Changes in animal husbandry in the Netherlands during the Neolithic

Dedecker, Alicia

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Figure 1 Artwork of the Schipluiden-Harnaschpolder settlement. This figure shows how the artist imagined what the settlement at Schipluiden-Harnaschpolder looked like. (Louwe Kooijmans, 2006, p. 491, Figure 27.2).

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Alicia Dedecker, s3220036

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Supervisor: Dr. N.Ø. Brusgaard

Leiden University, Faculty of Archaeology

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Table of Contents

List of Figures

List of Tables

1. Introduction

Many millenniums ago, man would hunt animals for food, while the women stay at home and gather food (Peter & Cummings, 2014, p. 9). This all changed during the Neolithic as a result of the Neolithic Revolution. The Neolithic Revolution caused for a period of change in which people replaced hunting and gathering with farming and animal husbandry and their settlements became permanent instead of temporary (Chu & Xu, 2024, p. 699; Thomas, 2013, p. 2).

Animal husbandry is the practice of keeping livestock for their products. Livestock are domestic animals and the most prominent animals that fall under livestock are cattle (*Bos taurus*), pigs (*Sus domesticus*), sheep (*Ovis aries*), goat (*Capra hircus*), chicken (*Gallus domesticus*), and horses (*Equus ferus caballus*) (Kenniscentrum InfoMil, n.d.). Going from hunting and gathering to farming and keeping animals as livestock caused the lifestyle of the people to change. People gained easier access to food and other products like milk and wool. In combination with farming, this easier access came with greater control over food production and an increase in food production, which allowed for the growth of the population (Scanes, 2018, pp. 108-110). Instead of moving from one site to another living a nomadic live, permanent villages were made (Olsson & Paik, 2016, p. 6; Thomas, 2013, p. 2).

While the Neolithic is considered to begin in 6500 BC, its starting date differs per region (Fowler et al., 2015, p. 4). The same goes for the Netherlands, where the Neolithic began around 5500 BC and ended in 2000 BC (Louwe Kooijmans, 2007, pp. 290, 295). During the Neolithic many different cultures were present. Three of these cultures are the Swifterbant culture, Hazendonk 3 group, and the Single Grave culture. The Swifterbant culture started around 5000 BC and ended in 3400 BC (Raemaekers, 2005, p. 261). It is mostly known for its Swifterbant ceramics (Raemaekers, 2005, p. 262). The Hazendonk 3 group began in 3900 BC and ended in 3400 BC (Raemaekers, 2005, pp. 261, 269). Hazendonk was contemporary with part of the Swifterbant culture and these two cultures were the predecessors of the Vlaardingen culture (Raemaekers, 2005, pp. 269, 271). The Single Grave culture lasted from approximately 2800 BC until 2400 BC (Drenth, 2005, pp. 347-349). This culture is related to cultures in Denmark and Germany and is known for burying only one person per grave instead of making grave chambers (Drenth, 2005, p. 333).

1.1 Previous research

To find out if animal husbandry took place, researchers look at the faunal remains, specifically from domesticated animals (Baker & Worley, 2019, p. 2; Lauwerier et al., 2005, p. 39). Distinguishing remains from domesticates from non-domesticated individuals can be done by measuring the length of the remains (Zeiler, 2006, p. 376). Bones of domesticates have a different size in comparison to their predecessors, because generally domesticates became smaller (Baker & Worley, 2019, p. 48). There are cases where domesticates grew bigger due intensified exploitation (O'Connor, 2000, p. 152), however size increase of livestock began primarily during the Roman Period and the Early Middle Ages and not during the Neolithic (Grau-Sologestoa, 2015, p. 132). Bones can also have pathologies, which are signs of injuries or diseases, such as trauma or joint disease (Baker & Worley, 2019, p. 50; O'Connor, 2000, p. 98). While not all pathologies are caused by humans (Baker & Worley, 2019, p. 52), the ones that are caused by humans can be indications of animal husbandry (Baker & Worley, 2019, p. 2).

Multiple articles about animal husbandry in the Neolithic have been published (Çakırlar, 2012; Halstead, 2024; Kamjan et al., 2021; Marciniak et al., 2017). Despite there being many more articles, almost all of them either cover only part of the Neolithic, a region outside of the Netherlands, or both. This does not mean that there are no articles about animal husbandry in the Netherlands during the Neolithic. In 2005 research was done about the archaeozoology in the Netherlands during the Palaeolithic until the Late Neolithic (Lauwerier et al., 2005). Lauwerier et al. (2005) concluded that during the Early Neolithic hunting wild animals was dominant, with some sites keeping livestock (pp. 47, 49, 53, 61). In the Middle Neolithic hunting wild mammals, especially deer and fish, was the main source of meat income (Lauwerier et al., 2005, pp. 53-54, 61). Finally in the Late Neolithic animal husbandry became more important than hunting and most of the meat came from cattle (Lauwerier et al., 2005, pp. 54, 57, 62).

1.2 Research question and aims

Despite previous research being conducted by Lauwerier et al. (2005), there are still questions left unanswered about animal husbandry in the Neolithic. Did the amount of kept animals change? Did they keep more individuals of a species as livestock? Did the reason why livestock was kept in the first place change? Did livestock live longer lives? This research aims to investigate these developments of animal husbandry by answering the following research question: 'How did animal husbandry develop in the Netherlands during the Neolithic?' In order to answer the research question, three sub questions were made: 'Did the relative abundancy of domestic livestock species change during the Neolithic?', 'Did culling practices change during the Neolithic?' and 'Did the purposes for which livestock were kept change during the Neolithic?'.

This research aims to answer the research question and sub questions through the help of three case studies. The Early Neolithic is about the site Medel-De Roeskamp, the site Schipluiden-Harnaschpolder is the focus of the Middle Neolithic, and the Late Neolithic is about the site Mienakker (see Figure 2). The sites each belong to a different Neolithic culture, the Swifterbant culture (Raemaekers, 2005, p. 6; Willemse et al., 2023, pp. 136-137), the Hazendonk 3 group (Jongste & Louwe Kooijmans, 2006, p. 5; Raemaekers, 2005, p. 269), and the Single Grave culture respectively (Drenth, 2005, p. 349; Kleijne, Beckerman, et al., 2013, p. 251). These specific case studies were chosen as they each belong to a different period and culture, have extensive reports written about them, are located in different parts of the Netherlands, and can tell us more about animal husbandry during the occupation of the sites.

Next to answering the research question, this research aims to review if the research by Lauwerier et al. (2005) still holds up, to bring new insights about the development of animal husbandry, spark more interest in this topic, and make the results of Dutch research more accessible to non-Dutch speakers.

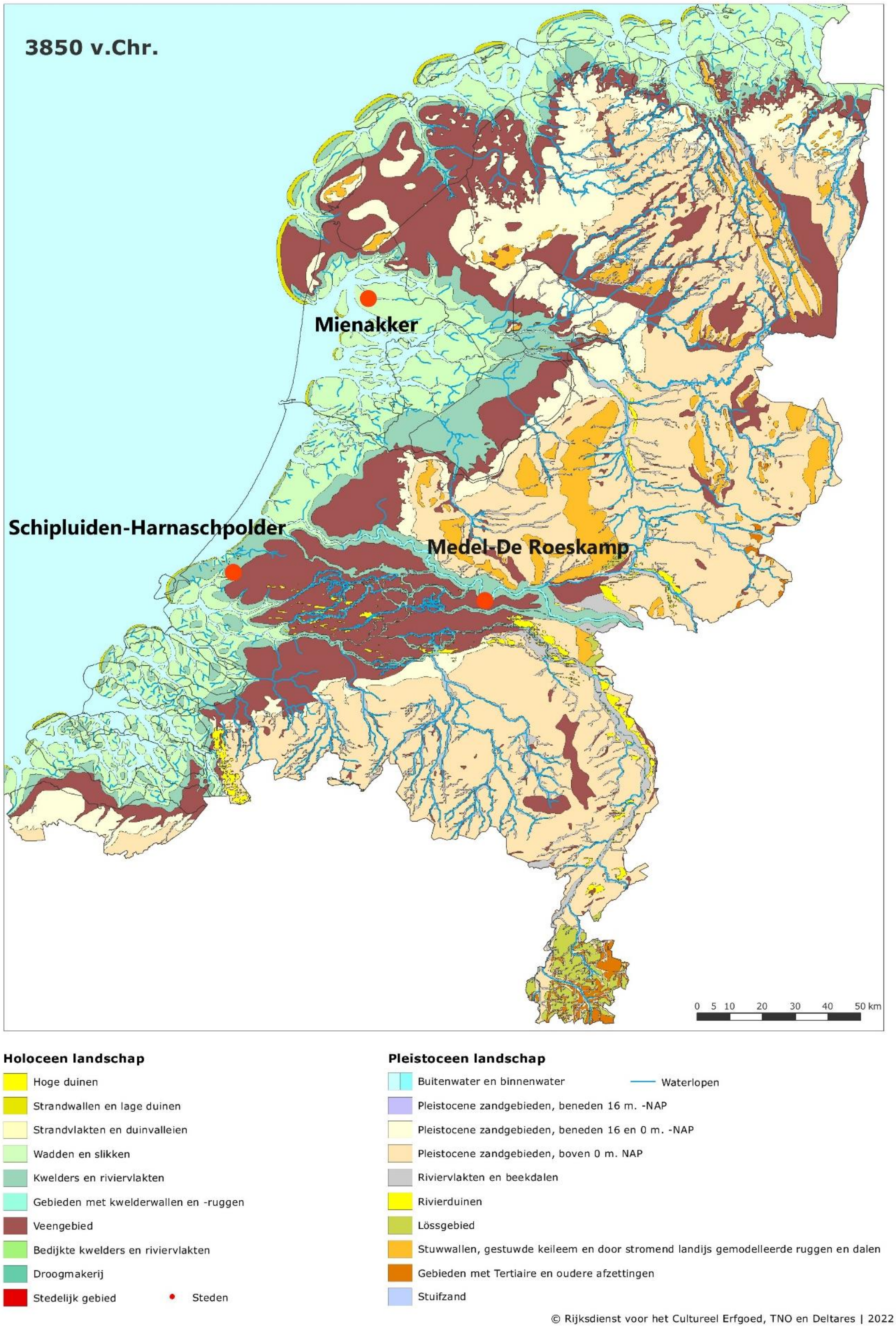


Figure 2 Palaeolographic map of the Netherlands in 3850 BC. This map shows the approximate location of Medel-De Roeskamp, Schipluiden-Harnaschpolder, and Mienakker with red dots. (Adapted from Vos et al., 2020).

1.3 Outline

Chapter 2 provides the necessary background information of the three case studies, Medel-De Roeskamp, Schipluiden-Harnaschpolder, and Mienakker. Chapter 3 explains the different methods used in the reports of the case studies and the methods used in this research. Chapter 4 shows the different results that were found during this research, which will be discussed in chapter 5 together with any problems that arose during this research and recommendations for future research. Finally chapter 6 will answer the sub questions and research question.

2. Case studies

2.1 Medel-De Roeskamp

The Swifterbant site that was chosen for this research is Medel-De Roeskamp and it is located in Tiel, Gelderland, the Netherlands (ten Anscher, 2023c, p. 1). Figure 3 shows the location of Medel-De Roeskamp. It was discovered during an archaeological coring campaign in 2012 (ten Anscher, 2023c, p. 1).

