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A Zooarchaeological Study of Animal Consumption in Medieval Viljandi

MA thesis

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Abstract

This thesis deals with animal bones from the medieval town of Viljandi. My aim is to study the consumption of different species and possible spatial, temporal and social differences thereof. Bone assemblages from Viljandi’s suburb, town and castle area are analyzed with osteological, quantitative and statistical methods.

Most of the consumed species in the town have been cattle, sheep, goat and pig, but there are also some evidence of horse meat consumption. Bird bones belong mostly to domestic fowl. Dogs and cats have most probably been kept as pets, despite that there are few indicators of other kind of utilization also. Wild animals have not been very abundant, although the species diversity is quite extensive, including quite extraordinary red deer and European bison. Spatial differences in the town show, that the castle area differs the most, however the suburbs and town are quite similar. Some patterns of the consumption of main domesticates in time are also seen, but any social differences are hard to draw. Nevertheless, occurence of various game and scarce bird species in the town and castle area is an indicator of higher status.

Key words: zooarchaeology, osteology, Middle Ages, animal consumption, urban bone assemblages.

Contents

Introduction

The present thesis deals with animal bones from the medieval town of Viljandi in Southern Estonia. Although some of the archaeological animal bones have been identified and respective reports have been appended to the excavation reports, and some articles about different findings have been written, no profound studies on zooarchaeological data from Viljandi have been carried out yet. My aim is to analyze some osteological material excavated in the last twenty years and to make initial conclusions about the animal consumption in Viljandi in the period of the Middle Ages, i.e. from the 13^{th} to the end of the 16^{th} century.

Viljandi belonged to the smaller Livonian towns during the Medieval Period. Although it was not as important as Tallinn or Tartu, it was a part of the Hanseatic League and a location for one of the most powerful strongholds of the Livonian Order – branch of the Teutonic Order. The number of written data about medieval Viljandi is small. The oldest source about the street network, plots and landowners is the Polish inventory from 1599 (Valk 2005, 97; Viljandi linn...). However, these documents do not include the social or cultural aspects of the people's life and therefore archaeological source material must be studied to investigate the town's history (Haak 2007, 40). One important, and often most numerous, source material is the animal bones.

Two main terms marking the discipline that studies archaeological animal bones, are zooarchaeology and archaeozoology. According to Reitz and Wing (2008, 3–4), the latter emphasizes the biological nature of animal remains and may be interpreted as the study of ancient animal remains without any relationship to human behavior. I, however, use and determine myself with the term *zooarchaeology*, since it reflects the anthropological perspective of studying animal remains for information about human behavior and implies a cultural and social perspective rather than a zoological or ecological one (Reitz & Wing 2008, 3–4). Zooarchaeology has two related goals: to understand the biology and ecology of animals, and to understand the structure and function of human behavior (Reitz & Wing 2008, 11). As Davis (1987, 19) has stated: "zooarchaeology bridges two disciplines – palaeozoology and anthropology / archaeology". To address these goals, zooarchaeology uses theories and methods from three sources: biological and physical sciences, anthropology and archaeology (Reitz & Wing 2008, 11).

Zooarchaeology has developed within the archaeological research: on classification and descriptions in the 19^{th} century, on cultural history in the early 20^{th} century, and on context and function in the 21^{st} century. Many research questions from earlier centuries guide modern zooarchaeological research, although the methods have changed. (Reitz & Wing 2008, 14) Early faunal studies in the 19^{th} century were largely conducted by scientists with biological education and interests (Reitz & Wing 2008, 15) and the way zooarchaeology was approached, was mainly palaeontological (O'Connor 2003, 71–72). In Estonia, the beginning of the use of the results and methods of natural sciences was related to the work of Constantin Grewingk in the end of the 19^{th} century – he laid the foundation for palaeozoology with the identification of animal bones found from the settlement site of Kunda Lammasmägi. At the same time and also in the beginning of the 20^{th} century the best osteologist in the world at that time and also a very good expert of Estonian faunal history was Aleksander Rosenberg. (Kriiska & Lõugas 2006, 270)

The palaeontological approach continued in the first half of the 20th century (Reitz & Wing 2008, 17). For a short period faunal remains in Estonia were not identified, but the work started again in the 1930's by palaeozoologist Johannes Lepiksaar (Kriiska & Lõugas 2006, 272). In 1940's the central issues in zooarchaeology were context and function, within they started also to consider the role of plants and animals in culture (Reitz & Wing 2008, 15). In Estonia in the post-war decade the help of Russian and Latvian zoologists was used to identify the animal bones, since J. Lepiksaar had emigrated to Sweden. In the 1950's the study of osteological material was started again, this time by zoologist Kalju Paaver. (Kriiska & Lõugas 2006, 275) In the Western countries in 1960's biology and geology had found their place in ecologically oriented archaeological research, although there were still many archaeologists, who did not consider the environmental material important while studying the cultures (Reitz & Wing 2008, 19). By the late 1970's, zooarchaeology as a whole was still discussing and testing its methodology, and few innovations specific to urban zooarchaeology had found their way into the literature (O'Connor 2003, 71). In Estonia the development of zooarchaeology during the post-war decades was not that intensive (Kriiska & Lõugas 2006, 290). As from the 1990's there are two palaeozoologists in Estonia, who have been studying the archaeological bones – Lembi Lõugas and Liina Maldre in the Institute of History, Tallinn University. L. Lõugas has been concentrating mostly on prehistoric and medieval fishing, the forming of the post-glacial seal populations, the temporal changes at the Pleistocene / Holocene transition and utilization of primeval natural resources. L. Maldre has focused mainly on domestic animals, studying their sex, age at death, pathologies, size and breeds. Some bone identifications, especially of the assemblages from Viljandi, has also been done by Paul Saks and Eha Järv from Estonian University of Life Sciences. (Kriiska & Lõugas 2006, 282–283)

In the beginning zooarchaeology was concerned with subsistence economies, rather than with the political economy of settlements and cultures (O'Connor 2003, 72). Now the connection between animal bones and cultural studies is becoming more and more relevant: the understanding of the structures that controlled production and distribution, and the social relations of those structures, are essential to a full interpretation of the animal bone evidence (O'Connor 2003, 73) and vice versa – animal bones are essential to understand these structures.

The only study about the animal bones from medieval Viljandi has been written by archaeologist Arvi Haak (2007). He considers bone assemblages partly from the same sites as I do in current study, but his survey remains rather superficial and generalizing. Works about other medieval towns in Estonia have also remained quite disperse and mostly from the zoologist's point of view. Liina Maldre has analyzed the age, sex, shape, size and pathologies of the main domesticates from Tartu, Pärnu and Tallinn (Maldre 1993, 1997a, b, 1998, 2003, 2007, 2008a, b). She has also investigated bone processing in medieval Tallinn (Luik & Maldre 2003) and written an article about dogs' coprolites, although not from the Medieval Period (Maldre 2003b).

Much inspiration, methods and ideas I got from Bengt Wigh's (2001) dissertation about the animal husbandry in the Viking Age Birka. Although this study does not include Medieval Period, it has a very good structure and analytical part to take as an example – he describes his methods and results very clearly, although there is a lack of theoretical part and other source material like historical documents. A second dissertation that I frequently used, was Anna-Kaisa Puputti's *Living with animals* (2009), where she has developed a very up to date theoretical approach, which is quite new in zooarchaeological studies. Yet another dissertation

I slightly used, is by Auli Tourunen, whose work is about animal bones from Turku to explore the role and importance of different animal species in the town and its hinterlands during Medieval and Post-Medieval Periods (2008). However, this study is not that useful for my thesis, because it bases more on historical documents and therefore I could not draw much comparisons to my own material yet.

The main source material for my thesis derives from the excavations carried out at the construction site of Viljandi's new Sports Centre in 1999. It was an area located just close to the medieval town wall but outside the town. Based on the great amount of animal bones, traces of iron processing and location at an important road leading to the town gates (the Riga gates), it has been interpreted that the site was a courtyard of a tavern, by which a smith has also worked (Tvauri 2000, 56). Although the cultural layer was very homogenous and exact chronology of different stratigraphical units was not possible, the site has been dated based on artifacts from the 14^{th} to the 16^{th} century (Tvauri 1999, 5).

The animal bones tell us a lot about economical trends at the time, differences in society, connections between the town and its hinterlands, trade, craftsmanship, agriculture, husbandry and living environment. The tavern and smithy site alone cannot give much information about the animal consumption in the whole town during this time period. Therefore I included also other sites in my study to see the differences and / or similarities between different parts of the town. Because of the nature of other source material and also because of limited time span, I could only use eight sites from the town in addition to the tavern and smithy site. Even though there have been a lot of excavations, most of the animal bones collected have not been identified or analyzed yet. So I can use only the sites where this work has been carried out, although the analysis have been done by other researchers who used somewhat different methods. Nine sites which are concerned in the present thesis are divided into three town areas: the suburbs, the town centre and the castle. All areas are different by social factor, because there were different rules and social hierarchy in medieval towns according to the inhabitants and housing in different parts of the town. And this distinction is expected to reflect also in the consumption of animals as selection of species, body parts and ages of individuals.

During the studies I have been quite critical towards my limited source material. The main problem is that although the largest bone assemblages come from urban excavations and in general form a very good source material for research, the town's excavations are mostly rescue excavations and therefore the material is biased and the possibilities to interpret it decrease. There are perhaps too few sites included in the work, so any results would be unsuitable to apply for the whole town. Likewise, many conclusions are based only on the tavern and smithy site material, because only there I could describe individual bone fragments by estimating their age, sex and size. Other bone assemblages were identified by Eha Järv and Paul Saks, who used somewhat different methods and therefore our obtained data are incomparable. Nevertheless, the total number of bone specimens studied in the present thesis is 26 788, which is a quite considerable amount for source material. Even though I cannot analyze the assemblages completely and get all the possible information, I can still make some conclusions based on the information I have. As Bengt Wigh (2001, 36) has well said: "it can prove more rewarding to analyze a greater number of bones, but with lower ambitions".

The questions I can arise based on my source material, are mostly economy oriented and related mainly with the distribution of species and their body parts. My primary aim is to study the meat supply of Viljandi in the Medieval Period.

- Which species contributed to the meat consumption and in which relative quantities?
- What does the distribution of body parts show – do the bones derive from butchery or kitchen waste?
- What can be concluded based on the age and sex distribution of the main domesticates?
- Would it be possible to get some knowledge about the herds?
- Further, how were the animals utilized? Are there evidences of pelt or bone processing?
- Which evidence are there for pet animals?
- What was the degree of wild animal meat consumption?
- Are there any consumption patterns influenced by certain time periods (e.g. the Livonian War)?
- Is it possible to say something about the variation of the three areas in the town?
- Is there enough material to see any temporal changes?

To answer these questions, all nine sites should be comparable and consistent. For that I applied three kinds of methods – description of the individual bone fragment, quantification of the bone assemblage and carrying out of statistical analysis.

My thesis does not apply to overall study of the animals in medieval Viljandi, because the source material forms only a part of the whole town. Instead, this paper could be treated as an introduction to subsequent and more profound studies. Since my knowledge of zooarchaeology before writing the thesis was minimal, it has had a very important personal aim: to acquaint myself with the basic methods, researchers and literature in the field of zooarchaeology.

The work is divided into six chapters. I will start with a theoretical background to my research in chapter 1 and continue with introduction of my source material and description of the methods in chapters 2 and 3. Fourth chapter is dedicated to the analysis of bone assemblage from the tavern and smithy site of Viljandi and fifth chapter to the rest of assemblages studied within my research. Finally, in chapter 6, I will discuss the results and try to answer the questions I posed.

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Chapter 1. Theoretical framework – from quantitative to qualitative

In this chapter I look upon the theoretical trends that form the base of my studies. First I present and discuss the empirical source material and point out its strengths and weaknesses. Then I write about giving meaning to the empirical data, so that it could be used in gaining knowledge about the society under investigation.

1.1. The empirical source material

As seen in the introduction, zooarchaeology was introduced already in the 19th century, when first great men got interested in prehistoric animal remains. And yet, it was only in the mid-20th century this discipline took the direction to the use of more scientific methods. The historical development of zooarchaeology is considered to be fundamentally connected to the rise of processual archaeology in the 1960's (Puputti 2009, 10). Even though a lot of criticism was and is directed towards this theoretical school, zooarchaeological studies, at least the basis of them, tend to stay in its framework. That is because zooarchaeology is based on empirical material – the animal bones. According to empiricism the data will speak for themselves without the benefit of any explicit theoretical perspective and are generally kept separate from the distortions of subjectivity and any interpretations made (Darvill 2008, 144).

However, to get information from empirical material, quantitative methods must be applied. These include counting of the fragments, distributing species and body parts, calculating age, sex and size of the animals. Also, looking for cut marks, identifying pathologies, working with entries in different databases, calculating operations and making diagrams. During the handling of this kind of data, the researcher must be of course objective, but he or she must also have some preunderstanding. It is important to have a hypothesis before the analysis, because posing questions and knowing, what to look for and on what to put more attention, makes the study most effective. As O'Connor (2008, 28) has said: "our study of the bones has to begin when the archaeological excavation is planned and not when it finishes".

Taphonomy

During the quantitative analysis it must be remembered to be critical towards the source material and also to ask, why the bones are deposited in the first place. Animal bones studied in a zooarchaeological research are only a small and modified part of the animals that lived, grazed and bred hundreds of years ago. Study of the processes by which animal bones are transformed by human and natural processes during their incorporation into archaeological deposits, their subsequent long-term preservation within those deposits, and their recovery by archaeologists, is called taphonomy (Darvill 2008, 448). As Terry O'Connor (2008, 19) has written: the domain of taphonomy is "the filters which lie between the original living populations of vertebrates and the dead bones on the researcher's bench, and between those bones and the published account of them". The term originates from palaeontology, but has been applied to archaeological bones by B. Hesse and P. Wapnish in 1985, and summarized by O'Connor (2008, 19–21), whose list of processes I use to place my source material as well:

1) *biotic processes* are those of the pre-death period, including also the human activity – in Viljandi most of the consumed animals derived probably from rural areas; life conditions for animals affected them during their lifetime, influencing their size, health, age and breeding;
2) *thanatic processes* are those which bring about the death and deposition of the remains of animals – mostly, as in the case of Viljandi, it is the slaughtering, butchering, cooking and consuming the animals in different ways in particular places;
3) *perthotaxic processes* are those which result in the movement and destruction of bones before they are incorporated into a forming cultural layer – in the town, after discarding the bones, they might have removed or accumulated in another place and for some time they might have been exposed to outer factors like gnawing and spreading by other animals;
4) *taphic processes* are those of physical and chemical changes which may result in a bone being well- or poorly preserved – in Viljandi the bones are quite well preserved;
5) *anataxic processes* are recycling processes by which buried bones are re-exposed to fluvial action, sub-aerial weathering, trampling and other attritional processes – in Viljandi these include mostly the construction works in Medieval and Modern Periods;
6) *sullegic processes* are archaeological activities – the location of the excavation plot, excavation methods (in case of Viljandi's tavern and smithy site quite a large area was investigated in a short time with no sieving, the bones were collected as one assemblage and chronological layers were hard to distinguish), sampling decisions (e.g. the decision of archaeologist to leave part of the bones from the castle excavations in 2002 unidentified) and treatment of the material after the excavations (the bone material from Viljandi stayed ten years in storages without any correct treatment);
7) *trephic processes* are the curatorial and research decisions related to sorting, recording and publication – in the present work these are strongly affected by my limited experience in zooarchaeological research.

