wet habitats and is resistant to waterlogged conditions as well as low levels of flooding (Zuo et al., 2014). Due to this plant's ability to lengthen petioles underwater, in combination with high root porosity, *Ranunculus sceleratus* helps to alleviate stress to the environment caused by flooding and nutrient pollutants (Zuo et al., 2014). Individual *Ranunculus sceleratus* plants can produce as many as 500,000 seeds every year (Van der Toorn, 1980). The Schöningen 12 II-4 assemblage contained 798 whole fruit fossils and 865 partial fossils. *Ranunculus sceleratus* is responsible for 44.82 % of the waterside and damp ground taxa and 11.23 % of the total assemblage. It is important to keep in mind the high yield of seeds that each individual *Ranunculus sceleratus* plant produces, as this impacts the prevalence of this species in the overall assemblage.

Ranunculus sceleratus technically has edible leaves. However caution must be taken because the plant is toxic when raw and is incredibly bitter (PFAF). The plant has many medicinal uses (anodynic, antirheumatic, antispasmodic, diaphoretic, emmenagogue, and rubefacient). However, care must be taken because the leaves of the plant can cause sores and blisters, and if chewed, inflammation of the tongue (along with blisters) occur (PFAF). The plant proves to be an effective fungicide if an extract is made from the leaves (PFAF).

***Rumex maritimus* (golden dock)**

The *Rumex maritimus* plant grows in habitats that experience frequent flooding (Van der Sman et al., 1991). The plant is very tolerant to flooding due to its ability to lengthen its petioles underwater, which helps bring the plant's leaves closer to or above the water's surface (Van der Sman et al., 1991). This plant is considered to have a long-life span and experiences various levels of dormancy throughout the year, specifically with deep dormancy occurring in the summer and a lower level of dormancy occurring in the winter and early spring (Van Assche et al., 2002). The schoningen assemblage contained 26 whole perianth fossils and 20 partial fossils. This accounts for 1.24 % of the waterside and damp ground taxa and 0.31 % of the total assemblage.

The leaves and seeds of *Rumex maritimus* can be ground and mixed with water to create a porridge or they can be cooked and eaten normally (PFAF). The leaves have an acidic flavor and should be consumed in moderation due to the presence of oxalic acid which can interfere with the body’s ability to absorb other nutrients when consumed in large quantities (PFAF). This plant has several medicinal properties. The leaves of this plant can be applied topically to treat burns (PFAF). Seeds of *Rumex maritimus* have aphrodisiac properties and contain as much as 5 % tannins (PFAF). Additional medical uses include a cooling effect from the whole plant and the ability to treat bloating with an infusion made from this plant (PFAF). Dark colored dyes may be created from the roots of this plant (PFAF).

***Schoenoplectus lacustris* (bulrush)**

This plant is considered a perennial plant that prefers wet environments (Duman et al., 2007). This plant can accumulate heavy metals in considerable amounts in its tissues (Duman et al., 2007). In general, *Schoenoplectus lacustris* prefers alkali marshes and other wetlands found in alluvial plains and surrounding riverbanks (Deák et al., 2014). The plant is salt tolerant and grows tall shoots (Deák et al., 2014). In the Schöningen assemblage there were 693 whole, nutlet fossils and 337 partial fossils. *Schoenoplectus lacustris* forms 27.76 % of the waterside and damp ground taxa and 6.96 % of the total assemblage.

Schoenoplectus lacustris offers a wide array of edible, medicinal, and practical possibilities. The roots can be eaten both cooked and raw and contain high amounts of starch (PFAF). Edible powder and syrup can both be made from this plant (PFAF). Pollen, young shoots, and the base of mature stems can be eaten raw or cooked, and the seeds can be ground into a powder mixed with flour for baking (PFAF). Finally, the buds can also be eaten raw. Medicinally, this plant was historically used to treat various cancers, and the roots were also used because of their astringent and diuretic properties (PFAF). The *Schoenoplectus lacustris* stems have been used for making paper, matting, and chair bottoms (PFAF).