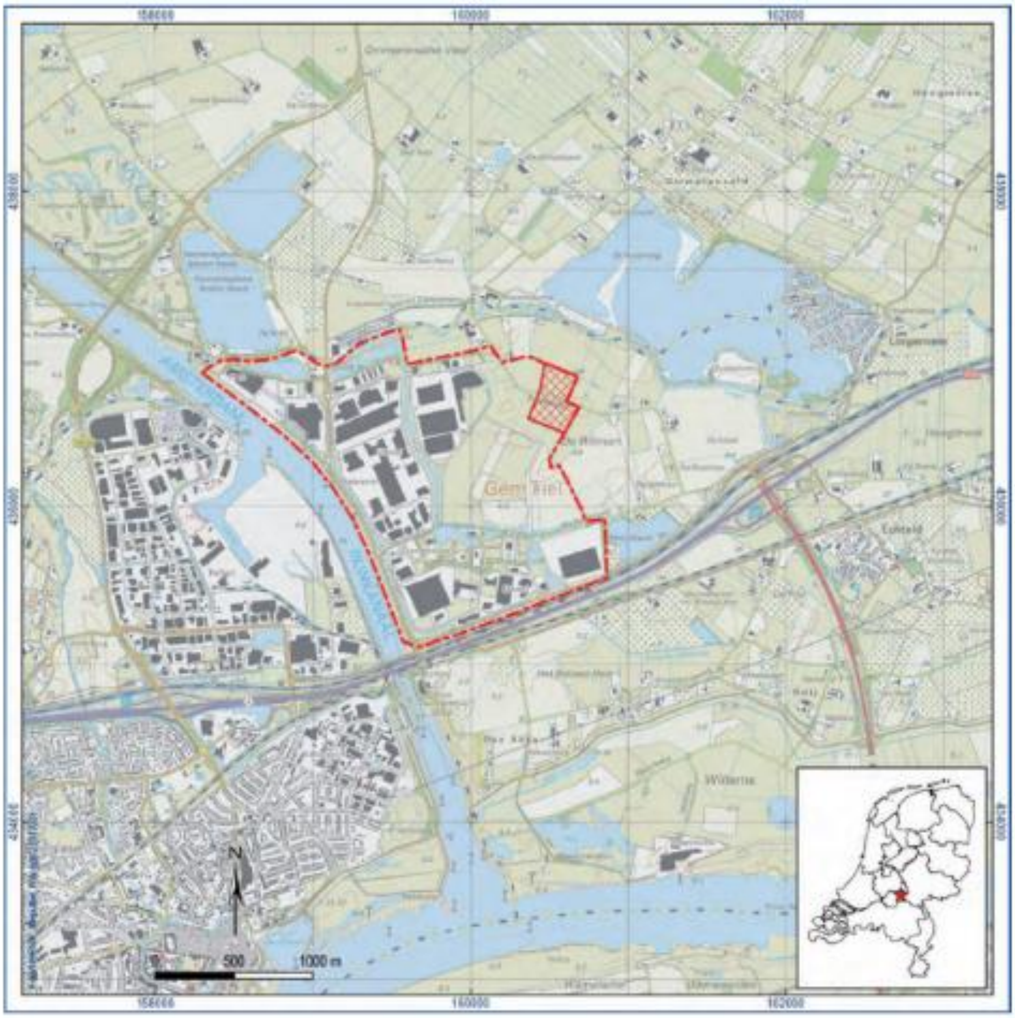


Figure 3 Map of Medel-De Roeskamp. This map shows where Medel-De Roeskamp is located in the municipality Tiel. (ten Anscher, 2023c, p. 2, Figure 1.1).

Before people could start excavating, trial trenches were conducted in 2014 (ten Anscher, 2023c, p. 3). It became clear that the site was preserved very well (ten Anscher, 2023c, p. 7). The excavation began in November 2016 and ended near the end of September 2017 (ten Anscher et al., 2023). The site is around 8.5 ha big, but the Early Neolithic part of this site is

16,650 m^2 (ten Anscher, 2023a, p. 26). With the use of ^{14}C dating, the occupation of the permanent settlement at the site was dated to 4300 until 4050 BC (Willemse et al., 2023, pp. 136-137; 142). This is contemporary with the middle phase of the Swifterbant culture, which spans from 4600 until 3900 BC (Raemaekers, 2005, p. 266). In this permanent settlement, animal husbandry came first and the hunting second in regards to obtaining meat (ten Anscher, 2023b, p. 865).

Faunal remains were obtained through a combination of mechanical excavation, hand collecting, and sieving on a 5, 2, and 1 mm mesh (Knippenberg, 2023, p. 204; ten Anscher, 2023a, p. 26). Most of the remains, about 94 %, were found through sieving. The faunal analysis was done by Archeoplan Eco by using reference collection of both the Faculty of Archaeology Leiden and Rijksdienst voor het Cultureel Erfgoed (Cultural Heritage Agency) in addition to its own reference collection (Esser et al., 2023, p. 640). In total, 334,688 mammal bone fragments were found during the excavation, but only 8,077 bone fragments could be identified to species or family (Esser et al., 2023, p. 654). This gives an identification rate of 2.3 %. Almost 99 % of the remains are smaller than 10 % of a skeletal element, making it difficult to identify the species and identify any butchering traces (Esser et al., 2023, pp. 645-646). Additionally, around 43 % of the remains are burned; only 0.5 % of the burned remains could be identified to species level (Esser et al., 2023, p. 646). On average around 20 remains per square meter were found.

Measurements were taken to differentiate domesticates from wild animals (Esser et al., 2023, p. 643), and epiphyseal fusion and eruption of teeth were used for age-at-death determination (Esser et al., 2023, p. 644). The division of Stiner (2002, as cited in Esser et al., 2023, p. 642) was used to separate the skeletal elements, complete bones, into nine different anatomical regions: horn/antler, head, neck, axial, upper front, lower front, upper hind, lower hind, and feet (Esser et al., 2023, p. 642). Instead of analysing each remain and counting the elements, Klein and Cruz-Uribe (1984, as cited in Esser et al., 2023, p. 641) was used to calculate the amount of elements per anatomical region (Esser et al., 2023, p. 641). One complete element counts as one, but for incomplete elements a correction factor was used according to their fragment size (Esser et al., 2023, pp. 641-642). Additionally, each region has its own calculated number of individuals, allowing for a better understanding of how many individuals were present. To calculate this, the found number of elements was divided by the number of elements in one individual in said region (Esser et al., 2023, p. 642).

For cattle age-at-death based on epiphyseal fusion and tooth wear Habermehl (1975, as cited in Esser et al., 2023, p. 644) and Grant (1982, as cited in Esser et al., 2023, p. 644) were used respectively (Esser et al., 2023, p. 644). Pig age-at-death used Zeder et al. (2015, as cited in Esser et al., 2023, p. 644) and Lemoine et al. (2014, as cited in Esser et al., 2023, p. 644) and was based on epiphyseal fusion and dental data respectively.

2.2 Schipluiden-Harnaschpolder

The site Schipluiden-Harnaschpolder is located in the Harnaschpolder in a corner in the Schipluiden municipality in the Netherlands (Jongste & Louwe Kooijmans, 2006, p. 5). It is located nearby the village Den Hoorn, as can be seen in Figure 4. In 2001, RAAP Archeologisch Adviesbureau B.V. carried out coring trials in the Schipluiden municipality to investigate if there were any sites underneath the soon to be build wastewater treatment plant (Jongste & Louwe Kooijmans, 2006, p. 3). A dune was found and after further exploration it turned out to be a site, which was given the name Schipluiden-Harnaschpolder (Jongste & Louwe Kooijmans, 2006, pp. 3-5).

Figure 4 Map of Schipluiden-Harnaschpolder. This map shows a close-up of the location of Schipluiden-Harnaschpolder. (Jongste & Louwe Kooijmans, 2006, p. 3, Figure 1.1).

Due to the high preservation quality of the site and the fact that the wastewater treatment plant would be built soon, plans were made to excavate the site (Jongste & Louwe Kooijmans, 2006, p. 5). The excavation was conducted by Archol B. V. in 2003 from June until mid-September (Jongste & Louwe Kooijmans, 2006, p. 7). To the excavators surprise, the site extended further than the originally thought 5,500 m^2 calculated area (Jongste & Louwe

Kooijmans, 2006, pp. 6-7). Because of this, there are more finds than expected, which lead to the exclusion of bone fragments that could not be identified to species or family level or to small/medium/large mammal category for their analysis (Jongste & Louwe Kooijmans, 2006, p. 11). As of writing this research, the excluded bones have not yet been analysed.

Based on the pottery finds from test pits, they presumed that the site predated the Vlaardingen group, which was later confirmed by the ^{14}C dating results of some samples (Jongste & Louwe Kooijmans, 2006, p. 5). According to these results, the occupation spans from 3630 until 3380 cal BC (Mol et al., 2006, p. 35), making the occupation contemporary with the Hazendonk 3 group (Jongste & Louwe Kooijmans, 2006, p. 5; Raemaekers, 2005, p. 269). Not only is the site one of the oldest sites in the coastal area of the Netherlands, the whole site was buried underground, remaining completely intact (Louwe Kooijmans, 2010, p. 19). The site is likely a permanent settlement (Louwe Kooijmans, 2006, p. 486), and the inhabitants considered animal husbandry more important than hunting in terms of obtaining meat (Zeiler, 2006, p. 403).

During the excavation, remains were collected through both hand collecting and sieving (Zeiler, 2006, p. 375). Additionally, 300 samples from features such as wells, pits, and sections were taken (Jongste & Louwe Kooijmans, 2006, p. 11). 138 samples of the 300 were used for zoological analysis (Jongste & Louwe Kooijmans, 2006, p. 11; Zeiler, 2006, p. 375).

Roughly 80,000 hand collected and 61,000 on a 4, 2, and 1 mm mesh sieved remains were found (Zeiler, 2006, p. 375). Only a part of these remains, approximately 20,000 hand collected and 6,100 sieved remains, were used for species/genus/family identification. These remains come from the 138 samples and include mammal, bird, and fish remains. On average around 26 remains per square meter were found. Zoological analysis was carried out by ArchaeoBone (Jongste & Louwe Kooijmans, 2006, p. 9). Identification was done by using the bone collection of the Archaeological Institute of Groningen University as a reference (Zeiler, 2006, pp. 375-376). Close to 10,000 remains from mammals could be identified and most of these remains were hand collected (Zeiler, 2006, pp. 375, 379). This gives an identification rate of 6.9 %. Besides species/genus/family identification, they also recorded characteristics and pathologies, such as burning, butchering, and ageing (Zeiler, 2006, p. 376). To differentiate domesticates from wild species, the remains were measured following the method of Von den Driesch (1976) on how to measure different elements from different species and were then distinguished based on height. Distinguishing pigs from wild boar was based mostly on extrapolation of the identified pig and wild boar bones (Zeiler, 2006, pp. 376, 391). Only a few of the pig/wild boar remains could be identified to either pig or wild boar, 14 and 24 remains respectively, giving a pig:wild boar ratio of roughly 1:1.7. The rest of the remains were then divided based on this ratio.

Zeiler (2006, p. 376) used epiphyseal fusion and dental eruption patterns to figure out the age-at-death of cattle and pigs. In 2020 a new analysis was carried out for the Schipluiden-Harnaschpolder cattle (Kamjan et al., 2020). They investigated cattle husbandry and analysed age-at-death, slaughter management practices, and cattle diet (Kamjan et al., 2020, p. 3) Age-at-death was determined by looking at tooth wear stages and epiphyseal fusion, slaughter management practices by analysing age-at-death, and cattle diet was determined by analysing isotopes of tooth enamel and animal bone collagen.

2.3 Mienakker

2.3.1 The old analysis

The site Mienakker is located in the municipality Opmeer in the province North Holland, the Netherlands (see Figure 5), and was first discovered in 1986 during an archaeological survey of De Gouw, a land consolidation (van Heeringen & Theunissen, 2001b, p. 171). After three trial trenches of one by two meters in 1989 (van Heeringen & Theunissen, 2001a, pp. 42, 180), organic remains were found (van Heeringen & Theunissen, 2001b, p. 172). To ensure the disappearance of the remains would not happen, the site was excavated in 1990 form April 9 until September 26 by ROB, Rijkdienst voor het Oudheidkundig Bodemonderzoek. The excavated area has a size of 840 m^2 and has been fully excavated leaving no finds undiscovered (van Heeringen & Theunissen, 2001a, p. 59). Due to the preservation quality of the remains and settlement features being excellent, the cultural landscape of De Gouw is one of the most important ones in Northwestern Europe that dates to the Late Neolithic (Döfler & Müller, 2008, as cited in Theunissen & Kleijne, 2013, p. 12). To determine the start of occupation, ^{14}C dating was conducted and this gave an occupation date corresponding to phase 3 of the Single Grave culture in 2650 until 2550 BC (Drenth, 2005, p. 349; van Heeringen & Theunissen, 2001b, p. 172).

