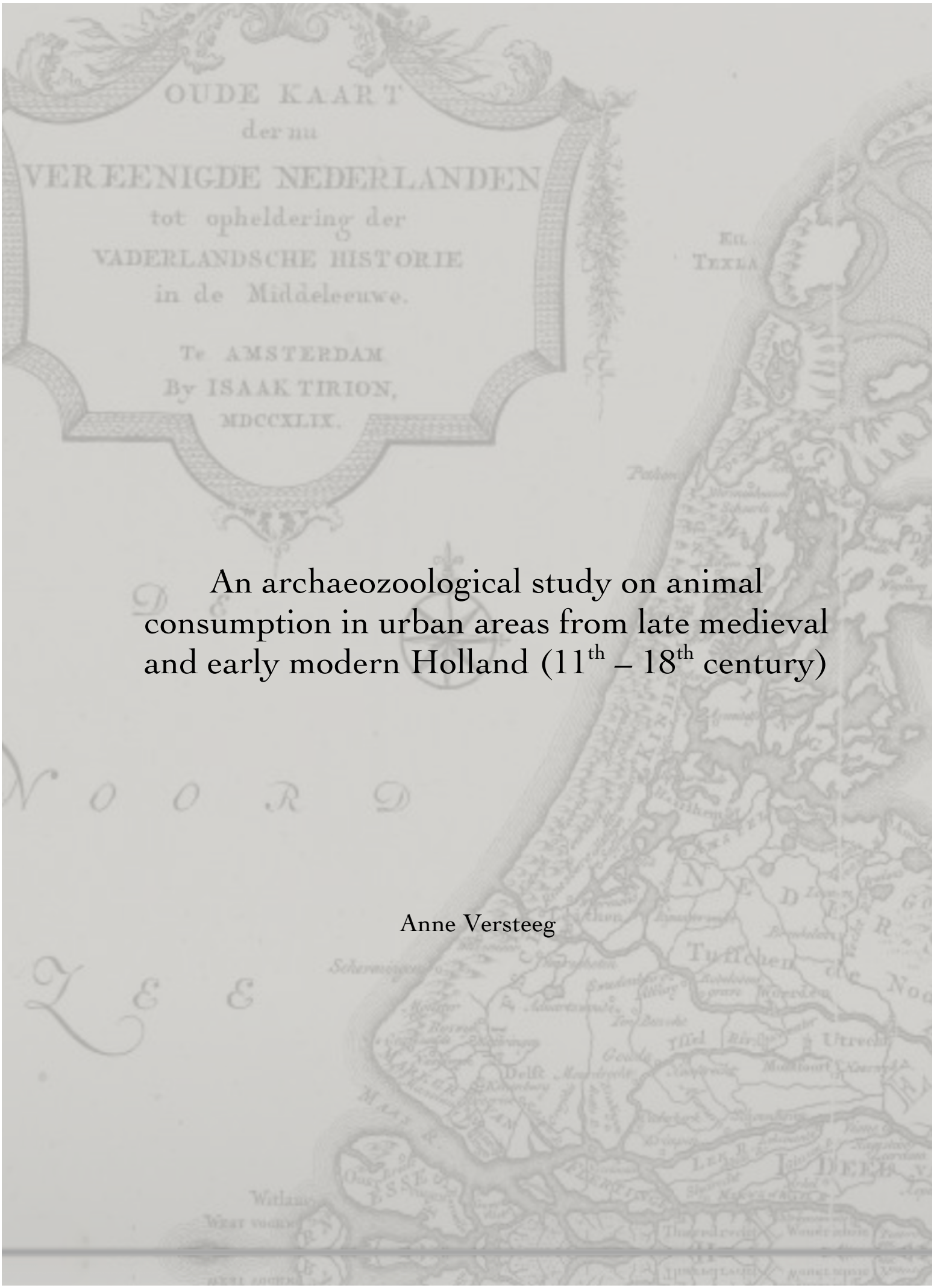

An archaeozoological study on animal consumption in urban areas from late medieval and early modern Holland (11th – 18th century)

Anne Versteeg

Contact information:
Name: Anne Versteeg
Address: -
Email: a.m.versteeg@umail.leidenuniv.nl
Telephone: -

Cover photo: Historical map of medieval Netherlands from 1749. Source: https://www.rijksmuseum.nl/nl/collectie/RP-P-OB-77.802

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Name:	Anne Versteeg
Student number:	1360116
Course:	MSc Thesis
Course number:	4ARX-0910ARCH
Supervisors:	Dr. Llorente Rodríguez
Specialization:	Archaeozoology
University:	University of Leiden, Faculty of Archaeology
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1. Introduction

1.1 Thesis objective

Zooarchaeology is a field of study with an ever-increasing importance within archaeology. Recently, research has been done on consumption patterns of the three main domestic animals from medieval Belgium. This research yielded interesting results concerning geographical and chronological trends. However, an updated version of such research is still missing in the Netherlands. The objective of this thesis is therefore to assess the archaeozoological assemblages of North- and South Holland in the Netherlands between the 11th and 18th century and to see whether there are similar patterns in the consumption of the three main domestic meat suppliers. To be able to make this assessment, an archaeological survey has been done. The object of these surveys is to help us to create a better understanding of medieval animal consumption.

1.2 Thesis outline

In the further subdivisions of this chapter the theoretical and research framework of this study is examined, including research done previously on archaeozoological assemblages in the Netherlands between the 11th and 18th century and current problems within this research. Chapter 2 describes the aims and questions posed in this research. This is followed by the description of materials included in the analysis and the methodologies used to explore consumption patterns in the region studied in Chapter 3. Chapter 4 describes the results of the archaeozoological survey performed on faunal assemblages from medieval Holland. This chapter is devoted to the analysis of the relative frequencies of the three main domestic animals, in the first place, and the Pig/Sheep ratio, in the second place. Chapter 5 elaborates on, and contextualizes the results to them discuss them through contrast with the data and hypotheses of the Belgian research. The final chapter is the conclusion, in which the results are highlighted and in which it will be discussed to what extent the research questions have been answered.

1.3 Medieval urbanization

Characteristic for the Middle Ages in Europe was the urbanization that began during the 9th century and lasted until early modern times (Verhulst 1999, 68). The Low

Countries were divided into principalities, such as the Duchy of Brabant, the Bishopric of Utrecht and the Counties of Flanders, Holland and Guelders (Paping 2014, 6; Rutte and Vannieuwenhuyze 2014, 114). Certain areas within these districts started urbanizing between the 10th and the 15th century because of their favorable geographic location near the North Sea and large rivers for transportation (Rutte and Vannieuwenhuyze 2014, 114). Especially the regions of Flanders and the southern Dutch principalities began developing quite early, between the 10th and 11th century, whereas the county of Holland, for example, started the urbanization process later (Leupen 1988, 9; Verhulst 1999, 68-69).

The larger part of the county of Holland started urbanizing at the end of the 12th and 13th century. Towns in these counties, such as Amsterdam and Rotterdam, grew from agricultural settlements with profitable economic circumstances to regional centers and port cities dependent on trade (Rutte and Vannieuwenhuyze 2014, 123-124). Much of this development was possible because of their advantageous position within the Dutch landscape, which formed part of the delta of the Rhine, Maas and Scheldt (Clason 1967, 4; Leupen 1988, 9; van Bavel and van Zanden 2004, 527). Urban industries, such as shipbuilding and textile production, developed greatly (van Bavel and van Zanden 2004, 504). Additional non-agricultural professions, such as brick production, lime burning and cheese making, developed in rural and urban areas (van Bavel and van Zanden 2004, 505). The samples of products from both urban and rural areas were produced for export, which caused the economy to flourish (van Bavel and van Zanden 2004, 503). Consequently, a market economy developed, in which the production of goods used for trade stood central, as opposed to a subsistence economy in which people only had to provide resources for themselves (Groenman-van Waateringe and van Wijngaarden-Bakker 1990, 284).

The growth of these urban areas and the economic change resulted in demographic developments, such as population expansion (van Bavel 2002, 9). The flourish in trade and economy also instigated that people who previously lived in rural areas, fled to the towns looking for new economic and social opportunities (Blockmans 2002, 300). The total urban population could not have outnumbered a few thousands around 1200 AD (Dijkman 2011, 4). Nonetheless, at the beginning of the 14th century the urban population was already around 30,000 people, and kept on growing to about

55,000 in the middle of the 14th century, with the total population of Holland being at a minimum of 260,000 (van Bavel and van Zanden 2004, 505; de Boer 1988, 32). During the 16th century, about 45% of the entire population of Holland inhabited towns, with a higher population density in the northern area than in the south (van Bavel and van Zanden 2004, 505; Bos 1990, 129). The coastal area also urbanized faster than the inland regions of the Dutch Republic (Paping 2014, 1).

Even though the urban population grew relatively fast during these ages, it must be mentioned that the towns within Holland that experienced this growth during the 13th and 14th century were still relatively small compared to other towns in Europe. The urban population of Holland was spread thin over several smaller and medium-sized towns, such as Leiden, Amsterdam, Delft and Dordrecht. None of the medieval Holland towns had a population more than 20,000 during these centuries (Dijkman 2011, 318; Vermoesen 2013, 201). However, during the 17th century, over 40% of the entirety of the population of the Dutch Republic lived in the county of Holland. The towns grew as well, with Amsterdam growing to at least 206,000 inhabitants in 1672 (Hoppenbrouwers 2001, 54; Nusteling 2018, 32).

At the beginning of the 16th century, the county of Holland was largely urbanized, with a high percentage of people working in professions other than agricultural jobs (van Bavel and van Zanden 2004, 503). The development of the urban areas also had an impact on the non-urban areas surrounding them. Because towns kept growing, the rural areas started focusing more on producing for city markets (Heeringen *et al.* 2017, 176). The average distance between marketplaces in towns within the Low Countries was about 25 kilometers at that time (Vermoesen 2013, 201).

The gradual development of urban centers, a market economy and population growth in towns also caused a higher necessity for food provisions. The consumers of these towns depended on food produced outside the towns (Ervynck and van Neer 2017, 65). Crop farming declined severely during this time, whereas market driven cattle and dairy farming, along with other non-agrarian activities, such as fishing increased in importance (Dijkman 2011, 8). The quality of the land declined due to peat exploitation and the population kept growing, which resulted in a shift to livestock production occurred (van Bavel and van Zanden 2004, 520-522). The keeping of animals became

more important over the centuries, when cattle and sheep became of multifunctional use through a result of the development of butter and dairy production and trade (Burema 1953, 13-14).

1.4 Food provisions and regulations within towns

Meat was an important food and protein source for urban households in the Middle Ages (Ervynck and van Neer 2017, 65). Towns were usually unable to produce enough food within their town walls for the ever-growing population and certain resources had to be brought in from outside the city walls. Food production took place mostly outside of the city, but was usually in the near vicinity (Groenman- van Waateringe and Wijngaarden-Bakker 1990, 284).

Before the urbanization period towns were spacious enough to let cattle and pigs roam the streets (van Herwijnen 1988, 20). During the urban growth, this rural aspect of developing towns changed and animals that were brought into town were subjected to strict regulations. For example, there was a restriction on keeping, slaughtering and selling animals within towns (Clason 1967, 26). Most medieval towns had regulations regarding the slaughtering of sheep, which comprised of certain months in which the slaughtering was allowed, although these time periods differed from town to town (Unger 1916, 131). The period in which slaughtering would be allowed in Rotterdam was before November 1st; in Leiden the slaughtering of sheep was allowed until November 11th (Unger 1916, 131). Similar regulations were also set for calves, who were not allowed to be eaten when younger than 8 weeks (Unger 1916, 132). In Leiden, it is known that during the 15th century, it became prohibited to let cattle roam the streets because it was considered to be unhygienic. Pigs were prohibited much earlier and they were only allowed to be kept inside a house or in a fenced courtyard (Smit 2001, 27). These strict regulations on the consumption and herding of certain animals might result in a bias on their relative abundance compared with other animals that were not subject to these regulations.