***Sparganium erectum* (bur reed)**

The *Sparganium erectum* plant is a macrophyte that prefers aquatic and semi-aquatic habitats such as wetlands, slow running rivers, and freshwater marshes (Piquot et al., 1996). This plant frequently grows in shallow ditches and forms colonies, as the plant is self-compatible (Piquot et al., 1996). *Sparganium erectum* can reproduce both sexually and vegetatively. However the plant typically struggles to outcompete other aquatic macrophytes (Piquot et al., 1996). The plant is hardy across a fairly wide range of temperatures, growing in the boreal regions of Europe and near to the Mediterranean as well (Piquot et al., 1996). The schoningen assemblage contained 19 whole and 3 partial fossilized *Sparganium erectum* fossils. This makes up 0.59 % of the waterside and damp ground taxa and 0.15 % of the total assemblage.

The roots and base of the stems from the *Sparganium erectum* plant can be cooked and then eaten (PFAF). Additionally, the plant has been used as an ingredient in infusions used to treat chills (PFAF). Aside from the aforementioned, additional uses of this plant are unknown.

4.2 Obligate Aquatic Taxa

***Characeae* sp. (stonewort)**

The *Characeae* family is a family of aquatic plants, like green algae (Larkin et al., 2018). Plants in this family grow in a wide array of conditions such as shallow or deep water that can either be high in nutrients or nutrient deficient (Larkin et al., 2018; Raam & Maier, 1993). *Characeae* plants can grow in brackish or fresh water and possess the ability to reproduce sexually or vegetatively (Larkin et al., 2018; Raam & Maier, 1993). Plants in the *Characeae* family produce many oospores, which makes it extremely abundant in the Schöningen assemblage. Oospores were not counted for this reason, as there were thousands of *Characeae* fossils in the sample. Additionally, the family contains many distinct species with similar plant part morphology, which makes individual identification to the genus or species level difficult, so identification was not attempted for this project.

There are no known ethnobotanical uses for *Characeae spp.*

***Groenlandia densa* (opposite leaved pondweed)**

This species is a perennial macrophyte that prefers to grow in mesotrophic, base-rich, flowing waters (Barrat-Segretain, 2001; Kohler & Meyer, 1986; Guo & Cook, 1990). *Groenlandia densa* prefers flowing water, which allows the flowers to alternate between being periodically submerged and exposed to the air (Guo & Cook, 1990). In the Schöningen sample there were 612 whole and 27 partial endocarp fossils. This makes *Groenlandia densa* 7.45 % of the obligate aquatic taxa and 4.32 % of the total assemblage.

There are no known ethnobotanical uses for *Groenlandia densa.*

***Myriophyllum spicatum* (Eurasian water milfoil)**

This plant is a perennial plant and is considered to be a deep water plant as it can grow in water from 1 to 10 meters deep, though it is typically found in ranges of 1 to 4 meters in depth (Planas et al., 1981; Pearsall, 1920; Aiken et al., 1979; Reed, 1977; Springer et al., 1961; British Columbia Ministry of Environment, 1981). *Myriophyllum spicatum* tolerates high velocity water movement and prefers nutrient rich, alkaline water (British Columbia Ministry of Environment, 1981; Springer et al., 1961). This plant tolerates brackish water with a salinity content of up to 10 % (Springer et al., 1961). The

Schöningen assemblage contained 2 whole fossilized fruits. This forms 0.02 % of the obligate aquatic taxa and 0.01 % of the total assemblage.

The roots of *Myriophyllum spicatum* can be eaten raw or cooked (PFAF). Medicinally, this species can be used as a demulcent and a febrifuge (PFAF). There are no additional known ethnobotanical uses for this plant.

***Myriophyllum* sp.**

This genus is comprised of aquatic submersed plants (Planas et al., 1981). There are many species within the genus that each have different ecological conditions. In the Schöningen assemblage not all *Myriophyllum* fossils could be identified to species level due to preservation status. Further ecological conditions cannot be derived from the genus alone. The sample contained 45 whole and 5 partial fruit fossils. This makes up 0.58 % of the obligate aquatic taxa and 0.34 % of the total Schöningen assemblage.

Some species of *Myriophyllum* have edible leaves or roots. However aside from this there are no additional ethnobotanical uses (PFAF).

