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An analysis of zooarchaeological methods applicable to dredging sites

By Romain Crutzen

Figure from Algemeen Dagblad
https://www.ad.nl/oss/langer-zandwinnen-uit-over-de-maas-maar-dan-wel-schoner~a9e0ac11/

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Romain Crutzen
1862219
1083VTHESY
Dr. Llorente Rodriguez
Leiden University, faculty of Archaeology
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1. Introduction

The area near Moordhuizen -known as Over de Maas- is one of the river forelands of the river Meuse in the Dutch province Gelderland (fig. 1). This body of water is 250 hectares large and is currently being exploited for sand extraction with the long-term goal of developing the area into a natural reserve for leisurely activities. Dutch commercial archaeological bureau Archol was employed to construct an archaeological expectancy report and concluded that the expected amount of archaeological material was not significant enough to justify an excavation (Hebinck & Heunks, 2011, 16). After this verdict dredging activities commenced and have been going on for several years. During these years, Moordhuizen has become possibly the largest archaeological finding place in the Netherlands with huge quantities of material, both Holocene and Pleistocene faunal remains alongside many archaeological remains from a spectrum of Holocene ages. Since these finds started to emerge, an effort has been made by volunteers and amateur archaeologists of the group called Expeditie over de Maas (EODM) to preserve the finds at Moordhuizen. Due to the nature of dredging activities, no material is found *in situ* which has lead to few attempts at

fig 1. Map of the Netherlands with the location of Moordhuizen from Hebinck & Heunks 2011

professional archaeology on site and no attempts have been made to carry out studies with faunal material found at Moordhuizen. Furthermore, the material is extracted in such a way that Holocene and Pleistocene faunal remains are mixed. No easily accessible dating method can be employed as every element needs to be individually dated with radiocarbon dating for example rather than dating the context.

As the material is not *in situ*, the only method of rough dating easily attainable is through biostratigraphy, categorizing the faunal remains into the European mammalian biozones (van der Made, 2018; Gliozzi *et al.* 1997).

Given the nature of the extraction at Moordhuizen, only megafauna (eg. mammoths, rhinoceros, etc.) and large and medium size mammals (eg. giant deer, aurochs, wolf, fox) are recovered in a recognizable state if at all separated from the dredged sediment. Still, a rough dating into Holocene and Pleistocene taxa should be feasible and some subdivision into different stages of the Pleistocene can be done by comparing found species to specimens of that species that have been dated accurately with absolute dating methods in the area (Gliozzi *et al.* 1997; Van Kolfschoten 2001).

In addition to the paleontological interest of these fauna, their relation to human activities has not been analyzed. Holocene human presence is evidenced by material culture and the domestic taxa themselves but human exploitation of the Pleistocene taxa -if that actually happened- cannot be that straightforwardly demonstrated. However, human interference can be proven in different ways that possibly do not necessarily require *in situ* finds. The estimated amount of Pleistocene skeletal elements given by the director of the depot, Nils Kerkhoven, is around 65,000 to 75,000 fragments. If the Moordhuizen Pleistocene material can be and is well-researched, this site would shed light on Hominid activity in an area where there are where there are very few Paleolithic sites as is the case with all lower-lying areas of the Netherlands. Proving hominid activity in this area is also somewhat relevant to research on Doggerland, which has been submerged by the North Sea during the Holocene but was occupied during the colder periods of the Pleistocene in which the sea level was low enough for Doggerland to emerge. In fact, many Paleolithic sites are present on the Eastern coast of Great Britain but few are located in the Netherlands as a result of the dynamic nature of the Dutch coastline in combination with the low altitudes which are characteristic of the Dutch landscape, a combination which has lead to erosion and disturbance of archaeological material and difficulty in locating sites.

The only absolute dating method that can be used in exploring whether Hominid activity can be inferred from finds collected at non-contextualized dredging excavations is radiocarbon dating. In this line, some effort has been carried out by J. (Hans) van der Plicht and Margot Kuitems (Centre for Isotope Research, Groningen Universiteit) who have performed an intensive radiocarbon dating program that included 281 mammal samples from the North Sea finds (Kuitems and van der Plicht forthcoming a, b). These analyses included human bones and all of them were from the Holocene. As there is no possibility of carrying out radiocarbon dating for this thesis, the focus will lie on relative dating possibilities.

This thesis will explore methods for dredging site Paleoanthropology and this exploration could serve as a protocol for further research on Pleistocene dredged remains from an archaeozoological perspective. Hypothetically such a protocol could allow reconstruction of Pleistocene hominin dispersion patterns if used on a large scale, especially for areas that are otherwise lacking preserved Paleolithic sites such the lower-lying areas of the Netherlands or Doggerland. The former hypothesis was very ambitious; Pleistocene humans were active in Moordhuizen. This hypothesis should still be kept in mind, but the main focus will be the new hypothesis: The Moordhuizen Pleistocene faunal material can be used for archaeological research. Initially, the idea was to attempt to use some of these techniques on the Moordhuizen material itself, an analysis that was in progress when Covid-19 complications arose as a result of which no access was possible to Leiden University facilities. Furthermore, the depot at Moordhuizen, which is run by volunteers, was unfortunately not able to receive visitors. This was an issue as the material at Leiden was not selected for its viability in this research; it was already present. It might take several years before the immense amount of material in Moordhuizen is processed by the volunteers. Because of these reasons, a shift in the focus of this research was deemed necessary into a theoretical exploration of the viability of the methods which might be able to prove Pleistocene human activity based on animal remains without the presence of a traditional field archaeology context, which allows for clearer site recognition and dating. If the Pleistocene material is proven to have archaeological merit, large scale research could be done with the vast amount of material. As such, the main research question to this thesis is as follows: *Is the Moordhuizen Pleistocene faunal material useful for scientific research?* In order to address this question, a series of sub research questions have been formulated in order to guide the research and explore a putative protocol:

- Is the climate and geography suitable for human occupation during the Pleistocene?
- What methods are used to infer human activity from animal remains?
- What archaeological methods could be employed in dredging sites and what issues are caused by the method of extraction?
- What post-depositional processes could have affected the material and to what degree is the material impacted by these processes?
- What methods of dating can be employed in the absence of a geological context?

2. Moordhuizen Site history and geology

Moordhuizen lies on the opposite side of the river Meuse to another dredging site known as De Lithse Ham. Supposedly, amateur scavenging efforts at De Lithse Ham has yielded (among other things) mammoth remains with alleged cut marks according to the information on the exhibition Bagger! in museum Jan Cunen, an exhibition on dredge site finds. This rib was found by Leo Stolzenbach according to this information. His son, Olaf, wrote on Pleistocene remains found at another site a few kilometers downstream of Moordhuizen, named Kerkdriel (Stolzenbach 1993). There is more information on Kerkdriel geologically than there is on

Moordhuizen, although the geologists consulted for research on Kerkdriel agree that the geology is extremely complicated as a result of constantly changing river courses and coastline and erosion caused by these rivers and coastline (Stolzenbach 1993). As both are river forelands of the Meuse, are at similar altitudes (fig. 2) and near to each other the geological situation is expected to be quite similar. The lithic artefacts found in Kerkdriel have been related to the Kreftenheye formation (Stapert & Johansen 2009; de Mulder *et al.* 2003) which consists of sand and gravel and has been dredged horizontally from the site of Kerkdriel for the purpose of cement making and seems to be covered by clay. Moordhuizen is also being exploited for sand but it is unclear if the dredging is done horizontally or vertically.

Before dredging activities commenced, geological coring surveys were carried out to confirm if the geological geomorphological map by Berendsen & Stouthamer (2001) was accurate, which it turned out to be the case. (Hebinck & Heunks 2011). The current day floodplain dates to around the year 288 (1732 BP), based on the logical deduction that older floodplains would have been eroded. Apart from that, little is known about the precise geology of the area. Some Paleogeographic maps of the Netherlands are freely available via the website of the governmental service for heritage (Rijksdienst voor Erfgoed), yet the oldest available map is from the beginning of the Holocene. It is however fair to assume that the river Meuse would alternate between being a meandering river and being a braided river coinciding with interglacial and glacial Pleistocene periods respectively, as this is often observed in periglacial areas (Ballantyne 2018) and in warm periods occasional submersion by the sea as it is also beneath current day sea level (De Mulder *et al*. 2003; Rijksdienst voor Erfgoed). As a result of this, the material from Moordhuizen was covered by fluvial deposits although erosion of both the dynamic river landscapes and the sea makes the stratigraphy highly complex. As it is an open air site which was not covered during the Weichselian, aeolian silt (loess) could have covered the site as well. There is no mention of this in the geological report, although other sources (fig. 2) indicate that aeolian silt only remains on the Eastern side of the glacial push moraine. The earliest available Paleogeographic map of the Netherlands adapted for this thesis shows that around 9000 BC the area around Nijmegen (Roughly the push moraine and loess areas) existed between rivers, similar to the modern day geography (ahn kaart). The Moordhuizen area (approximately 15 kilometers West from the western border of the push moraine) seems to have been covered by Pleistocene sand layers as (it is just in the light pink area) and sometimes the Meuse in a dynamic river landscape as well as the sea as at the onset of the Holocene it below 0 NAP (which is the current day sea level). Both Kerkdriel and Moordhuizen are in the lower lying Pleistocene sand area which suggests that their geology is quite similar. Another thing of note is that they are both next to River dunes at the onset of the Holocene which is interesting as higher lying areas are often considered to be more suitable for occupation.