Quantity and quality of the meat produced and traded was kept in check by regulations that developed more over the centuries (Unger 1916, 126). These regulations make it possible for the consumption patterns not only to differ between the cities and their rural surroundings, but additionally differ at a larger scale between

cities, as it was found in Belgium by Ervynck and van Neer (Ervynck and van Neer 2017, 71-72).

1.5 The keeping and importing of cattle, pig and sheep

The county of Holland kept an abundance of cattle, whereas pigs were usually more important in number in the eastern part of the Netherlands (Unger 1916, 120). Pigs were kept only for their meat and had no secondary function, whereas sheep had multiple uses, including providing milk and wool (Clason 1967, 209). Pigs were usually herded in mixed landscapes combining woodlands and pasture, sometimes together with cattle. It must be noted though that for cattle to graze in the same wooded area as pigs, large areas of open spaces with grasses are required (Groenman-van Waateringe and van Wijngaarden-Bakker 1990, 285).

Cattle breeding became more significant during the 13th century, when several cattle markets started to appear parallel to an increase in the production of butter and milk (Burema 1953, 14). Important cattle markets within Holland were located in Amsterdam, Haarlem and Hoorn (Burema 1953, 29; Unger 1916, 121). Before the 13th century, most animals were slaughtered at home, which changed when market halls for meat developed within towns (Burema 1953, 30). Because meat was important to feed the inhabitants of towns, the meat that was sold was examined thoroughly. Amsterdam, for example, had restrictions that made sure that spoiled meat was not sold (Burema 1953, 31).

Because of the restriction on animal keeping in cities, Clason pointed out that pig remains may be found more often in Late Middle Ages faunal assemblages than small ruminants such as sheep, given that pigs are easier to keep in smaller spaces (Clason 1967, 67). Additionally, even though Amsterdam had restricted the slaughtering of sheep within the city, there were no such restrictions for the slaughtering of pigs (Clason 1967, 67). Other than that, it was allowed to bring living animals inside the city. Dead animals were not allowed to be brought in, because they could not be inspected on their health (Unger 1916, 192). Furthermore, pigs were consumed often as the population thought that pork was highly digestible and therefore more suitable for food consumption (Clason 1967, 67). In addition, pigs also have a higher reproduction rate

than cattle, which might result in more dependence on pig herding for the meat supply in cities (Groenman- van Waateringe and van Wijngaarden-Bakker 1990, 285).

Historical sources barely mention the use of calf meat or other young animals before the 16th century (Burema 1953, 43). There is even historical evidence for the exclusion of slaughtering lambs and calves that are too young to be slaughtered and not allowed to be sold in the meat hall in the town of Leiden (Schneider 1953, 32).

However, pork has been noted to be eaten in abundance by both elite citizens and regular middle-class inhabitants of towns. People were therefore also dependent on grains to supplement their meals, since bread with meat was a commonly consumed meal (Burema 1953, 42). Grains and cereals were imported to Holland because of the soil deterioration caused by peat reclamation and flooded territory (Jones 2014, 104; Vermoesen 2013, 209).

Animals that were destined for slaughter were brought into towns and usually brought to the meat hall, where merchants were allowed to sell the meat. All meat that was brought into towns for trade and not for personal use of individual households were sold in these halls. This only changed in the early modern times (i.e., the 19th century) when, in Leiden for example, it became allowed to sell meat in your own store instead of the city hall (Schneider 1953, 19-20). Animals that were kept and died in towns such as Leiden, were ordered to be buried (Smit 2001, 28).

Nowadays, only certain parts of animals appear on the menu in restaurants and homes. In the Middle Ages people were less critical of the food that was available. Parts of the animal that contained large quantities meat have always been consumed, such as the upper limbs and the meat around the torso of the animal. In Haarlem there is evidence of the consumption of end limbs from cattle and sheep, which are rarely ever eaten because it contains very little meat (Esser 2002, 72). This evidence comes from taphonomical analyses where anthropic marks are analyzed. After slaughtering an animal for consumption, it is skinned and the carcass cut into pieces. This sequence of activities leaves bone surface marks such as cutmarks and chopmarks that provide information on butchery practices. Once the body parts were butchered they were sold on the market. A tertiary butchery process may have taken place at the kitchen and/or

during consumption. As a result, the archaeozoological record can show us whether animals were kept in certain places and slaughtered at home, or whether meat was brought to the market and sold there. In this case, in addition to the analysis of bone surface marks, the skeletal profile of the animals at a specific context can provide further support, such as the usual lack of phalanges and horncones at butchery or market refuse contexts (Groot and Lentjes 2013, 18).

1.6 Other consumed animals

Inhabitants of these towns consumed much more than just pork, mutton and beef. Important food sources other than the three main domesticated mammals include poultry, wild birds, fish and mollusks. Fish consumption grew throughout the Middle Ages during religious periods of fasting in which it was forbidden to consume meat (van Dam 2008, 312). Several fish species, such as salmon and trout, were considered luxury foods and were therefore mostly consumed by the elite (van Dam 2008, 309).

It is known that dogs and cats were rarely eaten as meals during the Middle Ages. However, they may have been consumed when food was scarce and hard to come by, though this is an exception and not the rule (Lauwerier 1997, 483). Dogs were first and foremost used for hunting, especially by the wealthier part of the population (Smit 2001, 28). Dogs and cats were also kept as pets, and were in general not consumed (van Wijngaarden-Bakker 1972, 38).

The consumption character of a taxon can be determined in the archaeozoological analyses by looking whether elements from an animal formed a complete skeleton, which is rare for consumption and slaughter waste, or if bones do not indicate entire skeletons but separate elements, mostly elements suitable for consumption, distributed over large areas (Lauwerier 1997, 483).

Other sources of food that were of importance to medieval towns include game taxa. However, game has been scarcely found within city center excavations of Amsterdam (van Wijngaarden-Bakker 1972, 35). Animals that are not considered as food sources at all, and are usually limitedly present in faunal assemblages, are horses. Horses were working animals and were usually not eaten during the Middle Ages because the Roman Catholic church was opposed to the consumption of horse meat

(Clason 1967, 60). Usually only several horse bones are found in a large faunal assemblage (Burema 1953, 42; van Wijngaarden-Bakker 1972, 35). However, in countries such as England and Italy, horse meat was more commonly eaten (Burema 1953, 43).

Food production and the consumption of animals within medieval cities in the Netherlands has been a research theme that has not been explored deeply yet. Excavation reports on medieval cities rarely provide a detailed chapter on archaeozoology. Though little, there has been academic research published on this matter, such as articles published by Lauwerier on the archaeozoology of medieval Netherlands (Lauwerier 1997; Lauwerier 2002). Nevertheless, an up-to-date collection on archaeozoological remains from medieval Netherlands is nonexistent. Remains of the three main domestic meat suppliers are the easiest to make an inventory of as they are less conductive to sample biases. To get a complete picture of the entire consumption pattern, birds, game, shellfish and fish should also be taken into account. However, information about these species is often missing from excavation reports, or not detailed enough.

1.7 Research framework

The sites discussed in this thesis are located in the western part of the Netherlands, more specifically the two provinces of North- and South-Holland (fig. 1). During the medieval times, these two provinces together formed the county of Holland. Cities within the county held essential positions in the network of waterways and the reclamation of the peat district in this area caused opportunities for new growth (Dijkman 2011, 6-12). During the late Middle Ages, the county of Holland contributed to more than 40% of the entire population of the Dutch Republic (Hoppenbrouwers 2001, 54). This swift change and growth in demography and economy makes the region an interesting study area.

Figure 1: Map of the county of Holland, depicted in colour, in medieval Netherlands, 1725. Source: Specht, C., 1725.

This thesis presents a survey of the present state of affairs of archaeozoological research in the larger cities of medieval Holland and thus, only exploring urban areas. Through the analysis of the relative frequencies of the main domestic meat-suppliers (cattle, pig and sheep), a better understanding of the mechanisms of meat consumption and food provisioning in medieval towns over the centuries is produced (Ervynck and van Neer 2017, 67).

Having an updated survey of archaeozoological finds in this area is of importance because it can lead to answering research topics including the relationships between man and animals and exploitation activities or consumption patterns within this specific time period and area (Lauwerier 2002, 225). In the case of this thesis, the research will be focused on exploring the consumption patterns among several towns within Holland. This can help us to understand which animals were most important in the research area, and how this affected the consumption pattern in late medieval and early modern towns in Holland.

Until now, there has not been much research into medieval archaeozoological assemblages from the Netherlands, let alone research published in English. Likewise, academic research into long-term changes in consumption patterns during the Middle Ages and the early modern period has been additionally limited (Vermoesen 2013, 215).

Therefore, it is important to bring to light more archaeozoological studies such as surveys, in order to be used for further research (Lauwerier 1994, 3). Archaeozoology sheds new light on social aspects of a community, but also tells us more about consumption and trade and whether animals were slaughtered at one location and eaten somewhere else (Lauwerier 2002, 227). These are examples of research topics still awaiting to be studied in depth within this research area.

The most recent study on the topic of medieval urban archaeozoology is the article by Ervynck and van Neer, which explores diachronic changes in the consumption of the three main domestic meat-suppliers in the southern Low Countries (Ervynck and van Neer 2017, 65). This study presents an archaeozoological survey of nine towns within the region of Flanders and Brussels. The faunal assemblages from these towns were analyzed to look for trends through time and space concerning the mechanisms of medieval meat supply (Ervynck and van Neer 2017, 67).

In their article, Ervynck and van Neer first calculated the relative frequencies of cattle, pig and sheep for the nine towns within the region of Flanders and Brussels. This is done by the calculations of the number of identified specimens (NISP) instead of using the minimum number of individuals (MNI) (Ervynck and van Neer 2017, 68). Using the NISP, the ratio between pig and sheep quantities was calculated, which has been named the P/S ratio. This ratio is used to show the diachronic changes in the relative frequencies between pig and sheep. These ratios are then compared for the nine different towns within the research area of Flanders and Brussels (Ervynck and van Neer 2017, 71) Cattle was excluded from the analysis because of the difference in meat consumption and meat volume. Additionally, each cattle bone represents a larger amount of meat than pig and sheep bones (Ervynck and van Neer 2017, 68). Finally, the authors argued that cattle remains are more often found than smaller pig and sheep remains, creating perhaps a wrong image of relative frequencies (Ervynck and van Neer 2017, 68).

This research used a large range of data, with sites dating from the 8th century to the 18th century. Separate tables for each site were made using the relative frequencies of cattle, pig and sheep because of the large datasets per town (Ervynck and van Neer 2017, 69). Their results show that the consumption of pig decreases in relative

importance throughout time within several cities, thus also showing that sheep rises in relative importance (Ervynck and van Neer 2017, 69). Furthermore, the article also evidences that Leuven, Gent, Aalst and Brussels display a relative high pig to sheep ratio before 1500, whereas the other cities analyzed – Ypres, Bruges, Antwerp, Lier and Mechelen – never reached a high pig to sheep ratio (Ervynck and van Neer 2017, 71). Most importantly, for all sites analyzed, there are no pig values above 20% after the 16th century (Ervynck and van Neer 2017, 69). The authors ascribe this decline to the shift from herding animals in the woods, towards breeding animals in confinement, near settlements. This system of breeding animals did not create the amount of meat needed to supply towns (Ervynck and van Neer 2017, 72).