***Potamogeton alpinus* (alpine pondweed)**

This freshwater plant grows in a wide range of different habitats but does best in slow running water less than 1.5 meters deep (Boedeltje et al., 2005; Wiegleb & Todeskino, 1983; Preston, 1995; Preston & Croft, 1997). *Potamogeton alpinus* can grow in acidic, neutral, or slightly alkaline water and can be found in both mesotrophic and eutrophic conditions (Wiegleb & Todeskino, 1983; Preston & Croft, 1997). This plant is a circumboreal species, which means it thrives in temperatures around 18 ˚ Celsius and can survive with moderately low light (Boedeltje et al., 2005). In the Schöningen assemblage there were 522 whole fossilized endocarps and zero partial fossils. This makes up 6.09 % of the obligate aquatic taxa and 3.53 % of the total assemblage.

There are no known ethnobotanical uses for *Potamogeton alpinus.*

***Potamogeton crispus* (curly pondweed)**

Potamogeton crispus is an aquatic plant that thrives in alkaline waters that are brackish and eutrophic with a maximum depth of 5.5 meters (Nichols & Shaw, 1986). This species does well in low light and can tolerate moderately high flowing water (Nichols & Shaw, 1986). In the Schöningen assemblage there were 132 whole and 3 partial endocarp fossils. This forms 1.57 % of the obligate aquatic taxa and 0.91 % of the total assemblage.

Once cooked, the young leaves and the roots of this plant can be eaten (PFAF). There are no additional known ethnobotanical uses for *Potagmogeton crispus.*

***Potamogetonaceae* sp.**

The genus *Potamogetonaceae* is one of the most common groups of vascular aquatic plants containing more than 100 individual species and many hybrids (Cook et al., 1974; Pip, 1987). Species within *Potamogetonaceae* grow in a wide range of different ecological conditions, making it difficult to discern information from the genus alone. All plants in the genus are aquatic macrophytes. However, the habitats range from freshwater to brackish, acidic to alkaline, deep to shallow water levels, and a wide range of temperatures tolerated. In the Schöningen assemblage there were 803 whole and 175 partial endocarp fossils. Additionally, there were 186 whole and 24 partial lid fossils. In total there were 1,188 whole and partial *Potamogetonaceae* sp. fossils in the assemblage. This makes up 13.85 % of the obligate aquatic taxa and 8.02 % of the total assemblage.

Different species within the *Potamogetonaceae* family contain edible plant parts, commonly the leaves, but occasionally also the roots or other parts (PFAF). Some species possess medicinal capabilities; however many do not (PFAF). More specific ethnobotanical information is difficult to discern from the family alone.

***Ranunculus* Sect. *Batrachium* sp.**

The section *Batrachium* of *Ranunculus* contains 30 species of aquatic and semi-aquatic plants that can be difficult to distinguish from one another (Wiegleb et al., 2017). The plants within this section have varied ecological tolerances; however many of the plants prefer oligotrophic environments with brackish and slightly alkaline water (Wiegleb et al., 2017). In contrast, some in the group prefer slightly acidic, eutrophic habitats (Wiegleb et al., 2017). Many plants in the *Batrachium* section prefer low water levels that are slow moving or stagnant; however some plants prefer larger rivers or lakes (Wiegleb et al., 2017). Plants in this section are difficult to identify to species level because of the similarities between species, but also because of the massive number of hybrid species that this section produces (Wiegleb et al., 2017). Fossils from this project were not identified to species level for this reason. There were 1645 whole and 167 partial fruit fossils in the Schöningen assemblage. This makes up 21.13 % of the obligate aquatic taxa and 12.24 % of the total assemblage.

Some species of *Batrachium* have edible leaves, however the plants in this genus are typically poisonous unless boiled (PFAF). There are a few species that have medicinal purposes such as antirheumatic and febrifuge (PFAF). More specific ethnobotanical information cannot be discerned without a species identification.

***Sparganium* cf. *emersum* (unbranched bur-reed)**

This plant is an aquatic vascular that grows at the edge of rivers, streams, and canals (Pollux et al., 2006). Typically, this plant prefers shallow water that moves slowly and contains high amounts of nutrients (Pollux et al., 2006). While the fossils in the Schöningen assemblage resemble *Sparganium emersum*, a concrete classification to the species level cannot be confirmed. It is assumed that the *Sparganium* in the assemblage is similar to *S. emersum* and most likely shares similar ecological tolerances. There were 7 whole fruitstone fossils in the assemblage and no partial fossils. This makes up 0.08 % of the obligate aquatic taxa and 0.04 % of the total assemblage.