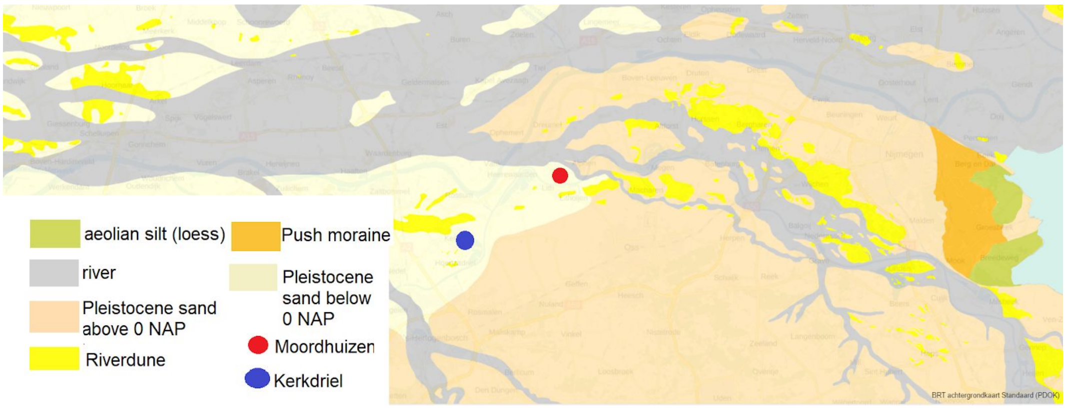

fig. 2 adapted from the map the Rijksdienst voor Cultureel erfgoed
http://rce.webgispublisher.nl/Viewer.aspx?map=Paleogeografischekaarten#
Geography from 9000 B.C. Scale 1:304.780

3. Pleistocene faunal-human relationship in the Netherlands

Most Pleistocene animal remains found in the Netherlands are from disturbed contexts (Çakirlar *et al.* 2018; Van Kolfschoten 2001) with the exception of gravel and clay pits in the South-Western part of the Netherlands and the ice pushed ridges of the Central Netherlands, such as Rhenen and (possibly) Nijmegen.

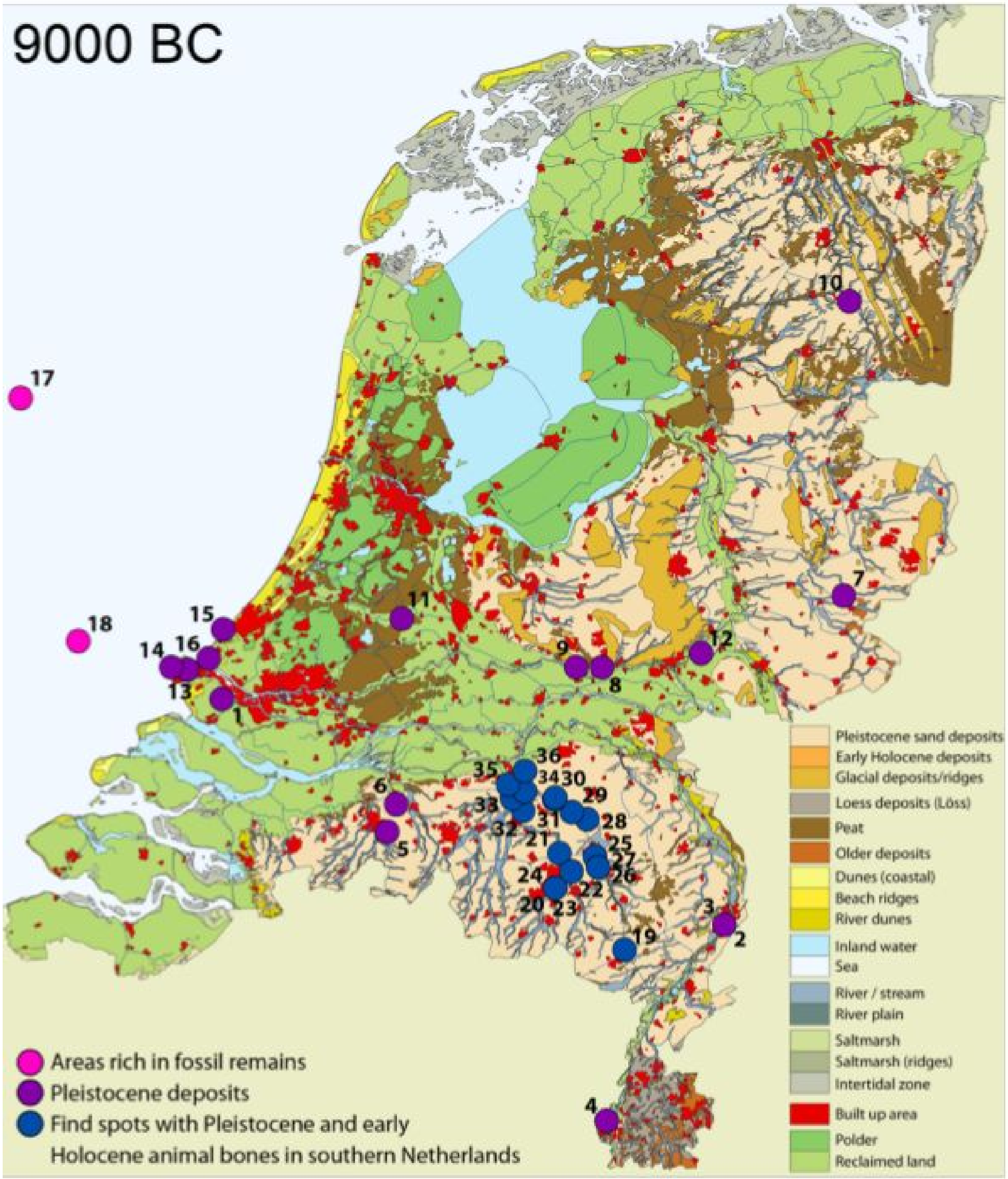

fig. 3 map from Cakirlar *et al.* 2018

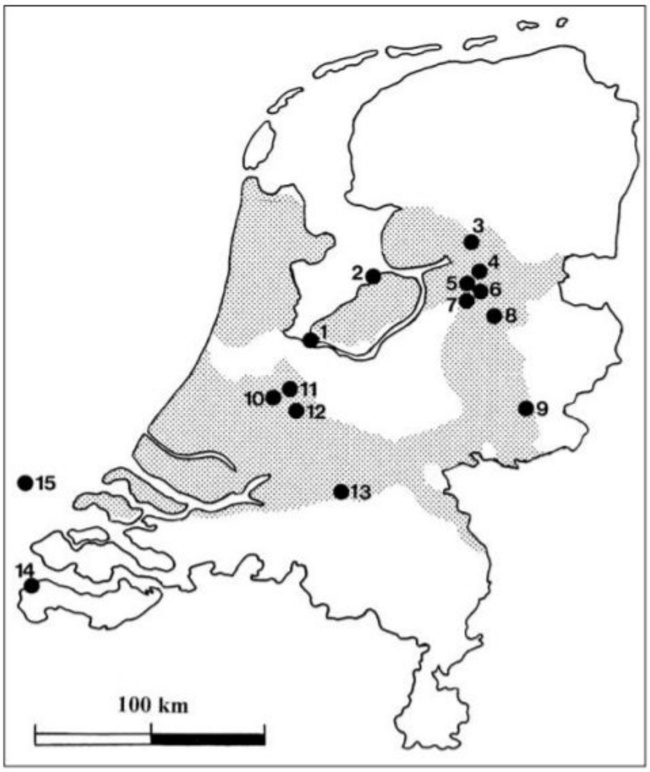

Fig. 3. Kaartje van de maximale verbreiding van de Formatie van Kreftenheye met vindplaatsen van zwartgepatineerde midden paleolithische vondsten: 1. Muiderberg (strand); 2. Flevocentrale; 3. Meppel; 4. Lichtmis; 5. Haerst; 6. De Tempel; 7. Sekdoorn; 8. Hooge Broek (Raalte); 9. Borculo (Hambroek); 10. Woerden; 11. Maarssen; 12. Nieuwegein; 13. Empel/Kerkdriel, 14. Cadzand (strand); 15. Middeldiep (Noordzee) (gerasterd naar De Mulder et al., 2003; bewerkt door L. Johansen, Haren & D. Stapert, RUG/GIA).

fig. 4

middle pleistocene finds of black patinated flint from Johansen *et al.* 2009 found in the Kreftenheye formation.

The nearby site of Kerkdriel (#13 on the Johansen *et al*. map, fig 4.) contains both Pleistocene mammals and Middle Paleolithic artefacts (Stolzenbach *et al.* 1993) and is very near to Moordhuizen. Apart from this, the focus on Paleolithic research in the Netherlands is mainly on the South of the Netherlands (De Jong 2016; Roebroeks *et al*. 1997) and the North of the Netherlands (Johansen and Stapert 2000; Prummel 2000) with occasional examples of sites in the West of the Netherlands such as Woerden (van Kolfschoten *et al.* 2011). Lower areas of the Netherlands have long been considered to be too wet for occupation during the Paleolithic as Paleolithic finds were mostly discovered on higher ground (De Jong 2016) as a result of the lower lying areas being considered too wet for occupation. Sites such as the Late Paleolithic site of Oudega in Friesland, the North of the Netherlands, (Niekus & Stapert 1994) disproved this notion as it is not found on Pleistocene sand deposits or otherwise high and dry areas; it is found on the lower, wetter lying areas of Friesland.

The Pleistocene medium-sized and larger mammals that are confirmed to have been present in the Netherlands are lion, saber tooth cat, bear, hyena, wolverine, at least five species of *Elephantidae* such as *Mammuthus*, several species of horses, at least six rhino species, tapir, wild boar and hippopotamus (Çakirlar *et al*. 2018). Of the species previously mentioned, most are possibly found in Moordhuizen as the Netherlands is quite geographically and climatically Homogenous.