1.8 Previous research

There have been other inventories of faunal remains from Dutch Medieval towns; however, these inventories are quite dated, have a different research area, such as the southern provinces, or the eastern part of the Netherlands, and differ in the animal species taken into account. These inventories have been published by R. Lauwerier (1997), W. Prummel (1982, inaccessible) and Groenman-van Waateringe and Wijngaarden-Bakker (Groeman-van Waateringe and van Wijngaarden-Bakker 1990, 285; Lauwerier 1997, 481).

The inventory published by Lauwerier presents a zooarchaeological survey of medieval towns within present-day Netherlands (Lauwerier 1997, 480). It contains 49 bone assemblages from 22 different towns all over the Netherlands. The survey included mammal remains of pre-urban and urban sites from medieval towns up to the 15th century (Lauwerier 1997, 480). It is not stated whether different contexts were studied. The article presents an inventory of all these assemblages, indicating the location of the site and its period, while additionally exploring the relative abundance of cattle, pig and sheep/goat (Lauwerier 1997, 482). Cattle, pig and sheep remains are presented as a percentage of only their total relative to each other, disregarding other mammal species. Whereas the remaining mammal taxa (horse, dog, cat and game) are shown as a percentage of the total number of identified bones from a site (Lauwerier 1997, 484). However, in contrary to the results from the research by Ervynck and van Neer (2017), Lauwerier (1997) states that in some locations, the consumption changed from mutton to pork, instead of the other way around as found by Ervynck and van Neer (2017) (Ervynck and van Neer 2017, 71; Lauwerier 1997, 484). Lauwerier claims that there are

no period-linked tendencies that are valid for all towns within his research area concerning the difference between the pig/sheep ratio during the late medieval ages (Lauwerier 1997, 484). Nevertheless, there seem to be slightly differences between several towns, such as Zwolle and Deventer, where it seems that pork was consumed more than sheep from the 14th century onwards (Lauwerier 1997, 484). However, the article does not state what method was used in calculating the differences between the consumption of mutton and pork presented in the overview. It is also unknown whether the NISP or MNI method was used.

1.9 Problems within current research

Studying food provisioning in medieval towns raises several problems that can make it difficult to compare research results with other articles (Ervynck and van Neer 2017, 66). There are three major problems for the study of medieval archaeozoology, namely accessibility, crucial differences in methodology and historical studies. Unfortunately, this information is not always available because most represent grey literature or academic dissertations (Lauwerier 1997, 480).

Some accessible reports do not guarantee usefulness. Being dependent on excavation reports from the past decades, the amount of detail presented differs enormously per report. Several datasets from excavations have missing information on the collection of materials, for example. The chronology of the material is also crucial for a valuable assemblage. The value is reduced when the faunal assemblages have been attributed to several centuries as, for example, being from the 12th to 18th century (Seeman 1984, 28). This covers such a wide historical period that the quality of these assemblages is questionable (Lauwerier 1997, 480). Finally, some archaeozoological datasets are often represented by assemblages that are too small to be of any significance.

The differences in methodology does not only apply to excavation reports, but also to research papers. Whereas some articles only survey the consumption patterns of the three main meat-suppliers, other choose to also include other mammals, birds and fish when debating medieval food provisioning (Ervynck and van Neer 2017, 65). However, when faunal remains are collected by hand, the possibility exists that bird and

fish remains might be underrepresented. When the soil has not been sieved, these remains can easily be overlooked because of their size (Lauwerier 1997, 480).

The criteria used to determine which sites have been taken into account also differ enormously. Whilst several surveys have researched a large range of archaeological contexts, such as castles, monasteries and small rural households, others have only researched urban contexts. These different research areas are problematic to compare, seeing as certain contexts are influenced by social mechanisms, such as a display of status (Ervynck and van Neer 2017, 66). Not only are comparisons impracticable, this also further limits the amount of papers available for research.

2. Aims and questions

The research presented in this thesis will be aimed at researching whether *similar geographical and chronological trends that were observed in Ervynck and van Neer (2017) can be extrapolated to the archaeozoological record of urban contexts within Holland*. This survey aims, on the one hand, to create a better understanding of the differences in food patterns between the rising cities during the late medieval and early modern time and, on the other, to decide whether trends visible in Flanders and Brussels were also present in a different area of the Low Countries. Are there differences or patterns in food provisioning that can be seen through the three main domestic meat-suppliers?

To learn more about the consumption patterns of urban areas, we need first to define which sites are eligible for research. The consumption of medieval towns will then be analyzed through excavation reports of the larger cities present in the county of Holland during these times, which include cities such as Leiden, Haarlem and Delft. This data will then be compared with the information known from the region of Flanders and Brussels. To gain insight in and knowledge on this topic, the following research questions will be addressed:

1. In which quantities were the three main domestic meat-suppliers, namely cattle, pig and sheep, consumed in medieval towns in Holland?
2. Do the relative frequencies of these three species evidence certain trends?
3. What is the pig/sheep ratio of these sites?
4. Are there any diachronic patterns visible within food provisioning through the pig/sheep ratio of the study area?
5. If so, are these patterns similar to the ones found in medieval Flanders and Brussels?

Answering these questions will be approached by first explaining how the research has been set up in the materials and methods chapter. Then, the faunal assemblages from different urban centers in the county of Holland will be analyzed. Next, a larger survey will be presented, containing all data for the medieval towns in question, which will help compare the cities within the study area. This survey will be used to answer the research questions in the results and discussion chapter.

3. Materials and methods

3.1 Research data

The data used in this research is gathered from multiple literature sources accessed through the UL library online catalogue, local archaeological archives from cities of North- and South-Holland and the BoneInfo archaeobiological database. In total, 61 sites from 10 cities have been analyzed.

This thesis will restrict itself purely to archaeozoological data received from excavation reports and other archaeozoological surveys. Historical sources detailing specific amounts of sheep or cattle that were herded will not be taken into account, seeing as these sources are unreliable and even less accessible than excavation reports (Ervynck and van Neer 2017, 66).

To answer the research questions posed in chapter 1, different methods have been applied. The data from excavation reports have been used to create a schematic overview to be able to compare the consumption of the three main domestic meat-suppliers from different medieval towns (tab. 3, Appendix A). Relative frequencies and pig/sheep ratio per and within towns are analyzed to determine diachronic and regional trends in the consumption of pig and sheep. The Pig/Sheep ratio is determined by using the relative frequencies of pig and sheep and then calculating the ratio of finds from pig versus those from sheep (Ervynck and van Neer 2017, 68). Finally, results are compared to the relative frequencies and Pig/Sheep ratios from Ervynck and van Neer (Ervynck and van Neer 2017, 69-70). The tables and figures used in this research are made using Microsoft Excel.

3.2 Specifications and limitations

The research area is focused on the medieval county of Holland to limit the data assemblages suitable for research. Within this county, specific sites have been chosen to include faunal assemblages that are of significant size. However, as mentioned before, the quality and value vary considerably per site. Time period, number of fragments found and the accessibility to archaeological publications pose dilemmas. How can such different sites be compared (Lauwerier 1997, 480)? Sieved assemblages are much more valuable to us, seeing as it is more likely that smaller fragments, such as scales and fish

bones will have been collected. Should an archaeological site not have been sieved, it is possible that there are no fish remains collected. This means that it will be difficult to assess the consumption pattern of a settlement, if not all information is available (Lauwerier 1997, 480). However, recent research has proven that the consumption of freshwater and marine fish hasn't played a significant part in human protein intake throughout the last two millennia in Belgium (Ervynck *et al.* 2014, 786). Most protein intake will therefore have been provided by the consumption of terrestrial animals, and perhaps plants (Ervynck *et al.* 2014, 786). To avoid these dilemmas and to limit the problems within comparing research, only the three main domestic meat-suppliers, cattle, sheep and pig, have been included in this research.

Comparisons between sites are also problematic because of the differences derived from the scale of excavations. How intensively a site has been excavated depends on the nature of the excavation, whether commercial or research based for example, which may result in different excavation reports. Also, whereas some towns have been excavated quite extensively, others have only a single cesspit that was used for the publications on archaeozoological remains from that location (Lauwerier 1994, 7-8). However, a smaller assemblage of faunal remains does not always necessarily mean that there were scarce animals present during the Late Middle Ages. Should there be enough larger datasets to work with, it is advised to exclude the smallest datasets because the total number of finds from cattle, sheep and pig within these assemblages can be too low to provide information on food provisioning. To be able to get enough information for statistical analysis, larger assemblages, and preferably multiple assemblages per town are needed. Datasets available from Holland tend to be small in general and the overall number of datasets is limited, which led to the decision to include several of the small datasets should the site in question be part of a larger datasets from similar periods, making sure that the average quality of a site would still be useful.

Most of the animal assemblages that have been recorded for this thesis represent fragmented pieces of mammals, especially the three main domesticates. These fragmented skeletal elements usually represent either slaughter or consumption waste (Groot 2010, 7). Consumption waste is characterized by elements from high meat-yielding body parts of the exploited animals, mainly domestic ungulates. Cranial

elements, and the lower part of the hind limbs of pigs are also considered consumption waste, whereas horncones, carpals, tarsals and metapodia from cattle, goat and sheep are considered slaughter, workshop or skinning refuse (Haaster *et al.* 2012, 11).

Several of the assemblages presented in this thesis are derived from cesspits. Because these deposits usually represent a variety of archaeological material that additionally can include refuse waste from different contexts and represent a large timespan, it may be difficult to establish what the faunal remains from these cesspits represent. For example, they might include a combination of slaughter and consumption waste. As not all excavation reports provide determinations of elements within a faunal assemblage, the faunal remains from the same cesspit are seen as one context.

Indication of the abundance estimators used in archaeozoological analyses, such as Minimum Number of Individuals (MNI), Number of Identified Specimens (NISP) or bone weight by taxa, may differ between faunal reports. Not all archaeozoological studies provided all the estimators and if they do provide it, methodologies may differ too much to create worthy comparisons when methodologies are not described (Albarella 2017, 9; Ervynck and van Neer 2017, 68). For example, there are a number of ways in which the MNI or NISP can be calculated, which is not always defined within an archaeological report or article (Amorosi *et al.* 1996, 138). The calculated MNI can increase relative to other species when only a small amount of bones is found, or because of specific parts of animals that are brought into a town. This can cause the MNI to be overrated (Amorosi *et al.* 1996, 136; Clason 1967, 29). The NISP is therefore more reliable for this research. The NISP is regarded as an observational unit to represent by the number of identifiable fragments of bones per taxa (Lyman 1994, 44). Unfortunately, Dutch archaeozoological studies scarcely mention which quantitative method has been used. Several assemblages do mention the number of elements found, which is regarded as the number of the original complete bones present in the assemblages, instead of fragments (Lyman 1994, 39). The use of NISP also has its disadvantages within this research. Animals that were brought into town alive and intact may be overemphasized within assemblages as opposed to animals that were disarticulated before being imported into towns (Klein and Cruz-Uribe 1984, 25). Fragmentation also has a disadvantageous impact on the NISP. Should a site be poorly preserved with a high fragmentation of faunal remains, the inter-assemblage

comparisons will be affected. The NISP from the intensively bone fragmented site will be relatively higher than a well-preserved site (Klein and Cruz-Uribe 1984, 25). In this situation, it is also assumed that pig, sheep/goat and cattle are identically affected by breakage (Grayson 1984, 21). This also occurs in assemblages that are affected by butchering activities. When animals have been butchered on the spot, more fragments of that specific animal will be represented in the NISP than that of others (Grayson 1984, 20).