Sparganium emersum could be used to create bedding (Bigga et al., 2015). There are no other known ethnobotanical uses for this species.

***Stuckenia pectinata* (sago pondweed)**

Stuckenia pectinata is an aquatic macrophyte that grows in water depts between 1.3 – 2.4 meters and prefers silty soil (Case & Madsen, 2004). This species is found in freshwater habitats and can reproduce both sexually and asexually (Ganie et al., 2016). *Stuckenia pectinata* grows at rapid rates and is linked to degradation of water quality and causes eutrophication in ecosystems, which is why it is considered by many to be a pest (Ganie et al., 2016). The Schöningen assemblage contained 1108 whole endocarp fossils and 16 partial fossils. This makes up 13.11 % of the obligate aquatic taxa and 7.59 % of the total assemblage.

There are no known ethnobotanical uses for this species.

***Zannichellia palustris* (horned pondweed)**

This plant is typically found in flowing freshwater; however it has also been documented in brackish conditions as well (Vierssen, 1982). This species is tolerant to waves and currents and is frequently found in lakes and rivers with maximum depths reaching 1.85 meters (Vierssen, 1982). *Zannichelia palustris* prefers to grow in substrate high in clay content and reproduces readily in eutrophic conditions (Vierssen, 1982). There were 2,365 whole fruit fossils and 732 partial fruit fossils found in the Schöningen assemblage. This makes up 36.11 % of the obligate aquatic taxa and 20.92 % of the total taxa present in the sample.

This plant can be used to stabilize muddy banks and can reduce water pollution (PFAF),; however there are no inherent ethnobotanical uses associated with *Zannichellia palustris.*

4.3 Unclassified Taxa

***Carex* sp.**

The *Carex* genus includes a large amount of species, more than 1,800 different species found worldwide (Schütz, 2000). The genus includes species that are tolerant to many different temperatures, but many are found within temperate wetlands (Alexeev, 1988). Nearly all *Carex* plants can be described as herbaceous perennials (Alexeev, 1988); however due to the sheer number of different species within the *Carex* genus it is not possible to produce more specific ecological information for the Schöningen site. The Schöningen sample contained 1,982 whole and 521 trigonous nutlet fossils. Additionally, the assemblage contained 8 whole utricle fossils. There were a total of 2,511 *Carex* fossils that could not be identified to the species level in the assemblage. This makes up 99.7 % of the total unclassified taxa and 16.96 % of the complete assemblage from Schöningen.

Species within the *Carex* family provide a multitude of ethnobotanical possibilities. Many species have edible seeds that can be consumed raw and roots that can be consumed after cooking (PFAF). Additionally, there are some species like *Carex arenaria* that can provide many medical uses with the roots providing diaphoretic and diuretic treatments and infusions that provide relief from skin conditions, rheumatism, and stomach disorders amongst other treatments (PFAF). Members of the *Carex* family can also provide raw materials that can be used for bedding and wadding (PFAF). Without identification to the species level, ethnobotanical information pertaining *Carex* use in Schöningen is only speculative.

***Chenopodium* sp. (goosefoots)**

This genus includes around 250 different plant species that grow in a wide range of ecological conditions (Bana et al., 2022). Plants in this genus can be found in tropical, sub-tropical, temperate, and sub-temperate climate conditions making it extremely widespread around the world (Bana et al., 2022; Tang et al., 2022). The wide range of tolerances exhibited by plants in this genus make it difficult to discern specific ecological information. There were 4 whole fossilized seeds found in the Schöningen sample and no partial seeds. This makes up 0.16 % of the unclassified taxa and 0.03 % of the total assemblage.

Nearly all species in the *Chenopodium* family produce edible seeds and leaves; however the plants often contain small quantities of saponins and oxalic acid, which can be toxic, and thus cooking the plants before consumption is recommended for maximum nutritional value (PFAF). Leaves from some *Chenopodium* plants can be used to make tea (PFAF). Plants in the *Chenopodium* family have many medical benefits and can be used to expel parasites and repel mosquitoes (PFAF). Additionally, some species within this family can be used to treat snake bites and cure hemorrhoids (PFAF). Some plants in this family also produce colorful dyes and can be used as fertilizers (PFAF).