Late-Paleolithic artefacts of the Hamburg and Ahrensburg cultures associated with exploitation of reindeer have been found in the Netherlands, but not in the context of reindeer which has lead to the notion that reindeer were not hunted in the Netherlands during the Late Paleolithic (Lauwerier, Prummel & van Kolfschoten 2016). Reindeer (*Rangifer Tarandus)* have been found in the North Sea which have been carbon dated and dated to 30.000 BC (Van Kolfschoten *et al*. 2011). This suggests that reindeer was present in the Netherlands some time before the Late Paleolithic but disappeared during the Late Paleolithic as a result of climate change. All radiocarbon dated *Rangifer Tarandus* from the South of the Netherlands also predate 30.000 BC (De Jong 2016). As the paleontological record of both the North Sea and the South of the Netherlands seem to contain no *Rangifer Tarandus* after 30.000 BC it is fair to assume that any *Rangifer Tarandus* in Moordhuizen would predate this, constructing quite a small time frame that can be used to research the hypothesis that Late Paleolithic hunters in the Netherlands did not hunt *Rangifer Tarandus (*Lauwerier, Prummel & van Kolfschoten 2016).

4. Ecozones and chronology based on taxa

As climate changes through time habitats of animals adapt. With these habitats, ecozones can be constructed that correlate with climate which allows for rough dating of bone material based on species alone (Gliozzi *et al.* 1997).

As the site of Moordhuizen is near the ice-pushed ridge of the Utrechtse heuvelrug which contains Paleolithic fauna *in situ* (van Kolfschoten 2001) the dated remains can be used to construct a chronology and rough dating. Other dated remains from the Netherlands described in the van Kolfschoten 2001 paper can also be used.

Species that are considered to have been possible prey and are of a medium or large size (as only these species are relevant to this thesis) will be listed here and subdivided into Early-, Middle- and Late Pleistocene based on Van Kolfschoten's 2001 paper. Species that are present during the entire or majority of the Pleistocene are excluded as mortality profiles will be unable to reflect any specialized hunting strategy as a result of hunting strategies changing over the course of the Pleistocene combined with the lack of context and levels to differentiate between ages (Stiner 1990). Some species present in two time frames exist in the archaeological record of the Netherlands at the end of one time frame and at the beginning of the other, these are included in the table. Other species that are present in exclusively in one of the Pleistocene time frames but are also present during the Holocene are excluded from the table. *Sus Scrofa* are present in the Early Pleistocene but reappear in the Holocene making their rough dating ambiguous, although a better examination of the relative degree of fossilization alongside measurements could make differentiation between Holocene and Early Pleistocene *Sus Scrofa* possible as Pleistocene specimens are generally larger than Holocene specimens as a result of climate change (Kurtén, 1965; Davis 1981). A similar issue is present with *Bos Primigenius* which could be handled similarly although is included in the table due to the similarity between *Bos* and *Bison* which makes species determination ambiguous for some elements. *Cervus Elaphus* was present for a large part of the Pleistocene as well as the Holocene (Kolfschoten 2001;De Jong 2016) which makes it impossible to construct a timeframe for a *Cervus Elaphus* population without any other means of dating, as a result of which it is excluded from the table.

Early Pleistocene	*Middle Pleistocene*	*Late Pleistocene*
Elephantidae *Mammuthus meridionalis* *Mammuthus trogontherii*	***Elephantidae***	***Elephantidae*** *Mammuthus primigenius* *Palaeoloxodon antiquus*

Anancus arvernensis		
Equidae *Equus bressanus*	***Equidae***	***Equidae*** *Equus hydruntinus*
Rhinocerotidae *Dicerorhinos etruscus*	***Rhinocerotidae*** *Stephanorhinus kirchbergensis* *Stephanorhinus hemitoechus*	***Rhinocerotidae*** *Coelodonta antiquitatis*
Suidae Sus Strozzii	***Suidae***	***Suidae***
Hippopotamidae *Hippopotamus Major*	***Hippopotamidae***	***Hippopotamidae***
Cervidae *Eucladoceros tegulensis* *Eucladoceros ctenoides* *Eucladoceros sp.* *Megaloceros verticomis* *Cervus rhenanus* *Alces gallicus* *Alces latifrons*	***Cervidae*** *Capreolus capreolus* *Megaloceros Giganteus*	***Cervidae*** *Megaloceros giganteus* *Alces alces* *Rangifer tarandus*
Bovidae *Soergelia minor*	***Bovidae*** *Bos primigenius/Bison priscus*	***Bovidae*** *Bison priscus* *Ovibos moschatus*

fig. 5 *based on Van Kolfschoten 2001 with Pleistocene mammals in the Netherlands relevant for research of Moordhuizen and potentially other dredging sites*

5. Materials

The vast majority of faunal remains from Moordhuizen are currently in a depot located near Moordhuizen. In 2017, a selection of archaeological material including faunal remains was loaned to the Faculty of Archaeology of Leiden University to analyze and categorize such evidence (Jansen and Driessen 2017) The animal remains of such selection were the object of study for this thesis. For comparison the reference collection in the Zooarchaeology lab of the Leiden University faculty of Archaeology was used.

6. Methods for Zooarchaeology in dredging sites.

To prove or disprove Pleistocene human activity in Moordhuizen, several methods will be discussed to construct an argument. Firstly, the specimens need to be selected. Secondly, those that can be identified as Pleistocene exclusive species will be recorded. The following criteria were taken into consideration:

1. Taxa: Species known to be exclusively present during the Pleistocene were primarily selected. The selection was based on the list of Pleistocene large mammals from the Netherlands (Kolfschoten 2001).

2. Size: Many extinct Pleistocene mammal species are clearly larger than Holocene mammals but also extant species that are present since the Pleistocene experienced a reduction in size world-wide derived from the climate change (Kurtén, 1965; Davis 1981)

3: Degree of mineralization (fossilization). In addition to size, material looking clearly mineralized with an ivory aspect and heavy weighted, was also selected as Pleistocene.

After a rough separation of material into Holocene and Pleistocene taxa, the species and skeletal elements of the Pleistocene material were determined with the help of Dr. Llorente Rodriguez, the Zoorchaeological lab of Leiden University assistant André Ramcharan, the reference collection present in the Laboratory for Archaeozoological Studies and several general atlases (Olsen, 1960 ; Schmid, 1972 ; Walker, 1985). Once the selection was made, elements were recorded taxonomically and anatomically. Abundance estimation of taxa will be provided as Number of Identified Specimens (NISP; Lyman 2008). Additional information annotated include the side of appendicular skeletal elements (left or right) and other taphonomical marks (cutmarks, chopmarks, gnawing marks, etc.) as described by Lyman (1994). Only about one thirds of the selected Pleistocene material from Moordhuizen present in Leiden has been identified and recorded before the closing of the faculties of Leiden University as a result of Covid-19. As a result of this, a shift in research focus was necessary as the recorded material was not sufficient for any statistical analysis. Because a research combining methods that do not necessarily require a dated context in order to infer human activity from a site with mixed remains, a more theoretically based exploration also seemed somewhat necessary.

The several zooarchaeological methods that can still be employed to assess whether hominids were active in the area will be introduced and explained in this chapter.

6.1 Mortality profiles and age estimation

Human behaviour and their relationship with animals can be reflected in the mortality profiles of the taxa represented in an assemblage. Different hunting habits result in different mortality profiles that can show a distinctly different age spread when compared to other forms of natural or biological accumulation of carcasses. These profiles are a result of determining the age of the animal based on its remains, thus reflecting their age of death. Combining all the estimated ages of the specimens of a taxa in a profile provides an idea of the frequency of ages at which animals died. If anything is ‘out of the ordinary’ from a natural mortality, it could imply human activity. One of the most commonly used theoretical mortality patterns is the ‘catastrophic’ profile, also called the L-shaped profile, which represents an entire living population (many young animals, progressively fewer animals correlating with age) but wiped out immediately by a single event (Stiner 1990). The resulting i mortality profile reflects the living demography of the population. This type of profile can be caused by a ‘catastrophe’, although it could also be human induced, such as ‘death pits’ (Voormolen 2004 for example) The natural mortality profile is, however, the so-called U-shaped profile or attritional profile. In this case, young and old animals are overrepresented and ‘prime’ age animals are underrepresented. The animals found in such a profile are thought to be animals that die of routine causes, such as accidents, starvation, disease, predation etc. , situations that commonly affect younger, inexperienced animals and weaker, older specimens. This is the most basic mortality profile as it sustains a similar demography and implies no human activity. Alternatively scavenging by hominids can lead to an attritional profile or scavenging by other animals. One of the most appealed profiles to suggest human activities in hunting societies is the prime dominated profile. Under natural circumstances, prime-aged animals their survival rate is higher as a result of their physical strength and speed (hence prime) and therefore this group is relatively underrepresented in natural mortality profiles. An overrepresentation of these animals usually implies human accumulation of prey animals. Other scavengers and predatory animals, either cursorial or ambush predators (Stiner 1990), produce profiles similar to the U-shaped or L-shaped profiles . In the later stages of the Paleolithic, some hominid sites, where ungulates were accumulated, show evidence for a dominance of prime-aged specimens (Stiner 1990). Mortality profiles dominated by old specimens have been considered to be typical signatures of scavenging (Klein, 1982; Klein and Cruz-Uribe, 1991; Stiner, 1990)

To construct a mortality profile, age determination of specimens is required. Diagnostic elements that can used for age determination include fused or unfused epiphyses of long bones and vertebrae, as well as suture fusion and dental eruption/emergence. The fusion calendars varies within skeletal elements and usually provide wider age ranges that those provided by dentition. Both methods of age determination were used and mostly follows Silver (1969). As age estimation of animals based on mandibular dentition is developed with living examples of these species, age estimation based on for example wooly mammoth molars can be quite difficult. Because there are no living examples of the Wooly mammoth, the age estimation system for African elephant molars will be used (Jachmann, 1988). Other teeth that are useful for age determination in mammoths are tusks -which are canines. In a cross-section of tusks, temporal markers are present as they grow periodically, which means that tusks can indicate the age of a mammoth upon death as well as the season of death

(Fisher 2018). Dentine on tusks forms in set increments which can be classified as first-order increments, second-order increments and third-order increments, which can be identified in tusks using magnification as all increments are visible as ‘lines’ using a transverse section of tusks. First-order increments represent (roughly) years, second-order increments represent (roughly) weeks and third-order increments represent days. Second-order and third-order increments are present between first-order increments, third-order increments are present between second-order increments. These increments likely correspond so well with our solar calendar as the difference in colour observed seems to be a result of change in diet as a result of seasonal differences in available food sources (Fisher 2018)

6.2 Cut marks

A clear and important indicator for human activity is the presence of cut marks. As processing animals for consumption or other uses leaves impressions on the bone left by a cutting or chopping tool, a presence of cut marks on Pleistocene taxa can indicate human activity.