For this thesis, faunal reports that do not mention the use any specific quantitative method, have been interpreted as NISP. Should an archaeozoological study used for this research provide the MNI, number of elements, or any other method, this will be mentioned in the complete overview of data used for this thesis (tab. 3, Appendix A).

Furthermore, only urban areas will be included in this research. As mentioned before, there are several reasons for this decision. Firstly, there are more publications available on medieval towns than rural areas or sites subject to social status. Secondly, farmsteads, households, monasteries and castles are largely influenced by social practices. Luxurious food prepared for the elite can create a wrong image compared to very simple food brought in from rural areas where food is provided solely by farms (Ervynck 2004, 218). Because of the social mechanisms within these sites, this is incomparable to medieval towns.

This does raise the question of which towns are considered urban areas. Towns with urban characteristics were still scarce in Holland during the 12th century. Because of the fast growth within the county of Holland, at least 20 towns gained city rights during the 13th century (de Boer 1988, 32). Cities which gained city rights early on include Delft (1246), Haarlem (1245) and Alkmaar (1254) (de Boer 1988, 36; Kruisheer 1988, 49). Apart from the right to name themselves city, these urban areas differ from smaller settlements through a change in political and economic dynamics, after which the arrival of tradesmen helped these urban areas grow even further (de Boer 1988, 35). The criteria that is most important for this research is that the urban centers mentioned were not dependent on the agrarian sector. Therefore, towns of concern in this thesis were not selected because of their city rights given that not all settlements who

received city rights also developed into a city with urban characteristics, and towns who might have acquired city rights much later did portray these characteristics (Paping 2014, 4). Den Haag will therefore be considered as an urban area in this research, even though it did not receive city rights during the medieval period (Paping 2014, 4).

Seeing as archaeozoological assemblages from medieval towns in the Netherlands are not easy to come by, assemblages from the period before urban areas were fully developed (i.e. from the 10th to the 12th century) have also been taken into account to be able to make better comparisons between the chronological changes from before the urban growth to the consumption pattern during this period. The shift from a rural or pre-urban settlement to an urban area is very gradual and difficult to distinguish within the archaeological record (Rutte and Vannieuwenhuyze 2014, 126). This gradual shift also appears in a different fashion and timespan within different towns. To define a limit from when settlements can be considered urban is very difficult and shall not be attempted in this thesis (Sarfatij 1990, 185). Therefore, pre-urban phases of settlements have been included in the data for this thesis, even though this usually represents assemblages from arable ground instead of completely developed urban areas (Sarfatij 1990, 185).

Most assemblages include remains from sheep, goat and sheep/goat. Because these two animals are osteologically difficult to distinguish and a clear identification can only be made by certain bones, the remains from sheep and goat have been combined together for further purposes (Clason 1972, 99). When sheep/goat remains were found at certain locations, these are included when mentioning sheep remains in this research.

This research will therefore present a survey on the three main domestic meat-suppliers from several large medieval towns in the county of Holland. The study area includes assemblages from Leiden, Delft, Den Haag, Rotterdam, Amsterdam, Haarlem, Gouda, Gorinchem, Alkmaar, Monnickendam and Rotterdam (fig. 2).

Figure 2: Map of present day Netherlands, portraying the locations of the medieval towns discussed in the text.

3.3 Archaeozoological assemblages

A total of 61 archaeozoological assemblages from ten towns have been studied: Amsterdam, Haarlem, Leiden, Alkmaar, Gorinchem, Gouda, Rotterdam, Monnickendam, Den Haag and Delft. These assemblages were then chronologically categorized according to the literature. Should a site have a large date range, then these will have been placed in order from their first noted century. For example, the site Gerechtsgebouw from Haarlem, has a chronology ranging between the 12th and 18th century, but has been noted as the first site from Haarlem because it is the only assemblage with a 12th century chronology (tab. 1).

Certain assemblages are from the same archaeological site and excavation, but have been mentioned separately. An example of this are the assemblages from Leiden, Aalmarkt 1 – 7. These seven assemblages have been published in the same excavation report. Thus, assemblages excavated from the same site will have the same name. To be able to distinguish these sites, they will have a number added to their name to clarify that they are from the same excavation but different assemblages.

The remains of cattle, pig and sheep were added up to create the total number of remains (N). Relative abundances of these three species considered are given in percentages for each assemblage. Several percentages have been rounded up or down to establish a clear 100% without using fractions to avoid misperception.

In addition, the pig/sheep ratio (P/S ratio) has been calculated by using the relative percentages of pig and sheep NISP per assemblage. These values have also been rounded up or down to represent numbers with a maximum of one decimal point. This has been done for most P/S ratios with a ratio of 0.1 or more. However, for the ratios below 0.1, the ratio will have been rounded up or down to represent a number with two decimal points, seeing as otherwise these number would show either 0.1 or 0.0, which would not be correct. The reports and papers used to gather these abundances are indicated in the results but can be consulted in an independent bibliographical section separated from the general bibliography for this thesis, which reflects only literature used in this text. When additional abundance estimators were used in the studied reports, such as the MNI or NISP, they are additionally indicated. Even though these

have not been used in this research, they may be practical for later reassessment and further research.

4. Results

4.1 Archaeozoological survey

The main data from the archaeozoological survey are presented in table 1 and more extensively in Appendix A (tab. 3), which also includes relative frequencies and literature references. These tables summarize all the medieval archaeozoological assemblages from Holland that were accessible and useful for this study. The total NISP surveyed in this research is 11,838 bone remains.

Table 1: Sites that have been analyzed for this research, with date range per site, the NISP, and the P/S ratio.

Municipality/site	**Date**	**N**	**P/S ratio**	**Reference**
Amsterdam				
De Nes	13-15	446	2.7	Baart 1977, 495
St. Olofskapel	14-15	398	3.4	Van Wijngaarden-Bakker 1972, 34
St. Pietersgasthuis 1	14-15	369	2.6	Clason 1966, 88-89
Ca	14-15	307	6	Baart 1977, 495
St. Jansstraat	14-15	124	8.2	Baart 1977, 495
Damrak	14-15	113	10	Baart 1977, 495
Warmoesstraat	14-15	46	0.9	Clason and van Wijngaarden-Bakker 1969, 258
St. Pietersgasthuis 2	15-16	57	3.2	Clason 1966, 88-89
Herengracht	17-18	221	0.4	Gawronski and Jayasena 2013, 30
Haarlem				
Gerechtsgebouw	12-18	378	1.4	Seeman 1984, 28
Grote Markt	13-15	682	2.1	Van Wijngaarden-Bakker 1980, 53
Bank van Lening	15	143	1.5	IJzereef 1977, 14
Gravinnehof A	15-17	173	0.3	Esser 2002, 71
Groenmarkt	15-18	80	0.4	Horrée 1988, 51
Gravinnehof B	17-18	17	3.2	Esser 2002, 71
Delft				
Voordijkhoornsepolder	12	17	0.1	Van der Jagt 2011, 139
Voldersgracht	13-14	18	0.6	Van der Jagt 2013 in van Dijk and Kerklaan 2017, 27
Buitenwatersloot	14	31	0.8	Van Dijk and Kerklaan 2017, 26
IHE	14-15	138	0.6	Bult 1992 in van Dijk and Kerklaan 2017, 2
Den Haag				
Annastraat	14	209	0.2	Carmiggelt and van Veen

				1995, 13
Lange Voorhout A	14-15	156	0.4	Jacobs and van Veen 1996, 14
Achterom A	15-16	49	0.07	Nieweg 2007a, 54
Voldersgracht	15-17	422	0.1	Nieweg 2007b, 41
Lange Voorhout B	16-17	46	0.6	Jacobs and van Veen 1996, 29
Lange Voorhout C	16-17	57	0.05	Jacobs and van Veen 1996, 42
Aprochestraat	16-17	552	0.2	Esser and Beerenhout 2012, 290
Boekhorststraat	17	143	0.3	Carmiggelt and van Veen 1995, 17
Achterom B	17-18	80	0.4	Nieweg 2007a, 57
Binnenhof	17-18	73	0.1	Carmiggelt 1992, 43
Rotterdam				
Grote Markt A	14-15	72	0.7	Esser *et al*. 2013, 365
Grote Markt B	15-16	641	0.1	Esser *et al*. 2013, 365
Timmerhuis A	16-17	140	0.4	Esser *et al*. 2015, 292
Timmerhuis B	17-18	325	0.4	Esser *et al*. 2015, 294
Alkmaar				
Hooge Huys	10-12	114	0.2	Clason 1972, 103
Hema	11-12	26	0.8	Clason 1972, 103
Witteveen	12-14	191	0.1	Clason and Brinkhuizen 1978, 129
City Hall	14	24	0.2	Clason 1979, 59
Laat 233-237	15-16	50	0.8	Van Haaster *et al.* 2012, 59
Langestraat	15-17	203	0.5	Esser *et al.* 2001, 205
Voordam	16	64	0.5	Van Haaster *et al.* 2012, 59
Ritsevoort	16-17	59	0.4	Van Haaster *et al*. 2012, 73
Nieuwesloot	16-17	41	2.4	Van Haaster *et al.* 2012, 81
Wortelsteeg	16-17	96	0.07	Esser and Gehasse 1995, 85
Gouda				
Bolwerk A	14-15	271	0.3	Esser *et al.* 2010, 245
Bolwerk B	14-15	72	1	Esser *et al.* 2010, 250
Bolwerk C	15-16	67	1	Esser *et al.* 2010, 254
Leiden				
Aalmarkt 1	12	60	1.9	Esser *et al.* 2011, 177
Aalmarkt 2	12-13	55	0.7	Esser *et al.* 2011, 179
Aalmarkt 3	13	384	1.5	Esser *et al.* 2011, 180
Aalmarkt 4	13	357	1.7	Esser *et al.* 2011, 189
Aalmarkt 5	13	165	1.1	Esser *et al.* 2011, 193
Aalmarkt 6	13	257	1.8	Esser *et al.* 2011, 200
Aalmarkt 7	14	95	1.3	Esser *et al.* 2011, 202
Vismarkt	14	204	0.9	Van Wijngaarden-Bakker 1979, 47
Aalmarkt 8	15	598	0.1	Esser *et al.* 2011, 205
Pesthuis	17	83	0.2	Van Hees and van Dijk 2018, 53

Gorinchem				
Groenmarkt	14-15	99	0.5	Hoogendijk 2012, 51
Groenmarkt 8	14-15	542	0.5	Weterings 2009, 275
Blijenhoek	16-17	104	0.04	Van Haaster and Cavallo 1997, 7
Monnickendam				
Town center	13-14	240	3.5	Seeman 1989, 126

4.2 Relative frequencies

To be facilitate the analysis, the relative frequencies of cattle, pig and sheep per town were plotted (figs. 3 to 8). These graphs show the diachronic changes within relative frequencies of these three animals per town. To be able to interpret the graphs better, all sites shown here were placed in the graph on the basis of the middle value of its date range as employed by Ervynck and van Neer (Ervynck and van Neer 2017, 68). In this way, an assemblage dated between the 15th and 16th century will have been placed at 1500 on the graph, whereas an assemblage dated to only the 16th century will have been placed at 1550.