***Ranunculus* sp.**

The genus *Ranunculus* is the largest genus in the *Ranunculaceae* family and contains around 600 different species (Baltisberger & Hörandl, 2016). Plants in this genus grow in a wide range of habitats and can be found in mountain regions, sub meridional zones, and temperate zones (Baltisberger & Hörandl, 2016). The variations in individual species within the *Ranunculus* genus make it hard to identify all of the seeds. The variations between *Ranunculus* species also make it difficult to discern specific ecological information pertaining to Schöningen. The Schöningen assemblage contained 2 whole *Ranunculus* seeds and no partial seeds. This makes up 0.08 % of the unclassified taxa and it makes up 0.01 % of the total assemblage.

The *Ranunculus* family generally produces plants that are toxic to humans; however often the leaves and roots can be eaten after they have been thoroughly cooked (PFAF). There are medical uses associated with various *Ranunculus* species (antirheumatic, diaphoretic, rubefacient); however as with the edible uses, caution is advised due to high levels of toxicity associated with most raw *Ranunculus* plants (PFAF).

***Viola* sp.**

The *Viola* genus belongs to the *Violaceae* family and forms one of the largest groups of angiosperms in the plant world (Shinohara et al., 2017). Within the *Viola* genus, there are around 600 different species of plant that are distributed throughout most regions of the world that do not experience frost (Ballard et al., 1998). The genus can be divided into two groupings based on morphology: stemless and stemmed plants (Shinohara et al., 2017). The large number of *Viola* make the seeds difficult to distinguish from one another. As a result species identification was not possible for this project. Without species identification there is little more ecological information that can be learned from the *Viola* genus. There was 1 whole fossilized seed in the Schöningen assemblage and zero partial fossils. This makes up 0.04 % of the unclassified taxa and 0.007 % of the total assemblage.

Viola plants provide many practical applications for humans such as edible flowers and leaves which can be eaten or used to make tea (PFAF). Additionally, various medical treatments can be derived from different *Viola* species like treatments for cancer and coughs (PFAF). Some *Viola* plants also contain significant amounts of salicylic acid which can be used to treat headaches, migraines, and insomnia (PFAF). Many plants in this family produce a strong fragrance and have been used for perfumes, incense, and breath fresheners, but the bright colored flowers that some species have can also be used to create dyes (PFAF). Ethnobotanical use of *Viola* plants at Schöningen can only be speculative without species level identification as the uses vary greatly between different species within the family.

Chapter 5: Discussion

The following chapter will include a synthesis of all the macro-fossil data in order to produce firstly an environmental reconstruction and then a discussion surrounding the probability of hominin plant subsistence. Previous environmental studies based on botanical remains have been conducted by Bigga, Schoch and Urban (2015). This paper aims to build upon their research with supplemental information from Schöningen 12 II-4.

5.1 Environmental Reconstruction of Schöningen 12 II-4 From Plant Macro-fossils

The macro fossil remains from Schöningen 12 II-4 indicate that the area surrounding the lake probably consisted of soil that was very wet. Nearly all terrestrial plants found in the assemblage prefer waterlogged conditions. Species found in the assemblage such as *Potamogeton alpinus* , *Biden* sp., *Ranunculus* sp., *Chenopodium* sp., and *Carex sp.* Indicate a temperate climate with temperatures around 18 ° Celsius.

A wide range of soil tolerances were exhibited by the species found at Schöningen 12 II-4;, however waterside and obligate aquatic species like *Schoenoplectus lacustris, Groenlandia densa, Myriophyllum spicatum, Potamogeton crispus,* and *Ranunculus batrachium* all display a tolerance for alkaline conditions, so that could be expected of the soil and waterbody.