Figure 5 Map of Mienakker. This map shows a close-up of the location of Mienakker. (Theunissen & Kleijne, 2013, p. 16, Figure 1.4).

The sediment that has been dug up was sieved on a 4 mm grid, resulting in finding about 67,000 mammal and bird remains (Lauwerier, 2001, p. 181). Together with the 2,204 remains from the 1989 trial trenches (Lauwerier, 2001, p. 180), there are approximately 69,000 mammal and bird remains. Of these remains, roughly 30,000 remains come from mammals (van Heeringen & Theunissen, 2001b, p. 174). On average around 42 remains per square meter were found. The faunal remains from 1989 were analysed by Schnitger (1990, as cited in Lauwerier, 2001, p. 180), and the mammal and fish remains from 1990 were also analysed by Schnitger (1991a, as cited in Lauwerier, 2001, p. 180) (Lauwerier, 2001, p. 180). The preservation quality of the remains from both years is considered moderate to poor (Lauwerier, 2001, p. 181; van Heeringen & Theunissen, 2001b, p. 173). This is caused by a combination of the strong fragmentation of the remains (Zeiler & Brinkhuizen, 2013, p. 155), and a high degree of burned bones, with 36 % of the mammal remains and 64 % of the bird remains being burned (Lauwerier, 2001, p. 181). Despite the moderate to poor preservation quality, it was possible to determine the species of 1,362 out of 34,890 mammal remains, giving an identification rate of 4.0 % (Lauwerier, 2001, p. 200; van Heeringen & Theunissen, 2001b, pp. 174-175).

While they are not livestock, many fish remains have been found (Lauwerier, 2001, pp. 180, 182; van Heeringen & Theunissen, 2001b, p. 176). 17,357 fish remains have been found, a little less than half of the found mammal remains (van Heeringen & Theunissen, 2001b, pp. 174, 176). Based on the finds from 1989, the yearly report from ROB (1990, as cited in van Heeringen & Theunissen, 2001c, p. 328) states that Mienakker is likely an extraction camp where fish was caught, processed, and transported to other places. Based on the animal species found, it is thought that the site was in use throughout the whole year (Lauwerier, 2001, p. 183).

2.3.2 The new analysis

Unlike the other sites, the remains of Mienakker have been analysed once more. This was done by specialist of the Odyssey project (Theunissen & Kleijne, 2013, p. 11). The Odyssey project takes a look at and investigates Dutch archaeological field research that was conducted between 1900 and 2000 and has not been investigated since. One of the sites they looked at was Mienakker, as it could give new insights in both the site as well as Neolithic life (Theunissen & Kleijne, 2013, p. 16). A new ^{14}C dating was done and the results gave the site a new date for the start of the occupation, around 2850 BC (Kleijne & Weerst, 2013, p. 26). Occupation took place between 2880 and 2480 BC (Kleijne, Beckerman, et al., 2013, p. 251), which is contemporary to the start until the end of the Single Grave culture from 2800 until 2400 BC (Drenth, 2005, p. 349). Just like Lauwerier (2001, p. 183) has suggested, it is thought that Mienakker was in use all year round (Kleijne, Beckerman, et al., 2013, p. 257). It was a small settlement where its main activities were farming, fishing, and foraging (Kleijne, Beckerman, et al., 2013, p. 258). The inhabitants did hunt for fur and hides, but this was only a small part of their lives (Kleijne, Beckerman, et al., 2013, p. 252).

The analysed mammal remains by Schnitger (1989, 1991 as cited in Zeiler & Brinkhuizen, 2013, p. 155) were re-analysed by Zeiler (Zeiler & Brinkhuizen, 2013, p. 155). Unfortunately it turned out to be impossible to re-analyse the faunal remains in its entirety, due to the sheer amount of material, its poor preservation, high fragmentation, and the remains being unsorted. Thus only a part of the material plus the finds that were not in the database were re-analysed. Zeiler and Brinkhuizen (2013) state that “After re-analysis of part of the material (including the special finds), therefore, the rest was sorted on the basis of Schnitger’s database.” as well as that some find numbers were not present in Schnitger’s database (p. 155). Additionally, Kleijne, Brinkkemper, et al. (2013) state that they did not study all of the analysed material from Schnitger (1990, as cited in Lauwerier, 2001, p. 180) in this research and that not all of the material from the previous research was analysed (p. 288). With the database from Projectgroep Archeologie AHR (2003, as cited in Zeiler and Brinkhuizen, 2013, p. 155) not available for public access, there is no way of finding out how many remains come from the previously analysed material and how many come from the material that was not analysed.

While most of the remains were identified correctly in the old research, the age-at-death of cattle received a new interpretation (Zeiler & Brinkhuizen, 2013, p. 155). For the age-at-death analysis, Habermehl (1973, as cited in Zeiler & Brinkhuizen, 2013, p. 155) was used and measurements of the remains were taken according to Von den Driesch (1976) (Zeiler & Brinkhuizen, 2013, p. 155). Differentiating pigs from wild boar was done by using a 1:2 domestic:wild ratio that was obtained by measuring confirmed pig and wild boar remains (Zeiler & Brinkhuizen, 2013, p. 156). In total 925 mammal remains were re-analysed, 572 of which the species could be identified (Zeiler & Brinkhuizen, 2013, p. 157).

3. Methodology

This research is based on literary research. The data is retrieved from the reports about excavations of three different Neolithic sites, Medel-De Roeskamp, Schipluiden-Harnaschpolder, and Mienakker. Each of the sites have an in depth report about the finds that were made during the excavation (Kleijne, Brinkkemper, et al., 2013; Louwe Kooijmans & Jongste, 2006; ten Anscher et al., 2023; van Heeringen & Theunissen, 2001a, 2001b, 2001c). With these reports, I will look at the data regarding cattle, pigs, sheep, and goats remains. Different methods are used for data analysis: NISP, epiphyseal fusion, eruption of teeth, and tooth wear analysis. This data will be used to make tables of the amount of remains of the different species and figures of the age-at-death. The gathered data will be presented in the results chapter and discussed and compared in the discussion.

3.1 Livestock

As mentioned before, animal husbandry is the practice of keeping livestock for their products. While there are many different livestock, this research will look at the following livestock: cattle, pigs, sheep, and goat. These species have been chosen as they were already domesticated before the Neolithic had begun (Caliebe et al., 2017, p. 1; O'Connor, 2000, pp. 148-149; Scanes, 2018, p. 114). Despite chickens falling under the category livestock, the earliest evidence of domestic chickens in southern Europe dates to around 700 BC and in the Netherlands it dates to the Late Iron Age and Roman Period (Baker & Worley, 2019, p. 3; Peters et al., 2022, pp. 4-5). This means that domestic chickens came after the end of the Neolithic, thus excluding them from this research. Horses are also considered livestock, but as the first direct evidence for domestic horses appears in the Bronze Age (Baker & Worley, 2019, p. 3; Bendrey, 2012, p. 136; Kavar & Dovč, 2008, p. 3; Zeiler & Brinkhuizen, 2013, p. 160), it will not be covered in this research. Domestic dogs have been around since before the Neolithic (Baker & Worley, 2019, p. 3; O'Connor, 2000, p. 149), but are not considered livestock and thus will not be covered in this research (Kenniscentrum InfoMil, n.d.).

3.2 NISP and MNI

NISP stands for number of identified specimen and consists of the amount of fragments that are present (Reitz & Wing, 2008, p. 167). MNE stands for minimum number of elements (Reitz & Wing, 2008, p. 226). One element is one complete bone. MNI stands for minimum number of individuals. The MNI is based on the MNE. For example, if one pelvis is found (MNE:1), there is at least one individual, but if four pelvises are found (MNE:4), there are at least four individuals. The MNI also depends on if the elements are from the left or right half of the skeleton, causing bones to be either left or right. Because of this, if five femurs were found, it does not necessarily mean that they belong to five individuals. Depending on how many left and right femurs were found, the MNI changes accordingly. Additionally one left and one right femur does not mean that there is one individual. If one femur is much smaller than the other or if one femur is fused while the other is not, it can indicate that they belong to two individuals, meaning that the MNI is also two. To summarize, the MNI is dependent on multiple factors: whether the elements are left or right, the size of the elements, and if the elements are fused or not. Unfortunately in reality it is difficult to be able to determine a MNI this precisely. Not only does it take a lot of time to analyse the elements for left or right, size, and fusion, if a lot of the bone fragments are fragmented or burned, it makes it quite difficult to gather more information besides the species and element. This is especially true for sieved remains, as this usually contains the small and fragmented remains, contrary to the bigger and less fragmented hand collected remains.

For this research being able to use the MNI to determine how the relative abundancy of livestock changed would be ideal, but unfortunately most of the reports about the case studies do not have a MNI, unless the NISP is very low. Regardless, the report about Medel-De Roeskamp did calculate the MNI of the different species by using a calculated MNE (Esser et al., 2023, pp. 641-642). As this MNE was calculated (Esser et al., 2023, p. 641), it gives less accurate results than if it was counted. Using this calculated MNE to calculate the MNI results in the MNI being even less accurate and thus less reliable. As for the other reports (Kleijne, Brinkkemper, et al., 2013; Louwe Kooijmans & Jongste, 2006; van Heeringen & Theunissen, 2001a, 2001b, 2001c), they do mention the MNE per element, but no further information was given, making it difficult to determine/calculate an accurate MNI. Considering that my own calculations for the MNI would be very rough estimates and even less reliable than the calculations made by Esser et al. (2023), I have chosen to use the NISP for the results instead. If the MNI for some species was calculated, it will be mentioned, but not used for the results.

3.3 Age-at-death determination

Multiple methods can be used in order to determine the age at which the individual has died. As this research investigates the ages at which livestock was slaughtered, it is important to get a clear overview of the age-at-death of the different species across the three case studies. With the given data about the fusion, tooth wear, and tooth eruption, I will make my own graphs depicting the age-at-death of the individuals from the four species.

3.3.1 Epiphyseal fusion

Long bones consist of a shaft and one or two epiphyses (see Figure 6), which are not yet fused in immature individuals (O'Connor, 2000, p. 92). When an individual grows up, the shaft and epiphysis fuse together. Epiphyseal fusion looks at this specific fusion in postcranial bones, bones which are not the cranium. As bones fuse at different ages, it is very useful for age determination. By analysing the bones and identifying if fusion has taken place, you can deduce whether or not the individual has lived to a certain age. If the bone is not fused, it means that the individual died before the fusion age, and if the bone is fused, it died after the fusion age.

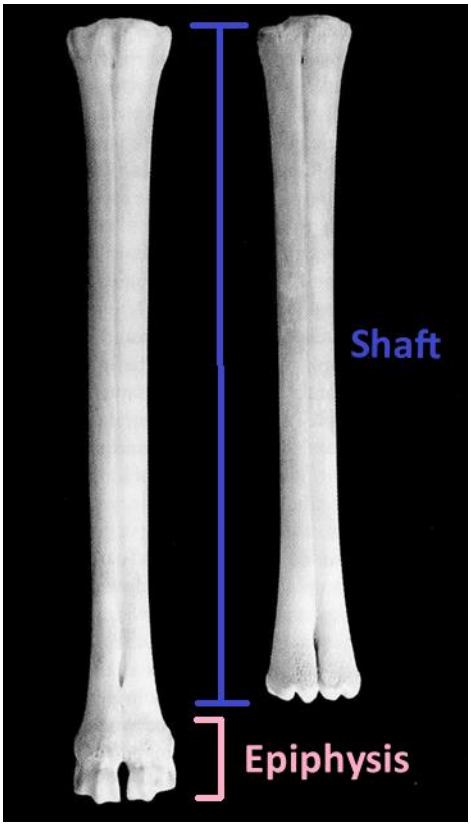


Figure 6 Picture of two roe deer metacarpals. This picture shows a fused metacarpal (left) and an unfused metacarpal (right). The shaft is shown in blue and the epiphysis in pink. (Adapted from O'Connor, 2000, p. 92, Figure 8.4.).

It should be noted that this method is only possible if the end of the shaft to which the epiphysis would be fused/is fused to is present in the long bone fragment. If only the middle part of the shaft is present it is not possible to determine if fusion took place.