As seen, the material that reaches on the working table of a zooarchaeologist, has gone through many processes. The strength of the empirical material – its factual nature – is biased by taphonomical processes. Thus, the most accurate documenting of the facts and features of the material is essential in order to get as much information as possible, although precise documenting does not guarantee a correct outcome of the analysis and true interpretations. However, the analysis of empirical bone material must be followed by subjective interpretation.

1.2. Interpreting empirical data

Only when the data is collected, the database fulfilled and calculations made, it is time to give meaning to the empirical material, to become interpretative and to see beyond the numbers. Interpreting the quantitative data and transforming it to once living animals consumed by people, a lot of information could be gained about the society and cultural pattern: the way animals were kept, fed, slaughtered and consumed reflects the cultural factors present in that time. Relationships between people and animals are constructed in daily encounters and communication, and they are closely intertwined with economic activities and subsistence

(Puputti 2008, 10). The problems being usually raised, especially for the historical time periods, are socio-economic and ethnic variations in foodways, market systems of animal-derived products and craft specialization (Puputti 2008, 11). But as Puputti (2008, 11) also says: “It has been acknowledged, that cultural factors deeply affect the choice of food, the discard patterns of animal remains and the relationship between people and different animal species, and that simple functional and economical interpretations of archaeological animal bone finds fail to take into account the complexity of attitudes to food and animals”. Hence, the possible interpretations should go even further, while trying to study the *mentality* of the society. What was the relationship like between medieval man and animal? What animals were more respected than others and why? What were the differences between different social classes of the town and how did animals represent someone’s higher or lower status? What were people’s attitudes towards the animals? These questions have become more and more abundant in later studies, because “attitudes to animals, besides being interesting in their own right, also open up the worldviews and social relationships in the past” (Puputti 2008, 11). Of course it is hard to answer these kinds of questions about culture and society based on animal bones – even if the material would be perfectly complete (which is hardly possible in archaeology). But I consider it very important to at least start posing these questions and to use the material that is available, because this inspires to study forward. After all, this is the nature of science – to evolve. Also, to answer the questions about the animal-man relationship and the society as a whole, interdisciplinary approach is needed. Bone material must be put side to side with other data offered by archaeology, history, anthropology, ethnology and all other fields that deal with cultural history and recreation of the past.

The viewpoints I outlined in the present chapter are in my opinion part of the nature of zooarchaeology. This is the way I see it and these are the problems I would like to find solutions. However, in my present work, as said, the source material is unfortunately not complete to study such fundamental issues.

Chapter 2. The material

In this chapter I give a brief overview of the town – its description, functions and significance during the Middle Ages. Then I present the locations of the town sites, where my research material derives from. I introduce the excavations of the tavern and smithy site, its methods, finds, interpretation and datings. Finally, I give a general description of the animal bones from all the sites.

2.1. Background – the town of Viljandi

Viljandi was one of the nine medieval towns in Estonia, being located on the high plateau above the lake valley. It was a rather small town with a territory of 10.2 hectares, with an addition of the castle area of 4.6 hectares. Viljandi was defended by a stone wall and four towers, it had two major gates – Tartu and Riga, and one minor gate leading down to the lake. The town was part of a fortification system of one of the mightiest castle of the Teutonic order in Livonia as an outer bailey. (Valk 2005, 96) The population in the town during the Middle Ages is estimated to 1000–1500 inhabitants (Haak 2006, 68). Despite its small size, Viljandi was at least since AD 1346 a member of the Hanseatic League together with Tallinn, Tartu and Pärnu in the territory of present-day Estonia (Haak & Russow in prep.).

The date of the starting point for the construction of the castle in AD 1224 has usually been seen as a start of activities in the territory of the medieval town as well. Its formation was rather intense since AD 1250, but the first mentioning of the town and determination of the borders of the town *mark* was not until in AD 1283. By the end of the 13th century, Viljandi was surrounded by a town wall. By mid-14th century it had emerged into a Livonian small town, clearly distinguishable from nearby villages. However, connection between town's people and agriculture were very intense. Even at the beginning of the 16th century the inhabitants still had gardens within the walls in addition to arable land close to the town. (Haak & Russow in prep.; Viljandi linn...)

It seems as if in the territory of the suburb human activities began during the first half of the 14th century (Haak & Russow in prep.). The suburb was a place for people of lower status and for the people who dealt with dangerous or unpleasant activities, like smithies and potters, butchers, tanners and other. Life in a suburb had also more agrarian characteristics, including animal husbandry. (Haak 2006, 68)

The sites considered in the present thesis are located scattered all around the medieval town area. Based on their location, I divided them into three groups: suburban area outside the town wall, the town itself and the area of Teutonic Order castle.

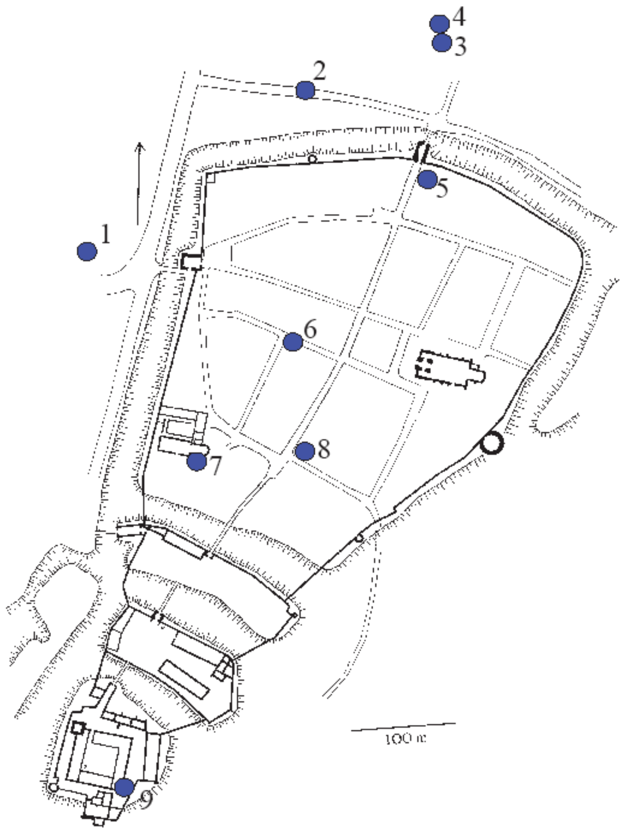


Figure 1. *Medieval Viljandi and the sites studied in the present paper. Suburban sites:* ***1*** *– Sports Centre 1999;* ***2*** *– Tartu Street 1996;* ***3*** *– Lossi Street 2001;* ***4*** *– Posti / Lossi Street 2001. Town sites:* ***5*** *– Lossi Street 1992;* ***6*** *– Munga Street 1989;* ***7*** *– St. John's Church area 1990, 1991;* ***8*** *– Pikk Street 1991. Castle area:* ***9*** *– Order castle 2001, 2002, 2003.*

2.2. The excavations of the tavern and smithy site

In the summer of 1999 archaeological rescue excavations on the construction site of an extension to the Viljandi's Sports Centre were carried out. The site situates west of the medieval old town, in front of the medieval Riga gate. The investigated area of about 330 m^2 had homogeneous medieval cultural layer, which was dated mostly from the 14^{th} to the 16^{th} century (Tvauri 2000, 56).

Description and methods

The excavation site was divided into 21 squares á 4 x 4 meters. The cultural layer was ca 0.8 to 3.5 meters thick and was excavated in four, generally 20 cm thick technical layers. Animal bones were not collected from the 13th square because of the disturbed cultural layer, and also not from the 1.5 meters thick uppermost cultural layer and from the first technical layer, because they contained the material from the 18th to the 20th century. (Tvauri 1999, 2–4) The second technical layer revealed the foundation stones of an outbuilding, with the dimensions of approximately 8 x 4 meters (Tvauri 2000, 56). Most of the bone specimens (3086 sp. – 59.3%) were collected from there. In the third technical layer a pavement consisting of small stones began to emerge and it continued into the next layer (Tvauri 1999, 5). Altogether 1789 (34.4%) bone specimens were collected there. The fourth technical layer reached the depth of natural undisturbed sand (Tvauri 1999, 5). Just above it was the pavement consisting of small stones that covered the whole western part of the excavated area (Tvauri 2000, 56). On the pavement a lot of slag, bases of furnaces, burnt stones, fractions of bricks and rusty nails were found (Tvauri 1999, 5). There were 332 specimens (6.4%) of animal bones found in that layer.

Finds, interpretation and dating

The material from the excavations on the construction site of the Sports Centre is quite special, since it differs considerably from the medieval and modern material that has been found inside Viljandi's old town (Tvauri 1999, 9). A lot of finds associated to smithy and horses were found: slag, bases of furnaces, nails, horseshoes and ice-nails, stirrups, spurs and fragments of horse-bits. Among the more spectacular finds were the dagger point, fragment of an iron helmet and two iron arrowheads. There were also knives, a file, pincers, an axe, borers, scythe, a bar of iron, iron heels, fragments of locks and hinges, iron buckles, etc. Unusually rare, considering the conditions in Viljandi, were potsherds and tile fragments. Also bone objects and the remains of bone processing were numerous, as well as animal bones. (Tvauri 2000, 56)

The construction remains on the excavation plot consisted of two lines of stones. The foundation stones of this approximately 7.5 meters long and 4 meters wide outbuilding lied straight on the natural subsoil. This indicates that the building was founded before the formation of the 15th to the 16th century cultural layer. (Tvauri 1999, 10) So, the beginning of the site formation started probably in the 14th century. The end of the medieval cultural layer is marked with two iron arrowheads from the 16th century (Tvauri 1999, 5).

Considering all the objects associating with a smithy and also the large amount of animal bones, it has been assumed that this was the site of a tavern, by which a smith had been working. This hypothesis is supported with the city maps of the 18th century, where a tavern has been marked at the place of the under discussion site. (Tvauri 2000, 56) Since the tavern and smithy themselves were located somewhere else, then the site investigated had been a paved courtyard with some outbuildings. Considering the increase of the find frequency and thickness of cultural layer towards west, it could be speculated that the tavern and smithy were situated somewhere under the present sports building. (Tvauri 1999, 10)

2.3. The bone material

As common to most of urban archaeological material, it derives from rescue excavations. Only in the castle area scientific excavations were performed, which means that there was more time to use more accurate documenting and methods (e.g. sieving). Fish bones were also collected, especially from the castle area. However, all of them were left out of the present studies, because it would have been too time and space consuming to analyze them in addition to mammal and bird bones. The analyzed bone assemblages include 6927 animal bone specimens from suburban area, 6816 specimens from the town and 13 046 specimens from the castle area.

The bone assemblage from the tavern and smithy site

Because of the time limits there was no soil sieving employed, thus the material is incomplete: there were practically no fish bones collected and evidently, some amount of mammal and bird bones were missed as well. This does not concern only smaller parts of the skeletons – according to Tourunen (2008, 47), sieving impacts also the recovery of bones of middle-sized animals like pig, sheep and goat, especially their vertebrae and ribs. Still, a considerable assemblage of research material was collected.

There were in all 5471 specimens found, whence 206 were very small pieces, 58 had fractured after the excavations, four of them were fish (two of them belonged to a pike) and one bone fragment belonged to a human – thus they were left out. From 5202 analyzed bones and bone fragments 4918 (i.e. 94.5%) were identified to the species, 257 remained doubtful and 27 specimens stayed unidentified. Since the amount of doubtful fragments was rather small, I added them to unidentified fragments. Hence the indeterminacy percentage of the concerned bone collection is 5.5% (284 sp.). Only firmly identified bones were used in subsequent quantitative analysis.

Among the bones there were 15 processed specimens, of which four could be attributed to certain species (mandible and scapula of a cattle, metatarsal of a horse and antler of an elk). Additionally there were 25 worked fragments in the material collected as items (Tvauri 1999, list of findings) that were separated from the bone assemblage and thus I did not include them in my analysis.

The bone assemblages from other sites in Viljandi

Other sites were excavated from 1989 till 2003. Only a small part of all the excavations carried out in that time period is included in my work, because I used only the material, where animal bones have been already identified and material is contemporaneous with the tavern and smithy site. The bones were identified by two researchers from Estonian University of Life Sciences (former Estonian Agricultural University): Paul Saks (Lossi Str. 1992, Munga Str. 1989, St. John's Church area 1990–1991, Pikk Str. 1991) and Eha Järv (Posti / Lossi Str. 2001, Lossi Str. 1992 and 2001, St. John's Church area 1990, Pikk Str. 1991, Order castle 2001–2003). Since they used different methods for recording and measuring the material, I could only use the raw data – number of fragments by species and by bone elements. Because of time limit the additional data (e.g. measurements to calculate the withers' heights or assessments for age and sex) are not gained by me. In some identification reports Järv and

Saks had separated horncores from rest of the cranium, but generally they had registered them as part of the cranium. Therefore, I will present the crania and horncores as one bone element. Also, in case of some objects the bones of sheep and goat have been distinguished from each other, but in the present study I will consider them together, as I did in the analysis of the tavern and smithy site. In the material also human bones were found which I left out of the analysis: three specimens from Munga Street, that can be related to the nearby cemetery (Valk 1990, 26); 66 human specimens from St. John's Church area, that also derive from the cemetery; and 11 specimens from Pikk Street.