The obligatory aquatic plants give a lot of insight into the lake environment. *Zannichelia palustris*, which makes up 20.92 % of the total taxa present, is an aquatic plant with a preference for soil with high clay content. Other taxa in the assemblage like *Stuckenia pectinata*, have an affinity for silty soils. It is likely that the lake's bed had a decent amount of clay content to support the plant ecosystem. The water was most likely alkaline, based on the preferences of species like *Groenlandia densa, Myriophyllum spicatum, Potamogeton crispus,* and *Ranunculus batrachium.* The edges of the lake would have been relatively shallow to support the likes of *Sparganium emersum* and species in the *Batrachium* section. The middle of the lake may have had depths between 2 and 5 meters as shown by the preferences of *Myriophyllum spicatum* and *Potamogeton crispus.* The water quality was most likely fresh water that had high nutrient levels which is supported by the ecological tolerances of *Myriophyllum spicatum* and *Sparganium emersum.* Many of the plants in the assemblage like *Potamogeton alpinus* and *Ranunculus* sect *batrachium* prefer slow moving or stagnant water. Other plants in the assemblage prefer decently flowing water, like *Zannichelia palustris* and *Myriophyllum spicatum,* so the water body was likely not stagnant and may have even contained certain areas with higher and lower flowing water.

5.2 Archaeological Evidence for Early Hominin Plant Exploitation

Hominin evidence for plant exploitation is limited in the archaeological corpus due to general poor preservation of organic materials. However, a significant amount of evidence exists connecting hominins to plants dating as far back as 2,000,000 years ago. Kanjera, an Oldowan site dating to around 2,000,000 years ago, shows evidence for plant processing through use wear traces of underground storage unit (tubers, roots), or other similarly soft plant parts (Lemorini et al., 2014). Additional evidence from Sima del Elefante in Spain from 1,200,000 years ago demonstrates that hominins were eating unprocessed plants as starchy carbohydrates were retrieved from the dental calculus of teeth uncovered (Hardy et al., 2017). The site Gesher Benot Ya'aqov in Israel, dated to 790,000 years ago, provides evidence of over 100,000 macrobotanical specimens believed to be anthropogenic, including cracked nutshell fragments (Goren-Inbar et al., 2002). While limited, the evidence connecting early hominins to plants is clearly present.

5.2.1 The Schöningen Spears

The wooden throwing spears found at Schöningen 13 II-4 demonstrate important direct evidence of early hominin plant exploitation. At Schöningen, 12 different implements have been identified including 9 spears and 1 lance (Schoch et al., 2015). The wooden objects were all carved from spruce or pine, soft wood, and shared many characteristics including the removal of branches and a polished surface (Schoch et al., 2015). The craftsmanship demonstrated by these spears shows that the hominins at Schöningen were capable of complex, multistep plant processing. Experimental archaeology tests confirmed that the spears were suitable for hunting as the weapons were balanced and accurate enough to target larger animals at a range of 35 meters (Schoch et al., 2015). This experiment shows that these spears would have proven effective hunting tools for the hominins and its clear from the number of implements that these hominins were capable of producing these weapons repeatedly. Hominins capable of manipulating wood to create such precise tools most likely would have also been capable of exploiting plants for food, medicine, and other types of tools.

5.2.2 Evidence for Controlled Use of Fire

The earliest evidence tying hominins to the controlled use of fire is present from approximately 400,000 years ago onward (James et al., 1989; Roebroeks & Villa, 2010). This is important to note because there are plants present in the Schöningen assemblage which would require some level of cooking to make the plants useful as food or medicine. This is the case for *Ranunculus* sp., *Potamogeton crispus, Sparganium erectum,* and a few other plants in the Schöningen assemblage (PFAF). The dating of Schöningen at 300,000 years ago makes it reasonable that the hominins present could have possessed a level of mastery over fire which would make this feasible.

Despite the possibility that the hominins may have possessed the capability to build fires, the evidence for the presence of fireplaces at Schöningen, as originally argued by Thieme (2007), has been refuted through careful analysis of the sediment (Stahlschmidt et al., 2015; Thieme, 2007). If the hominins were gathering plants at Schöningen for processing, this process cannot be confirmed with archaeological evidence and does not appear to have been happening at Schöningen.

5.2.3 Hominin Diet

From the butchered horse skeletons and hunting spears found at Schöningen, we know that the hominins were eating horse meat (Serangeli et al., 2015). While the hominins were eating horse meat, they were also probably eating plants as well. It is important to consider the availability of plant resources in the area which may have contributed to the hominin subsistence strategy.