6.3 Bone breakages

Bone breakages can indicate hominid activity (Lyman, 1987) as bones contain bone grease and marrow, which have a high caloric value (Outram, 2001) and were thus possibly extracted. As a result of a lacking geological record and stratigraphy,however, post-depositional processes that may have influenced the bone material are more difficult to evaluate as a result of which hominid bone breakages for marrow and bone grease extraction become difficult to ascertain. One proxy to investigate the degree in which post-depositional and environmental processes impacted an assemblage is assessing the frequency and fragmentation of the so-called compact bones (Marean, 1991). In experimental destruction of skeletal elements, by exposing them to both hammer stones and hyenas, compact bones such as tarsals, carpals and fibulae remained intact. If many of these elements are found are not intact, this must be the result of post-depositional processes. Marean proposes a system for calculating a ‘completeness index’ for compact bones, which could, when applied to Moordhuizen, give an idea of the degree of (destructive) post-depositional processes and impact possible interpretations of fragmented bone material, or make cut marks contextually more likely to be either man made or abrasion depending on the completeness index. In combination with the previously mentioned ‘completeness index’.

6.4 Axial/Appendicular ratio

Another method that could be employed to deduce human activity from a faunal assemblage is proving a statistically significant absence of appendicular skeletal elements or abundance of axial skeletal elements of prey animals (Klein 1987; Stiner 1991). This is based on the notion that appendicular skeletal elements (limbs) or skulls in the case of Stiner (1991) are the easier option to transport as these elements can be chopped off and are thus more likely to be transported. It is also based on the notion that hominid cave sites rarely include axial skeletal elements other than skulls of large prey: animals are hunted on plains and are too heavy to transport fully. As a result, the appendicular skeletal elements or skulls are more likely to be transported by both humans and carnivores (Klein 1987; Stiner 1991). An overabundance in vertebrae seems to indicate the place of death as the axial skeleton is left behind.

6.5 Taphonomic biases

The methods previously discussed suffer from some issues caused by taphonomy as depositional processes and post-depositional processes can result in biases (Lyman 1984). An example of this is fluvial winnowing (Voorhies 1969), which could have influenced the accumulation of faunal remains at Moordhuizen as flotation properties are different in bones impacting the distance it can travel in a river.

Another cause of biases are post-depositional processes which influence different skeletal elements differently as a result of their different densities (Lyman 1994). Bones with low structural densities are less likely to preserve as they are more suspect to breakages by processes such as erosion, trampling and carnivore activity. As a result of this young animals can be underrepresented as their bones are less structurally dense and can be unfused, which leads to issues in mortality profiles.

7. Results

The few recorded remains were recorded in a digital database that was lost as a result of a hard drive malfunction and could not be re-recorded as a result of the still ongoing Covid-19 measures and the limited timeframe in which this thesis is written. Due to the method that was used for determination, in which species and skeletal element were written on a card next to the fragment prior to being discussed with the available expert and subsequently recorded into a digital database, some results could still be salvaged after the selective reopening of the lab. Because these cards were never intended to be used in the actual results, the labels are quite incomplete. In the lost database the percentage of completeness was indicated as well as age indications, taphonomical marks and weight, which are not present on the cards. For some elements it was still clear which card corresponded to them. These elements have an estimated completeness % based on pictures of the elements sent by Dr. Llorente Rodriguez. The mammoth Atlas was still present in my memory as its completeness was striking. The species that have been identified and could be salvaged from the notes are:

Species	***Element***	***Symmetry***	***Rough completeness in %***
Equus sp.	*Metatarsus*	*Left*	
Equus sp.	*Metatarsus*	*Right*	
Elephantidae sp.	*Rib*	*indeterminate*	
Elephantidae sp.	*Tusk*	*indeterminate*	
Elephantidae sp	*Vert. Thoracale*	*Central*	*<10*
Elephantidae sp..	*Vert. Thoracale*	*Central*	
Elephantidae sp.	*Calcaneum*	*Left*	
Elephantidae sp.	*Calcaneum*	*indeterminate*	*95*
Elephantidae sp.	*Humerus*	*Left*	

Mammuthus Primigenius	*Atlas*	*Central*	
Mammuthus sp.	*Rib*	*indeterminate*	
Rhinoceridae sp.	*Carpal*	*Left*	
Coelodonta antiquitatis	*Humerus*	*Left*	
Bison sp.	*Astragalus*	*Indeterminate*	*95*
Bison sp.	*Ulna*	*Left*	
Bison sp.	*Cranium*	*Central*	
Bos/Bison	*Vert. Cervicale*	*Central*	
Bos/Bison	*Vert. Thoracale*	*Central*	*10*
Bos/Bison	*Calcaneum*	*Left*	
Bos primigenius	*Tibia*	*Left*	
Bovidae sp.	*Calcaneum*	*Right*	
Bovidae sp.	*Humerus*		
Ursus sp.	*Ulna*	*Right*	

fig. 6. recorded remains gathered from tags that were part of the identification process

Many indeterminate fragments were also present (some of which were clearly Pleistocene due to their size) and large quantities of tusks/ivory.

8. Discussion

In this chapter the proposed methods will be examined and issues within these methods will be explored. The conclusions of these discussions will then be kept in mind with the evaluation of the previous efforts at dredging-archaeology by Stolzenbach (Stolzenbach 1993).

8.1 Species

The identified species of *Mammuthus* and *Coelodonta* are only present during the Late-Pleistocene in the Dutch Pleistocene record (Van Kolfschoten 2001) which makes them suitable for mortality profiles as they can be dated (although roughly). *Bison sp.* seem to have been present at the end of the Middle Pleistocene and the beginning of the Late Pleistocene, which also allows for rough dating and thus construction of mortality profiles could be employed. Species of *Ursidae* are not mentioned in figure 5. Different species of *Ursus* were present during the entire Pleistocene in the Netherlands so no real conclusions can be drawn merely from the presence of *Ursus*. The relatively large amount of *Bovidae* and *Elephantidae* suggests that the area was quite open and plains-like. The *Equidae* had to be measured to conclude definitively if they are Pleistocene, which was impossible due to the closing of the faculty. The fossilization suggests however that these specimens are in fact Pleistocene.

8.2 Mortality Profiles

Mortality profiles can reflect hunting strategies. Human hunting strategies are different throughout the Pleistocene, however. Because no distinction between Early, Middle and Late Pleistocene from the animal remains alone in certain important species (such as *Cervus Elaphus)* can be made*,* as a result of its presence during the majority of the Pleistocene (Van Kolfschoten 2001). Other species can be used, for example *Bison,* which has been associated with specialized hunting strategies during the Middle Pleistocene in Schöningen (Voormolen 2004) which resulted in a Catastrophic mortality profile.

As archaeological sites have been identified containing animal remains for which mortality profiles have been constructed, many different kinds of hunting strategies have been recognized, as a result of which it becomes difficult to recognize an archaeological site based on merely kill-off patterns. Catastrophic profiles can be connected to humans in sites where herd behaviour of animals was exploited as part of a hunting or scavenging strategy. A Pleistocene example of this strategy in Europe is found at Schöningen (Horninge, 2012;Voormolen 2004). As Moordhuizen is similar to Schöningen, as they are somewhat near to each other and both feature a body of water which can be exploited in a hunting strategy by taking advantage of herd behaviour. Catastrophic profiles can also indicate non-selective hunting episodes, but with no other indicators of hominid activity this could also indicate carnivore behaviour. Some carnivores, solitary ambush predators, rely on chance encounters to kill their prey rather than long term tracking, which results in a distribution across age categories that reflects the living population (Stiner 1990). Attritional profiles would not indicate human activity, although they do not rule out human activity. More indicators are required however to determine if hominids were active. Prime dominated profiles are found in some sites during the later stages of the Paleolithic (Stiner 1990). This profile has since then been recognized in some older sites (Gaudzinski, 1995; Valensi and Psathi, 2004; Krönneck *et al.*, 2004). An overrepresentation of prime aged animals would indicate hominid activity (using an attritional profile as a baseline). The earliest evidence for an archaeological site containing a faunal assemblage dominated by specimens in their prime, dates to the Middle-Paleolithic (Wallertheim cf. Gaudzinski, 1995; Valensi and Psathi, 2004.) Theoretically this means this strategy could be of use with the Moordhuizen assemblage, assuming they hunted species exclusive to the timeframe in which they were active and animals were being hunted rather steadily after the emergence of the hunting strategy. The prime-dominated pattern has been recognized in natural accumulations as well (Wolverton, 2001; Wolverton, 2006; Kahlke and Gaudzinski, 2005) , however. As a result of this, merely a mortality profile is not enough to prove human presence at this site.