The downside of portraying the relative frequencies of species is that these graphs can be biased should a site have unfavorable preservation conditions, which can affect the amount of information lost because of taphonomic processes. This may lead to a one-sided dataset (Groenman-van Waateringe and van Wijngaarden-Bakker 1990, 283). The frequencies calculated and used in this research are all relative and therefore interdependent, which is not a downside *per se,* but detailed attention has to be payed when interpreting this data (Ervynck and van Neer 2017, 68; Grayson 1984, 19).

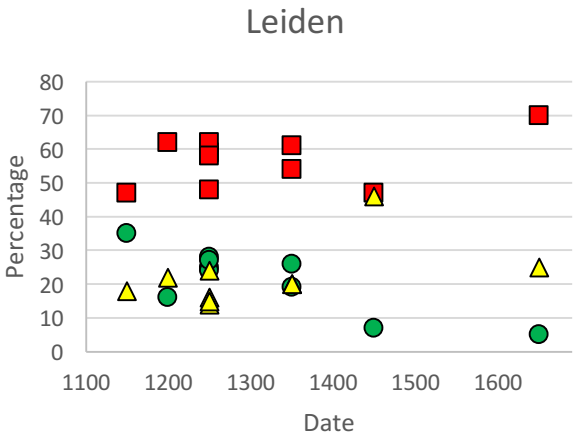

Figure 3: Relative frequencies of cattle (red squares), pig (green circles) and sheep (yellow triangles) for Leiden, derived from 10 assemblages.

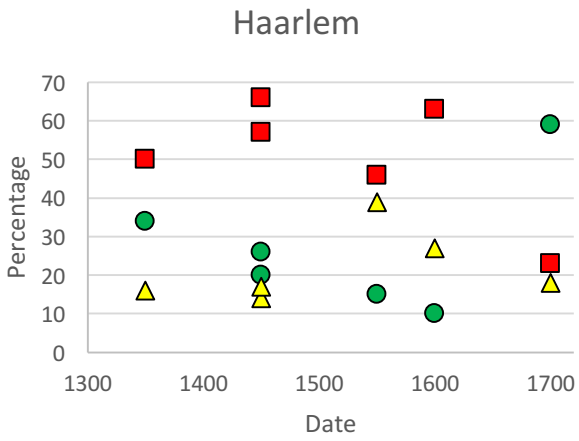

Figure 4: Relative frequencies of cattle (red squares), pig (green circles) and sheep (yellow triangles) for Haarlem, derived from 6 assemblages.

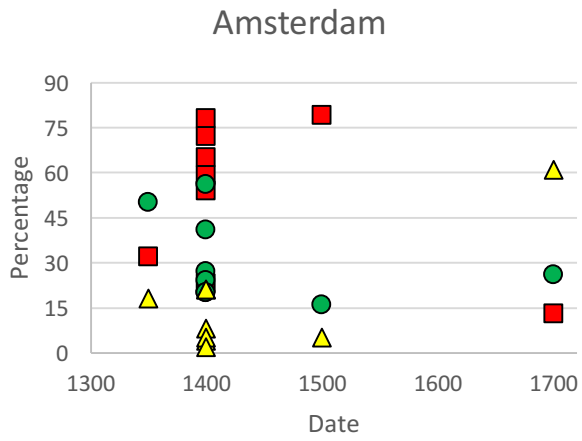

Figure 5: Relative frequencies of cattle (red squares), pig (green circles) and sheep (yellow triangles) for Amsterdam, derived from 9 assemblages.

From the relative frequency of the studied animal remains, the towns of medieval Holland can be divided into two groups. On one side, Leiden, Haarlem and Amsterdam (fig. 3, 4 and 5) have similar graphs and Den Haag and Alkmaar (fig. 6 and 7), on the other. The first set of plots, exhibit a decline in the relative importance of pig through time. At the start of the 12th century and during the 13th century, pig remains were more frequent than sheep remains in most assemblages. This situation switches during the 14th and 15th century, in which sheep remains become more abundant. Cattle remains within these assemblages are continuously more abundant than sheep and pig remains, as should be expected from medieval consumption sites. There are two outliers in the assemblages of Haarlem and Amsterdam (fig. 4 – 1700, 22; fig. 5 – 1700, 15), in which cattle remains seem to be relatively less frequent than pig remains.

The youngest assemblage from Amsterdam is curious by itself. The trend that can be seen during the 14th to 16th centuries completely shifts from the one assemblage that dates to 1700. This is a relatively large assemblage compared to others from Amsterdam (tab. 3, Appendix A). The remains derived from a city center cesspit, which makes it difficult to ensure a defined depositional history. Should this assemblage be disregarded, the graph for Amsterdam does show a small decline in relative frequency of pig. However, this is only contrasted by a relative rise in cattle, whereas the sheep stay at low frequencies, as opposed to Leiden and Haarlem, where sheep rises in relative importance (fig. 3-5).

Den Haag, Alkmaar and Rotterdam (fig. 6, 7 and 8) show a different situation. At these sites, pig has always been the least prominent stock within these assemblages. The only exception is an assemblage from Alkmaar, from the 16th -17th century, where the percentage of pig remains is higher than those of sheep. The relative amount of cattle remains differs somewhat between these three towns, but as already explained, the overall quantity of meat from cattle will usually have been more than that of sheep or pig. The trends that can be seen within the assemblages from Den Haag, Alkmaar and Rotterdam are fairly consistent, with a continuously low frequency in pig remains, and a higher relative frequency of sheep and cattle remains. There are no curious outliers within these figures.

From these three towns, only Alkmaar shows one situation in which pig remains were of larger relative importance than sheep remains (fig. 7 – date 1600). The frequency of sheep remains from this assemblage is suspiciously low, only 7% of the entire assemblage, whereas pig remains accumulate to 17% of the assemblage. This assemblage consists of 41 remains, which in itself is too small to be significant enough for research. Therefore, in this situation this assemblage cannot be looked at individually.

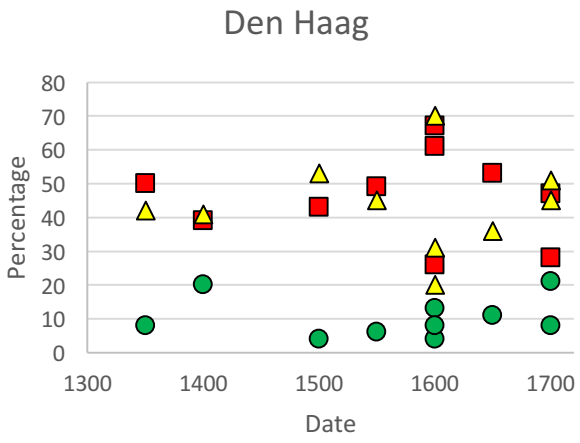

Figure 6: Relative frequencies of cattle (red squares), pig (green circles) and sheep (yellow triangles) for Den Haag, derived from 10 assemblages.

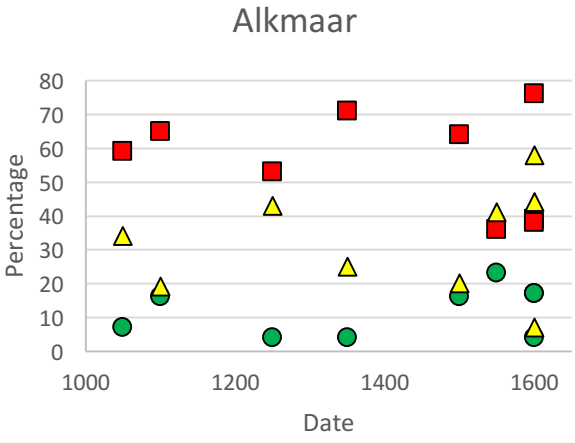

Figure 7: Relative frequencies of cattle (red squares), pig (green circles) and sheep (yellow triangles) for Alkmaar, derived from 8 assemblages.

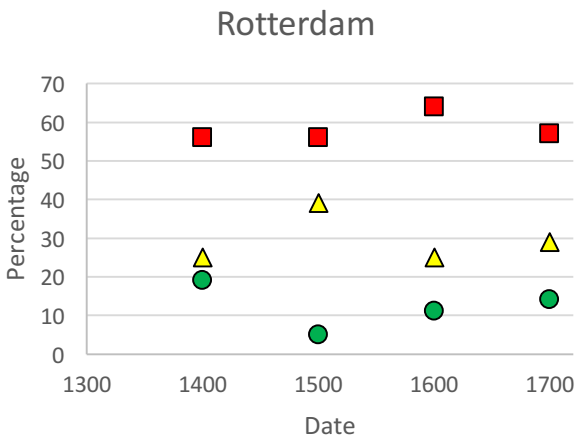

Figure 8: Relative frequencies of cattle (red squares), pig (green circles) and sheep (yellow triangles) for Rotterdam, derived from 4 assemblages.

4.3 Pig/Sheep ratio

To be able to see diachronic changes in the consumption of pork and mutton during the late medieval times, the pig/sheep ratio of all ten towns from medieval Holland presented in the archaeological survey (tab. 3) have been calculated. The aim is to explore geographical and diachronic differences in the consumption patterns.

There are some distinct differences between certain towns. Most locations show P/S values ranging between 0 and 4, with the exception of Amsterdam, which has values up to 10.0 (fig. 9). It should be mentioned that the P/S ratios of Gorinchem hides another point at ((1400, 0.5) (fig. 9).

Amsterdam shows the highest P/S ratio, with three outliers of 6, 8.2 and 10. As mentioned before, there were no restrictions within the city of Amsterdam concerning pig slaughtering, but there were restrictions on sheep slaughtering. This could be taken as an indication that pork was consumed more frequently than mutton. Because of the strict regulations concerning importing dead animals to the market, it is unlikely that mutton will have been brought into town already dismembered and butchered. The sheep therefore could not have been slaughtered in the rural areas and then brought in to markets but transported alive to towns to be slaughtered there. Pigs are also easier to keep in small spaces, such as the streets and courtyards of Amsterdam. This could further provide a reason for Amsterdam to have a higher frequency of pig remains than sheep. Should the higher frequency of pig remains be because they were kept in

individual households, this could be supported by analyzing (healed) trauma pathologies, especially those located in tibias and fibulas. It was common practice to tie the hind limbs of pigs together when keeping them in the yard or another restricted space of a household. This can cause different kind of trauma pathologies to these bones that could eventually heal (Seeman 1989, 129).

One site from Monnickendam has also been included in table 3, Appendix A, but is not portrayed in the figures used in this main text. This is because there is only one assemblage present. However, this one site does show similarities to Amsterdam. Monnickendam is located very close to Amsterdam, sharing its hinterland. As it is the case for Amsterdam, Monnickendam shows a remarkably high P/S ratio between the 13th and 14th century. Amsterdam and Monnickendam are the only two towns with a P/S ratio higher than 3.0.

It might be argued that the samples are somehow skewed. There are several factors that can cause a biased faunal assemblage. For example, sheep are very prone to diseases, such as the liver fluke parasite (Albarella 1999, 870; van der Jagt 2010, 47). This might have been a reason for people to prefer to keep other animals, namely pigs. However, because the amount of sheep remains is already quite high in medieval Holland, this is probably not the case. An abundance of sheep in the late Middle Ages can be caused by the cloth market and the wool industry that was developing greatly in Holland. Most of the sheep remains from Alkmaar represent adult animals, suggesting that these sheep could have been firstly used for secondary products such as wool and milk, and when they served this purpose, were only slaughtered for their meat (Clason 1972, 99).