Plenty of the species present in the Schöningen assemblage can be consumed raw like the seeds of many *Carex* species, the roots of both *Myriophyllum spicatum* and *Schoenoplectus lacustris*, and the leaves and shoots from *Hippuris vulgaris* and many species in the *Bidens* genus as well (PFAF). Young leaves of *Alnus* species, such as *Alnus glutinosa* found in the Schöningen 12 II-4 assemblage, can also be consumed raw (Bigga et al., 2015). These plant parts that can be consumed raw would have been accessible options for the Schöningen hominins. Archaeological evidence that predates Schöningen proves that hominins possessed the capabilities to forage plants for consumption, so even without direct evidence it would be probable that the Schöningen hominins also possessed this ability.

The techniques involved for preparing an herbal infusion or a boiled meal don't require much sophistication making it plausible that the hominins were capable of cooking food (Bigga et al., 2015). This would make it possible for the hominins to remove oxalic acid from plants like *Rumex maritimus* and species belonging to *Chenopodium* (Bigga et al., 2015). Many plants found in the schoningen 12 II-4 assemblage can be eaten after being cooked like the young leaves of *Potamogeton crispus* and the roots and stems of *Sparganium erectum* (PFAF). It is plausible that the hominins at Schöningen possessed the capacity to cook food, which opens up the possibility of a lot of foraging options.

It is highly likely that early hominins had to rely on plants to maintain a nutritious diet similarly to how modern humans must eat fruits and vegetables daily. Previous research has shown the importance of C_4 plants in early hominin diets as a main carbon source (Paine et al., 2018). C_4 plants would have been prevalent in Schöningen, and while these plants might not offer substantial amounts of protein, they would have been high in fiber and likely would have been known to the hominins at this time (Paine et al., 2018).

The roots of *Schoenoplectus lacustris* are known to have considerable amounts of starch (PFAF). Starch is an important aspect of hominin diet, as it contains carbohydrates and glucose, which are essential for energy (Hardy, 2018). *Schoenoplectus lacustris* plants made up almost 7 % of the total plant assemblage from Schöningen, so it was prevalent enough to be collected by hominins. A study performed on 10 Neanderthal individuals from the site El Sidrón in Spain showed 9 out of 10 individuals to have starch granules in their dental calculus (Hardy et al., 2011). This provides direct evidence connecting early hominins with eating plants, so it is possible that the hominins at Schöningen were also collecting starch rich plants to consume.

5.2.4 Paleolithic Medicines

The ability to turn plants into medicine logically must have been essential knowledge for early hominins for survival purposes. One study showed the presence of compounds that would curb appetite of bitter-tasting foods in the dental calculus of a Neanderthal, which has been proposed as evidence to support the idea that certain plants were being used as medicines (Hardy et al., 2011). Self-medication through secondary compounds found in plants has also been widely observed amongst many non-human primates (Huffman, 1997; Krief et al., 2005; Rodriguez & Wrangham, 1993). Wild chimpanzees have been observed eating plant parts low in nutritional value that are also used in traditional medicine from African communities as a way to self-medicate (Krief et al., 2005). Thus, It is possible that the ability to self-medicate from plant exploitation may have been a retained trait from the last common ancestor more than 6 or 7 million years ago (Hardy, 2018; McGrew, 2010). If this holds true, it would ascribe similar abilities to early hominin species such as the ones at Schöningen.

Medicinal properties were plentiful amongst the Schöningen assemblage; however archaeological evidence is lacking to directly link the hominins with ethnomedicinal uses of the plants. Certain plant species which provide anti-parasitic, antifungal, astringent or febrifugal properties may have been imperative for survival. It is probable that the hominins at Schöningen would have had some knowledge of the medicinal properties of certain plants in the area; however without direct evidence this is a speculative theory.

Chapter 6: Conclusion

This thesis project had two main goals surrounding the botanical macro-fossils remains found at Schöningen 12 II-4. The first goal was to use the plant macro-fossils to better understand the environment. The second goal was to analyze the fossils for potential exploitation opportunities for the hominins that were hunting there.