3.3.2 Tooth eruption

Eruption of teeth is used to determine how old an individual is. Most mammals have two sets of teeth, deciduous teeth and permanent teeth, which erupt at different ages (Hillson, 2005, p. 211). Because of this, if a tooth has erupted, the individual is older than the age at which the tooth erupts (Groot, 2010, p. 49). Likewise, if a tooth has not erupted, the individual is younger than the eruption age. The age at which certain teeth erupt differ per tooth and species (Groot, 2010, p. 49-50). There is however one problem with tooth eruption, it is only possible when the teeth are in the mandible. Without mandible, it is impossible to determine if the tooth erupted or not.

3.3.3 Tooth wear

Tooth wear looks at how worn teeth are. Teeth of animals wear down over longer periods and is often caused by grinding teeth, eating food, and the contact with the tongue and cheeks (Hillson, 2005, p. 214). The wear stages each correspond to a certain age range (Grant, 1982). Where Grant (1982) can only be used on near complete lower jaws (Lemoine et al., 2014, p. 180), Lemoine et al. (2014) can be used on all teeth, even if they are loose (p. 191). There is however one downside to this method. The tooth wear stage age range does not always correspond with the correct age. It is possible for teeth to wear down faster, for example when they food with sand grains or when they wear bits for transporting heavy objects (Brown & Anthony, 1998, p. 331; Greenfield et al., 2018, p. 1; Groot, 2010, p. 51). This results in a tooth wear stage that corresponds to a much higher age than the actual age of the individual. If more teeth are present of one individual, for example the teeth are in the mandible, it is possible to gather more accurate data than when you are dependent on one tooth. With the teeth in the mandible, analysis on both tooth wear and tooth eruption can be performed, giving a more accurate age-at-death.

3.4 Sheep/goat category

Not only are sheep and goat closely related to each other (Salvagno & Albarella, 2017, p. 1), but they also often come from mixed herds (Jeanjean et al., 2022, p. 2). This makes it difficult to distinguish which bones comes from which species (Boessneck, 1969, as cited in Salvagno & Albarella, 2017, p. 1). Unfortunately, distinguishing sheep and goat remains found during excavations is even harder. Not only are the remains often fragmented, they can also be burned. This makes species identification more challenging, especially when it could be one of two similar species. As a consequence, sheep and goat remains often form one category, sheep/goat, instead of two categories (Buckley et al., 2010, p. 13; Jeanjean et al., 2022, p. 2). The reports used in this research are the same. With the exception of a few remains that could easily be identified to either sheep or goat, the remaining remains are all in the sheep/goat category. For the results I will only use the sheep/goat category, but will mention if any sheep or goat were identified.

3.5 Mienakker old and new analysis

As stated before, it is unknown exactly if the faunal remains from the new analysis are remains that have not been looked at, remains which were already analysed, or a mix of both. This is a problem for the cattle and pig remains, as they have a big difference in amount of remains between the two studies. Since the Mienakker database from both the old as well as the new research are not available for public access, there is no way of checking how many remains from the new analysis were/were not analysed in the old analysis. Because of this, the remains from both analyses cannot be put together as one whole. That is why the results regarding the remains from the old and new analysis will be looked at independently in this research.

4. Results

4.1 The Early Neolithic

4.1.1 Cattle

In total 1,549 cattle remains were identified, approximately 59 % of which were hand collected (Esser et al., 2023, p. 655). Additionally 24 remains were found of which it is uncertain if it is cattle or their wild counterpart, aurochs (*Bos primigenius*) (see Table 1). The lowest calculated MNI is 1 for horns and the highest MNI is 9 for lower hind (Esser et al., 2023, p. 660). The individuals were likely taken from somewhere else to the settlement and then slaughtered on site (ten Anscher, 2023b, p. 867).

Medel-De Roeskamp				
	NISP	NISP in %	Weight in g	Weight in %
Cattle	1,549	20.1	53,671.0	46.1
Cattle/aurochs	24	0.3	3,315.4	2.8

Table 1 NISP and weight of cattle and cattle/aurochs remains from Medel-De Roeskamp. This table shows the NISP and weight of the cattle and cattle/aurochs remains according to data from Esser et al. (2023, pp. 655, 724). The NISP in % and weight in % are based on the total NISP and weight of the identified mammal remains respectively. (Table: Alicia Dedecker).

Age-at-death shows that there are many cattle deaths in their first three years, in particular between one and a half and three years (Esser et al., 2023, p. 661). There is a high mortality profile from the ages three to six months based on the tooth wear, pointing to slaughter of calves (Esser et al., 2023, pp. 662-663). After cattle reaches the age of three, the number of slaughters decreases sharply (see Figures 7, 8).

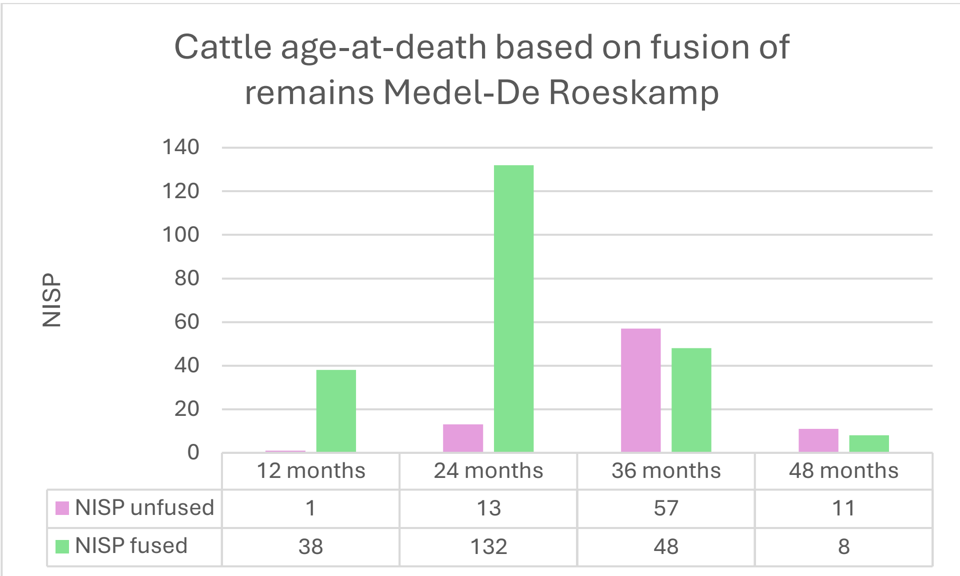


Figure 7 Medel-De Roeskamp cattle age-at-death based on fusion. This figure shows the age-at-death of cattle according to the data from Esser et al. (2023, pp. 662, 729). Unfused means the remains are younger than the indicated age and fused means the remains are older. NISP unfused also includes fusing remains, as they are younger than the fusion age. (Figure: Alicia Dedecker).

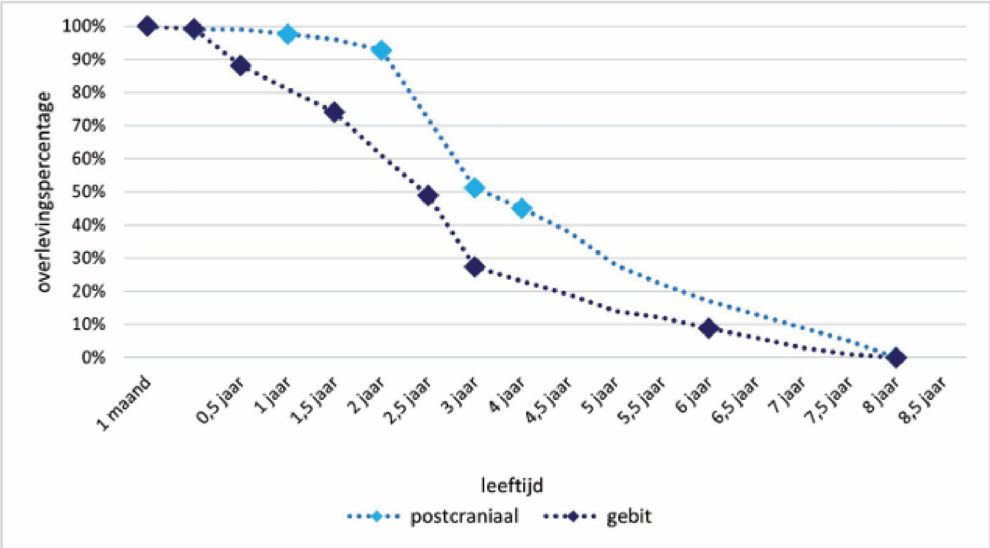


Figure 8 Medel-De Roeskamp cattle survival percentage. This figure shows the survival percentage of cattle ranging from 1 month until 8.5 years based on 290 postcranial bones (light blue) and 45 dental elements (dark blue). (Esser et al., 2023, p. 661, Figure 21.11).

4.1.2 Pig

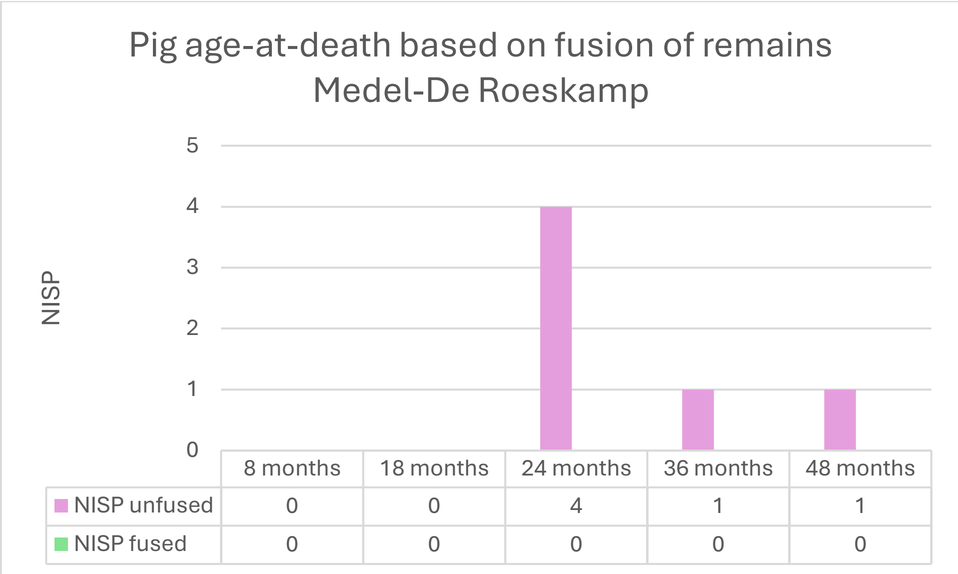
Although only 14 pig remains were identified, a big part of the pig remains fall under the 4,812 remains from the pig/wild boar category as can be seen in Table 2 (Esser et al., 2023, pp. 655, 664). Of these remains, around 32 % were collected by hand. Based on size of molars and the astragalus, it is estimated that less than 20 % of the pig/wild boar remains come from wild boar (ten Anscher, 2023b, p. 864). Going off this estimation, it means that there would be 3,864 pig remains, which is 50.2 % of the total amount of remains. Teeth size analysis was done to find out if there was one or two pig/wild boar populations and although it is likely one population, the population presumably consists of pig-wild boar hybrids (Esser et al., 2023, pp. 664-668). For the pig/wild boar category there is a calculated MNI of 7 for neck and a MNI of 26 for lower hind (Esser et al., 2023, p. 669).

Medel-De Roeskamp				
	NISP	NISP in %	Weight in g	Weight in %
Pig	14	0.2	127.5	0.1
Pig/wild boar	4,812	62.6	31,011.9	26.6

Table 2 NISP and weight of pig and pig/wild boar remains from Medel-De Roeskamp. This table shows the NISP and weight of the pig and pig/wild boar remains according to data from Esser et al. (2023, pp. 655, 724). The NISP in % and weight in % are based on the total NISP and weight of the identified mammal remains respectively. (Table: Alicia Dedecker).