Chapter 3. The methods

Zooarchaeological material can be studied by many different methods, comprising studies in morphology, chemistry, history, medicine, evolutionary changes, psychology, philosophy and many more. Most of the researchers, including myself, use morphological methods and the data collected from the source material is based on visible observations and physical features. In the following chapter I describe the methods I have used in the present thesis. These include methods for describing the individual fragment (estimation of age and sex, measurements, cut marks and pathologies), methods for quantifying the data (NISP, MNI, diversity of species and body parts) and methods for statistical analysis. I used methods for describing the individual fragment only for my main source material, i.e. the animal bones from the tavern and smithy site, while quantitative and statistical methods were applied to all bone assemblages. For some analysis I used several methods in order to compare the results. I did not analyze the strengths or weaknesses of the methods, because those are widely used in zooarchaeological works and therefore trustable.

Before analyzing bones from the Sports Centre site, I washed and systematized them. I had previously taken some courses to gain basic knowledge in biology and zoology, but contacts with osteology had been brief. So I began my osteology studies and simultaneously the identification of the source material under supervision of Eha Järv – laboratory assistant in the Morphology Department, Estonian University of Life Sciences. Since the bone material from Viljandi was not so fragmented, I learned the osteology of main domestic mammals (cattle, goat / sheep, pig, horse and dog) fairly fast. The determination process lasted about five months, from June to the end of October 2009.

3.1. Methods for describing the individual bone fragment

The first step in describing a bone specimen is its anatomical and thereafter taxonomic identification (app. I and II). By specimen I mean a skeletal element, i.e. the whole bone, or a fragment of a bone (Lyman 2008, 27). Usually, including this thesis, the identification is based on morphology, "the form and structure of individual organisms" (Allaby 2009, 401). For reference collection I used the anatomical collection of the Anatomy museum in the Zoomedics in Estonian University of Life Sciences. In addition to the skeletal material I found help in the following literature: *Teeth* by Enn Ernits (2000), *Atlas of Animal Bones* by Elisabeth Schmid (1972), *Comparative Anatomy of Domestic Animals* by Robert Barone (1999) and *The Anatomy of Domestic Animals, II. Bones* by Enn Ernits and Paul Saks (2004). From the latter I also took all anatomical terminology used in the present work (app. II).

The taxonomic identification can also be based on the measurements (proportions) of the bones. The latter method is used, when the species are very similar to each other by their bones and are hard to differentiate – for example sheep and goats.

When the bone specimen is identified to species, it should be measured, if possible. The measurements are necessary for calculating the withers' heights, estimating sex and, as said, in some cases identifying the species. In all measurements I used the standards published by von den Driesch (1976). Measurements were taken with a digital caliber with an accuracy of 0.1 millimeters.

The age of animals is usually determined by tooth eruption, tooth wear and epiphysial closure (O'Connor 2008, 80). The method of tooth wear complements data gained from tooth eruption, because the latter can be used only in the cases of not fully matured animals (Puputti 2008, 13). In my study I used the data of tooth eruption presented by Schmid (1972, 77) and the method of epiphysial closure as suggested by Silver (1963, 252–253) for late maturing breeds. Age estimation based on tooth eruption is considered more reliable than the one based on epiphysial closure, because the latter is dependent on several factors such as nutrition, and can therefore deviate from the true age of an individual (Puputti 2008, 13). However, O'Connor (2008, 83) has questioned the term "erupted", because it could mean that clearly "erupting" tooth in the archaeological bone specimen could not have been yet erupted through the gum in a living animal and therefore it might have been recorded as "unerupted" in a study of the live animal. In the case of epiphysial closure I distinguished two phases to assess the age of an animal: open and closed epiphysis. If the epiphysis was closing or had closed recently, I considered it as closed. There were only few epiphyses in the material, even though bones without it were quite numerous. This could mean that loose epiphyses were not preserved or were not collected during the excavations, but it can also indicate to displacement of soil during different earth works. Estimating the age of individual it must be realized though, that the assessments can be applied only if we consider all the changes of the body to have been taken place normally in a certain time period (O'Connor 2008, 83).

Sexing of species is based on different methods. I estimated sex only for cattle and goats, using the measurements of horncores and metacarpals. The latter method is widely used, because metacarpals are usually found unbroken, in large quantities and they show sexual dimorphism more clearly, because bulls' metacarpals are more massive than of cows – probably because of the larger body mass that put extra pressure on the bones in frontal part of the body (Boessneck 1956, 84). In the metatarsals the sexual distinction is not that obvious.

Withers' heights calculations are different for every species and include the measurements of different bones and different factors to multiply the values with. The results must be considered very carefully, because the calculations for single individuals can hardly define the average withers' height for the whole herd or group of individuals. One problem, for example, is that, when animals were slaughtered young, before their skeletons were fully fused, then this part of the herd is missing from the measured sample, biasing the sample mean (O'Connor 2008, 154). Also, it must be remembered that bones of one assemblage could derive from less number of individuals than the number of bones used for calculations. For example, in my study it could be assumed that withers' heights estimations I made based on nine horse bones, could derive from less than nine individuals. The data I got for the animal sizes in medieval Viljandi, is based only on the calculations gotten from the tavern and smithy site bone assemblage.

There can be different marks inflicted on the bones after the death of the animal. According to Noe-Nygaard (1995, 180), they can mostly be distinguished as cut marks, scrape marks, sawing marks, impact marks and chop marks and those marks can be made by different actions like skinning, butchering and marrow-fracturing. The skinning marks are not different from those made during other processes such as butchering, and so, only the repeated pattern of position of the marks, combined with knowledge of which skeletal elements are likely to be affected by skinning, render it possible to recognize them (Noe-Nygaard 1995, 182). Noe-Nygaard (1995, 183–186) has distinguished two types of butchering: dismembering (mostly close to the major joints) and food processing (reducing the size of the dismembered pieces). The filletting marks are produced when the meat is cut free from the bone and marrow fracturing is indicated by two types of cut and scrape marks in order to get the bone marrow. Any kind of human made marks can be confused with trampling marks, caused by the burial process of the bone (Noe-Nygaard 1995, 183–186). In Viljandi's tavern and smithy material I did not distinguish any certain marks. I only recorded them as cut- or chopping marks and did not study them any further. Fine cut marks I attributed to knives and deeper marks to other chopping tools. Partially I also designated the location of cut marks, but in most cases I did not record the location that precisely. I can only present the material and remark that there were cut marks on 2130 specimens (40.9%) (table 1). However, this percentage does not indicate a real amount of bones with cut marks, because the material is fragmented. I also recorded 253 specimens with gnawing marks (4.9%) (table 1), i.e. indicators of the specimens' taphonomical processes. The gnawing had been done by dogs and rodents, but certainly there were teeth marks from other animals as well.

Pathologies can tell us much about animal health and care, as well as their harnessing in different works. In this thesis I had to limit myself with a bare mentioning of the pathologies and anomalies I noticed (app. IV), but probably there were more of them than I could distinguish. For example, missing teeth could have been fallen off already during the animal's lifetime or only after its death, but since I am not qualified in pathologies, then I did not make any differentiations in the cases of empty alveoli (c.f. O'Connor 2008, 103–104). It is also important to ask, what is "pathological" and what is "normal" or "individual variation", because many features can fall somewhere in between (O'Connor 2008, 107). And it is likewise important to ask, how much pathology should we expect to see and at what point did a condition seen in the bone specimen become significant to the animal, in terms of feeding, breeding or mobility (O'Connor 2008, 104)? When did the animal start to feel pain? Or did a disease become visible on a bone whatsoever (O'Connor 2008, 98–99)?

3.2. Methods for quantifying the bone assemblage

I recorded all bones and bone fragments in a computer database Microsoft Office Excel 2007. The chart consists various data about every bone specimen: species, complete / fragmented, bone element, left / right side of the body, processing marks, pathologies, age, cut marks, gnawing marks, measurements and other notable remarks. I identified the skeletal element as precisely as possible, although later it turned out that such accuracy was not even necessary in the following analysis. In case of mandibles and maxillas I marked also the presence of teeth. These teeth were considered together with the jawbones, so they are not reflected in the number of single teeth. However, since in the distribution of the bone types I distinguished all features of cranium as one type, then the exact number of teeth is not important. During the identification process I took as many measurements as possible in order to make different analysis when needed. Most of the measurements are not used in the present thesis, but they could come relevant somewhat in the subsequent studies. Among the material there were also two small burnt bone fragments and five fragments that had turned green as a result of the contact with some metal. If some fragments obviously belonged together, i.e. probably broken during the excavations, then I considered them as one specimen. And if the compatibility was not so evident, I just marked the potential coherence.

In anatomical distribution it is important to distinguish bones that are rich or poor in meat, because this information can reveal the type of a find. Meaty body parts derive from kitchen and meals' waste and include vertebrae, costae, humeri, ulnae and radii, scapulae, coxae and sacrums, femora, tibiae, patellas and fibulae. Non-meaty parts include cranii, metapodials, carpals, tarsals and phalanges and derive from slaughtering waste (c.f. Wigh 2001, 58–59). I will consider this distribution in the analysis in chapters 4 and 5.

The most important goal in quantifying the material is to analyze, how the species and body parts of the animals are represented in the bone assemblage. The first thing to do is to count the *number of identified specimens* (NISP) – the main parameter I used for describing and quantifying the bone assemblage in the present study (table 1, app. III). However, there are several problems with NISP, because it does not give an actual review of the population – all fragments could derive from a single individual. NISP is also affected by the identification percentage, because some species are more difficult to determine. Lyman (2008, 29–30) has presented a list of all possible problems concerning it, wherefrom I will bring out the ones related to my own work:

1) the number of elements that are identifiable varies intertaxonomically – that means different species have different number of skeletal elements;
2) large specimens will be preferentially recovered relative to small specimens;
3) NISP is affected by butchering patterns and differential preservation;
4) NISP is a poor measure of diet, because the bones of one cattle provide more meat than the bones of one sheep;
5) NISP does not contend with articulated elements (should one mandible with three teeth attached to it be considered as one specimen as I have done in my present study, or as four specimens?).

So, NISP counts have their place, but it is a description of the bone assemblage rather than as an estimator of any population parameters (O'Connor 2008, 67). However, NISP has an advantage of being additive or cumulative – the analyst does not have to recalculate it every time new specimens are added to the assemblage, and that property makes NISP a fundamental measure (Lyman 2008, 28).

The other method I used to quantify the bone specimens was the *minimum number of individuals* (MNI) (table 1), which is usually defined as the most commonly occurring kind of skeletal specimen of a taxon in a collection (Lyman 2008, 39). It means that the specimens of the most abundant skeletal element are sorted into left- and right-side specimens and then the higher count is taken as the smallest number of individual animals which could account for the sample (O'Connor 2008, 59). That is the way I calculated the MNI in my work as well. The problem with MNI is that rare taxa are always over-estimated – a single specimen attributed to a rare taxon (e.g. brown bear in my material) will give an MNI of one, while other taxa with the same MNI might be represented by more bones (e.g. cat in my material) (c.f. O'Connor 2008, 60). Also, a MNI value will not show the number of animals that lived or were slaughtered either on the excavated sites or in the town as a whole (Wigh 2001, 45). Another problem is related to aggregation – if one individual is represented in multiple assemblages, for example in two waste-pits, it will be counted twice (Lyman 2008, 45; O'Connor 2008, 60). However, in my material this problem is not relevant, because I treated my source material as one homogenous assemblage without distinguishing any strata.

One of the central issues in my thesis is a diversity of species in different parts of Viljandi (app. I and III). The comparison of animal bone assemblages from different sites within the town should reveal some patterns in the consumption of meat and therefore some differences between social classes. However, the comparative method is not free of problems, because the bone assemblages from different sites are of different size and character. It would be impossible to compare a few hundred animal bones from rescue excavations in a medieval street site with almost ten thousand bone specimens from scientific excavations in the castle area. But I have thirteen sites in Viljandi to compare with each other and the joining of assemblages gives more equal basis for comparison.

3.3. Statistical methods

In the present work I used the chi-squared test as a statistical tool to study the relationship between sample size and species diversity. The chi-squared test can be used to assess the correspondence between distributions in a wide variety of different situations (Shennan 1988, 65). The purpose of this test for me is to see the contingency of the homogeneity of the sites. The test is commonly used and useful and it provides a convenient bridge from concepts of statistical significance to concepts of the strength of the relationship between variables (Shennan 1988, 65). In archaeology the chi-squared test for cross-classified data is usually employed (Shennan 1988, 70). There the data for the contingency table is categorized or classified in terms of two different criteria (Shennan 1988, 71), in my work the site with its period and the number of fragments of one taxon, i.e. three main domesticates – cattle, sheep / goat and pig (app. V). The calculation of chi-squared test is based on the difference between the observed and expected values for each category (Shennan 1988, 71). For calculations I used the internet-based program (*Tools for science. The chi-square contingency table analysis*), where values are easily entered and the program gives the result for a contingency table.

The material analyzed in the chi-squared test must show homogeneity. According to O'Connor (2003, 79), if I want to summarize the meat supply and its changes through time, then the samples have to represent the "average" of that certain time period. Therefore I need to aggregate data from a number of contemporaneous contexts in order to lose context-specific variation (O'Connor 2003, 79).

Chapter 4. The results of the osteological analysis of the animal bones from the tavern and smithy site

In the following chapter I present the results of the osteological analysis of the bone specimens from suburban tavern and smithy site (in the present chapter referred to simply as Viljandi), derived from the excavations of the Sports Centre construction (fig. 1: 1). I consider every species separately, treating its anatomical distribution, age and sex, butchery and gnawing marks and possible evidence for size. Birds and game will be handled together in one subchapter due to their small quantity.

4.1. General data about the material

The bones from Viljandi Sports Centre site were generally quite well preserved. However, they were not cleaned or washed after the excavations, but stored directly in carton boxes and plastic bags, where they stayed for ten years. Due to that they were partially more fragmented and some bones might have had incorrect labels on their boxes – therefore it is possible that some material is placed in the wrong context. However, since in the present study I handle the source material as one homogenous set, it will not influence the outcome. Further, quite a lot of bones without any context and labeling had been on an exhibition in the Museum of Viljandi some time after the excavations. I did not include them in this study, because they were probably collected from the uppermost layers. The uncertainty remains, if they were from the medieval cultural layer or not.