To satisfy the first aim, each species present in the assemblage was recorded and the ecological tolerances were presented. An analysis of these tolerances showed that the climate was temperate with the presence of some trees, but mostly low coverage plants like various sedges. Plenty of flowering plants would have decorated the water side. The waterbody, on the other hand, was large and slow moving with a dense coverage of *Characeae* algae and plenty of leafy aquatic plants covering the surface. This information provides important context for the hominin activities that occurred at Schöningen 12 II-4 by setting the scene.

Many taxa present in the Schöningen 12 II-4 assemblage could not be identified to species level. Some taxa present in the assemblage produce significantly fewer seeds, and some were better preserved than others. All these factors led to some level of bias in the dataset. However the conditions of the environment remain nonetheless clear as seen by the overlapping tolerances between the species present. Care was taken to note biases in the data to ensure the most accurate representation.

To satisfy the second aim of this project, a database containing ethnobotanical data was consulted to gain a general understanding of the known uses of each taxon present in the Schöningen 12 II-4 assemblage. Later, literature pertaining to Pleistocene ethnobotanical evidence and nonhuman primate plant exploitation was used to build an argument for hominin plant exploitation at Schöningen. Without direct evidence to support these claims, the information connecting the hominins to plant exploitation is speculative. However, it is difficult to believe that the hominins present did not rely on any plant exploitation at all. For now, the speculative analysis will have to prove sufficient until more concrete evidence is uncovered to connect hominins with plants.

This project's methodology could have been improved in many ways. Firstly, the sample used was originally collected with the intention of a micro faunal analysis. As a result, the sample was sieved to 500 micrometers. A typical botanical analysis would use a much finer sieve size. Taxa that produce seeds smaller than 500 micrometers will not be present in the assemblage for this project. Additionally, the sample collected was primarily representative of the waterbody, and terrestrial taxa are therefore limited. These factors create a data bias and limit the amount of environmental information that can be derived from botanical remains.

Another way this thesis could have been strengthened is the inclusion of a palynological analysis. A pollen analysis would give an even more detailed reconstruction of the environment at Schöningen 12 II-4. The sample used for this project could not have provided pollen samples as it was dry sieved. Also, this project's duration was a limiting factor to the scale of reconstruction possible. In the given amount of time, a palynological analysis would not have been feasible.

Future research pertaining to hominin plant interactions would be beneficial for our understanding of Paleolithic subsistence strategies, ethnomedicinal capabilities, and soft tool production. Studies on hominin dental calculus could provide valuable information about plant exploitation, including what types of plants were being consumed for food and medicinal properties. Additional botanical studies might focus on secondary plant properties for a better understanding of the history of human self-medication. This research could be further strengthened with a synthesis of evolutionary studies and studies of non-human primates.

Abstract

The Paleolithic site of Schöningen located in Middle Saxony Germany has been an important focus of research in Central Europe since the 1980s, when excavations first began due to the preservation status of the artifacts uncovered. The site is near an open-cast lignite mine, so early research was the result of rescue archaeology. The waterlogged conditions at Schöningen allowed for the preservation of wooden hunting spears, providing some of the oldest wooden artifacts in the world. This preservation of organic materials is rare and provides an important insight into the relationship between hominins and plants approximately 300,000 years ago. This thesis expands upon the environmental conditions and potential for plant exploitation by the hominins that were hunting at the site by analyzing botanical macro-fossils recovered from Schöningen 12 II-4. This layer was excavated as part of the rescue archaeology operation and is chronologically contemporaneous with the 'Spear Horizon,' so the data from this project can give important context to the environmental conditions and the opportunities for plant materials that would have been available to the hunters. Despite the low archaeological context for this layer, the few artifacts recovered from Schöningen 12 II-4 demonstrate the presence of hominins in the area and show the widespread use of the site. Ecological conditions derived from the fossilized taxa retrieved at Schöningen 12 II-4 will be used to better understand the climate during the interglacial period. These taxa also provide a wealth of opportunities for exploitation in the form of food and medicine. These exploitation opportunities will be explored along with evidence to support the claims that hominins could have possessed the capabilities required to undertake plant identification and preparation. There is much debate within the archeological community about the interactions between hominins and plants due to the scarce amount of evidence available. This thesis project will investigate this relationship and discuss the possibilities further.

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