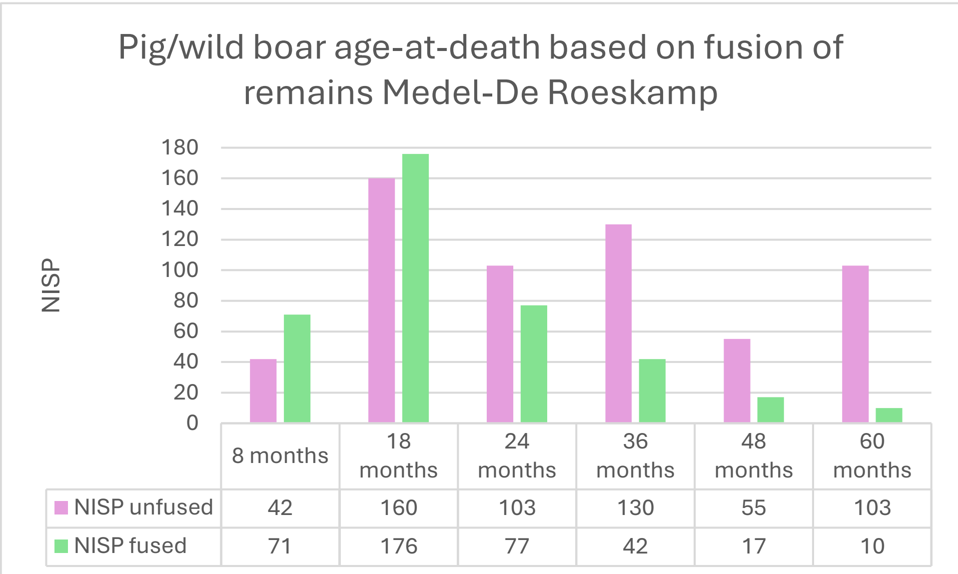
Results show that animals were slaughtered on site (ten Anscher, 2023b, p. 866), with most of them being between the ages of eight months and three years (Esser et al., 2023, p. 670).

There is however a big difference between age-at-death based on epiphyseal fusion and dentition (see Figures 9, 10, 11). Dental data shows that 70 % was killed before reaching 18 months, while epiphyseal fusion shows that only 40 % was killed (Esser et al., 2023, p. 671). This difference might be due to bad preservation of young animal bones.



	8 months	18 months	24 months	36 months	48 months
NISP unfused	0	0	4	1	1
NISP fused	0	0	0	0	0

Figure 9 Medel-De Roeskamp pig age-at-death based on fusion. This figure shows the age-at-death of pigs according to data from Esser et al. (2023, pp. 671, 731). Unfused means the remains are younger than the indicated age and fused means the remains are older. NISP unfused also includes fusing remains, as they are younger than the fusion age. (Figure: Alicia Dedecker).



	8 months	18 months	24 months	36 months	48 months	60 months
NISP unfused	42	160	103	130	55	103
NISP fused	71	176	77	42	17	10

Figure 10 Medel-De Roeskamp pig/wild boar age-at-death based on fusion. This figure shows the age-at-death of pig/wild boar according to data from Esser et al. (2023, pp. 671, 731).Unfused means the remains are younger than the indicated age and fused means the remains are older. NISP unfused also includes fusing remains, as they are younger than the fusion age. (Figure: Alicia Dedecker).

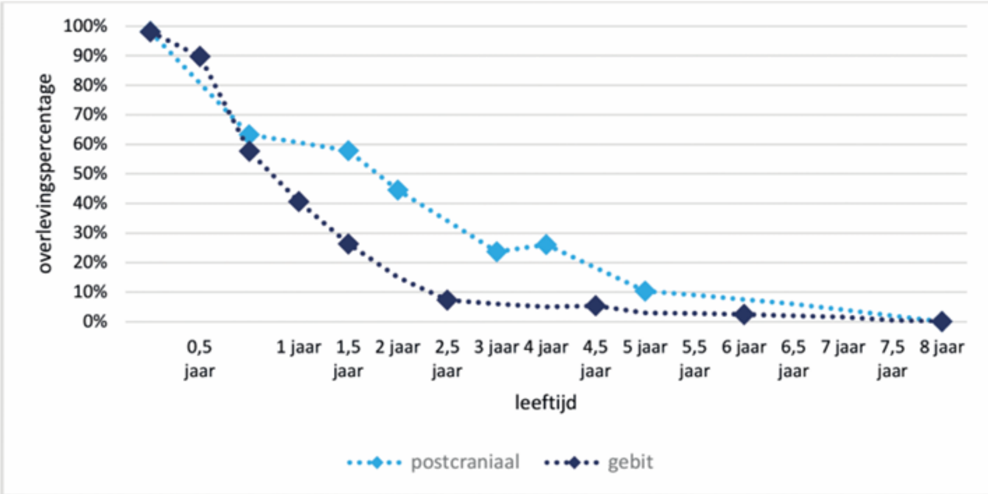


Figure 11 Medel-De Roeskamp pig/wild boar survival percentage. This figure shows the survival percentage of pig/wild boar ranging from 0.5 years until 8 years based on 942 postcranial bones (light blue) and 124 dental elements (dark blue). (Esser et al., 2023, p. 670, Figure 21.21).

4.1.3 Sheep and goat

There are only 126 remains in the sheep/goat category (see Table 3), 22 % of which were hand collected (Esser et al., 2023, p. 655). Based on dental elements, it is thought that these remains belong to a minimum of five individuals (Esser et al., 2023, p. 674). Zeder (2002, as cited in Esser et al., 2023, p. 644) was used to determine the age-at-death (Esser et al., 2023, p. 644). Esser et al. (2023, p. 674) notes that based on 14 postcranial bones and 22 dental elements, that the animals were slaughtered between the ages of two and four years. Additionally, the individuals were slaughtered on site (ten Anscher, 2023b, p. 866).

Medel-De Roeskamp				
	NISP	NISP in %	Weight in g	Weight in %
Sheep/goat	126	1.6	527.1	0.5

Table 3 NISP and weight of sheep/goat remains from Medel-De Roeskamp. This table shows the NISP and weight of the sheep/goat remains according to data from Esser et al. (2023, pp. 655, 724).The NISP in % and weight in % are based on the total NISP and weight of the identified mammal remains respectively. (Table: Alicia Dedecker).

4.1.4 Products

Slaughtering traces were found on only 1.4 % of the remains, with most traces found on cattle and pigs (Esser et al., 2023, p. 656). These traces are cut and chop marks and point towards slaughtering, removal of limbs, and skinning. Additionally, pathologies have been found on cattle remains: shin splits, arthritis, and lopsided growth in the metapodium and pivot joints.

4.2 The Middle Neolithic

4.2.1 Cattle

4.2.1.1 The old analysis

In total 3,553 cattle remains were found (see Table 4), with 92 % being found through hand collection (Zeiler, 2006, pp. 378, 380, 382, 388). With its sheer amount of remains, it is dominant in both number of remains as well as total weight. Despite many remains, it is unknown exactly how many individuals were kept. Based on skeletal elements that were found and belong together, it is thought that the remains are deposited as a result of on site slaughter or consumption (Zeiler, 2006, p. 388).

Schipluiden-Harnaschpolder				
	NISP	NISP in %	Weight in g	Weight in %
Cattle	3,553	36.8	82,386	58.4

Table 4 NISP and weight of cattle remains from Schipluiden-Harnaschpolder. This table shows the NISP and weight of the cattle remains according to data from Zeiler (2006, pp. 378-382).The NISP in % and weight in % are based on the total NISP and weight of the identified mammal remains respectively. (Table: Alicia Dedecker).

Age-at-death was mostly determined by looking at fusion in limb bones (Zeiler, 2006, p. 389). Additionally, information was gained from tooth eruption (see Figure 13), but there was only a limited amount of information that could be gained and it was less detailed than bone fusion (Zeiler, 2006, p. 390). The results from age-at-death determination show that cattle from all ages was killed (see Figure 12). This points towards cattle being kept for meat as well as other purposes, such as breeding.

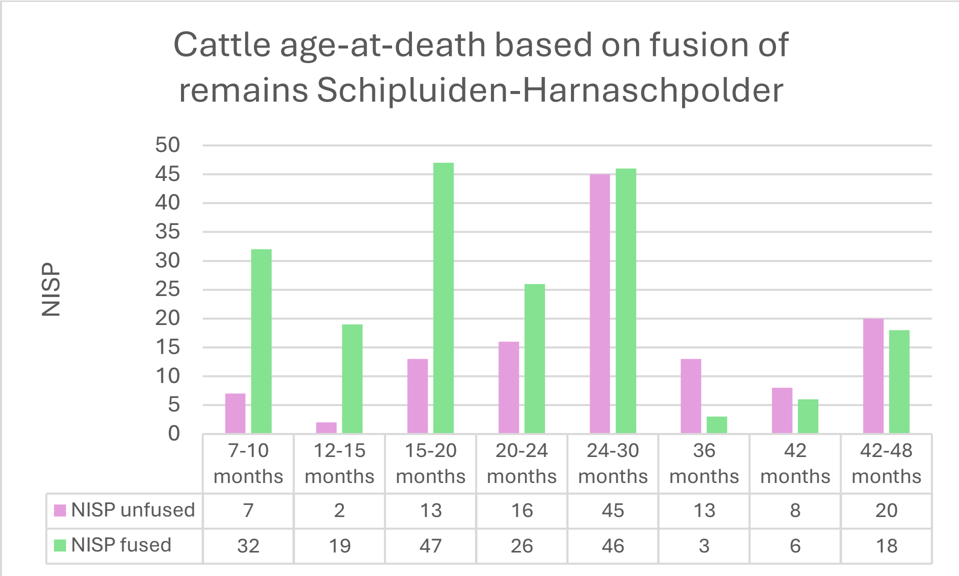


Figure 12 Schipluiden-Harnaschpolder cattle age-at-death based on fusion. This figure shows the age-at-death of cattle according to the data and age ranges from Zeiler (2006, p. 390). Unfused means the remains are younger than the indicated age range and fused means the remains are older. (Figure: Alicia Dedecker).

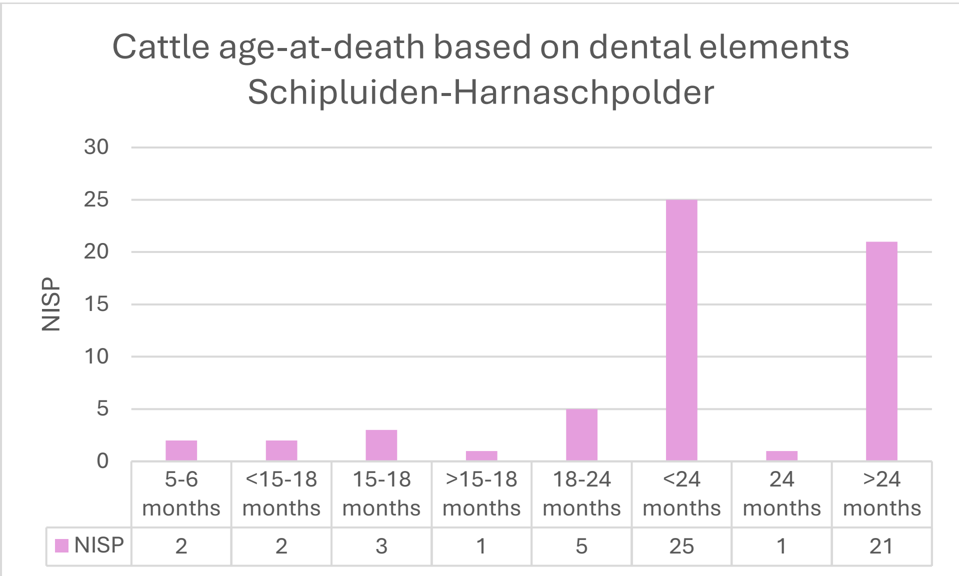


Figure 13 Schipluiden-Harnaschpolder cattle age-at-death based on dental elements. This figure shows the age-at-death of cattle according to data and age ranges from Zeiler (2006, p. 391). (Figure: Alicia Dedecker).

4.2.1.2 The new analysis

Unlike the age-at-death age ranges from Zeiler (2006, p. 391) (see Figure 13), Kamjan et al. (2020, p. 7) has more precise age ranges for the age-at-death based on tooth eruption and wear stages (see Figure 14). It shows that a lot of the analysed fragments belong to individuals between 6 and 15 months old and 15 and 26 months old. The diet of cattle shows that cattle were kept close to the settlement (Kamjan et al., 2020, p. 15).