Most of the specimens belong to domestic animals (table 1), wherefrom the most numerous, according to NISP, is cattle, followed by sheep / goat, pig and horse. Less finds derive from dog, cat, domestic fowl and goose. Among wild mammals the most numerous is mountain hare, but all other games – roe deer, elk and brown bear are represented with a single bone specimen.

Included in the material is also one fragment of a human humerus. Human bones in towns' osteological material are not anything exclusive but are frequently found. This single bone was a distal part of left humerus and carried a lot of trampling marks. The bone could have come from disturbed soil of nearby graveyard and been subject to different factors like animals and repositioning within the soil until it finally became deposited in the cultural layer. In the further analysis the human bone is left out.

Table 1. *The number and percentage of NISP, MNI, cut marks and gnawing marks for every species from the Sports Centre, i.e. tavern and smithy site in Viljandi.*

Species	**NISP**		**MNI**		**Cut marks**		**Gnawing marks**	
	Nr. of sp.-s	%	Nr. of sp.-s	%	Nr. of sp.-s	%	Nr. of sp.-s	%
Cattle	3047	62,0	47	38,5	1372	45,0	98	3,2
Sheep / goat	912	18,5	38	31,1	337	37,0	96	10,5
Pig	571	11,6	19	15,6	206	36,1	43	7,5
Horse	314	6,4	4	3,3	129	41,1	3	1,0
Dog	45	0,9	4	3,3	18	40,0	3	6,7
Cat	6	0,1	1	0,8	2	33,3	0	0,0
Domestic fowl	11	0,2	3	2,5	0	0,0	0	0,0
Goose	3	0,1	1	0,8	1	33,3	0	0,0
Mountain hare	6	0,1	2	1,6	1	16,7	1	16,7
Roe deer	1	0,0	1	0,8	0	0,0	1	100,0
Elk	1	0,0	1	0,8	0	0,0	0	0,0
Brown bear	1	0,0	1	0,8	0	0,0	0	0,0
Total	4918	100,0	122	100,0	2066	-	245	-

Minimum number of individuals shows a distinct tendency in the distribution of species. Altogether 122 individuals of different species could be distinguished in the material. By the values of MNI, the interval between cattle, sheep / goat and pig is not as high as according to NISP. But the interval between pig and horse has increased. Within the material some dogs and fowls, one cat and two mountain hares were found. All other species were represented by a single individual.

4.2. Cattle (*Bos primigenius* f. *taurus*)

The cattle is the most numerous species among analyzed material. It is represented by 3047 specimens (61.9% of identified bones) and at least by 47 individuals according to MNI based on left metacarpals. Applying collected data, I made different analysis about anatomical, age and sex distribution and about withers' height. For some fragments the exact bone type could not be identified, hence 3035 fragments are studied below.

Anatomical distribution of cattle bones

The most numerous body parts of the cattle were costae and different fragments of cranium (fig. 2). It must be noticed though, that the large amount of mentioned fragments derive from the high fragility of these body parts. Also, there might occur some bias, because some fragments could derive from other large ungulates instead (i.e. horses or elks). Yet again, general ratio of the body part distribution stays the same. Cranium and costa were followed by vertebra, scapula, coxa and sacrum, which are all body parts rich in meat. All other bone types stayed below 10% - more of them were among parts of hind limbs.

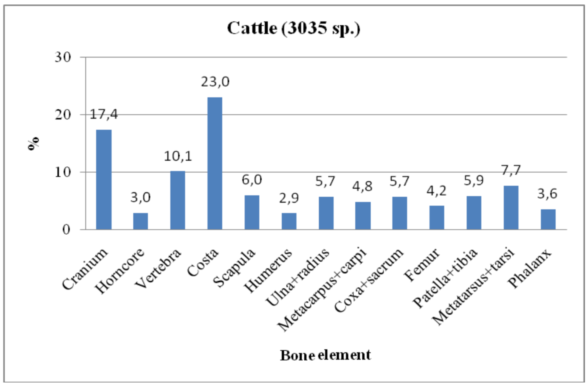
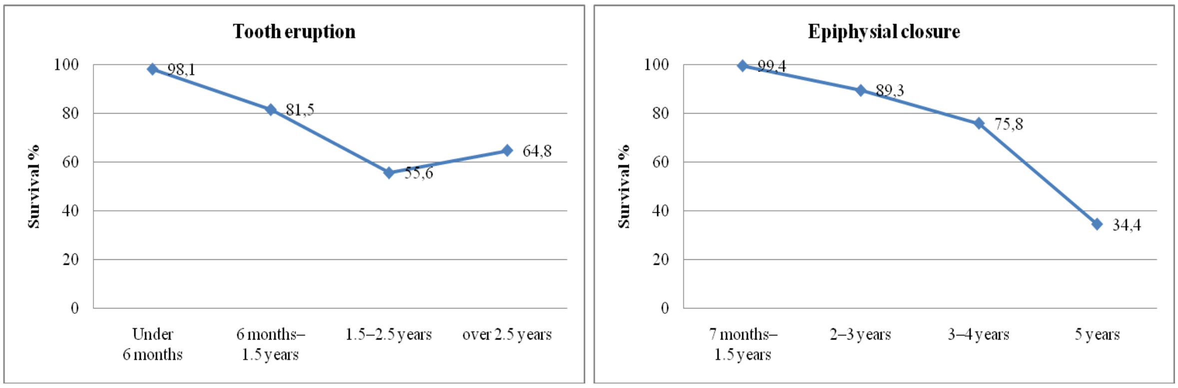


Figure 2. *The distribution of cattle (Bos primigenius* f. *taurus) bone specimens from Viljandi by bone element.*

Cattle bones related to meatier body parts formed in all 63.6% and specimens poor in meat thus 36.4%. Almost half of the cattle bones (45%) carried cutting or chopping marks and 3.2% of the bones had been gnawed by other animals – most probably by dogs, cats, pigs and rodents.

Age at death – cattle

As already described in chapter 3, I used two methods to estimate animals' age at death: tooth eruption by Schmid (1972, 77) and epiphysial closure by Silver (1963, 252–253). I determined age for 668 cattle specimens (21.9%), wherefrom 54 mandibles I could use to assess age based on tooth eruption. Four age groups could be distinguished from the tooth eruption: under 6 months, 6 months – 1.5 years, 1.5–2.5 years and over 2.5 years. Only one mandible belonged to a calf under half a year, most of them (24 sp.) were from 1.5–2.5 year old cattle. The survival percentage shows that most of the animals were slaughtered in their first or second year.



Figures 3, 4. *The age distribution of cattle (Bos primigenius* f. *taurus) from Viljandi based on tooth eruption in the mandible (according to Schmid 1972) and on epiphysial closure (according to Silver 1963).*

On the basis of epiphysial closure I determined age for 614 cattle specimens. Here as well four age groups can be distinguished according to when fusion normally occurs (Silver 1963, 252–253): 7 months – 1.5 years, 2–3 years, 3–4 years and 5 years. Unlike the diagram concerning tooth eruption (fig. 3), the epiphysial fusion (fig. 4) shows, that most of the cattle were slaughtered as mature animals, after reaching age of 4 to 5 years. Since majority of age assessment was done based on the epiphysial fusion, these results should be considered more genuine than the ones based on tooth eruption.

Sex distribution among cattle

In the present study I used the measures of horncores and metacarpals to determine the sex of the cattle. I performed several bivariate analysis, where two values are compared with each other (c.f. Wigh 2001, 63). It must be noted that only bones of adult animals can be used for sex assessments (Wigh 2001, 51).

To use horncores as a source for sex assessment, necessary measures are usually length, basal circumference and basal diameter (Maldre 1993, 32). Since I did not take the circumferences during identification process, I could use only O'Connor's method (1982, 22). Out of 90 horncores 48 were suitable for this kind of studies. Since it is a quite complicated task to distinguish horncores from younger individuals, I did not do it here and therefore some bias might occur. Still, general results should be quite representative.

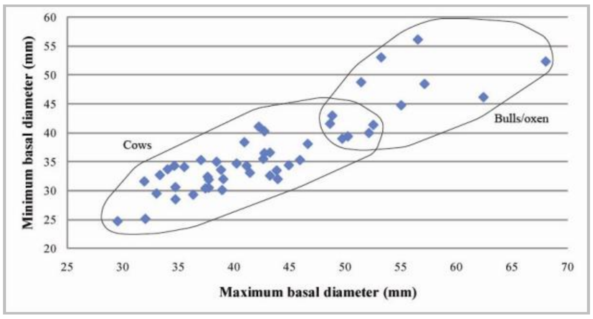


Figure 5. *Sex distribution of cattle (Bos primigenius* f. *taurus) from Viljandi based on the measurements of 48 horncores (according to O'Connor 1982).*

In figure 5 roughly two groupings of horncores become visible: smaller horncores shown on the left are probably from cows and larger horncores shown on the right are probably from bulls and oxen. The intersection might represent both sexes. Considering this distribution, up to 73–85% of the assemblage might have been cows and 15–27% bulls or oxen.

In the case of metacarpals the most representative measure is the breadth of distal epiphysis (Wigh 2001, 66; Wiig 1985, 495), in the present study taken from 79 specimens.

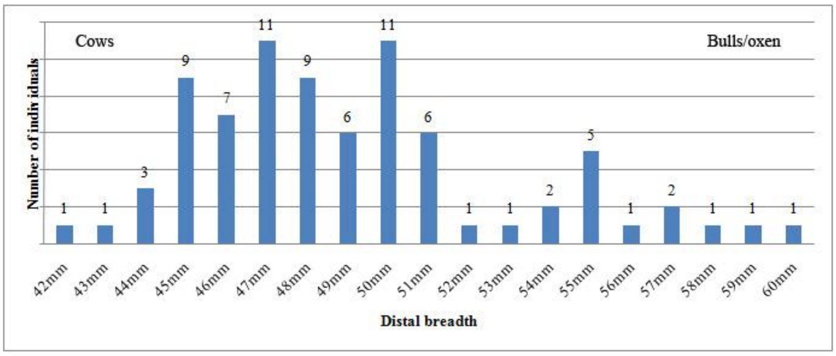


Figure 6. *Sex distribution of cattle (Bos primigenius* f. *taurus) from Viljandi based on the measurements of 79 metacarpals (according to Wigh 2001 and Wiig 1985).*

Practically the same proportion between males and females was also gained with following two methods. In figure 7 the distal breadth is plotted against smallest diaphysial breadth according to a method by Wigh (2001, 67). The present measurements show cows forming 82% of the assemblage.

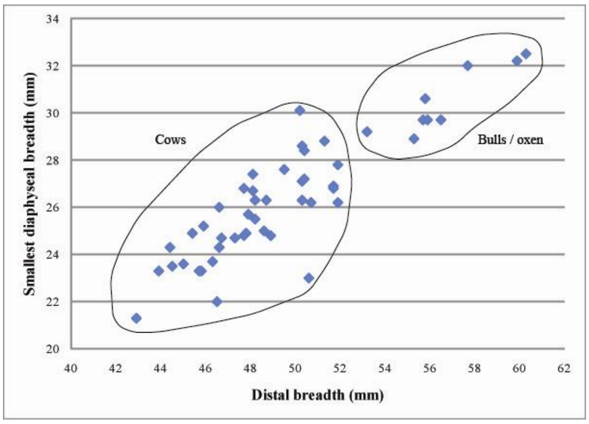


Figure 7. *Sex distribution of cattle (Bos primigenius* f. *taurus) from Viljandi based on the measurements of 49 metacarpals (according to Wigh 2001).*

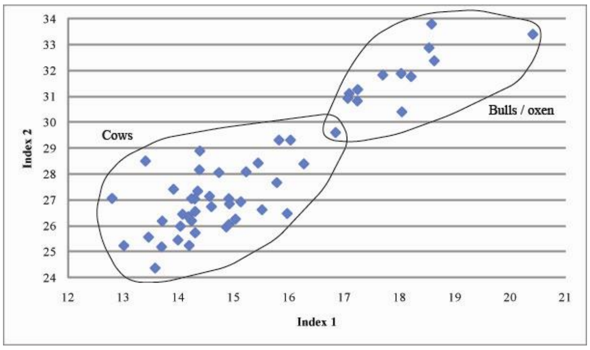


Figure 8. *Sex distribution of cattle (Bos primigenius* f. *taurus) from Viljandi based on the measurements of 51 metacarpals. Index 1 = smallest diaphysial breadth / greatest length x 100; Index 2 = proximal breadth / greatest length x 100 (according to Mennerich 1968).*

In figure 8 the method from Mennerich (1968, 35) is used and here seemingly a little increase in the number of bulls and oxen can be seen, forming up to 25% of the assemblage.

Diagrams created showed the general predominance of cows. According to all the results, approximately 75–80% of the assemblage might be considered as cows and 20–25% as bulls and oxen. Of course only a very small number of bones could be used for this kind of analysis, but the outcome is very typical of an urban assemblage and therefore could be trustable (see more details in chapter 6).

Size of cattle

To calculate the withers' height of cattle, several methods are used. These include the lengths of different bone types. The most reliable bone type is metacarpus, since it is also the most reliable bone to assess the sex of cattle (chapter 3.1). I used two methods: figure 9 shows the results according to the method by von den Driesch and Boessneck (1974, 338).

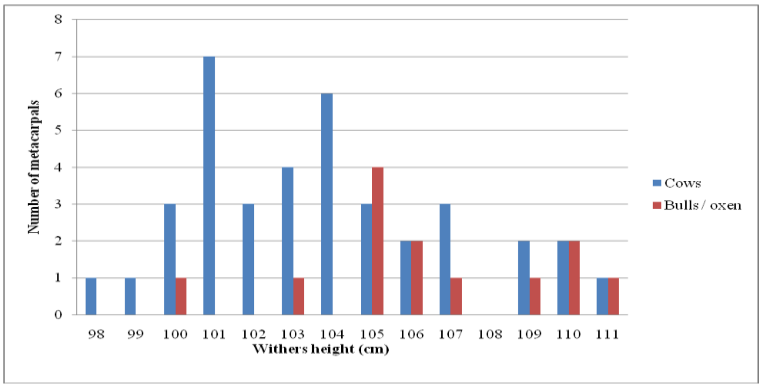


Figure 9. *Withers' heights of cattle (Bos primigenius* f. *taurus) from Viljandi based on the measurements of 51 metacarpals (according to v. d. Driesch & Boessneck 1974).*

In figure 9 the male cattle (13 metacarpals) tend to stay on the right side of the chart and cows (38 metacarpals) are more numerous in smaller withers' heights. Most of the results are between 100–107 cm. The mean value for the withers' height of the cows is 103.8 cm and of the bulls / oxen it is 106.3 cm. Still, since the assemblage is small and unequal between two sexes, exact conclusions are difficult to draw.