8.3 Age determination for construction of mortality profiles

The method to determine mammoth age based on tusks (Smith and Fisher 2011) could be very relevant for Moordhuizen as tusks are easy to identify and age determination with tusks can be very accurate, which would result in an accurate mortality profile. In the material from Moordhuizen present at Leiden, no tusk is intact enough for this method. It is unclear if there are any intact enough tusks at the depot although it seems likely when taking into account the estimate made by the director of the depot, Nils Kerkhoven, that around 65,000 to 75,000 Pleistocene skeletal elements are present. As tusks are easy to recognize, individuals would not need to be trained in order to assist in finding tusks among the material, making it possible before all of the material is sorted, somewhat avoiding a hurdle. Mistakes in age determination can be made as a result of sexual dimorphism in Elephantidae (Fisher 2008; Smith and Fisher 2011), as juvenile male tusks can resemble adult female tusks in size. A manner of distinguishing between juvenile male and adult female elephants is examining the length of pulp cavities, which in males extend past the alveolar margin distally. In female Elephantidae, the pulp cavity of the tusk ends proximal to the alveolar margin. In Moordhuizen, this can lead to issues, as the tusks are often

not present in the context of a cranium, making it impossible to indicate the location of the alveolar margin. Smith and Fisher (Smith and Fisher, 2011) suggest usage of principal components analysis (PCA) to distinguish elder females from juvenile males in the absence of an alveolar margin (or presence of only the exterior part of a tusk). For this, they used features that can be considered 'landmark', easily recognizable features present in all tusks. These features that are then compared to their location on an axis, which in this case is the length of the tusk from the tip to the end following the curve. Comparing the distal end of the pulp cavity to the main axis leads, calculating a value for it. Plotting these results will lead to a plot with two distinct clusters that can be interpreted as female and male. If this is then combined with a circumference value gained from several points on the tusk (excluding the most distal 50 cm to avoid wear and breakage influencing the results) it can be plotted in a two dimensional graph, as tusks increase in circumference during life. Tusks of males increase proportionally more compared to the length of the tusks, allowing the differentiation between old and young and female and male, which combined in a plot allows for a differentiation between old females and young males.
The Smith and Fisher analysis is done with relatively few samples, however. With the possibly very large sample size and no reason to assume a statistically significant overrepresentation of one sex, it is fair to assume that the tusks are roughly 50% female and 50% male. If all dubious tusks are classified as female initially, these dubious tusks can be reclassified as being juvenile males if for example 60% of the tusks turn out to be female. In that case, the extra 10% can be inferred to be juvenile male if the sample size is large enough.

The rough age component of the already collected data was mostly lost although a few infant specimens were present, gathered from unfused sutures and epiphyses.

8.4 Cut marks

An issue with cut marks is that, to the naked eye and even with the use of a magnifying glass, cut marks and marks as a result of post-depositional processes can be very similar (Dominguez-Rodrigo *et al.* 2009; Blumenschine *et al.* 1996; Olsen and Shipman 1988). Marks left by animals can also seem very similar to cut marks, as can marks left by curators or excavators (although the latter two would be recent and thus contrast the fossilized remains from Moordhuizen, making them easily distinguishable). The post-depositional processes that are of interest are sedimentary abrasion and trampling. Sedimentary abrasion is a possible factor during the Pleistocene as glaciers and braided rivers can cause sedimentary abrasion and leave marks on bone surfaces. As this site is an open air site, trampling also could have occurred. (Olsen and Shipman 1988) Trampling can not be proven if sedimentary abrasion is not eliminated. This is difficult as a result of the lack of geological data. The location of the site does allow for a possibly quick preservation as fluvial depositions could have covered the remains quite quickly minimizing trampling damage. It is difficult to know as there barely is any information on the Pleistocene geology and geomorphology of

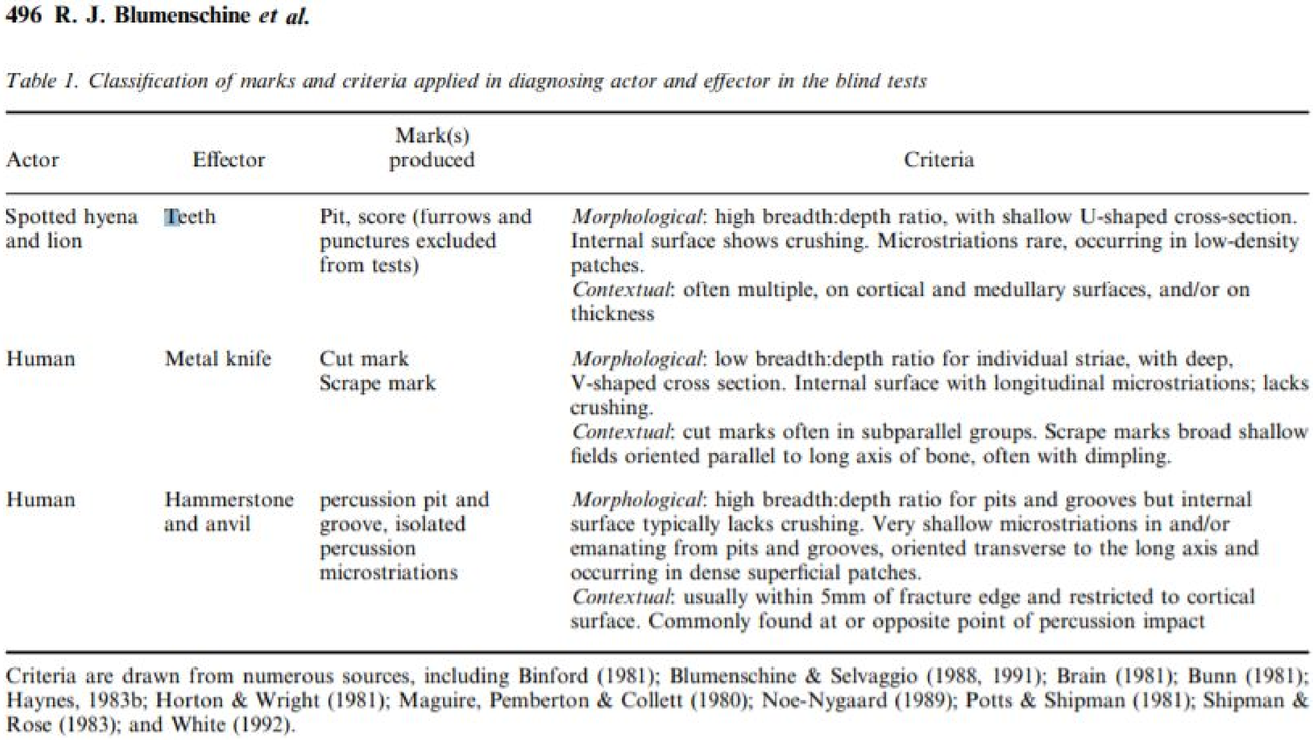

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Table 1. Classification of marks and criteria applied in diagnosing actor and effector in the blind tests

Actor	Effector	Mark(s) produced	Criteria
Spotted hyena and lion	Teeth	Pit, score (furrows and punctures excluded from tests)	*Morphological*: high breadth:depth ratio, with shallow U-shaped cross-section. Internal surface shows crushing. Microstriations rare, occurring in low-density patches. *Contextual*: often multiple, on cortical and medullary surfaces, and/or on thickness
Human	Metal knife	Cut mark Scrape mark	*Morphological*: low breadth:depth ratio for individual striae, with deep, V-shaped cross section. Internal surface with longitudinal microstriations; lacks crushing. *Contextual*: cut marks often in subparallel groups. Scrape marks broad shallow fields oriented parallel to long axis of bone, often with dimpling.
Human	Hammerstone and anvil	percussion pit and groove, isolated percussion microstriations	*Morphological*: high breadth:depth ratio for pits and grooves but internal surface typically lacks crushing. Very shallow microstriations in and/or emanating from pits and grooves, oriented transverse to the long axis and occurring in dense superficial patches. *Contextual*: usually within 5mm of fracture edge and restricted to cortical surface. Commonly found at or opposite point of percussion impact

Criteria are drawn from numerous sources, including Binford (1981); Blumenschine & Selvaggio (1988, 1991); Brain (1981); Bunn (1981); Haynes, 1983b; Horton & Wright (1981); Maguire, Pemberton & Collett (1980); Noe-Nygaard (1989); Potts & Shipman (1981); Shipman & Rose (1983); and White (1992).

Fig 7. Criteria from *Blumenschine et al. 1996* the area. In a research done by Blumenschine *et al.*(1996) experimental samples of bone cut by a metal knife, bone subjected to percussion with a hammerstone and anvil and a sample exposed to hyena were given to subjects who had to identify the cause of the marks, using both contextual and morphological markers. For this, they used their naked eye with strong lighting and 16 power hand lens or a x16 power microscope. These test subjects ranged from novice (around 3 hours of experience) to expert. The novice group identified 86% of the cut marks, scraping marks, percussion marks and carnivore marks correctly.

This percentage only increased in analysts with a higher degree of experience. This leads to the conclusion that marks made by animals are quite easily distinguishable from hominid marks using the criteria formulated by Blumenschine *et al.* (1996) In the past, research on the different morphology of cut marks compared to trampling marks have yielded varying results which makes it difficult to state whether or not trampling marks can be distinguished from cut marks (Dominguez-Rodrigo *et al.* 2009). A protocol has been created by M. Domínguez-Rodrigo *et al*. (2009) in a paper which evaluates these contrasting conclusions, analyses the methods and proposes a new protocol as the contrasting conclusions were a result of differing methodologies. If cut marks created by the extraction method used in these dredging activities are absent or clearly different from cut marks/trampling marks, this protocol could be used on all pleistocene material that shows either cutmarks or trampling marks. Domínguez-Rodrigo *et al.* suggest that light magnification is the best method, but no magnification whatsoever does not suffice for the identification of cut marks, also suggested by Blumenschine *et al.* (1996).