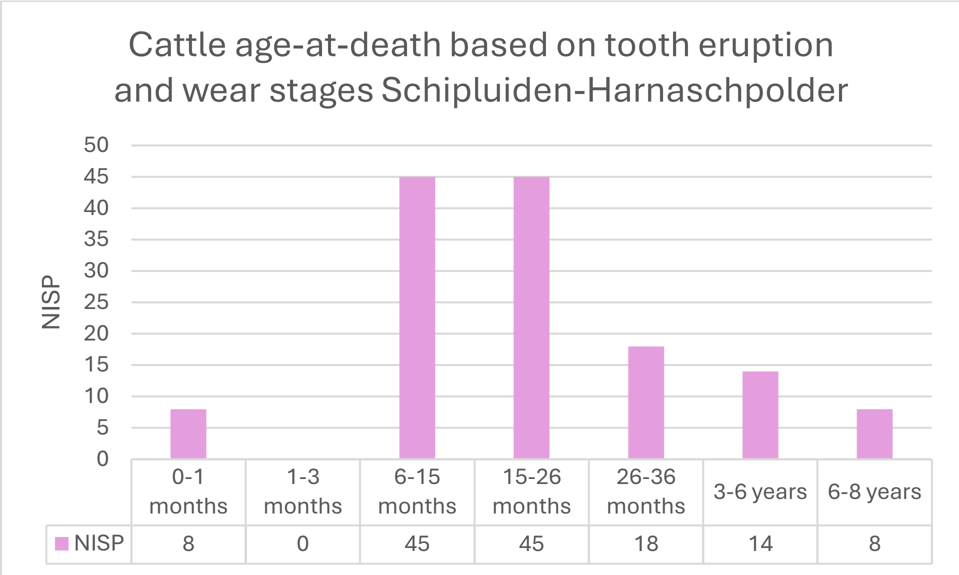


Figure 14 Schipluiden-Harnaschpolder cattle age-at-death based on tooth eruption and wear stages. This figure shows the age-at-death of cattle according to data and age ranges from Kamjan et al. (2020, p. 7). (Figure: Alicia Dedecker).

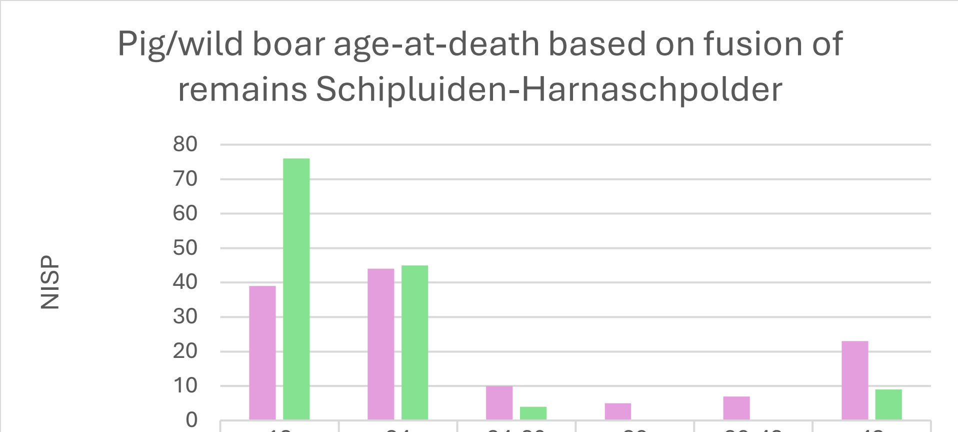
4.2.2 Pig

Pigs have less identified remains in comparison to the cattle remains, 1,056 remains were found as can be seen in Table 5, but like cattle, it has a high percentage of hand collected remains, namely 88 % (Zeiler, 2006, pp. 378, 380, 382). Besides pig remains, 1,804 wild boar remains have been found (Zeiler, 2006, pp. 378, 380, 382). Remains from all bone elements were found, indicating that people slaughtered the animals on site and did not kill them elsewhere (Zeiler, 2006, p. 391). Yet again, it is unknown how many individuals were kept, mostly because the exact amount of pig remains is unknown.

Schipluiden-Harnaschpolder				
	NISP	NISP in %	Weight in g	Weight in %
Pig	1,056	10.9	8,528	6.0

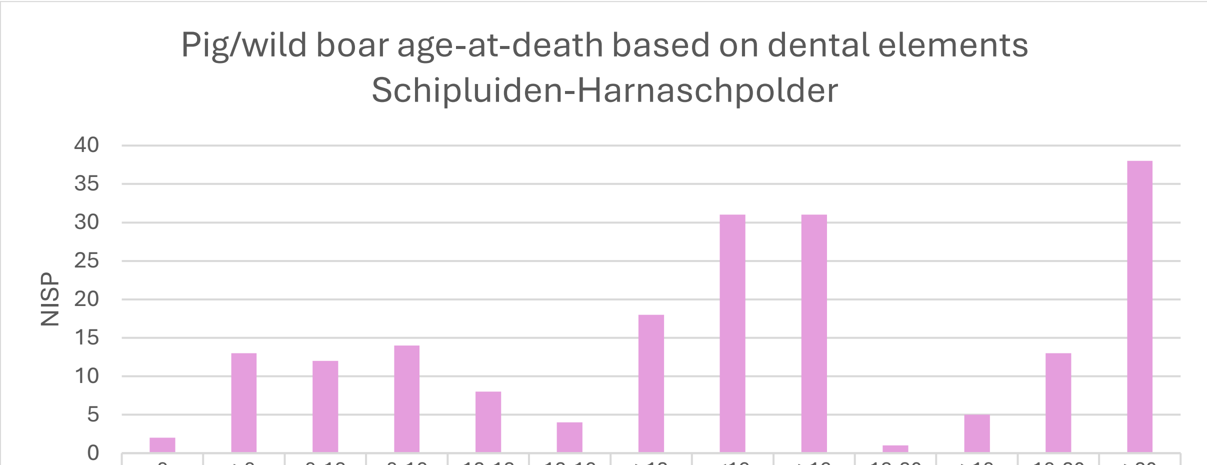
Table 5 NISP and weight of pig remains from Schipluiden-Harnaschpolder. This table shows the NISP and weight of the pig remains according to data from Zeiler (2006, pp. 378-382).The NISP in % and weight in % are based on the total NISP and weight of the identified mammal remains respectively. (Table: Alicia Dedecker).

Age-at-death was based on the fusion of postcranial bones (see Figure 15) and tooth eruption patterns from both pigs and wild boars (see Figure 16) and shows that pigs of all ages were slaughtered (Zeiler, 2006, p. 392). Because age-at-death was based on the remains of both domesticated pigs and wild boars, the understanding of domestic pig slaughter patterns remains unclear.



	12 months	24 months	24-30 months	36 months	36-42 months	42 months
NISP unfused	39	44	10	5	7	23
NISP fused	76	45	4	0	0	9

Figure 15 Schipluiden-Harnaschpolder pig/wild boar age-at-death based on fusion. This figure shows the age-at-death of cattle according to the data from Zeiler (2006, p. 392). Unfused means the remains are younger than the indicated age range and fused means the remains are older. (Figure: Alicia Dedecker).



	8 months	>8 months	8-13 months	8-16 months	12-13 months	12-16 months	>12 months	<16 months	>16 months	13-20 months	>18 months	18-20 months	>20 months
NISP	2	13	12	14	8	4	18	31	31	1	5	13	38

Figure 16 Schipluiden-Harnaschpolder pig/wild boar age-at-death based on dental elements. This figure shows the age-at-death of pig/wild boar according to data and age ranges from Zeiler (2006, p. 393). (Figure: Alicia Dedecker).

4.2.3 Sheep and goat

Despite having identified almost 10,000 remains (Zeiler, 2006, p. 379), no remains from either sheep or goat have been identified (Zeiler, 2006, pp. 378, 388). There are two possible reasons for this. First, sheep and goat remains were present, but were not identified due to being too fragmented or burned. Second, the people of Schipluiden-Harnaschpolder did not have any sheep or goats. While this last reason is unlikely as most Neolithic sites have at least a few identified sheep and goat remains (Zeiler, 2006, p. 408), it cannot be ruled out entirely.

4.2.4 Products

Gnawing and butchering marks have been found on multiple remains, all of which were hand collected (Zeiler, 2006, pp. 385, 389). 96 cattle remains have some sort type of butchering marks, with half of them coming from meat carving (Zeiler, 2006, p. 389). These different types are butchery marks, chop and cut marks, and cut marks due to skinning can be observed on different skeletal elements. Unlike cattle, domestic pig remains show no butchering marks and the only butchering marks they did find were on remains from the pig/wild boar category (Zeiler, 2006, p. 391). The butchering traces found on pigs/wild boars occurred while removing the meat and/or splitting the body in parts. Additionally two tarsalia have cut marks that were made during skimming.

Besides butchering marks, pathologies were found on seven cattle remains (Zeiler, 2006, p. 386). The cattle remains display abnormal growth, a sign to both old age and/or strain. While the latter can be the result of using cattle for transport (Baker & Worley, 2019, p. 2), this is unlikely in this case as there are only a few remains with these pathologies (Kamjan et al., 2020, p. 12).

Even though many cattle remains have been found, there is a lack of evidence for milk production in Schipluiden-Harnaschpolder (Louwe Kooijmans, 2006, p. 503; Zeiler, 2006, p. 390). Neither the cattle’s ages at time of death nor pottery sherd analysis show any evidence regarding milk production (Louwe Kooijmans, 2006, p. 503). Having said that, the new analysis by Kamjan et al. (2020) did find evidence for milk production. This new analysis was able to identify milk residues on ceramic vessels through the help of organic residue analysis (Kamjan et al., 2020, p. 12).

As no sheep nor goat remains have been identified (Zeiler, 2006, pp. 378, 388), nothing can be said about sheep and goat products.

4.3 The Late Neolithic

4.3.1 Cattle

4.3.1.1 The old analysis

759 cattle remains have been identified (see Table 6), making cattle the most prominent found mammal species (van Heeringen & Theunissen, 2001b, p. 175). Despite the large number of fragments, there is no mention if it was possible to determine which skeletal elements were present or if a MNI was calculated.

Mienakker old analysis		
	NISP	NISP in %
Cattle	759	55.7

Table 6 NISP of cattle remains from the old analysis of Mienakker. This table shows the NISP and weight of the cattle remains according to data from van Heeringen & Theunissen (2001b, p. 175).The NISP in % is based on the total NISP of the identified mammal remains. (Table: Alicia Dedecker).

Age-at-death was determined based on dental data by using Higham (1967, as cited in Zeiler & Brinkhuizen, 2013, p. 160), and the results show that more than 50 % of the cattle remains are from very young individuals, often younger than one month old (Lauwerier, 2001, p. 181; van Heeringen & Theunissen, 2001b, p. 177).

4.3.1.2 The new analysis

The new analysis has identified 416 cattle remains which can be seen in Table 7 (Zeiler & Brinkhuizen, 2013, p. 157). Cattle was likely kept on site, seeing as many cattle hoof prints were found at the site (Kleijne, Beckerman, et al., 2013, p. 252). Skeletal elements come from all over the body (Zeiler & Brinkhuizen, 2013, p. 158). Age-at-death was based on both epiphyseal fusion as well as dental data (Zeiler & Brinkhuizen, 2013, p. 159). The epiphyseal fusion results point towards around a quarter of the cattle being slaughtered before reaching an age of three and one third living longer than four years old (see Figure 17). On the other hand, dental data, including found mandibles, points towards more cattle, circa 60 %, being slaughtered before becoming three years old (see Figure 18).

Mienakker new analysis				
	NISP	NISP in %	Weight in g	Weight in %
Cattle	416	72.7	6,782.2	94.4

Table 7 NISP and weight of cattle remains from the new analysis of Mienakker. This table shows the NISP and weight of the cattle remains according to data from Zeiler & Brinkhuizen (2013, p. 157).The NISP in % and weight in % are based on the total NISP and weight of the identified mammal remains respectively. (Table: Alicia Dedecker).