Landscape is also an important factor to explain differences in frequencies. Whereas herds of pigs usually require a wooded area to thrive, sheep need more pasturage, moist meadows, and saltings (Seeman 1989, 132). There were larger forested areas, where pigs are more easily kept, in the northern part of Holland. The coastal area of Holland included large areas of reclaimed marshes and peat bogs, which had been turned into polders and pasture (Bos 1989, 32). These pasture lands are much more suitable for sheep herding than pig herding (Jones 2014, 101-104).

Looking at the slaughter ages might also provide an explanation for a large amount of remains. The average slaughter age of the pigs found at the St. Olofskapel was one and a half years, with none of the animals exceeding three years of age (van Wijngaarden-Bakker 1979, 35). This is also evident in the faunal remains from Haarlem, Gravinnehof, and Alkmaar where all pigs had a slaughtered age of three and a half or younger, with most of them not surpassing two years of age and several showing evidences of being slaughtered within their first year (tab. 2) (Clason 1972, 100; Esser 2002, 73). This is interpreted as young animals being slaughtered when winter was drawing near and food provisions had to be stocked up on to overcome this period, so they were only kept in the city, but not bred (Clason 1967, 62). Other archaeozoological assemblages from Amsterdam and Haarlem unfortunately do not mention mortality profiles. Fully grown pigs have not been found at any of the sites from medieval Holland that mention age at death, indeed proving that pigs were only kept for their meat and slaughtered as soon as they reached their largest size (i.e. specimens between 2-3 years old). There are a few sites from which remains of piglets have been found, such as Alkmaar and Gorinchem.

Table 2: Table of all known slaughtering ages from pig remains. All ages are in years unless stated otherwise. Towns mentioned in this table correspond with the towns from Appendix A, tab. 3.

Town	Slaughter age
Amsterdam – St. Olof	1.5 – 3
Alkmaar - Ritsevoort	3 months – 3.5
Alkmaar – Nieuwesloot	1 – 3.5
Alkmaar – Hema / Hooge Huys	6 months – 3.5
Den Haag - Aprochestraat	7 months – 3.5
Den Haag - Voldersgracht	1 – 3.5
Delft - Buitenwatersloot	< 2
Gorinchem – Groenmarkt 8	2 months – 3.5
Haarlem - Gravinnehof	Average of 2 years, <1 – 3.5
Leiden – Aalmarkt 1	< 3.5
Leiden – Aalmarkt 3	1 – 3
Leiden – Aalmarkt 4	7 months – 3
Leiden – Aalmarkt 5	1 – 3.5
Leiden – Aalmarkt 6	Average of 1 year – max 3.5
Leiden – Aalmarkt 8	1 – 3.5

Leiden – Pesthuis	< 3.5
Rotterdam – Grote Markt	< 2.5
Rotterdam – Timmerhuis A	< 2
Rotterdam – Timmerhuis B	< 2

The P/S ratio of Alkmaar seems to be rather high during the 17th century (1600, 2.4). This might be affected by the remarkably low percentage of pig and sheep remains compared to cattle remains, as can be seen in the relative frequency graphs (fig. 7). The site from which this P/S ratio has originated is only 41 NISP. With a relative percentage of pig remains of 17% (which equals to n=7), and a relative percentage of sheep remains of 7% (which equals to n=3), the P/S ratio might wrongly imply that there is evidence of an abundance of pigs.

Haarlem has one high P/S outlier as well, with a value of 3.2 between the 17th and 18th century. Even though the outlier of Alkmaar might be wrongly interpreted, the outlier from Haarlem actually implies a higher frequency of pig remains found compared to the cattle and sheep. Whereas the outlier from Alkmaar relates to a relative frequency of 17%, the one from Haarlem relates to a high relative frequency of pig remains, i.e. 59%. Additionally, the outlier on the P/S ratio from Haarlem is calculated from a very small assemblage. So even though the pig remains are 59% of the total NISP, this percentage derives from 10 bone fragments. The assemblage was included because, as is stated before, there is so little information available on archaeozoological remains from (medieval) Holland.

The relative frequency graph of Den Haag shows a small trend in the relative frequency of pig remains from the 15th century onwards. The P/S ratios of Den Haag contrasts with the other assemblages. P/S values are always below 1 throughout time. Therefore, the small increase in the relative frequency of pig (fig. 7) does not indicate an absolute increase. It is possibly caused by the decrease of cattle remains, which is why the P/S ratio remains continuously low. It is also curious to see that the P/S ratios of Den Haag and Delft are somewhat similar. This could be because these two towns are geographically close to each other, sharing perhaps the import from the rural areas surrounding it.

Because the plotted relative frequency and the Pig/Sheep ratio graphs individually might lead to different interpretations, it is important to view these graphs together and to compare and contrast them. For reasons of clarity, they have both been published in this research, however, they reveal different trends when looked individually or combined.

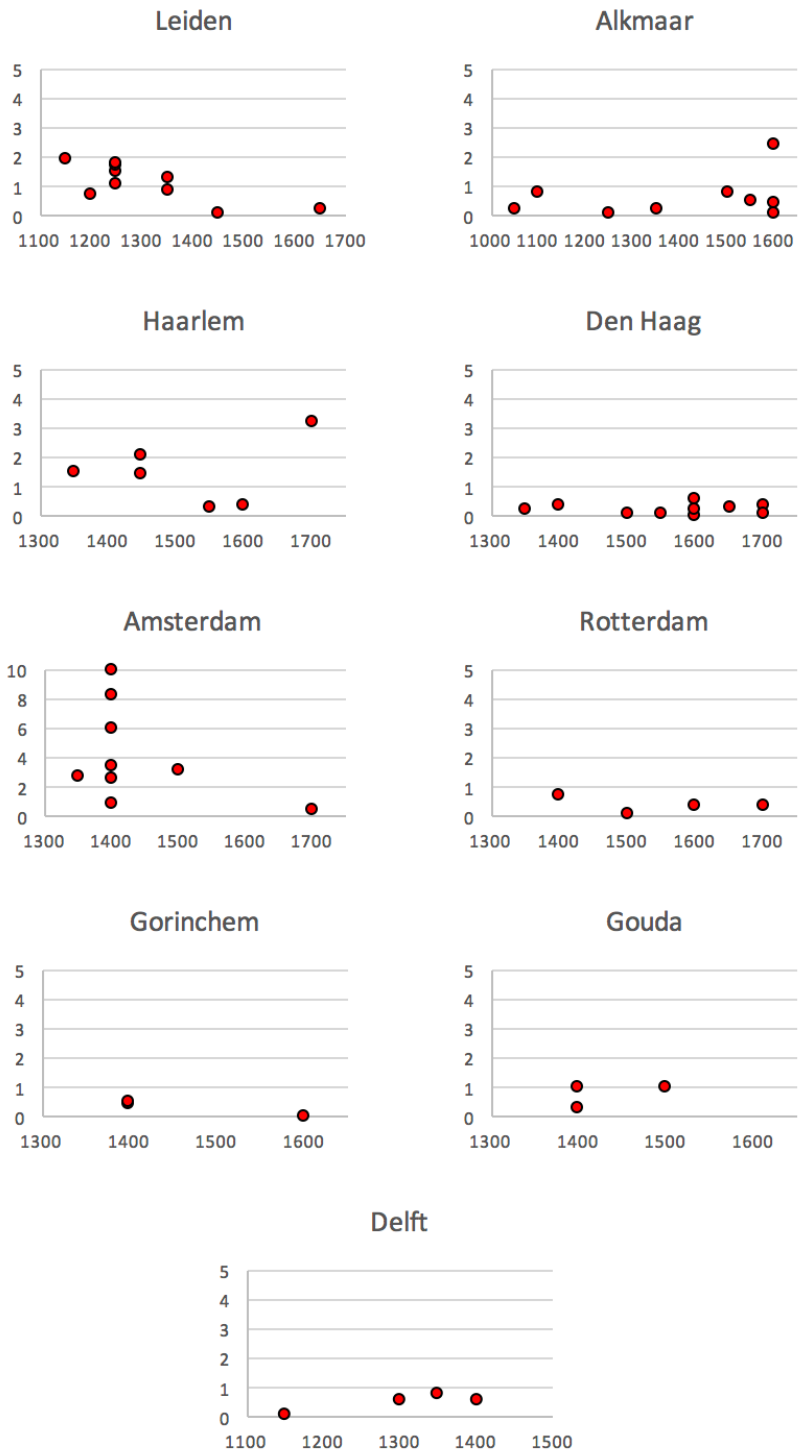

Figure 9: P/S ratios for 9 towns within medieval Netherlands. All figures have a maximum P/S ratio of 5, except for Amsterdam, which is enlarged to an Y value of 10.

5. Discussion

5.1 Expected results

Just as the research from Flanders and Brussels, there has been more research on the ratio between pig and sheep in medieval Europe. In English medieval archaeological sites, sheep and cattle bones tend to be equally abundant, compared to the fewer presence of pig remains (Albarella 1999, 868). In the Northern Coastal Area of the Netherlands archaeozoological research has also been done on early Medieval food consumption. This research also evidences that cattle and sheep were the most frequent animals, and was explained by way of a more suitable landscape for cattle and sheep (Prummel 2001, 74).

The relative importance of pig has been known to be higher in the eastern part of the Netherlands, where archaeozoological research on towns such as Deventer, Zwolle and Aalten have provided relative pig frequencies over 20% (Groenman-van Waateringe and van Wijngaarden-Bakker 1990, 287). The difference between the eastern and western provinces of the Netherlands is possibly explained by the sandy soils in the eastern area, where pigs might have adapted better to local conditions (Groenman-van Waateringe and van Wijngaarden-Bakker 1990, 287).

Therefore, expectations were that in medieval Holland, the Pig/Sheep ratios and the relative frequencies would be relatively low compared to the eastern Netherlands, and cattle would be the most frequently consumed animal. It was also expected that the continuously low P/S ratios from the 15th century onwards evidenced in Flanders would also be present itself in the research done in Holland (Ervynck and van Neer 2017, 70). The results of this thesis suggest that this is not necessarily the case. Some of the samples analyzed such as Amsterdam, Leiden and Haarlem, exhibited several outliers of the P/S ratio. These results were unexpected although the increase in pig might be related with an unintended bias derived from the selection of certain assemblages, that should be taken into consideration. The small sample size of some assemblages for statistical analyses might have had a biased impact in the results as well.

5.2 Comparisons with other research

The results presented in this thesis have been made to be comparable to the research on Flanders and Brussels in the southern Low Countries (Ervynck and van Neer

2017, 69). Results from these authors have similar trends in the relative frequencies of the domesticates of interest in this thesis, and presented a decline in relative importance of pig remains as well. Leuven and Gent show a clear decline of pig frequency over the centuries, with the relative frequencies being higher during the 12th century. Mechelen and Antwerp have a continuously low relative percentage of pig remains, never exceeding 30% between the 12th to the 17th century. There was no data from Flanders and Brussels which showed a steep increase in the consumption of pig resulting from the decline in relative importance of sheep remains (Ervynck and van Neer 2017, 69).