SEM is another method often employed to identify marks on bone surfaces. Usage of the scanning electron microscope is often employed by Pat Shipman. Using a scanning electron microscope (SEM) provides some advantages over the more common methods of magnification, which use light, as it provides a higher resolution, a greater field of depth and a capability of higher magnification than light microscopes (Shipman 1981). The main drawbacks are the small reservoir (4 inches x 2 inches x 1 inch or roughly 10cm x 5cm x 2,5 cm, which is an SEM with a 'large' reservoir) and need to be coated in gold-palladium. To avoid covering original specimens, Xantopren blue coldcure silastomer copies of the original were made by Shipman, which provide a sufficient detailed picture. As a result of the high monetary and temporal cost of this method and the supposed accuracy of hand magnification in the identification of cut marks (Blumenschine *et al.* 1996; Domínguez-Rodrigo *et al.* 2009) along with the allowed volume of the bone material makes it impractical for Moordhuizen, as it is mostly reliant on a lot of data. Another issue is that the classification of bones as being Pleistocene is mainly based on their large size, as a result of which they would not fit in the SEM. As this publication is from 1981, SEM has been further developed over the last 40 years. A new method of SEM, the so-called tabletop SEM has been developed, which cuts down on preparation time and cost as no coatings have to be applied (among other things) (Krishnamoorthy *et al.* 2010) which for archaeology also means that no duplicates have to be made, cutting down on costs even more. In the study done by Dittmar et al. (Dittmar *et al.* 2015) a tabletop SEM is used on human bone material. As the volume of an SEM is still too small for a human cranium (Dittmar *et al.* 2015), the entire Moordhuizen bones mostly can not fit without preparation. A proposed preparation method is Alec Tiranti RTV putty silicone, which is a little under half the cost of Xantopren blue coldcure silastomer and less subject to error, which in the case of Xantopren leaves residue on the bones. In order for a Moordhuizen cut mark to be examined, a cast would have to made of the entire bone (or the bone needs to be chopped) for it to fit in an SEM. The cast can be cut in order for it to fit in the SEM without destruction. In theory, destruction of the Moordhuizen material for SEM analysis can be warranted as this material would otherwise not be used for any archaeology. As a result of the ease and accuracy of identification with low magnification and light however, this method would be unnecessarily expensive, time-consuming and destructive. (Blumenschine *et al.* 1996; Domínguez-Rodrigo *et al.* 2009)

In butchery, the head is often disarticulated (Stiner 1991), which results in chopping marks on the atlas and axis as a result of this disarticulation. Due to the post-depositional processes present at Moordhuizen a mere fracture of an atlas or axis along the correct axis is not sufficient. Deep marks need to be present positioned laterally on the axis or atlas (representing a 'failed' disarticulation attempt).

The analyzed material in the lab showed no clear cut marks so far, although the material was quite rough as a result of post-depositional processes, so many could have been lost.

8.5 Dredging and cut marks

The method of extraction also needs to be taken into account. With dredging, teeth dislodge the sediment which results in loose sediment, that can be transported to the surface by suction or be carried up by a conveyor belt. A possible influence on the material that dredging could have is that the teeth which dislodge sediment could leave impressions that are similar-looking to cut marks, although this information is merely gained from examining dredging machine patents. It is unclear which machine is used at Moordhuizen and how this machine's method of extraction impacts bone material. Attempts at contacting the volunteers of EODM regarding this matter have not yielded any results as of 16-07-2020. For now this seems to not have not been researched in an archaeological context, specifically the impact of the dredging process on archaeological finds. If the blades in dredging activities leave similar marks, experimental archaeological research is required prior to analysis focusing on cut marks, examining these bones and comparing their bone surfaces under light magnification to other bone surfaces impacted by all possible processes, although it is very likely that if any marks are left it is visibly fresh compared to the fossil bone material although it is not impossible that the teeth would leave impressions rather than make cuts.

The broad question whether or not humans were active around Moordhuizen during the Pleistocene could be answered with the identification of cut marks. Furthermore, this cut mark protocol could be applied to a rib that allegedly has a cut mark (Stolzenbach 1993; Bagger! Museum Jan Cunen).

8.6 Alleged cut mark and previous attempts at dredging archaeology in the area

As a result of the possibility that the marks on the mammoth remains found by Leo Stolzenbach in Lithse Ham are the result of other processes which resemble cut marks (carnivore scavenging, trampling), further examination of the cut mark is required (Dominguez-Rodrigo *et al.* 2009; Blumenschine *et al.* 1996; Olsen and Shipman 1988). Assuming that this cut mark is not a cut mark as a result of the lack of (available) academic literature would be a discredit to Leo Stolzenbach and Olaf, who were prolific collectors of archaeological material from dredging sites as well as Leo being professional preparator and Olaf's writing being published in an archaeological journal. After consulting the current conservator of the collection, Drs. Will Brouwers, I was told that the specific bone was described in detail in volume 4. of the journal 'Archeologie' by Leo's son, Olaf Stolzenbach from 1993. In this journal the specific Lithse Ham mammoth bone with cut marks is not discussed. This Lithse Ham bone would be of high interest as Lithse Ham is directly on the opposite side of the Meuse to Moordhuizen. Although the Meuse has historically been hard to cross this was likely very different in the highly dynamic Pleistocene landscape, which means that if Pleistocene hominids were present at Lithse Ham, this would make it more likely that Pleistocene hominids are present in Moordhuizen. Leo and Olaf Stolzenbach can not be asked directly how the cut marks were determined as they have both passed away. Another dredging site is discussed in the writings of Olaf Stolzenbach, namely the side of Kerkdriel, which is on the Moordhuizen side of the Meuse a few kilometers downstream (fig. 2). The work of Olaf Stolzenbach describing this site proves interesting insights on the possibilities of dredging-site archaeology. After scavenging for pleistocene mammals and lithic artefacts and asking the dredging operators it became clear that lithic artefacts were often accompanied with fossil mammal remains, being extracted somewhat simultaneously. This dredging was with a clear goal of dredging up sand for cement production and dyke fortification, as a result of which the initial depth was -21m (Stolzenbach, 1993). The artefacts that have been found are described as being Clactonian and are extensively documented with drawings. The dating is however unclear as geology around rivers is extremely complex according to the consulted geologists of the Rijks Geologische Dienst (R.G.D.). Two bones that seem retouched (fig. 8: figuur 67, figuur 68 from Stolzenbach 1993) that have been interpreted as being Bison Priscus and one indet. (but supposed Cervid) came up simultaneously with Clactonian artefacts and show a higher degree of fossilization than mammoth bones that have been extracted from a higher layer of sand (the ‘clactonian’ sand layer and the higher, mammoth containing sand layer separated by sterile layers of clay and loam). In the same context with the same degree of fossilization a s human bone fragment was extracted (figuur 74 from Stolzenbach 1993). If this specific bone can be located a ZooMS analysis is a possibility to determine the species of Homo. Other elements of interest that are not assigned to any clear context but are of interest are Pleistocene faunal remains that are interpreted as

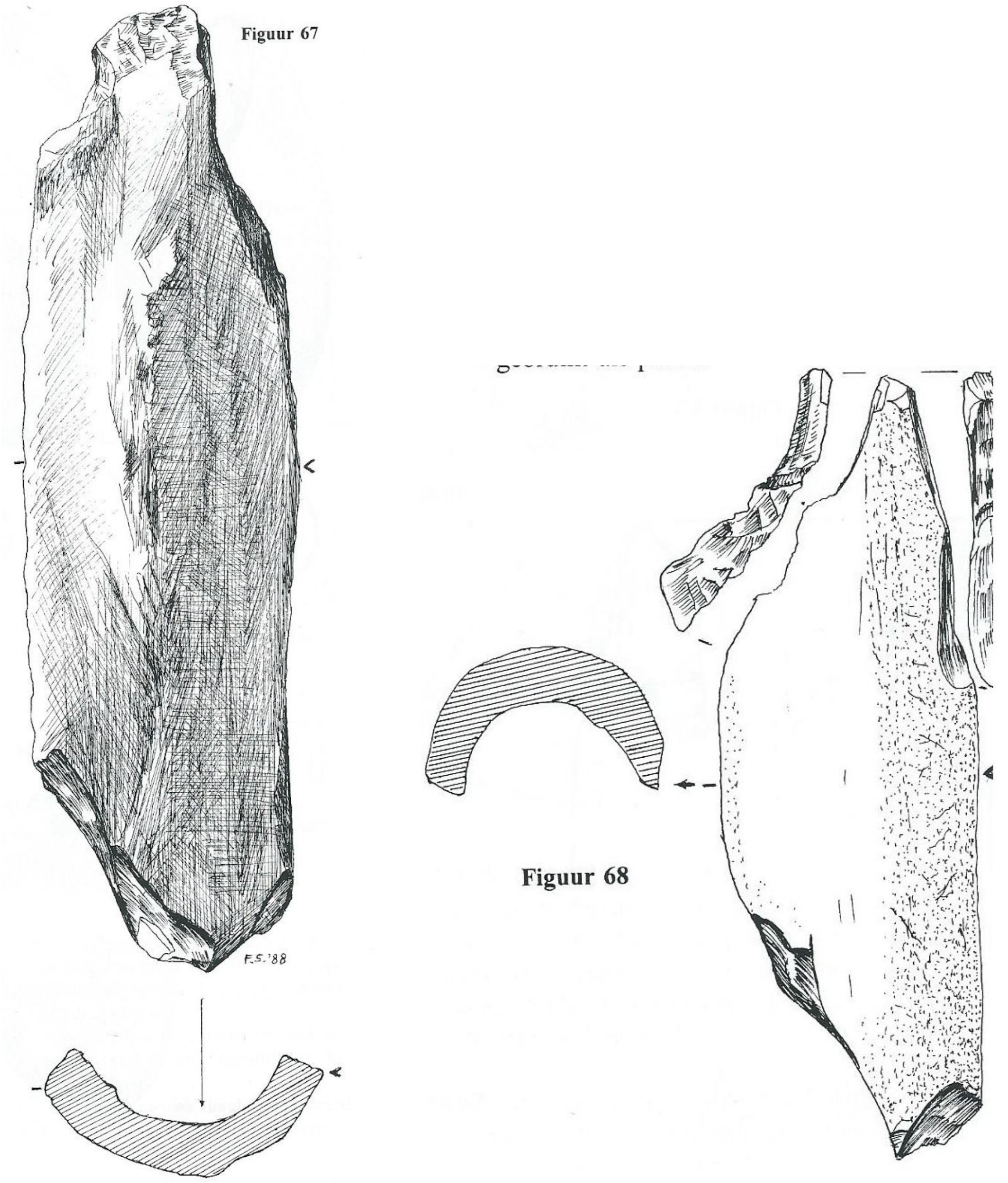

fig. 8 - figuur 67/figuur 68 from Stolzenbach 1993 depicting retouched bones, alleged *Bison Priscus* and *Cervidae sp.*

being for example diggers and anvils. Although Mr. Stolzenbach took carnivores into account, post-depositional processes such as trampling do not seem to have been researched. Out of a vast amount of material only a few were selected as artefacts. No literature is mentioned, although the supposed Lissoir (fig 9: figuur 5 from Stolzenbach 1993) does resemble Paleolithic bone lissoirs (Soressi *et al.* 2013)