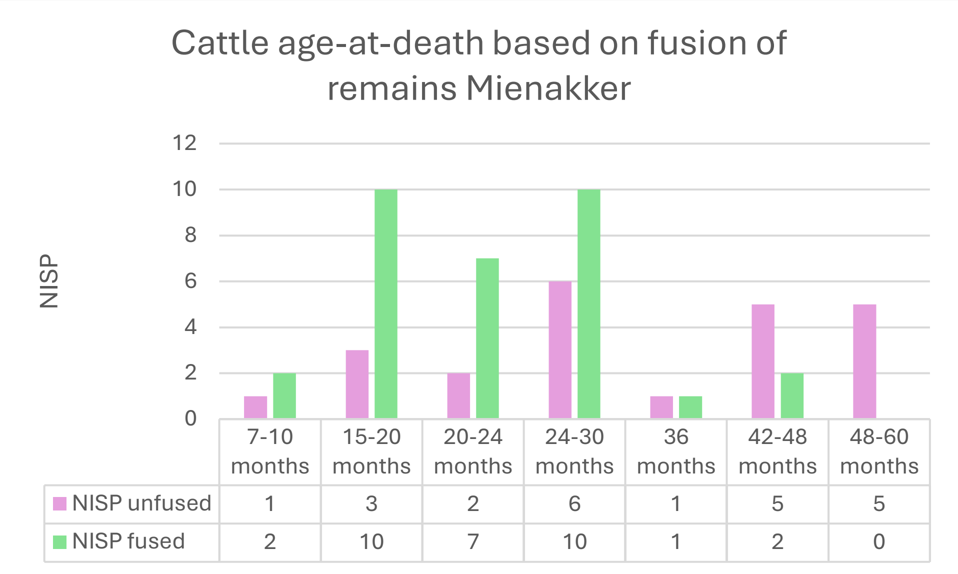


Figure 17 Mienakker cattle age-at-death based on fusion. This figure shows the age-at-death of cattle according to the data from Zeiler & Brinkhuizen (2013, p. 161). Unfused means the remains are younger than the indicated age range and fused means the remains are older. (Figure: Alicia Dedecker).

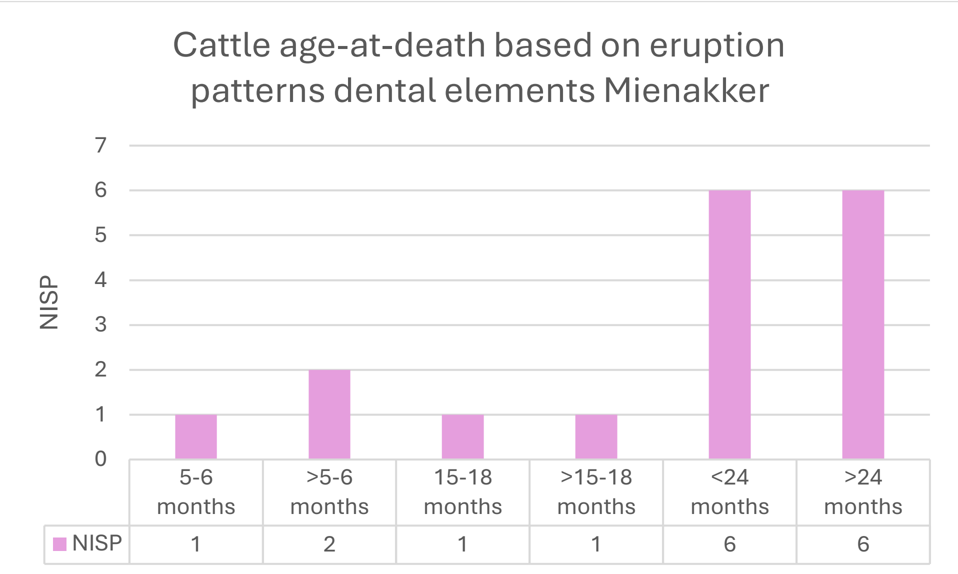


Figure 18 Mienakker cattle age-at-death based on eruption patters of dental elements. This figure shows the age-at-death of cattle according to data from Zeiler & Brinkhuizen (2013, p. 162). (Figure: Alicia Dedecker).

4.3.2 Pig

4.3.2.1 The old analysis

Only 9 remains, or 0.7 % of the total remains, were identified as pig/wild boar (van Heeringen & Theunissen, 2001b, p. 175). It is assumed that these remains could belong to one young individual (Lauwerier, 2001, p. 181). Neither which elements nor age-at-death of the remains are mentioned.

4.3.2.2 The new analysis

The new analysis identified 7 remains as pigs (see Table 8) and 15 as wild boar (Zeiler & Brinkhuizen, 2013, p. 157). Apart from one pig remain, all of the pig remains were determined with the domestic:wild ratio of 1:2 (Zeiler & Brinkhuizen, 2013, p. 156). Age-at-death was based on epiphyseal fusion and indicate that three remains belong to individuals younger than 15-20 months, 24-30 months, and 42 months old (Zeiler & Brinkhuizen, 2013, p. 161). Two other remains belong to individuals older than 24 months and 36 months old.

Mienakker new analysis				
	NISP	NISP in %	Weight in g	Weight in %
Pig	7	1.2	23.7	0.3

Table 8 NISP and weight of pig remains from the new analysis of Mienakker. This table shows the NISP and weight of the pig remains according to data from Zeiler & Brinkhuizen (2013, p. 157).The NISP in % and weight in % are based on the total NISP and weight of the identified mammal remains respectively. (Table: Alicia Dedecker).

4.3.3 Sheep and goat

4.3.3.1 The old analysis

Close to no sheep nor goat remains have been found with only one identified sheep remain and one sheep/goat remain, contributing to 0.2 % of the total identified mammal remains (van Heeringen & Theunissen, 2001b, p. 175). Unfortunately no further analysis was done, so it is unknown if these remains belong to the same individual and what the age at time of death was.

4.3.3.2 The new analysis

The new analysis has eight remains in the sheep/goat category (see Table 9) (Zeiler & Brinkhuizen, 2013, p. 157). Additionally one sheep remain is identified, which was identified as another species in the old analysis (Zeiler & Brinkhuizen, 2013, p. 158). Only one remain could be used for age-at-death determination and showed that the individual was older than 20-24 months (Zeiler & Brinkhuizen, 2013, p. 161).

Mienakker new analysis				
	NISP	NISP in %	Weight in g	Weight in %
Sheep/goat	9	1.6	17.1	0.2

Table 9 NISP and weight of sheep/goat remains from the new analysis of Mienakker. This table shows the NISP and weight of the sheep/goat remains according to data from Zeiler & Brinkhuizen (2013, p. 157).The NISP in % and weight in % are based on the total NISP and weight of the identified mammal remains respectively. (Table: Alicia Dedecker).

4.3.4 Products

4.3.4.1 The old analysis

29 mammal remains have butchering marks, but whether these remains belong to cattle, pigs, or another species is not stated (Lauwerier, 2001, p. 182). The hunting of wild mammals appeared to be without meaning, as the people were mostly living off of meat from cattle. The small amount of phalanxes found suggests that after the cattle was skinned, the hides were transported to another location (van Heeringen & Theunissen, 2001c, p. 148).

4.3.4.2 The new analysis

Only a limited amount of remains have visible slaughtering traces (Zeiler & Brinkhuizen, 2013, p. 156), but these traces cannot be found on the pig and sheep/goat remains (Zeiler & Brinkhuizen, 2013, p. 158). Cattle remains do have visible traces and indicate both skinning and cutting meat from the bone. The remains are also considered a combination of slaughtering and consumption waste. With its sheer size in terms of bone weight, cattle was considered the most important meat supplier (Zeiler & Brinkhuizen, 2013, p. 172). Additionally fish was also considered important for the people's diet. Evidence for keeping livestock for any other products is practically absent from this site (Kleijne, Beckerman, et al., 2013, p. 253).

5. Discussion

5.1 Relative abundancy livestock species

The most prominent livestock species in terms of remains across all the sites is cattle. Of the total amount of remains, 20.1 % belong to cattle in the Early Neolithic site Medel-De Roeskamp, 36.8 % belong to cattle in the Middle Neolithic site Schipluiden-Harnaschpolder, and 55.7 % (old analysis) and 72.7 % (new analysis) belong to cattle in the Late Neolithic site Mienakker (see Tables 1, 4, 6, 7). There is a big contrast in percentage between the old and new analysis of the Mienakker remains. This is caused by the big difference in total amount of remains, 34,890 in the old research and 925 in the new research (Lauwerier, 2001, p. 200; van Heeringen & Theunissen, 2001b, p. 175; Zeiler & Brinkhuizen, 2013, p. 157). These results show that the relative abundancy of cattle increased during the whole Neolithic.

The change in relative abundancy of pigs is less clear than that of cattle. This is because of the fact that only 14 pig remains from Medel-De Roeskamp could be identified (Esser et al., 2023, pp. 655, 664), with the rest of them, likely 80 %, being in the pig/wild boar category. Going of off this estimation, there is a steep decline from 50.2 % of the total remains in Medel-De Roeskamp, to 10.9 % in Schipluiden-Harnaschpolder (see Table 5). In Mienakker even less percentage of the total remains belong to pigs, only 0.7 % (old analysis) and 1.2 % (new analysis) (see Table 8). During the Neolithic, a decrease in relative abundancy of pig can be seen.

The last livestock species, sheep and goat, are far less prominent during the whole Neolithic. In Medel-De Roeskamp only 1.6 % of the total remains are from sheep/goat (see Table 3). Unlike the sites from the Early and Late Neolithic, no sheep or goat remains have been found in Schipluiden-Harnaschpolder (Zeiler, 2006, pp. 378, 388). For Mienakker 0.1 % (old analysis) and 1.6 % (new analysis) of the total remains belong to sheep/goat (see Table 9). The reason as to why no sheep/goat remains have been found at Schipluiden-Harnaschpolder, but have been found in other Middle Neolithic sites is still unknown (Zeiler, 2006, pp. 378, 388, 408). It is clear that the relative abundancy of sheep and goat decreased during the Neolithic.

5.2 Culling practices

In the Medel-De Roeskamp most cattle had died between the ages 1.5 and 3 years old (Esser et al., 2023, pp. 661-663). While cattle of all ages was killed in Schipluiden-Harnaschpolder (see Figure 12), many of them died between 6 and 26 months old (see Figure 14). As for Mienakker, the analysis by Zeiler & Brinkhuizen (2013) shows that many individuals died before becoming three years old. During the whole Neolithic, most of the cattle population died before reaching an age of three.

How age-at-death for pig changed during the Neolithic is hard to determine, due to a lack of identified pig remains. Fourteen pig remains in Medel-De Roeskamp were identified (see Table 2) and age-at-death determination could only be done on six remains, most of which belong to individuals younger than 24 months old (see Figure 9). Based on age-at-death of pig/wild boar, most individuals were killed between the ages of eight months and three years (Esser et al., 2023, p. 670). For Schipluiden-Harnaschpolder, age-at-death was yet again based on pig/wild boar and shows that pigs/wild boars of all ages were killed (Zeiler, 2006, p. 392). Age-at-death of pigs in Mienakker was based on five remains and show that individuals of all ages were killed (Zeiler & Brinkhuizen, 2013, p. 161).

With how little sheep/goat remains have been found across al of the case studies, it is difficult to determine how the culling practices for sheep and goat have changed. Based on epiphyseal fusion and dental data of Medel-De Roeskamp sheep and goat, it is thought that the individuals were slaughtered between the ages two and four years old (Esser et al., 2023, p. 674). Schipluiden-Harnaschpolder has no sheep/goat (Zeiler, 2006, pp. 378, 388), and Mienakker only has one remain belonging to an individual older than 20-24 months old (Zeiler & Brinkhuizen, 2013, p. 161).

All of the livestock was likely slaughtered on site (Kleijne, Beckerman, et al., 2013, p. 252; ten Anscher, 2023b, pp. 866-867; Zeiler, 2006, pp. 388, 391). While livestock of all ages was killed, most of them were killed before becoming three years old.

5.3 Purposes keeping livestock

5.3.1 Meat

Slaughtering traces were found on both Medel-De Roeskamp cattle and pig remains (Esser et al., 2023, p. 656), indicating that people kept cattle as well as pigs for obtaining meat (Esser et al., 2023, p. 709; ten Anscher, 2023b, p. 864). Additionally, the decrease in mortality profile of cattle after three years suggest that the people slaughtered them when they weighed the most (Esser et al., 2023, pp. 622-623). This further points towards cattle being kept for meat.