In figure 10 I calculated the withers' heights according to Matolcsi's method (1970), where sexes have not been distinguished. In this calculation most of the withers' heights stay between 104–109 cm and the mean value is 108,9 cm.

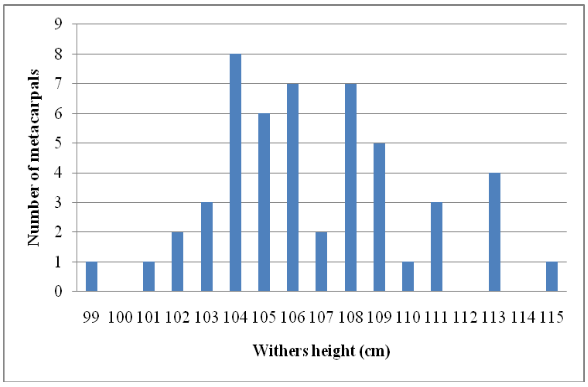


Figure 10. *Withers' heights of cattle (Bos primigenius* f. *taurus) from Viljandi based on the measurements of 51 metacarpals (according to Matolcsi 1970).*

Anomalies

In bovids and some cervids there might occur a congenital or during lifetime caused absence of the second permanent premolar in the mandible (O'Connor 2008, 119). In my material two mandibles with these features occured. Another anomaly of mandible was the one with very narrow body and with very sloping transition to *processus coronoideus*. Other anomalies and pathologies were found on the postcranial skeletal parts. One cervical vertebra had a porous vertebral body with some formation of a new bone. Four thoracical vertebrae seemed to have their epapophysis harmed during the growing period of the animal, because they were quite slantwise (app. IV: 1). Two lumbalic vertebrae had also defects: one had some kind of fracture in its vertebral body (app. IV: 2) and the other was porous and had strange epapophysis with "splitted" end. Three costae had healed fractures. Some limb bones were also anomalous: a proximal end of one radius had very strange shape and one femur seemed to have had some kind of trauma during animal's lifetime. A metatarsus had proximal end with one tarsal bone attached to it, an effect called spavin (app. IV: 3) and this usually indicates to too much or too heavy work during animal's lifetime (Baker & Brothwell 1980, 117–118).

4.3. Sheep (*Ovis ammon* f. *aries*) and goat (*Capra ibex* f. *hircus*)

Sheep and goats were the second numerous species (912 sp. – 18.5%) in the tavern and smithy site material, represented by at least 38 individuals based on the MNI of left metacarpals (table 1). To distinguish these two taxa from one another, some extra time and knowledge is needed and there is an elaborated method to do that. Some types of bone, the cranium, deciduous teeth, metapodials, tali and the distal phalanges, possess more readily identifiable characteristics (c.f. Boessneck 1969). During the identification process I distinguished these two species only on the basis of horncores and skulls: 97 specimens were verified as goats and 11 specimens as sheep. Later, while working with the Excel chart, I analyzed the measurements of sheep / goats' metacarpals in order to differ them and got a clear result of 21 sheep and 11 goat specimens (fig. 11).

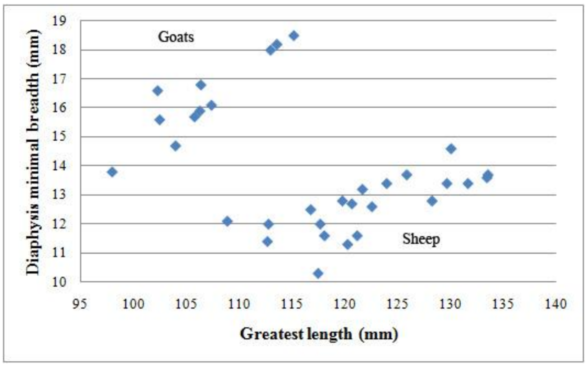


Figure 11. *The distribution of sheep (Ovis ammon* f. *aries*) *and goats (Capra ibex* f. *hircus) from Viljandi based on the measurements of 32 metacarpals.*

Thus, 108 goat and 32 sheep specimens are studied in the subsequent analysis, while other bones are concerned as sheep / goat.

Anatomical distribution of sheep and goat bones

Among sheep and goat specimens body parts rich in meat (488 sp. – 53.6%) and poor in meat (422 sp. – 46.4%) were represented almost equally (fig. 12).

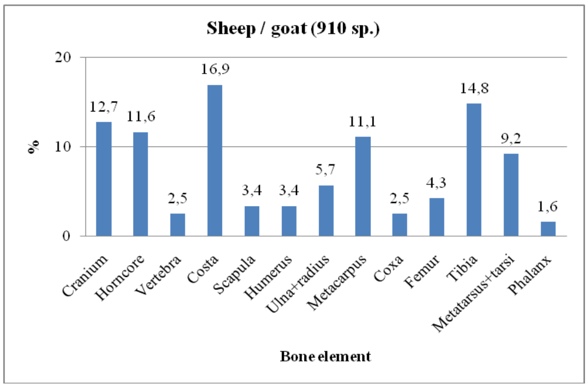


Figure 12. *The distribution of sheep / goat (Ovis ammon* f. *aries / Capra ibex* f. *hircus) bone specimens from Viljandi by bone element.*

In comparison with the distribution of cattle body parts, some remarkable differences emerge. Most numerous bone elements – cranium and costa – as well as parts of forelimbs and upper parts of hind limbs are proportionally the same for both species. Differences occur in the numbers of vertebrae that are proportionally more numerous among cattle bones; and numbers of horncores, metapodials and tibiae, which are proportionally much more numerous among sheep / goat bones.

Butchery marks were found on 37% of the bones, most of them on tibiae, metapodials, cranium fragments and costae. Some specimens (10.5%), generally parts of limbs, were also gnawed.

Age at death – sheep and goats

Age for 242 sheep / goat specimens (26.5%) was assessed according to Silver's (1963, 252–253) and Schmid's (1972, 77) methods. Only 26 mandibles could be used, wherefrom 84.6% belonged to animals slaughtered in the age from 9 months to 2 years. The rest of the individuals had been slaughtered in their second to fourth year. More accurate results were gained analyzing the epiphysial closure, where four age groups could be distinguished according to when fusion normally occurs (Silver 1963, 252–253): ca 10 months, 1–2 years, 2–3 years and 3–4 years.

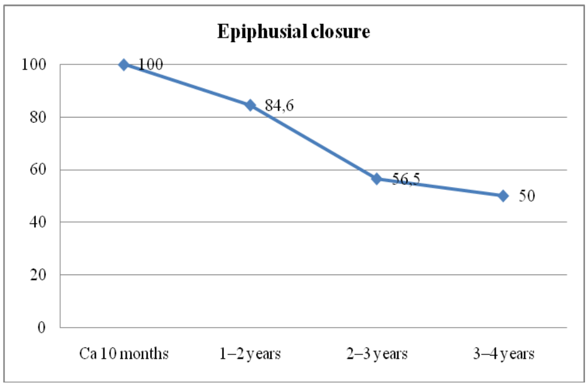


Figure 13. *The age distribution of sheep / goats (Ovis ammon* f. *aries / Capra ibex* f. *hircus) from Viljandi based on epiphysial closure (according to Silver 1963).*

According to figure 13, all lambs and kids survived their first year. However, approximately half of them were slaughtered before they were sexually matured, most likely in their second autumn.

Sex distribution among goats

Sex distribution of sheep and goats can be estimated through measurements of metacarpals and morphological differences of horncores and pelvises (c.f. Boessneck 1969). The latter I did not study during the identification process, hence only metacarpals and horncores are used in this paper. I could not do any distinction among sheep bones because of the absence of some necessary metacarpal measurements and because of only seven sheep horncore fragments were identified and one of them measured. Goat horncores with required measurements, on the contrary, were more available.

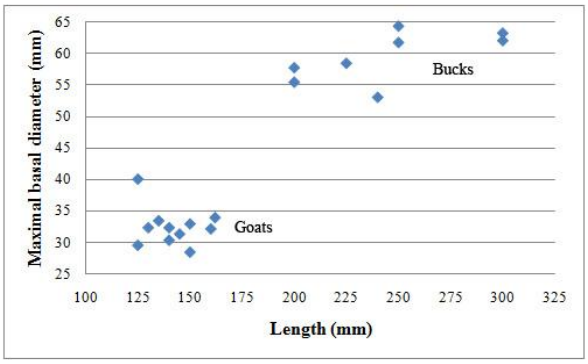


Figure 14. *Sex distribution of goats* (*Capra ibex* f. *hircus*) *from Viljandi based on the measurements of 19 horncores.*

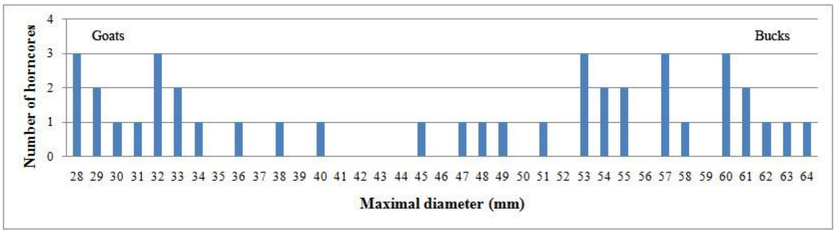


Figure 15. *Sex distribution of goats (Capra ibex* f. *hircus) from Viljandi based on the measurements of 40 horncores.*

In figure 14 goats (11 sp.) outbalance the bucks (8 sp.) just a little, but in figure 15 it is vice versa (goats with 16 sp. and bucks with 24 sp.). The source material is quite small and therefore it is hard to estimate the true distribution. However, figure 15 is based on much more specimens and therefore is more reliable.

Size of sheep and goats

In the present study the suitable bones for the calculation of sheep and goats withers' heights are metacarpals. Since very few of these bones were complete and from mature animals, the results about withers' height should be concerned only as illustrative and not as a confident outcome. Figure 16 shows the results for sheep withers' heights according to Teichert's method (1975). Most of the results are between 57–60 cm.

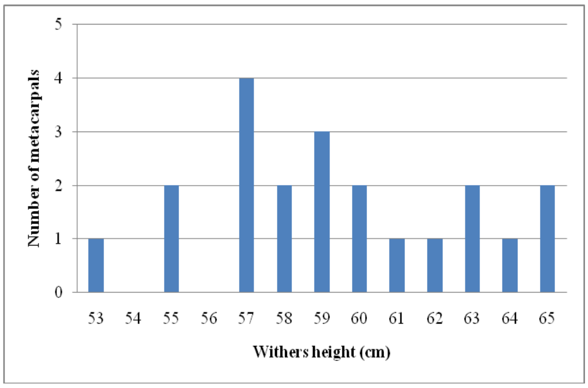


Figure 16. *Withers' heights of the sheep (Ovis ammon* f. *aries) from Viljandi based on measurements of 21 metacarpals (according to Teichert 1975).*

In calculating the withers' heights for goats, Schramm's method (1967) is generally used and here most of the withers' heights are between 58–61 cm.

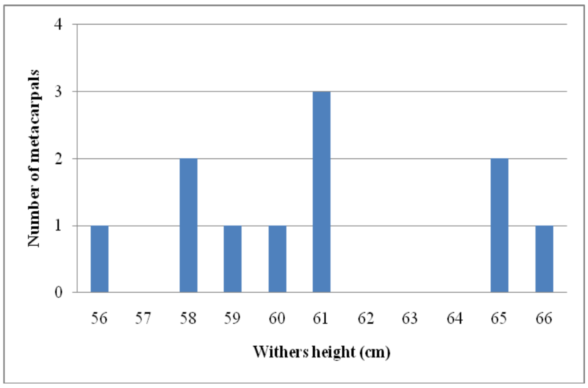


Figure 17. *Withers' heights of the goats (Capra ibex* f. *hircus) from Viljandi based on the measurements of 11 metacarpals (according to Schramm 1967).*

Anomalies

One specimen, a lumbalic vertebra, had a bit odd shape, but any reason for that is hard to give.

4.4. Pig (*Sus scrofa* f. *domestica*)

Pig bones were the third most common bone finds in Viljandi's medieval tavern and smithy site. They formed out of all identified bones 11.6% (571 sp.), including at least 19 individuals based on the MNI of right ulna (table 1). I identified only domestic pigs, although some additional fragments could have belonged to wild boar as well: two radii seemed too long and slim for a domesticate (about 153–155 mm, while two other measured radii were 124–125 mm long). One tibia was also very long (217.2 mm) compared to others (four of them were 170–180 mm, one 206 mm long). Also there were six fragments of cranium that had some questionable features. Nevertheless, whereas mentioned bones were not firmly identified, they are out from the subsequent analysis. Sex assessment for pigs is usually based on upper and lower canines (Payne & Bull 1988, 32), but in the present study I did not measure the canines during identification process. There were not any anomalous bones among pig specimens, except one mandible that had its first molar very much worn compared to other teeth (app. IV: 4).

Anatomical distribution of pig bones

In total 569 specimens were distributed between different body parts (fig. 18).

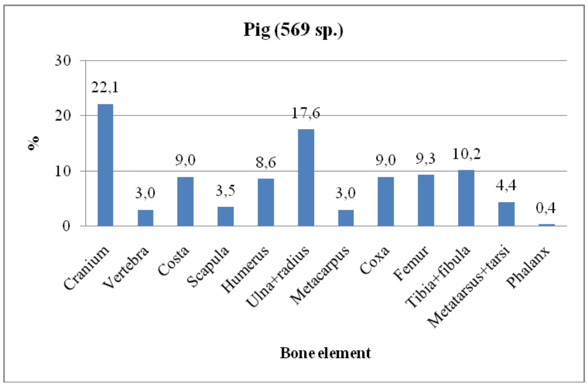


Figure 18. *The distribution of pig (Sus scrofa* f. *domestica) bone specimens from Viljandi by bone element.*

Although the fragments of cranium are again most numerous, the dominating body parts are still the ones with more flesh (70.1%). As among sheep and goats, vertebral specimens are quite small in number. Butchery marks were found on 36.1% and gnawing marks on 7.5% of the bones.