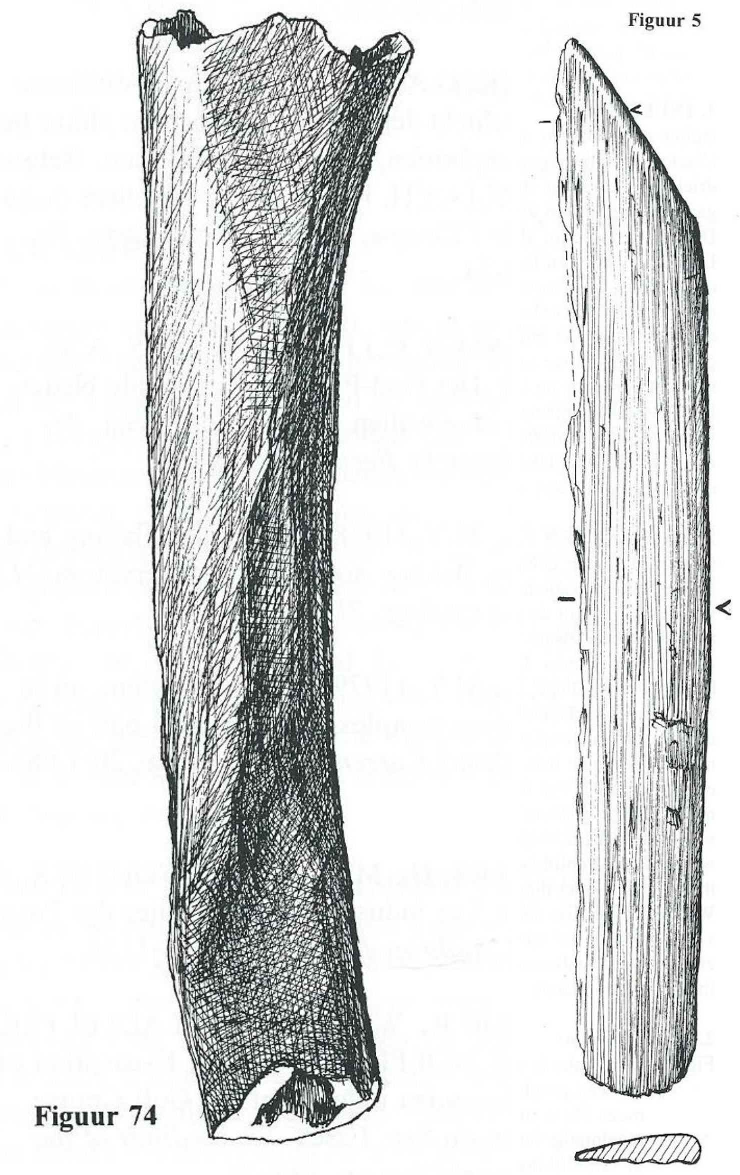

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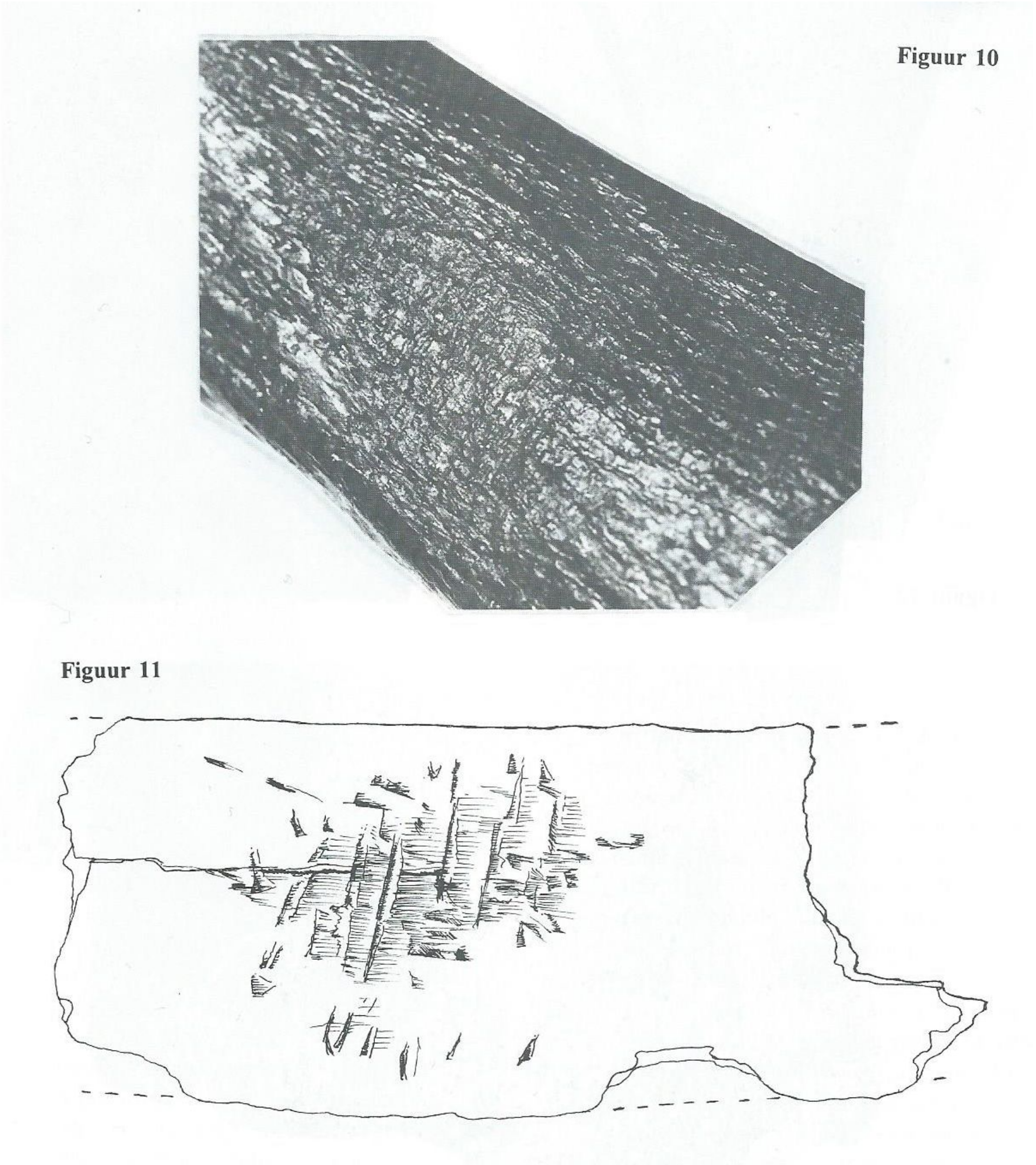
fig 9. Figuur 74 and Figuur 5 from Stolzenbach 1993: supposed hominid and lissoir respectively

Another item of interest is a mammoth rib, which according to the author has been used as an anvil (fig 10: figuur 10 and figuur 11 from Stolzenbach 1993). Because no methodology or referenced papers are present it is unclear if Stolzenbach used the proposed light magnification (Blumenschine *et al.* 1996; Domínguez-Rodrigo *et al.* 2009). From the drawings alone, it is too difficult to examine the validity of these claims. This, in combination with the lack of consideration of



Figuur 10

Figuur 11

fig 10. Figuur 10 and Figuur 11 from Stolzenbach 1993, mammoth rib, possibly used as anvil abrasive post-depositional processes makes it unlikely that many of these ‘cut marks’ are actual cut marks. Another issue that is not mentioned is the possible influence of the dredging method, which could ‘chop’ bones. Chopped bones are all attributed to human activity in this journal. Although the species determination methodology is absent, it is fair to assume that Igor Stolzenbach was proficient in species determination as a result of the collecting done over many years with Leo Stolzenbach. An issue with this journal is that post-depositional processes do not seem to have been considered, or any academic literature on the matter of trampling, It does prove that dredging can be archaeologically valuable, however, if an archaeologist is present as Pleistocene bone material being dredged up alongside Paleolithic artefacts. This simultaneous extraction does say something, and it can be argued that all the combined material does prove human activity during the Pleistocene in the Kerkdriel area. As it is very close to Moordhuizen (figure 2) it is very plausible that hominids were also active in Moordhuizen if they were active in Kerkdriel. Bone breakages Bone breakage as an indicator for human activity can not be employed with the currently proposed methodology. Outram argues for a re-evaluation of skeletal elements otherwise deemed ‘indeterminate’ as these bone splinters could be an indicator of marrow extraction. There are three main issues with this leading to this method not being available. Firstly, the manner in which the bones are extracted from the ground, with dredging activities fractures many brittle elements. Secondly, the classification in either Pleistocene or Holocene at this site is dependent on determining species, for which the material has to be mostly intact. This can be overcome by the use of ZooMS, however, of which the pros and cons are discussed in the ZooMS section. Some material is of an indeterminate species and an indeterminate skeletal element, but can be categorized as Pleistocene as a result of lithification. Lastly, post-depositional processes have also likely fractured bones.