Concerning the P/S ratios of Flanders and Brussels compared to those of Holland, Rotterdam, Gouda, Gorinchem, Delft and Den Haag seem to have similar trends to those exhibited by Lier, Ypres, Antwerp and Bruges (Ervynck and van Neer 2017, 71). All the sites have low P/S ratios all throughout time. Rotterdam, Gouda, Gorinchem Delft and Den Haag are located relatively close to each other in the most southern part of Holland, which could have an impact on the P/S ratios, whereas Lier, Ypres, Antwerp and Bruges are relatively far away from each other. The similar ratios in Holland could be environmentally explained, with larger forested areas, where pigs are more easily kept, most probably in the northern part of Holland. The coastal area of Holland includes large areas of reclaimed marshes and peat bogs, which had been turned into polders. When the drainage of water had reached a maximum within these areas, the land was turned into pasture (Bos 1989, 32). These soil types and pasture lands are much more suitable for sheep herding than pig herding (Jones 2014, 101-104). Even though the Belgian towns are further apart, the similar ratios also have an environmental aspect. The authors explain that the towns with lower P/S ratios, namely Ypres, Bruges, Mechelen, Lier and Antwerp, are all located in areas of salt-marshes and salty meadows, as well as areas with heath-land vegetation, which is well-suited for sheep herding, but less suited for pig breeding (Ervynck and van Neer 2017, 71). These trends may show that environmental factors may have played an important role in the consumption pattern of medieval Low Countries towns.

Even though Amsterdam shows higher P/S ratios than the other towns analyzed, the one P/S ratio from Monnickendam does seem to support the notion that similar environmental factors might have influenced these assemblages as well. In this case, the

open landscape surrounding Monnickendam with ditches, bog rivulets and saltings along the coast are not optimal conditions for pig herding (Seeman 1989, 132). It is possible that Amsterdam and Monnickendam were dependent on pig suppliers from other parts of the country. However, to be able to support this hypothesis, more research will have to be done on towns and rural areas surrounding Amsterdam.

The P/S ratio of Leuven can be considered similar to that of Leiden, starting with a ratio of 2 around the 12th/13th century, and dropping to less than 0,5 after the 14th century (Ervynck and van Neer 2017, 71). The slowly decreasing P/S ratio of Leiden – and therefore of pig frequency - could be explained by the cloth industry, which started to grow after the reclamation of land made it very difficult to grow cereals. The fields were then used for the grazing of sheep to supply wool for the cloth industry (Jones 2014, 104). This might also cause a preference for the consumption of sheep as opposed to pig. Even though this does provide an explanation for the decrease of the P/S ratio, it does not explain why Leiden has a higher P/S ratio between the 11th and 13th century compared to other towns in this area.

The P/S ratios for towns in Flanders do not have values higher than 1, meaning more sheep remains than pig remains were found, for any of the analyzed towns after the 15th century. This is not in line with the results presented in this research. In medieval Holland, Alkmaar and Haarlem evidence a (slight) rise in P/S ratio from the 15th century onwards. Amsterdam also has one outlier exceeding a ratio of 3 during the 15th century (fig. 9). The price of mutton was higher than the price of beef between 1600 and 1660, which might explain a decrease in sheep remains relative to cattle remains (IJzereef 1989 in Esser *et al* 2001, 204). Because of the relative importance, this might also influence pig remains to therefore rise in relative importance.

In addition, Haarlem had the proper conditions for pig herding nearby, with the forested belt of dunes, which provided excellent pasturage (Seeman 1989, 132). It is possible that the city of Alkmaar was dependent on the same hinterland as Haarlem. This would indicate that the forested area near Haarlem would have produced the surplus of pigs that were then sold to multiple towns.

The increase of relative importance of sheep – or the decline of relative importance of pigs – does not relate directly to an absolute increase or decline. A decrease in the consumption of pork will lead to a relative increase in sheep remains, even though this does not necessarily indicate that mutton was consumed more over the centuries (Ervynck and van Neer 2017, 72). The overall trend in Belgium from postmedieval centuries show lower frequencies for pig and cattle, with a relative increase in sheep. In the cities analyzed from Holland, some of them definitely exhibit a small increase in relative sheep frequency as well, such as Leiden, Haarlem and Amsterdam. However, this trend is not that clear for other towns. Although Den Haag and Alkmaar also show a relative increase in sheep remains, this is correlated with a small increase in pig remains as well. The reason for this trend is the slight decrease in cattle remains, the P/S ratio remaining low at any time. The decrease in the relative importance of sheep can also be seen in the case of Haarlem.

The slight decrease in cattle remains does not inevitably mean that beef was consumed less in Holland as in this thesis we are only surveying urban and not rural areas. In addition, cattle bones are quite large, the quantity of meat is still higher than that from pig and sheep. The outliers on cattle frequency during these times could have also been caused by a cattle plague, which caused the meat to be scarce and very expensive (Burema 1953, 162). Cattle details from 17th – 18th century Haarlem (Gravinnehof) additionally evidence that these animals did not surpass the age of three and a half years, which suggests that these animals were mainly kept as meat supply instead of secondary purposes such as the dairy industry (Esser 2002, 74). However, this is curious if these animals have been brought in from the countryside, where cattle especially would normally lead longer lives and only send to the market after serving other purposes in the dairy industry and being used for traction (Groot and Lentjes 2013, 18).

It is important to note that Ervynck and van Neer were able to select archaeozoological assemblages with a clearly defined depositional history, whereas the archaeozoological record of medieval Holland is quite scarce (Ervynck and van Neer 2017, 68). All available information that was found about the faunal assemblages from the ten cities analyzed, was used for this research, even if it was not entirely sure that the faunal remains from these sites would represent exclusively consumption refuse

deposits. There is a possibility that several of these assemblages might also represent stray finds, slaughter waste, or a different depositional history. Although this could be determined partially by the presence of remains from animals that were not likely to be consumed (Gawronski and Jayasena 2013, 29), more taphonomical analyses are required in order to undoubtedly characterize medieval faunal assemblages from Holland and hence, consumption patterns. When more excavation reports become available on medieval urban areas in Holland, an extension on this research could provide more evidence for more visible and feasible trends.

It is also important to note that cities were much larger in Flanders during the medieval centuries than in the Netherlands. Whereas residents of Haarlem were around 10,000 inhabitants during the beginning of the 15th century, in Bruges this number lies around 46,000 inhabitants, and Brussels counted as much as 19,000 residents (Kan 1995, 54). Compared to urban centers in Flanders, Holland can be seen as a peripheral area. This also implies that consumption trends may be more visible in the southern Low Countries, seeing as a larger number of inhabitants consume more meat. Nevertheless, the importance of the development of Holland in the medieval times cannot be underrated. These small towns grew to large economic and industrial areas (Regteren Altena 1988, 80). The diachronic changes in consumption patterns of pre-urban settlements to urban settlements provide information on this growth, and the changes in lifestyle of the inhabitants of these towns.

Methodology is another important factor that may have an impact on the differences between the research from Belgium and this thesis. Even though both analyses use the NISP to calculate relative frequencies, the literature available on medieval and early modern archaeozoological assemblages from Holland was scarce, and several smaller assemblages had to be used for analysis. Some of these might have been disregarded should more excavation reports with zoological details have been available. However, acknowledging this, these smaller assemblages were crucial within this research as data was limited. The faunal remains from Belgium were considerably larger than those available from Holland. Consequently, it is acknowledged that limitations as such could have an impact in the results. Nevertheless, this survey has yielded interesting results that can be used for future research.

5.3 Further research

Further research is needed to improve and enlarge the dataset and results presented in this thesis. It is important to note that this survey should be complemented with more data. Most importantly, a better understanding of medieval food consumption can be addressed by analyzing mortality patterns of pig, sheep and cattle for every site. This will provide more insight in the ages animals were slaughtered and what the animal was exploited for, especially concerning sheep and cattle. Slaughter ages can be determined by analyzing tooth growth (eruption and tooth wear stages) and the epiphyseal fusion in long bones (van Wijngaarden-Bakker 1972, 35).

When animals have erupting teeth, the surface is covered in enamel. The ageing of animals by wear stages is based on that over a certain number of months or years, the enamel on their teeth wears away. These tooth wear stages are determined for cattle, sheep/goats and pigs (Grant 1982, 91). These stages of tooth wear can be helpful in determining the relative age of animals. These are, however, not absolute ages and can only be used to give an indication or estimation of age (Grant 1982, 105). Teeth are most likely to withstand various postdepositional forces, so the use of teeth for determining the age of death of animals is very useful (Greenfield and Arnold 2008, 836). This would be beneficial for further research, should the assemblages contain enough preserved teeth.

Long bones have different fusion stages in different animals. By analyzing these stages of the fusing of epiphyses from the faunal assemblages, it is possible to determine at what age the animal stopped growing. All mammals have different stages of epiphysis fusion. In the case of pigs, for example, when the animal is around one year old, the distal humerus, proximal radius, proximal phalanx 2, and the acetabulum start to fuse. The next fusion event starts when the pig is around two years of age, when the distal tibia, distal fibula, distal metapodias, and the proximal phalanx 1 fuse (Bull and Payne 1982, 67). The third group of bones that fuse between three and three and a half years of age are the proximal humerus, proximal and distal ulna, distal radius, proximal and distal femur, proximal tibia and proximal fibula (Bull and Payne 1982, 67). These events and ages differ per animal, but have been well defined, and is very useful for ageing faunal remains.

Unfortunately, the majority of the articles and excavation reports used for this research do not mention dental development and wear stages or the fusion of epiphysis, which means there is a 'gap' in the archaeozoological record. These assemblages will have to be revisited and detailed should this research be performed. This data will also contribute to answering more complex research questions, such as visible trends in the absolute decline or increase of importance of pig and sheep remains.

Additional research on the trauma pathologies will also help us to understand past human-animal relationships better. This will shed light not solely on the consumption of animals, but on the interaction of humans and animals before slaughtering, husbandry and what was the main exploitation of animals (Groot 2008, 42). In addition, research on the relationship between town and countryside and the origin of animals consumed in these towns would also be necessary, to document the local exchange networks between towns and their rural hinterland (Groot and Lentjes 2013, 19). This can be done by including faunal assemblages from the countryside in the research, while mostly analyzing what elements have been found. Additional taphonomical analysis can also help us to understand the function of each deposit. Is there an abundance of slaughter or workshop refuse, or does the assemblage mostly contain consumption waste (Gautier 1987, 48-49)?

Within archaeozoology there is also still much to gain from the study of all groups of faunal remains from medieval sites. Several research papers and books only analyze the consumption of fish or mammals. However, to be able to reconstruct the entire consumption pattern of a society, all this data should be integrated. This does require all archaeological sites to be sieved for example, seeing as without these collection methods the data will also be biased because smaller remains of fish and microfauna will not be recorded, and capable researched able to analyze these species (Groenman-van Waateringe and van Wijngaarden-Bakker 1990, 283).

Another approach to archaeozoological research in medieval towns is to combine archaeozoological finds with stable isotopic analysis. Food chains and ecosystems can be reconstructed by looking at natural distribution of carbon and nitrogen isotopes (Zangrando *et al.* 2014, 128). The use of strontium isotopes in

livestock allows us to explore the origin of the livestock as strontium can be used for geological reference. This is done by looking at the strontium isotope radios in skeletal tissues and comparing them to strontium ratios of the environment (Laffoon 2012, 2372; Tornero 2010, 163). Stable isotope analyses can therefore be useful to recreate environmental conditions in which livestock lived and help to provide more information on farming regimes (Bogaard and Outram 2013, 334; Tornero 2010, 164).