Age at death – pigs

Age was estimated in the case of 217 pig bone specimens (38%). Only ten mandibles were used to assess age at death. Most of them belonged to about 1.5 year old individuals. Of course, there were also older animals among the material, whose teeth were quite worn, but I did not apply any methods based on tooth wear in this study. Most of the specimens (205 sp.), were studied based on epiphysial closure by Silver (1963, 252–253) and four age groups, according to when fusion normally occurs, were distinguished: ca 1 year, 1–2 years, 2–2.5 years and 2.5–3.5 years.

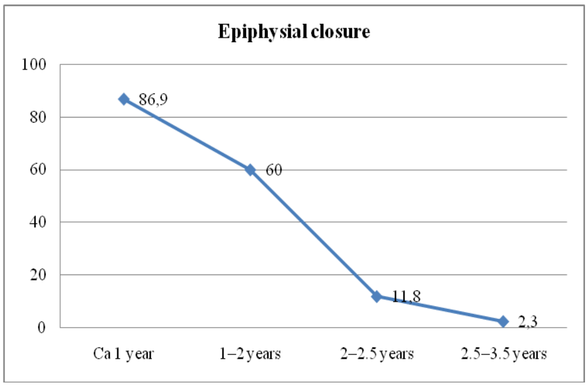


Figure 19. *The age distribution of pigs (Sus scrofa* f. *domestica) from Viljandi based on epiphysial closure (according to Silver 1963).*

The analysis of epiphysial closure (fig. 19) shows, that most of the animals were slaughtered before reaching osteological maturity in the age of 2–3 years. However, full body size was already gained by this age.

Size of the pigs

Only ten complete and fully matured bones were available for calculating the withers' heights for pigs in Viljandi's tavern and smithy site. I used Teichert's method (1990). A problem is, of course, that the numeral factors in the formulas are quite large and therefore could induce errors.

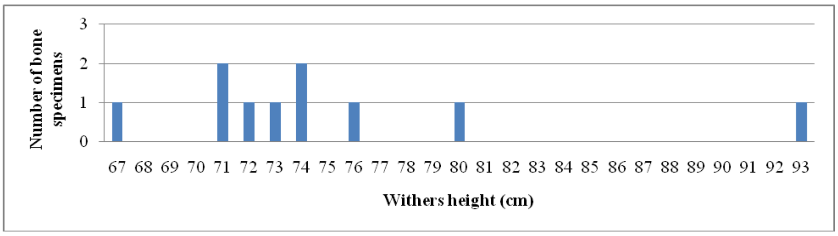


Figure 20. *Withers' heights of the pigs* (*Sus scrofa* f. *domestica*) *from Viljandi based on the measurements of one radius, tibia, talus and seven metapodials (according to Teichert 1990).*

As seen in figure 20, most of the pigs have withers' height between 71 and 74 cm. One metacarpal gave the result for very large individual compared to the others, with withers' height of 93.2 cm.

4.5. Horse (*Equus ferus* f. *caballus*)

There were 314 horse bone specimens (6.4%) among the material from Viljandi, including at least four individuals based on MNI of left metatarsals (table 1). Some fragments, especially from metapodials, were not firmly determined because of the high similarity between metacarpals and metatarsals. Horse's sex can be determined based on the presence of canine teeth and morphological features of the pelvis. I did not apply neither, because some mares can have canines as well, therefore the first method is unconfident. During the identification process I did not study the fragments of pelvis in a way to make sexual distinctions.

Anatomical distribution of horse bones

Specimens of horse cranii, costae and vertebrae were most numerous – these are the bones most fragile, but among them also the biggest bias might occur, since some of the fragments might belong to cattle instead. However, during the identification I determined all questionable fragments as cattle / horse or just large ungulate, thus only firmly identified fragments were attributed to horse.

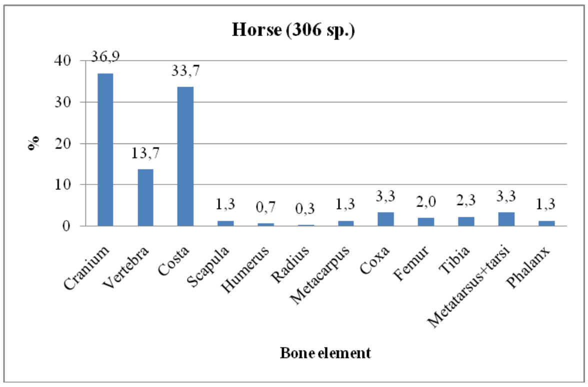


Figure 21. *The distribution of horse (Equus ferus* f. *caballus) bone specimens from Viljandi by bone element.*

Among the material 57.2% (175 sp.) of the bone specimens derived from meatier body parts like vertebrae and costae. Cut marks were on 41.1% of the bones and a few specimens were also gnawed.

Age at death – horses

I could assess age for 19.1% (60 sp.) of the horse bone material. Most of them (55 sp.) were based on epiphysial closure (Silver 1963, 252–253), where four age groups, according to when fusion normally occurs, were distinguished: 13–18 months, 1.5–2 years, 3–3.5 years and 4.5–5 years.

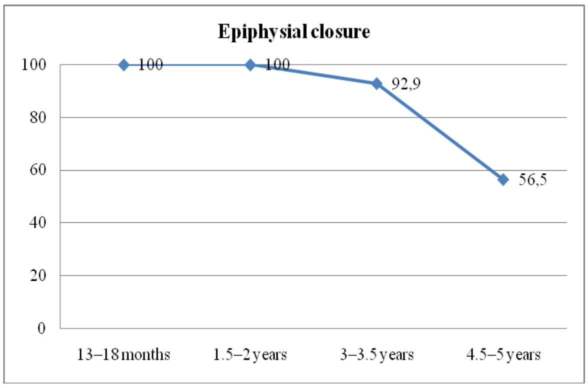


Figure 22. *The age distribution of horses (Equus ferus* f. *caballus) from Viljandi based on epiphysial closure (according to Silver 1963).*

According to the results in figure 22, all young horses survived and half of them died or were slaughtered after they became mature at the age of 4–5 years.

Based on teeth, I assessed age for five specimens, using the preparation of incisors from the anatomical collection of Zoomedics in Estonian University of Life Sciences: three of the incisors belonged to horse(s) at the age of 6–8 years, one belonged to approximately 9–11 year old horse and regarding one tooth it could only be said that it derived from an individual older than 3.5 years.

Size of the horses

Greatest lengths of nine whole and fully developed bones were used for calculations of withers' heights according to Vitt's (1952) method: two metacarpals, three tibiae and four metatarsals gave results for seven horses with withers' height between 128 and 136 cm and two horses between 136 and 144 cm. However, some of these bones might derive from the same individual.

Anomalies

One mature horse, at least over five years old, had three thoracic vertebrae fused together (app. IV: 5) and consequently a stiff back. Probably it is a result of some trauma.

4.6. Dog (*Canis lupus* f. *familiaris*) and cat (*Felis silvestris* f. *catus*)

Quite few dog and cat bones represent most probably pets in Viljandis' tavern and smithy material and therefore cannot be very abundant in kitchen and butchery waste.

Dog

Dogs were represented by 45 bone specimens (0.9%). Based on the MNI of right femur, at least four dogs are among the material of Viljandi's tavern and smithy site (table 1).

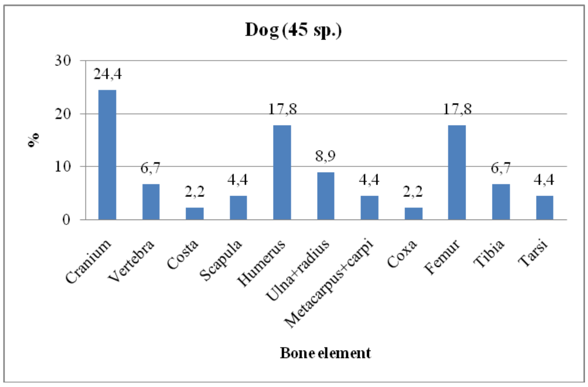


Figure 23. *The distribution of dog (Canis lupus* f. *familiaris) bone specimens from Viljandi by bone element.*

Larger percentage of cranium comes from seven mandibles, two teeth and two fragments of a skull. The rest of the specimens mostly derive from limbs (fig. 23). On 18 dog bones there were also cut marks, most of them located on the humeri and femora. The indications of possible consumption or skinning will be discussed later. Three specimens had also been gnawed.

Age could be estimated for 25 specimens (55.6%), based on the method by Silver (1963, 252–253). All of them, except for one femur, had their epiphyses fused: five specimens derived from dogs at least 6–9 months old, four specimens from dogs at least 10–12 months old and 17 specimens from dogs at least 1–2 years old. One femur with unfused epiphysis belonged to a dog under 1.5 years old.

Since sex for dogs can be identified only based on os bacculi, and there were no such bones among my source material, any sexual distinction is not possible.

Withers' heights for dogs were calculated according to Harcourt's method (1974). Eight specimens were used, giving the results from 35.9 to 60.5 cm, belonging to small- to medium-sized animals.

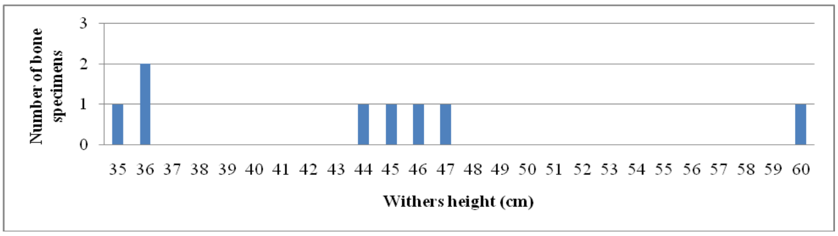


Figure 24. *The withers' heigths of dogs (Canis lupus* f. *familiaris) from Viljandi based on two humeri, four femora and two tibiae (according to Harcourt 1974).*

One dog bone had some anomaly: a femur with a mark on its proximal cranial side, looking like something had impacted the bone during the animal's lifetime and then healed (app. IV: 6).

Cat

Only six specimens (0.1%) of cat bones were identified among the material from Viljandi's tavern and smithy site, including two humeri, one ulna and femur and two tibiae. It is possible, that they all derive from one individual. In that case it was a relatively young cat, since no epiphyses were closed. One humerus and one femur had a few cut marks on them.

4.7. Birds and game

Birds

Probably since there was no sieving employed during the excavations, very few bird bones were collected and they do not represent the activities at the site in any way. Only 11 specimens of domestic fowl (*Gallus gallus* f. *domesticus*) and three specimens of geese (*Anser sp.*) were firmly identified. Although, I could not distinguish, if the specimens derive from wild or domesticated goose. Eight additional bird bone fragments stayed questionable.

Game

Among wild animals the mountain hare (*Lepus timidus*) was most numerous – represented by six specimens from the pelvis and hind limbs. Other species were represented only by a single specimen: a metatarsus from roe deer (*Capreolus capreolus*), a processed antler fragment from elk (*Alces alces*) and second phalanx from brown bear (*Ursus arctos*). There were some other bones that could belong to wild animals as well: fragments of humerus and costa from elk, fragment of a premolar from roe deer, one possible tibia from wolf (*Canis lupus*) and fragments of possible wild boar cranium already mentioned in chapter 4.4 about pigs. In addition there were three processed elk antler fragments among the findings.

Chapter 5. The analysis of animal bones from other sites in Viljandi

In this chapter I present the bone material from other sites in Viljandi in addition to my main source material from the Sports Centre site. I give an overview of the excavations, datings, species and body part distributions. General background for the sites was given already in chapter 2, all results are being discussed in chapter 6.

5.1. Suburban area

Four sites situated by the two main gates of medieval Viljandi yielded animal bone assemblage of 6928 specimens dated to 14th to 16th century (app. III). The material from the tavern and smithy site just in front of the medieval Riga gate (fig. 1: 1) was presented in chapters 2 and 4. The rest of the suburban sites situate near the Tartu gate north of the medieval town.

5.1.1. Tartu Street 1996

In summer of 1996 there were small scale rescue excavations between the streets of Tartu and Lossi (fig. 1: 2). During the replacement of nine sewer wells the cultural layer from 14th to the middle of the 16th century suburb was found and investigated. It was preserved only in the corners and edges of the wells, therefore the material is small. Animal bones – in total 149 specimens were collected from five wells. (Sarv 1996)

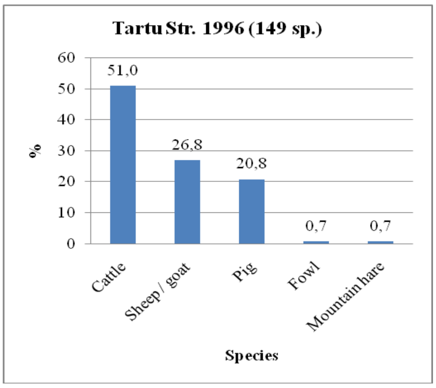
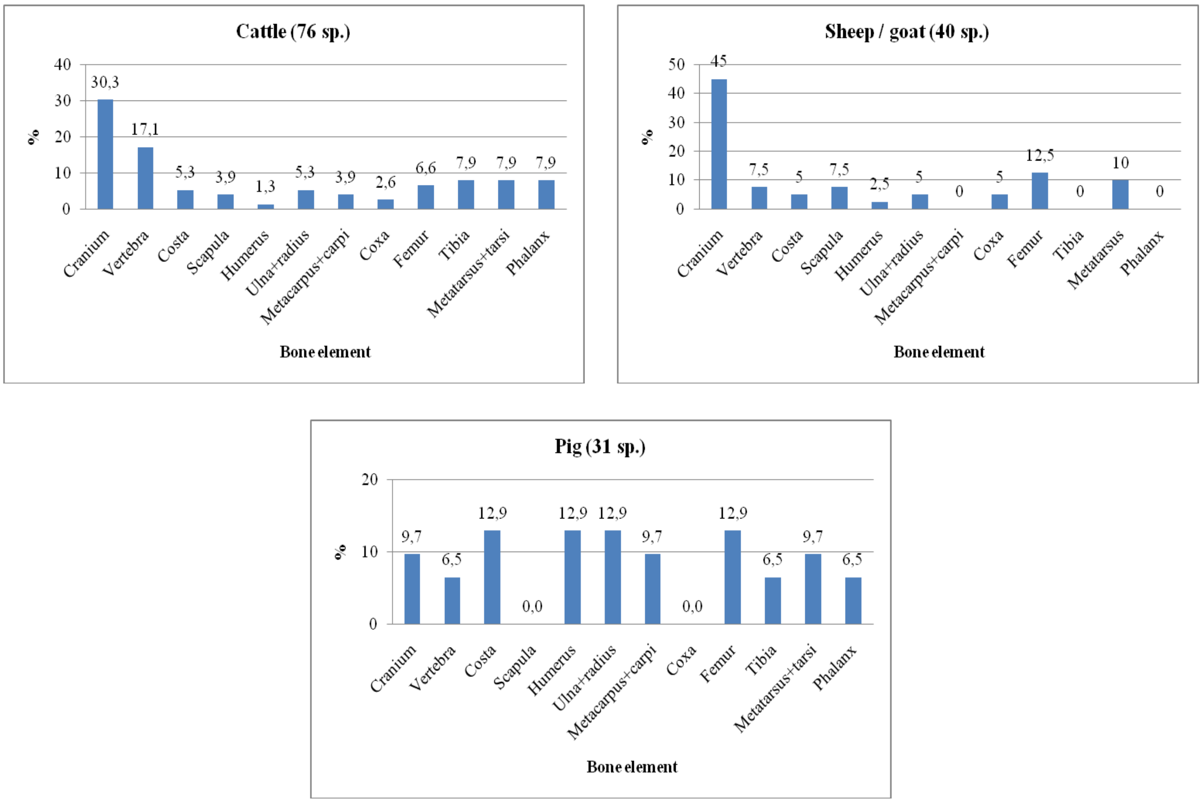


Figure 25. *The distribution of bone specimens from Tartu Street by species.*

Nearly half of the bones belongs to cattle, the rest to sheep / goats and pigs. Fowl and mountain hare are represented only by one specimen each.