For Schipluiden-Harnaschpolder, half of the consumed meat comes from cattle as is suggested by the butchering marks and the high weight percentage of cattle remains (Louwe Kooijmans, 2006, p. 503). Many cattle were slaughtered at their peak weight, indicating that meat exploitation was the main reason for keeping cattle (Kamjan et al., 2020, p. 11). Pigs on the other hand have no butchering traces, but the pig/wild boar remains do have butchering traces, which occurred during meat removal (Zeiler, 2006, p. 391). These Middle Neolithic results are contradictory with the results from Lauwerier et al. (2005, pp. 53-54, 61) where it is stated that hunting wild mammals was the main source of meat income. This suggest that this conclusion by Lauwerier et al. (2005) has become outdated.

Mienakker stands out of the three sites. Not only is the amount of remains of livestock small in comparison to the other sites, it is the only site where a lot of fish remains were found. Their diet consisted of a combination of cattle meat and fish (Zeiler & Brinkhuizen, 2013, p. 172). Without another Late Neolithic site as reference, it is hard to say if Mienakker is an accurate representation of a Late Neolithic sites. Whether or not Mienakker is an exception to other Late Neolithic sites, it shows that not all sites in the Late Neolithic were completely dependent on animal husbandry.

5.3.2 Milk

Many Medel-De Roeskamp calves were slaughtered when they were around three to six months of age, which coincides with the highest milk yield of cows (Esser et al., 2023, p. 662; ten Anscher, 2023b, p. 867). This does not immediately prove that they kept cows for milk, as not enough data is present about the sex of the cattle to prove this point (Esser et al., 2023, p. 662), but it does mean that it is likely that the people took this into account during slaughtering (Esser et al., 2023, p. 709). While it was initially thought that Schipluiden-Harnaschpolder cattle were not kept for their milk due to lack of evidence (Louwe Kooijmans, 2006, p. 503; Zeiler, 2006, p. 390), Kamjan et al. (2020) proved the opposite through organic residue analysis which showed milk residues were present on ceramic vessels (p. 12). Additionally many remains come from mature females (Kamjan et al., 2020, pp. 11-12). Besides and there is also a high slaughter rate of individuals between 6 and 15 months old. This suggest that females were kept for milk production and that young individuals were slaughtered after they no longer helped their mother produce milk. There is no evidence of keeping cattle for milk in Mienakker (Kleijne, Beckerman, et al., 2013, p. 253).

5.3.3 Other purposes

The pathologies found on Medel-De Roeskamp cattle can occur due to trauma and old age, but both could also occur due to overload. Bartosiewicz et al. (1997, as cited in Esser et al., 2023, p. 663) states that this lopsided growth is caused by overload and is exclusively found in bones of working animals. Esser et al. (2023, p. 709) suggests that cattle was also kept for dragging or carrying heavy things.

Pathologies have been found on Schipluiden-Harnaschpolder cattle (Zeiler, 2006, p. 386), but are likely due to old age and not overload (Kamjan et al., 2020, p. 12).

There is too little information about sheep and goat to determine why they were kept in Medel-De Roeskamp (Esser et al., 2023, p. 709). Ten Anscher (2023b, p. 866) assumes that the sheep and goat were kept for their fur and wool, instead of their milk and meat due to the people having better ways of getting more milk and meat. Schipluiden-Harnaschpolder has no sheep and goat remains, so nothing can be said about sheep and goat products during the Middle Neolithic. As for Mienakker, with how little sheep/goat remains were found it is impossible to determine why they were kept.

5.4 Limitations

5.4.1 Identification rate

This research has used data from multiple literary sources, but to what extent are the results an accurate representation of the truth? A lot of remains are burned or fragmented, making it almost impossible to determine the species. This means that there is a bias in the sense that the results are only based on the small percentage of remains that could be identified. As there are many non identified remains, it is likely that some cattle, pig, sheep, or goat remains could not be identified and are lacking from any further analysis that was done. In the case of Schipluiden-Harnaschpolder, about 141,000 remains were found (Zeiler, 2006, p. 375), but only about 10,000 remains could be identified (Zeiler, 2006, p. 379). That is an identification rate of 6.9 %, the highest out of all three sites. Furthermore, for many remains it was uncertain if it was cattle or aurochs, or pig or wild boar and were put in the cattle/aurochs or pig/wild boar categories. As for age-at-death, this is based on the found remains of which the species was know and it is possible to preform age-at-death analysis on. With how many remains are unidentified, it is unknown how close the results are to the actual numbers. Although no sheep and goat remains were found in Schipluiden-Harnaschpolder, Zeiler (2006, p. 408) mentions this in combination with a statement about how most Neolithic sites have some sheep and goat remains. So while the identification bias cannot be avoided, one can back up their results by comparing them with other articles about the same region, culture, and time period.

5.4.2 NISP vs MNI

One of the biggest limitations of this study has to do with the MNI and NISP. For the sub question ‘Did the relative abundancy of domestic livestock species change during the Neolithic?’ the ideal data to use would be the MNI in combination with the NISP. This would give the most accurate minimum and maximum amount of individuals (O’Connor, 2000, p. 60). This means that with MNI it is still unknown precisely how many individuals were present, but with NISP it is known that there cannot be more individuals than the NISP. Using the MNI does come at the cost of having to analyse each remain for size, fusion, and if the remain comes from the left or right part of the skeleton. Not only does this cost a lot of time, it is also difficult to calculate (Domínguez-Rodrigo, 2012, p. 51). NISP on the other hand is quicker and easier to calculate, but gets bigger if there is a high fragmentation (Domínguez-Rodrigo, 2012, p. 48). While caution needs to be taken when using an NISP for sites with high fragmentation, it is, in my opinion, a better alternative than using a MNI which is determined with difficult calculations based on the NISP. NISP is also used more often than MNI, as is indicated by an higher amount of articles have used NISP than articles that have used MNI in their title (Lyman, 2018, p. 46, Figure 3).

5.4.3 Limitations in reports

For this research three case studies of excavations were used, Medel-De Roeskamp from 2016-2017, Schipluiden-Harnaschpolder from 2003, and Mienakker from 1990. While these sites have good and elaborate reports written about them, there were some unforeseen limitations. During this research, there have been multiple instances where the reports have some sort of contradiction, mistake, or missing information. Because of this, caution needs to be taken when using these results. For example, in Louwe Kooijmans and Jongste (2006) there is a contradiction about the samples used for remains identification. Jongste and Louwe Kooijmans (2006) state that 128 samples were used (p. 11), while Zeiler (2006) state that 138 samples were used (p. 375), a difference of ten samples. Another contradiction has to do with age-at-death based on fusion. The tables in Zeiler (2006) about age-at-death based on epiphyseal fusion all state that "(epiphysis) fused = younger than indicated age" and "(epiphysis) unfused = older than indicated age" (pp. 390-393, 399-400). This contradicts with what is said earlier in the article: "if the bone has fused, the animal lived beyond that age and if the bone has not yet fused" (Zeiler, 2006, p. 389).Multiple articles state that the latter is correct (O'Connor, 2000, p. 92; Ruscillo, 2014, p. 8001). Another report with an unforeseen problem was with the Mienakker reports (van Heeringen & Theunissen, 2001a, 2001b, 2001c; Zeiler& Brinkhuizen, 2013). As I have explained before, it is unknown if there is an overlap between the faunal remains from the old and the new research. This does not make the data less reliable, but it comes at the cost of having to look at both remains separately instead of together.

5.5 Recommendations

More research can be done on the development of animal husbandry in the Netherlands during the Neolithic. Not only can new case studies be researched, older sites where not everything has been analysed can be re-analysed for a better understanding of the faunal remains of the site. Take for example Mienakker where not all of the analysed material was re-analysed (Zeiler & Brinkhuizen, 2013, p. 155). If, when given enough time, new research were conducted, the new results would allow for better interpretations. Additionally more in depth research can be done. This research investigated sites from different cultures, but to further our understanding of animal husbandry, research can be conducted with a focus on the development of animal husbandry from only one culture.

6. Conclusion

This research has investigated how animal husbandry developed through the help of three case studies, three sub questions, and one research question.

The first sub question is ‘Did the relative abundancy of domestic livestock species change during the Neolithic?’. From the different livestock species cattle is the one with an increase of relative abundancy during the Neolithic. The Early Neolithic started with a large group of cattle, but this grew in the Middle Neolithic and even further in the Late Neolithic. The relative abundancy of pig is harder to determine due to the fact that a lot of pig remains are in the pig/wild boar category. Looking at the relative abundancy based on the estimated amount of pig remains from the pig/wild boar remains, it shows that there is a steep decline from the Early to Middle Neolithic and reaches close to zero in the Late Neolithic. Sheep and goat were the least kept livestock. There were only a few sheep and goat in the Early Neolithic, but during the Middle and Late Neolithic almost no sheep and goat were kept.

The second sub question is ‘Did culling practices change during the Neolithic?’. Culling practices did not see much change during the Neolithic. The age at which most cattle have died stayed around three years old. Due to the little amount of identified pig remains, not much can be said other than pigs of all ages were killed. This cannot be said about sheep and goat, as they have do not have enough age-at-death data in order to form a good conclusion about the culling practices of sheep and goat. Throughout the whole Neolithic, all of the livestock was slaughtered on site.

The last sub question is ‘Did the purposes for which livestock were kept change during the Neolithic?’. Meat was an important reason for keeping livestock. In the Early Neolithic meat came from both cattle as well as pig. This changed during the Middle Neolithic where cattle became the most prominent meat supplier. While cattle was still an important meat supplier during the Late Neolithic, fish was added to their diet. Besides meat, cattle was also kept for their milk. Evidence for milk production has been found for both the Early and Middle Neolithic sites, but no evidence has been found for the Late Neolithic site. While it is likely that sheep and goat were kept for their fur and wool, there is not enough information to make a definitive conclusion.

And finally the research question is ‘How did animal husbandry develop in the Netherlands during the Neolithic?’. Some parts of animal husbandry changed, while other parts stayed the same. The relative abundancy of cattle increased, while that of pig, sheep, and goat decreased. The culling practices stayed almost the same where most cattle was killed before the age of three and pig of all ages was killed. The place where the livestock was slaughtered also stayed the same during the Neolithic, namely on site. Last but not least, cattle became a more important source of meat income, while pigs became less important. Additionally cattle was kept for their milk during the Early and Middle Neolithic, but not during the Late Neolithic. So while animal husbandry did see some development in the Netherlands during the Neolithic, for the most part it did not have any big developments.

Abstract

The Neolithic is a period where people went from living as hunter-gatherers to farmers. This change gave rise to animal husbandry. Many articles have looked into the development of animal husbandry during the Neolithic within different regions, but the Netherlands region is lacking in research. This research investigates how animal husbandry developed in the Netherlands during the Neolithic while looking at the relative abundancy of livestock, culling practices, and the purposes for keeping livestock. The livestock species which are investigated are cattle, pig, sheep, and goat.

To investigate this development, three case studies are used: Medel-De Roeskamp, Schipluiden-Harnaschpolder, and Mienakker. Each of these case studies belongs to a different period in the Neolithic. NISP and age-at-death determination methods are used for determining relative abundancy and culling practices respectively. A combination of age-at-death and pathologies is used in order to determine for which purposed livestock was kept. The used age-at-death determination methods are epiphyseal fusion, tooth eruption, and tooth wear.

The results show that while the relative abundancy grew for cattle, it decreased for pig, sheep, and goat. The culling practices stayed the same for each species, most of the cattle being killed before becoming three years old and pig, sheep, and goat of all ages was slaughtered. During the Early and Middle Neolithic, cattle was kept for their meat and milk and pigs were kept for their meat. This changed in the Late Neolithic as now cattle was kept only for their meat and pigs were no longer kept for their meat. Not enough sheep and goat remains were found to determine why sheep and goat were kept.

This research concludes that while animal husbandry in the Netherlands during the Neolithic did develop in some ways, relative abundancy, it did not have much development in other parts, culling practices and purposes for keeping livestock.

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