Furthermore, research on whether these trends are also visible in the eastern part of the Netherlands, or if, as suggested, there are higher P/S ratios because of the more wooded areas, would be beneficial for a better understanding on consumption patterns in medieval Netherlands. This would add to the research, and would also be helpful in determining whether pigs were herded elsewhere and imported to the larger cities, or whether they did not produce a surplus.

An integrated study of eco-archaeological aspects of medieval societies in the Netherlands would also be advised (Groenman-van Waateringe and van Wijngaarden-Bakker 1990, 283). To be able to view a society completely and correctly, one also has to look at the reconstruction of the landscape, and combine archaeobotanical research with archaeozoological research. Moreover, the surveys of different parts of medieval Netherlands should be combined to create an updated survey concerning the entire country as opposed to separate studies for each area.

6. Conclusion

This thesis has investigated the current status of archaeozoological research in Holland regarding the consumption patterns on the three main domesticates through time. It obtained interesting results evidencing that diachronic trends in the relative frequencies and Pig/Sheep ratio can be detected and are comparable to a certain extent to those of Flanders. As stated in Chapter 2, the aim of this thesis was to explore in what quantities the three main domestic meat-suppliers were consumed; whether the relative frequencies evidences trends; to determine the Pig/Sheep ratio of these towns; and to investigate whether the diachronic patterns would be similar to medieval Flanders.

The use of relative frequencies and the Pig/Sheep ratio has proven to be useful to a certain extent. The methodology presented in this thesis provides an approach to view patterns and trends within the quantity of remains from the three main domestic meat suppliers in medieval North- and South Holland: cattle, sheep and pig. One important aim of this research was to compare the archaeozoological record of late medieval and early modern towns in the county of Holland to those of Flanders and Brussels in order to check homogeneity of patterns within the Low Countries. To achieve this goal, an updated survey has been presented on all available archaeozoological assemblages from Amsterdam, Rotterdam, Delft, Den Haag, Alkmaar, Haarlem, Gorinchem, Gouda and Leiden. Earlier archaeozoological surveys from the Netherlands were outdated or inaccessible and failed to address differences in methodology. The archaeozoological data analyzed in this thesis resulted in unexpected diachronic and geographical trends for medieval Holland.

The results from this study indicate that there were indeed diachronic and regional trends in food consumption during the late medieval and early modern times in Holland. Several trends were not necessarily expected nor in line with research done in other parts of the Low Countries. One of the results that was evidenced in Flanders but did not correspond with this research is the continuously low P/S ratio, meaning a relative abundance of sheep remains as opposed to pig remains, after the 15th century. The results evidence that most of the noticeable trends were influenced by environmental factors and landscapes surrounding the towns in question. The connecting landscape factors of these towns are that they are all dominated by salty

meadows, marshes, bogs, heath-landscapes and polders, which are well suited for sheep herding, whereas pigs tend to favor wooded areas. These results are encouraging and larger sample sizes would benefit future research.

Even though considerable progress has been made, there is much to gain from expanding o archaeozoological research on medieval Netherlands. This study provides a framework for further research on this subject. Future research on similar trends in the eastern parts of the Netherlands might extend the explanations of landscape influenced trends. It is important that further analyses should be undertaken in these areas.

To be able to expand more on research such as this, it is important to make archaeozoological reports and excavation reports describing faunal remains more accessible. More specific research topics will be able to be answered should more data become available, such as the analysis of absolute importance as opposed to relative importance of cattle, sheep and pig remains. However, it is advised to view this research in a broader context, while also consulting research on historical sources, the relationship between town and countryside and the incorporation of other eco-archaeological aspects to create a more detailed understanding of medieval food production and consumption.

Abstract

This thesis presents a new survey of archaeozoological data from 10 towns, with a total of 60 assemblages, from the medieval county of Holland to determine diachronic and geographic trends in the meat consumption in urban areas. The methods used are based on the recent article by Ervynck and van Neer, which suggested that integrating the archaeozoological data from the southern Low Countries with research from the Netherlands would be beneficial for current research (Ervynck and van Neer 2017, 72).

The research was performed by calculating the relative frequencies of cattle, pig and sheep, and consequently, calculating the Pig/Sheep ratio. This data has been collected in one survey. The diachronic and geographic trends that emerged from this survey were investigated and compared to the results from similar research in Flanders.

The results of this study suggest that environmental factors were a very important influence in the consumption patterns of medieval towns. There are similarities in the relative frequencies and Pig/Sheep ratios of towns with similar environmental factors, mostly those towns located in areas of salt marshes, peat bogs and alluvial districts. These environments are much more suitable for sheep herding than pig herding. Other trends are less clear. The Pig/Sheep ratio is somewhat higher in towns such as Amsterdam, Alkmaar and Haarlem than expected from the research done in Flanders. It is still uncertain what the main cause for these high Pig/Sheep ratios is. However, it does seem that the consumption of pig is likely to have been less than the consumption of sheep based on the relative frequencies. Future research on these towns in comparison to the countryside is therefore advised.

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Appendix A: Inventory of archaeozoological remains

Table 3: Complete survey of archaeozoological remains from late medieval and early modern Holland, concerning ten different towns and 61 different assemblages. N is the total amount of remains from cattle, pig and sheep. The percentages are relative and calculated by using N. The P/S ratio is calculated using the relative frequencies of pig and sheep. Ref. archaeozoology is the literature from which the data has been used.

Municipality / Site	Date	n	%cattle	%pig	%sheep	P/S	Ref. archaeozoology	Comments
Amsterdam								
De Nes	13-15	446	32	50	18	2.7	Baart 1977, 495	
St. Olofskapel	14-15	398	65	27	8	3.4	Van Wijngaarden-Bakker 1972, 34	MNI also in literature
Sint Pietersgasthuis 1	14-15	369	23	56	21	2.6	Clason 1966, 88-89	
Ca	14-15	307	72	24	4	6	Baart 1977, 495	
St. Jansstraat	14-15	124	54	41	5	8.2	Baart 1977, 495	
Damrak	14-15	113	78	20	2	10	Baart 1977, 495	
Warmoesstraat	14-15	46	59	20	21	0.9	Clason and van Wijngaarden-Bakker 1969, 258	
Sint Pietersgasthuis 2	15-16	57	79	16	5	3.2	Clason 1966, 88-89	
Herengracht	17-18	221	13	26	61	0.4	Gawronski and Jayasena 2013, 30	MNI also in literature
Haarlem								
Gerechtsgebouw	12-18	378	66	20	14	1.4	Seeman 1984, 28	
Grote Markt	13-15	682	50	34	16	2.1	Van Wijngaarden-Bakker 1980, 53	
Bank van Lening	15	143	57	26	17	1.5	IJzereef 1977, 14	
Gravinnehof A	15-17	173	46	15	39	0.3	Esser 2002, 71	
Groenmarkt	15-18	80	63	10	27	0.4	Horrée 1988, 51	

Gravinnehof B	17-18	17	23	59	18	3.2	Esser 2002, 71	
Delft								
Voordijkhoornsepolder	12	611	53	6	41	0.1	Van der Jagt 2011, 139	Number of elements in literature
Voldersgracht	13-14	18	28	28	44	0.6	Van der Jagt 2013 in van Dijk and Kerklaan 2017, 27	
Buitenwatersloot	14	31	45	26	29	0.8	Van Dijk and Kerklaan 2017, 26	
IHE	14-15	138	60	15	25	0.6	Bult 1992 in van Dijk and Kerklaan 2017, 27	
Den Haag								
Annastraat	14	209	50	8	42	0.2	Carmiggelt and van Veen 1995, 13	
Lange Voorhout A	14-15	156	39	20	41	0.4	Jacobs and van Veen 1996, 14	
Achterom A	15-16	49	43	4	53	0.07	Nieweg 2007a, 54	MNI also in literature
Voldersgracht	15-17	422	49	6	45	0.1	Nieweg 2007b, 41	
Lange Voorhout B	16-17	46	67	13	20	0.6	Jacobs and van Veen 1996, 29	
Lange Voorhout C	16-17	57	26	4	70	0.05	Jacobs and van Veen 1996, 42	
Aprochestraat	16-17	552	61	8	31	0.2	Esser and Beerenhout 2012, 290	
Boekhorststraat	17	143	53	11	36	0.3	Carmiggelt and van Veen 1995, 17	
Achterom B	17-18	80	28	21	51	0.4	Nieweg 2007a, 57	MNI also in literature
Binnenhof	17-18	73	47	8	45	0.1	Carmiggelt 1992, 43	
Rotterdam								
Grote Markt A	14-15	72	56	19	25	0.7	Esser *et al.* 2013, 365	
Grote Markt B	15-16	641	56	5	39	0.1	Esser *et al.* 2013, 365	
Timmerhuis A	16-17	140	64	11	25	0.4	Esser *et al.* 2015, 292	

Timmerhuis B	17-18	325	57	14	29	0.4	Esser *et al.* 2015, 294	
Alkmaar								
Hooge Huys	10-12	114	59	7	34	0.2	Clason 1972, 103	
Hema	11-12	26	65	16	19	0.8	Clason 1972, 103	
Witteveen	12-14	191	53	4	43	0.1	Clason and Brinkhuizen 1978, 129	MNI also in literature
City hall	14	24	71	4	25	0.2	Clason 1979, 59	
Laat 233-237	15-16	50	64	16	20	0.8	Van Haaster *et al.* 2012, 59	
Langestraat	15-17	203	30	24	46	0.5	Esser *et al.* 1997, 205	
Voordam	16	64	36	23	41	0.5	Van Haaster *et al.* 2012, 68	
Ritsevoort	16-17	59	39	17	44	0.4	Van Haaster *et al.* 2012, 73	
Nieuwesloot	16-17	41	76	17	7	2.4	Van Haaster *et al.* 2012, 81	
Wortelsteeg	16-17	96	38	4	58	0.07	Esser and Gehasse 1995, 85	
Gouda								
Bolwerk A	14-15	271	51	12	37	0.3	Esser *et al.* 2010, 245	Pre-urban period
Bolwerk B	14-15	72	56	22	22	1	Esser *et al.* 2010, 250	
Bolwerk C	15-16	67	74	13	13	1	Esser *et al.* 2010, 254	
Leiden								
Aalmarkt 1	12	60	47	35	18	1.9	Esser *et al*. 2011, 177	
Aalmarkt 2	12-13	55	62	16	22	0.7	Esser *et al*. 2011, 179	
Aalmarkt 3	13	384	59	25	16	1.5	Esser *et al.* 2011, 180	
Aalmarkt 4	13	357	62	24	14	1.7	Esser *et al.* 2011, 189	
Aalmarkt 5	13	165	48	28	24	1.1	Esser *et al.* 2011, 193	

Aalmarkt 6	13	257	58	27	15	1.8	Esser *et al.* 2011, 200	
Aalmarkt 7	14	95	54	26	20	1.3	Esser *et al.* 2011, 202	
Vismarkt	14	204	61	19	20	0.9	Van Wijngaarden-Bakker 1979, 47	MNI also in literature
Aalmarkt 8	15	598	47	7	46	0.1	Esser *et al.* 2011, 205	
Pesthuis	17	83	70	5	25	0.2	Van Hees and van Dijk 2018, 53	
Gorinchem								
Groenmarkt	14-15	99	55	15	30	0.5	Hoogendijk 2012, 51	
Groenmarkt 8	14-15	542	35	25	40	0.5	Weterings 2009, 275	
Blijenhoek	16-17	104	45	2	53	0.04	Van Haaster and Cavallo, 1997, 7	
Monnickendam								
Town center	13-14	240	64	28	8	3.5	Seeman 1989, 126	

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