Figures 26–28. *The distribution of cattle (Bos primigenius* f. *taurus), sheep / goat (Ovis ammon* f. *aries / Capra ibex* f. *hircus) and pig (Sus scrofa* f. *domestica) bone specimens from Tartu Street by bone element.*

The outcome is very typical – most of the specimens from cattle and sheep / goat derive from the fragile cranium, rest of the body parts are represented by quite equal amounts. In case of the pig most of the fragments are parts of limbs.

5.1.2. Lossi Street 2001

In the summer of 2001 archaeological supervision was needed in 160 meters long heating pipeline trench in Lossi and Koidu Streets (fig. 1: 3). The cultural layer was quite poorly preserved, but still informative about the formation of a permanent settlement in a suburban area in the 14th century (Valk 2001). From the collected animal bone specimens, dated from the 14th to the 16th century, 427 were identified by E. Järv (2002, 26–31). Some of the fragments (probably from the 16th and 18th centuries) were accidentally left out from the analysis. However, the absence of these identifications would probably not influence the general outcome.

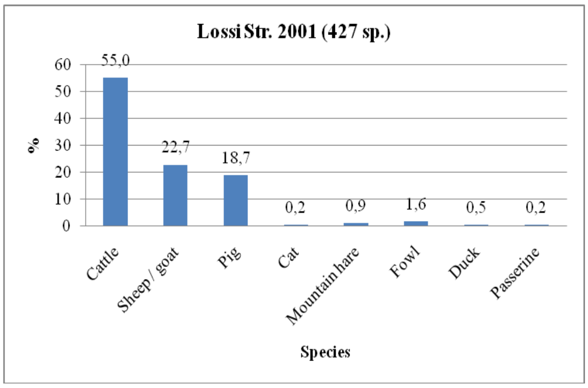
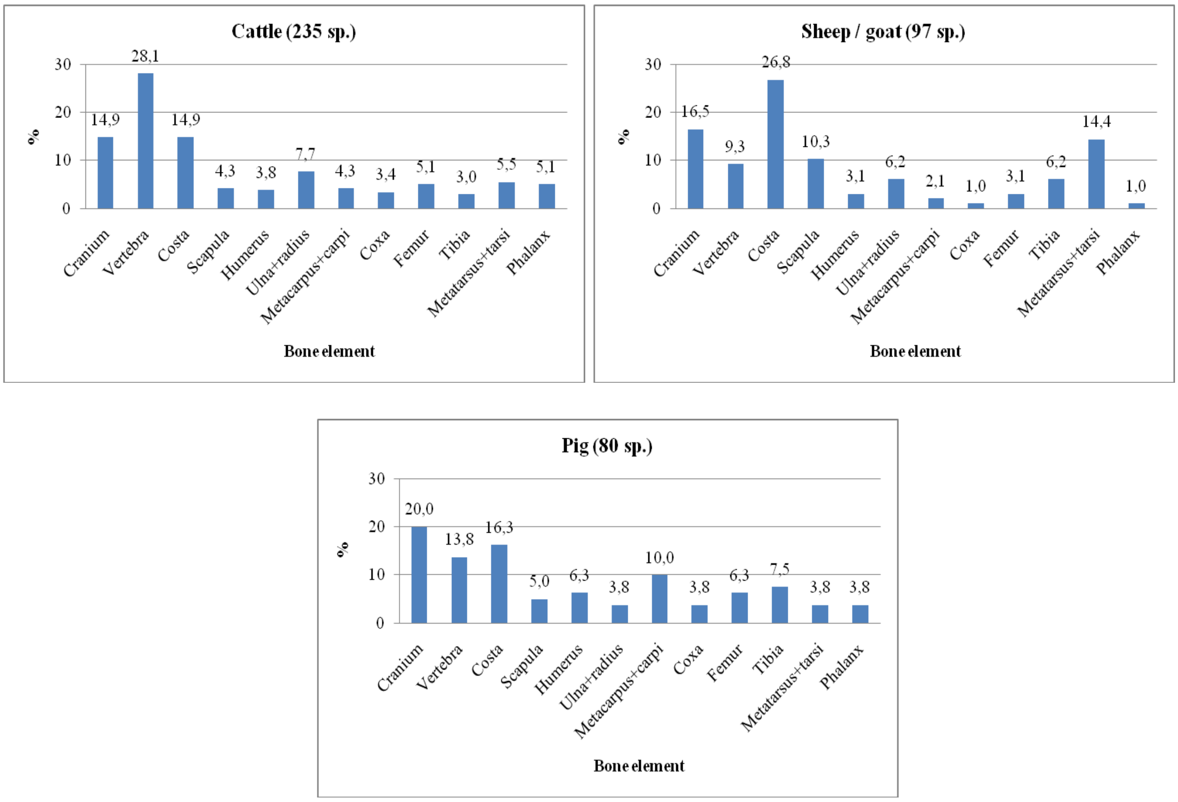


Figure 29. *The distribution of bone specimens from Lossi Street by species.*

Cattle is again most numerous, followed by sheep / goat and pig. Single specimens derived from cat (1 sp.), mountain hare (4 sp.) and some birds (10 sp.).



Figures 30–32. *The distribution of cattle (Bos primigenius* f. *taurus), sheep / goat (Ovis ammon* f. *aries / Capra ibex* f. *hircus) and pig (Sus scrofa* f. *domestica) bone specimens from Lossi Street by bone element.*

The cattle's body parts, except more easily broken cranii and costae, are represented quite equally and show no special consumption patterns. Nevertheless, vertebrae, representing meatier body parts, are rather numerous. In the case of sheep and goats the fragments of cranii and costae are again most numerous, but notable is the abundance of metatarsals and tarsals, while metacarpals are much less represented.

5.1.3. Posti / Lossi Street 2001

The rescue excavations in Posti and Lossi Streets (fig. 1: 4) in the winter of 2001 were the continuation of the heat pipeline placement. The trench was 48 meters long and was not excavated as deep as the natural soil in all its parts because of the weather. The cultural layer was 20–30 cm thick and contained findings from Medieval (14th–16th centuries) and Modern Times (18th–19th centuries). The intermediate period of Early Modern Times (the Livonian War and the 17th century) seemed to be missing. The presence of slag, processed bones and needles indicate a nearby workplace of a smith, a bone craftsman and a tailor. (Haak 2002) Altogether 1433 animal bone specimens were identified by E. Järv (2002, 5–14). Even though there are some bones from the Modern Times among the material, the assemblage can be dated and belongs mostly to the Middle Ages.

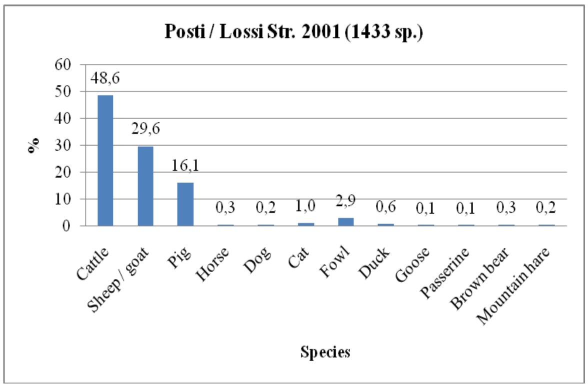
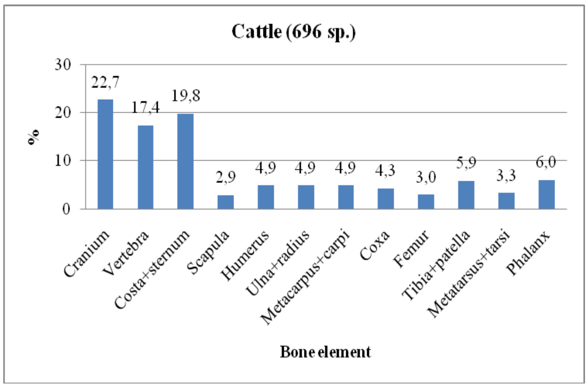
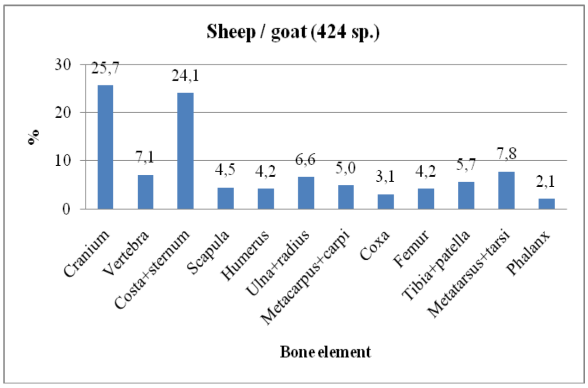
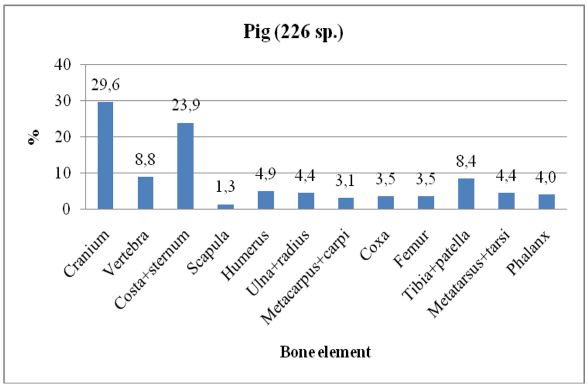


Figure 33. *The distribution of bone specimens from Posti / Lossi Street by species.*

Because of the larger bone assemblage probably there are more species presented. In addition to most common domesticates few horse (5 sp.) and cat bones (14 sp.) were also found. Game were represented by few mountain hare (3 sp.) and brown bear (4 sp.) bone specimens. Birds were represented by 54 specimens, of which 42 belonged to fowl.







Figures 34–36. *The distribution of cattle (Bos primigenius* f. *taurus), sheep / goat (Ovis ammon* f. *aries / Capra ibex* f. *hircus) and pig (Sus scrofa* f. *domestica) bone specimens from Posti / Lossi Street by bone element.*

5.2. Town area

Four sites in the town area yielded animal bone assemblage of 6816 specimens dated to the 13th to the 17th century (app. III).

5.2.1. Lossi Street 1992

The site excavated in Lossi Street in the spring and summer of 1992 was situated just beside the medieval Tartu gate, including also the gate area (fig. 1: 5). An excavation area of 75 m^2 revealed also the gate walls and a medieval pavement. The cultural layer was dated from the middle / the third quarter of the 13th century to the middle of the 16th century (or to the beginning of Livonian war). (Valk 1992) Out of 724 animal bone specimens 678 (93.8%) were identified.

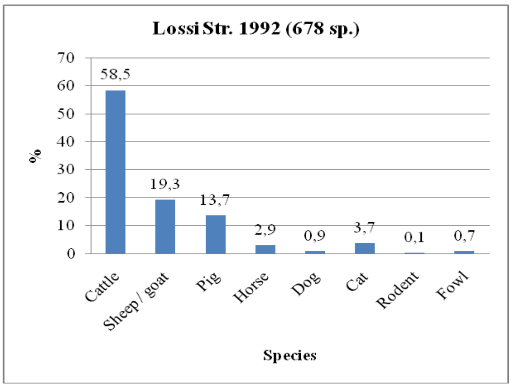
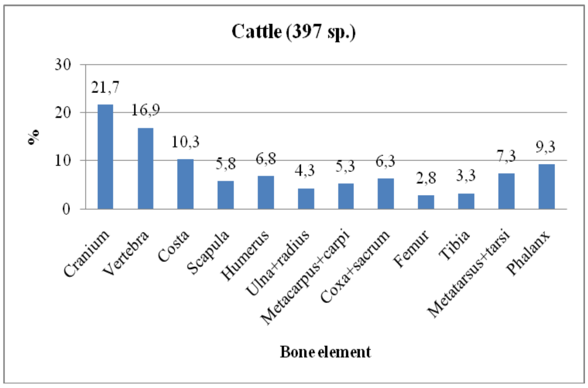
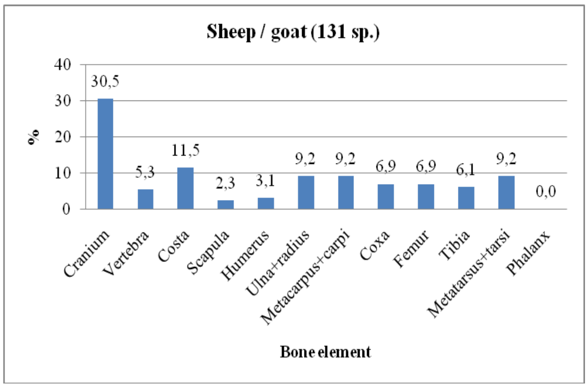
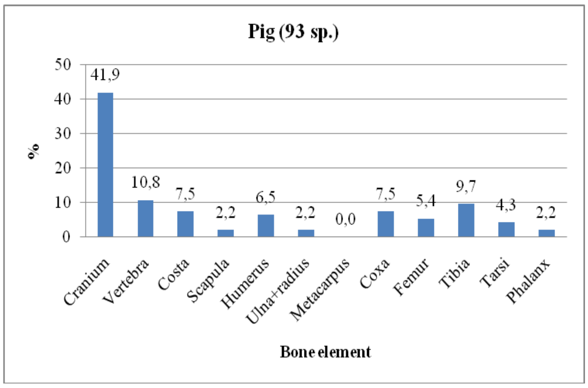


Figure 37. *The distribution of bone specimens from Lossi Street by species.*

Twenty horse bones come mostly from costae and vertebrae. Cat was represented by 25 specimens. There was also one fragment of a wild bird, but it is left out of the analysis.