8.7 Axial/Appendicular ratio

An issue with the approach that infers a human scavenging strategy based on the amount of axial elements present compared to the appendicular elements is that it is mostly based on research done on cave sites. The main goal is determining whether faunal assemblages are a result of hominid activity or of carnivore activity (Klein 1987). Due to the species found (large plain mammals such as mammoth) and the current day height map of the region caves are not a likely presence. There is some elevation dating from the Saalien, mainly a glacial push moraine at Nijmegen. As is visible in figure 2, the distance to this elevation is easy to walk in a few hours as it is roughly a 15 kilometer walk. The elevation seems to have been gradual in nature for a long time after its formation, however. Caves could have started out as aeolian and then be carved out by the sea (De Mulder *et al.* 2003) or the rivers (Culver 2004) although no research can be found mentioning caves and Nijmegen. It seems much more likely, therefore, that if animals around Moordhuizen were hunted, killed and consumed, their entire carcass would be intact at their location of death as a result of a more nomadic approach of hunters. Following herds rather than living out of possible burrows near Nijmegen seems more likely. Assuming the Pleistocene humans active in the area had a nomadic lifestyle, this method would probably not be very valuable although it is worth to assess the relative frequencies of vertebrae compared to skulls and the appendicular skeleton. The same mechanisms that apply to cave sites could still apply if camps were set up semi-permanently and if these camps situated at too large of a distance from the killing site to drag entire carcasses to the basecamp for processing and consumption. Although this seems unlikely as this would waste half an animal, if not more. It seems more efficient to move a camp to a carcass rather than parts of a carcass to a camp, only to have to hunt or track down another animal in order to get the same caloric value that is gained from the entire carcass. If there is in fact a disproportionately large amount of axial skeletal elements or skulls this could also still indicate carnivore activity. This method is optimal with caves and large amounts of appendicular skeletal elements, as ungulates do not often wander into caves (Klein 1987). A possible solution is a combination of the amount of axial skeletal elements/appendicular skeletal elements and mortality profile, focussing on prime age animals (Stiner 1990). This allows for exclusion of many animals that died of natural causes, namely the older and younger specimens. Not all skeletal elements preserve equally well, however, which leads to a bias in skeletal elements (Faith and Thompson 2018) as a result of post-depositional processes that impact different elements differently as a result of their structural density (Lyman 1994).

8.8 ZooMS

As a result of dredging and post-depositional processes many bone fragments are too small to determine taxa. Methods exist to determine species without using morphological characteristics, however, which means that identification on species level can take place with just a bone fragment. One of these methods is ancient DNA, also referred to as aDNA, which is very costly to use in large assemblages (Buckley 2018), alongside an unpredictable likelihood of success and a requirement of specialized facilities. An alternative that is more suitable to large assemblages is ZooMS which uses Mass Spectrometry to analyze proteins in bone, which has multiple advantages for large assemblages such as Moordhuizen as protein is more abundant, protein survives for a longer amount of time and ZooMS is a lot cheaper. It can also, in theory, be used to find hominid remains. ZooMS can be used with the Moordhuizen material that is too fragmented to determine the species based on morphology. An issue is that there are simply too many fragments to use ZooMS on all of the suitable fragments. A suggestion is selecting indeterminate fragments with (plausible) cut marks for ZooMS. Although cut marks can almost always be identified with light magnification (Blumenschine *et al.* 1996; Domínguez-Rodrigo *et al.* 2009), SEM is a possibility with the more fractured elements that were determined taxonomically with Zooms. Furthermore, species that are not obviously Pleistocene (not megafauna) can also be identified with this method. An analysis of Moordhuizen material with selection of indeterminate elements with possible cut marks and then applying ZooMS can shed light on human activity and behaviour around Moordhuizen. An issue is that a sequence has to be available for the ZooMS results to be compared to in order to determine species. Theoretically, these sequences can be gained from obvious examples of a species such as intact skeletal elements. There is a database available with protein sequences called UniProt (Buckley 2018). Non-destructive methods of ZooMS also exist (Martisius et al. 2020), which allows for cut mark analysis after species determination which is relevant for fragile fragments. Using UniProt and ZooMS could work for the alleged hominid from Kerkdriel (Stolzenbach 1993), which was dredged up alongside Clactonian tools. Using it on possible hominids in Moordhuizen is also possible, although no archaeologists was present in order to get an idea of the rough context, which means that a lot of bones will have to be analyzed in order to find a Non-*Homo Sapiens* hominid which will prove Pleistocene hominid activity. Currently the only hominid that seems to have its sequence present in Uniprot is *Homo Sapiens*. It is possible to prove that this morphologically hominid bone is not *Homo Sapiens*, which would make it more likely that it is *Homo Erectus*, as the researcher of the Kerkdriel material suggests. (Stolzenbach 1993). Practically, it would take a very long time to analyze all bones and locate hominids among the Moordhuizen material. Furthermore, a ZooMS expert is required and analyses are very time consuming.

9. Conclusion

The lack of knowledge on post-depositional processes and lack of context due to the excavation method makes Paleolithic archaeology difficult in dredging sites. Dredging is often employed in river areas where geology is often complex as well as a result of the dynamic nature of fluvial landscapes in which sediment is eroded as a result of which stratigraphy becomes unclear (Stolzenbach 1993; De Mulder *et al.* 2003). Because of a lack of traditional context and thus accurate dating methods, professional and scientific archaeology often discards dredging sites as a source of valuable information. In spite of this, archaeological knowledge can be gained and there is room for development of dredge-site archaeology to increase the knowledge that is gained from such sites. Although the knowledge gained is superficial in nature, it can be useful information in areas that are otherwise lacking Paleolithic sites, such as the majority of the Netherlands. In addition to the lower lying areas of the Netherlands, the intricacies of dredging and how it can be used in Paleolithic archeology is relevant in the North Sea where 'normal' Paleolithic excavations can not be conducted, but is of importance as Doggerland, which is currently the North Sea, was the land bridge between the Netherlands and Britain, the latter being relatively very rich in Paleolithic sites.

When examining the faunal remains that were able to be recorded after data loss, an issue that was impossible to solve due to Covid-19 alongside geological data, human occupation of the area could well be possible. The area would have been rich in water, during warmer areas seawater, during colder periods periglacial or meandering rivers. The animals present in the assemblage support this, the large presence *Elephantidae* and Pleistocene *Bovidae* indicate an open landscape (Hebinck & Heunks 2011; Balantyne 2018 ; De Mulder *et al.* 2003 ; Rijksdienst voor Erfgoed).

In the site of Moordhuizen, the most practical way of proving or disproving human presence during the Pleistocene is selecting Pleistocene bone fragments and inspecting them for cut marks with light magnification, as experimental evidence shows that this method has a high degree of success and can be even easily taught to volunteers to speed up the process of locating all bones with cut marks (Blumenschine *et al.* 1996; Dominguez-Rodrigo *et al.* 2009). The employing of volunteers would be very helpful as the material is extremely numerous. The other methods for distinguishing cut marks from other natural marks are too time-consuming and too expensive to apply to Moordhuizen as the success rate is also not necessarily higher (Blumenschine *et al.* 1996; Dominguez-Rodrigo *et al.* 2009). It can not be fully ruled out that dredging machines cause similar marks in bone material to cut marks as there is no experimental archaeological data on this although these machines would likely leave marks coloured differently than the fossilized remains. Carnivore marks and trampling are distinguishable from cut marks almost without fail (Blumenschine *et al.* 1996; Dominguez-Rodrigo *et al.* 2009). Mortality profiles can be useful in proving human activity as they reflect specialized hunting strategies which are likely to be reflected in a mortality profile as these methods can be applied to Pleistocene species using period-specific species and ecozones (Gliozzi *et al.* 1997; van Kolfschoten 2001), which could reveal for example a strategy driving animals into a body of water reflecting a catastrophic profile as is present with Bison during the Middle-Paleolithic in Schöningen for example (Voormolen 2008).

The degree in which the post-depositional processes have influenced the material is unclear, which can lead to a bias of older specimens as bones of young specimens are more fragile (Lyman 1994) and makes bone fragmentation for marrow and bone grease extraction difficult to ascertain. A completeness index (Marean) could be constructed to give an idea of the degree of fragmentation caused by depositional processes. Although the traditional archeological meaning of 'context' is absent when finds are dredged, a new type of context emerges that is unfortunately absent in the Moordhuizen material. Although time windows were used, these were too broad and bags contained mixed material. From the Stolzenbach paper (Stolzenbach 1993) it can be gathered that contexts can still be constructed, albeit more rough and dubious contexts than usual field archaeology. This is dependent on the manner in which dredging takes place although a horizontal approach allows for much more archaeological potential. If for example a sand layer is dredged between two clay layers in order to gain sand and lithic artefacts and animal bones with cut marks are dredged up simultaneously some statements can be made about the local Paleolithic population. In vertical dredging, mixing of material of vastly different is inevitable, but using smaller time windows does allow for some context, especially if the original context is not disturbed before dredging. If a time window only contains Pleistocene remains, a context is somewhat present, although not nearly as much can be said about a dredging context than a field archeology context as a result of the process and the lack of present soil or other contextual material of interest.

For optimal dredging site archaeology horizontal dredging at a geologically understood depth and small time windows is preferred. With these small time windows context that was present before dredging is more intact as bone material near to each other gets dredged up somewhat simultaneously. These smaller dredged contexts can also be examined for butchery marks alongside the culling profiles to get a rough idea of human behaviour or presence in areas otherwise lacking in Pleistocene sites or possibilities of field excavation.

In Moordhuizen only rough dating can be done and subsequent mortality profiles, alongside the cut mark investigation in order to determine hominid activity.

Abstract

Dredging site archaeology needs to be further developed in order to understand Paleolithic hominid behaviour in areas otherwise lacking in Pleistocene sites. This thesis explores zooarchaeological methods and their viability related to dredging sites, focusing on the dredging site of Moordhuizen in the Netherlands. A combination of chronology based on ecozones, mortality profiles and cut mark analysis could be employed in Moordhuizen to deduce human activity.

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