Figures 38–40. *The distribution of cattle (Bos primigenius* f. *taurus), sheep / goat (Ovis ammon* f. *aries / Capra ibex* f. *hircus) and pig (Sus scrofa* f. *domestica) bone specimens from Lossi Street by bone element.*

5.2.2. Munga Street 1989

Rescue excavations in the water pipeline trench in Munga Street (fig. 1: 6) were carried out in the spring of 1989. Approximately 60 m^2 were investigated. Human activity on the site started in the first half of the 14th century, when a drainage system of ditches with woven fences was constructed. Later it became a street, whence a 40–70 cm thick cultural layer from the second half of the 14th to the beginning of the 16th century had been preserved. At that time a smithy or maybe even an iron production site was situated nearby, probably in adjacent Sepa Street, because of the numerous slag findings – most of them derive from the second half of the 15th and the first quarter of the 16th century. In the first half of the 16th century the street was covered with a 40–70 cm thick sand filling, on which a pavement was laid. This pavement was used and maintained till the beginning of Livonian war in 1560's, when the Russians surrounded and finally occupied the town. In the war period the pavement was sporadically repaired, but finally, during the leveling of ruins it was covered with debris layer and any later street layers were impossible to distinguish. (Valk 1990)

Animal bones – in total 540 specimens – were collected from three different time periods: 1) from the cultural layer dating to the 14th to the beginning of the 16th century (142 sp.), 2) from between the pavement stones and pad dating to the first half of the 16th century (probably the second quarter) (82 sp.) and 3) from the debris layer dating to the second half of the 16th century, maybe also to the beginning of the 17th century (315 sp.) (Valk 1990).

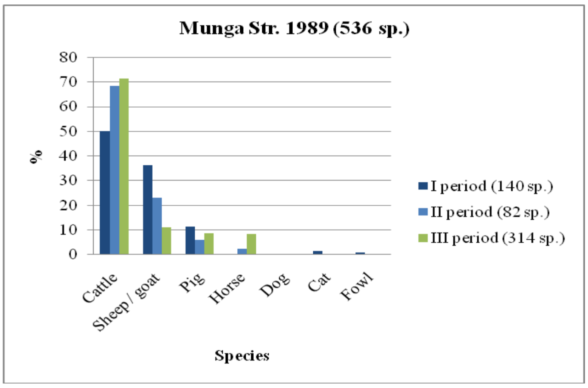
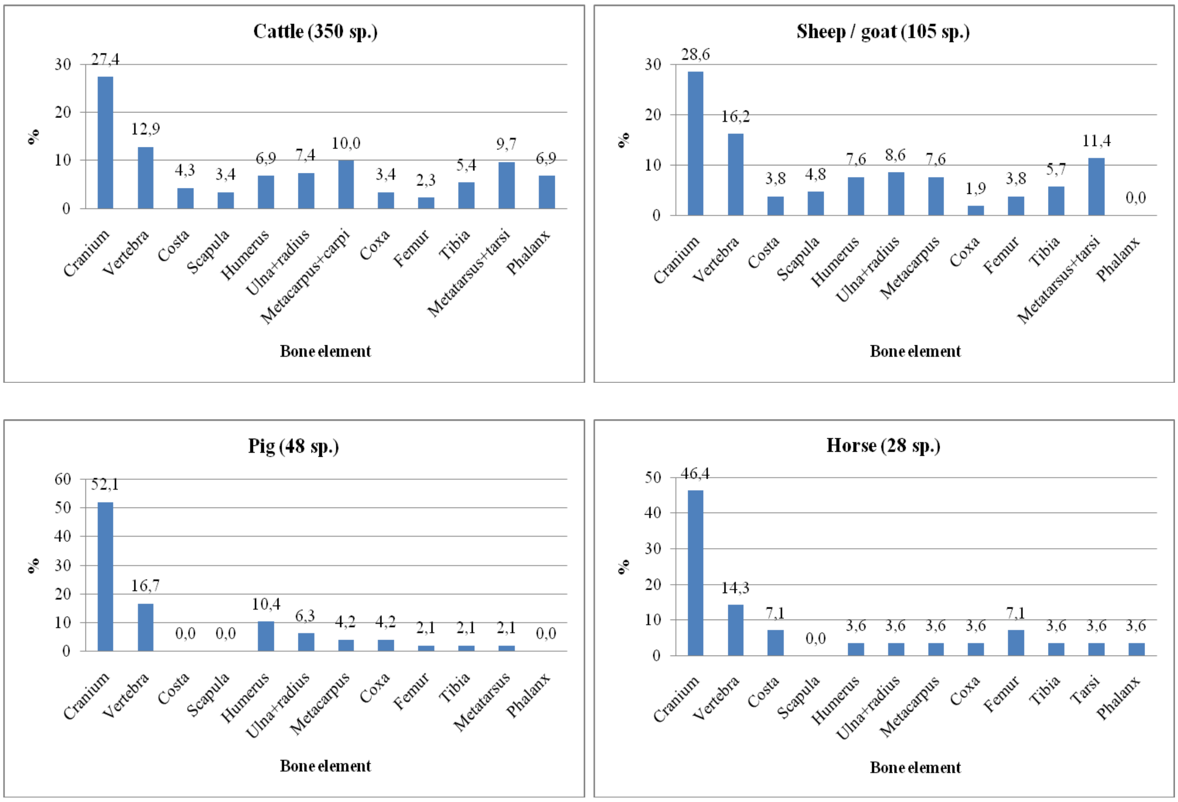


Figure 41. *The distribution of bone specimens from Munga Street by species according to three time periods.*

The importance of cattle increased during the 14th to the beginning of the 17th century and at the same time the consumption of sheep / goats decreased. Pig's importance has been almost the same, while horse was totally absent in the first period, but it became as common as pig in the third period. Dog and cat were represented sporadically. Two specimens from fowl and one from a larger bird were found. Since the assemblages from different periods are rather small, I present the body part distribution through all time periods (fig. 42–45).



Figures 42–45. *The distribution of cattle (Bos primigenius* f. *taurus), sheep / goat (Ovis ammon* f. *aries / Capra ibex* f. *hircus), pig (Sus scrofa* f. *domestica) and horse (Equus ferus* f. *caballus) bone specimens from Munga Street by bone element.*

5.2.3. St. John's Church area 1990–1991

Excavations in the area of St. John's Church (fig. 1: 7) were carried out at the end of the 1980's and in 1990–1991. The first investigations yielded some animal bones, but since the documentation is missing, only the excavations in 1990 and 1991 are included here. (Valk 1991, 5–6; 2004, 422–423)

Excavations in 1990

Due to the reconstruction works of St. John's Church in summer of 1990 some archaeological supervision was needed. The investigated trench was located outside the church building and comprised of approximately 165 m^2. According to the excavation results, the area around later St. John's Church had probably been arable land at the end of the Prehistoric Period. The first earthwork and construction took perhaps place just after the arrival of Germans at the beginning of the 13th century. Intensive and rich cultural layer was formed fast, maybe only in some decades. There were lots of animal bones, ceramics and everyday objects, several waste pits and also traces of a smithy and iron processing. However, no remains of buildings were found, therefore it is difficult to interpret the function of the site. It could have been a market- or merchandise place, or maybe an economical courtyard for some larger estate. Based on the findings, the cultural layer is dated from the second half of the 13th to the 14th century, but on the basis of written sources and town's topography it is dated only to the second half of the 13th century. Then the cultural layer was covered with 0.5–1.4 meters thick fill soil, probably from digging the town moat. In the following period there were no more traces of intensive life activity. Instead, the construction of the church was begun and the area became part of a churchyard. (Valk 1991)

The animal bones – in total 2313 specimens – derive mostly from the cultural layer dating to the second half of the 13th century (and maybe also to the 14th century). Among them also some material from the debris layer was found dating to the 14th and 15th centuries. In the summary of analysis of the report (Saks 1991a) all the bones were considered together and I did not distinguish any chronological periods, because it would have taken too much time and effort to re-calculate other researchers' identifications. From all the bones only 43 fragments (1.8%) remained unidentified. This probably indicates an incomplete recovery of the bones – since sieving was not employed, many smaller specimens were not collected.

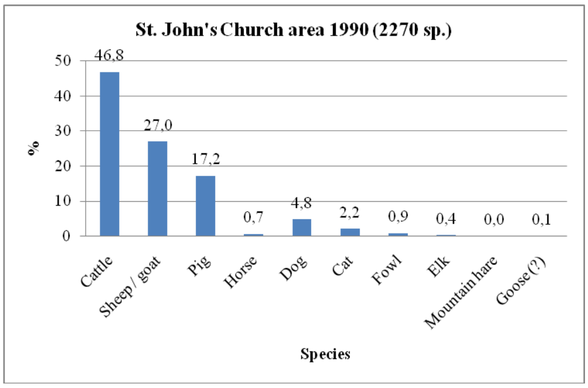
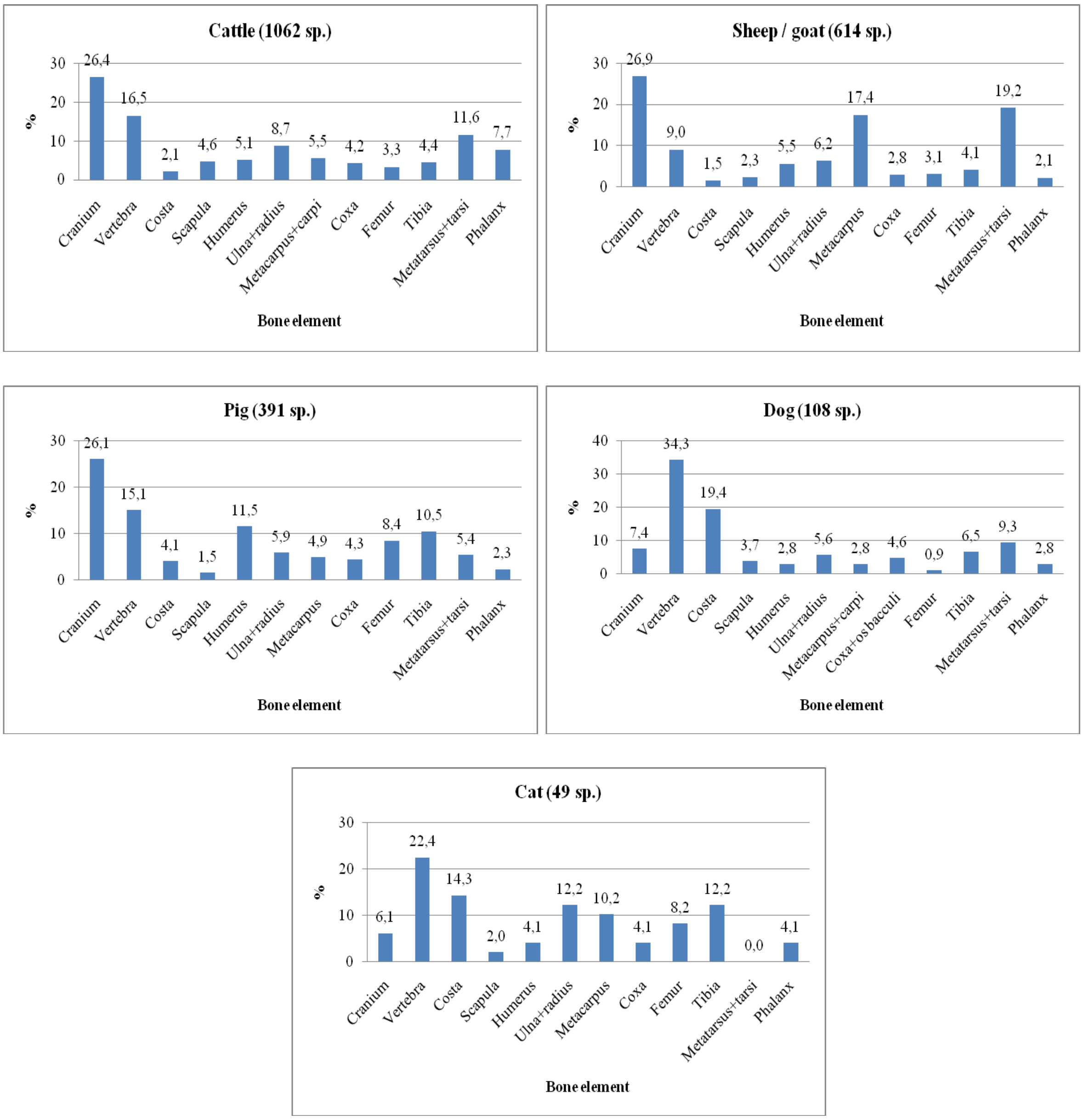


Figure 46. *The distribution of bone specimens from St. John's Church area by species.*

The composition of species is quite common (fig. 46), with cattle as most numerous, followed by sheep / goat and pig. Horse was represented by 15 specimens, mostly from cranium. Fowl occurred by 20 specimens, all from limbs.



Figures 47–51. *The distribution of cattle (Bos primigenius* f. *taurus), sheep / goat (Ovis ammon* f. *aries / Capra ibex* f. *hircus), pig (Sus scrofa* f. *domestica), dog (Canis lupus* f. *familiaris) and cat (Felis silvestris* f. *catus) bone specimens from St. John's Church area by bone element.*

The abundance of sheep / goat metatarsals is evident, while among dog bones the dominance of vertebrae is remarkable.

In general the bones were food disposals, except the specimens of dogs, cats and fowls that were preserved quite unbroken. Based on the osteometric data by Saks (1991a, 1–3), cattle were small and slender, with withers' height a bit over one meter. Some of the bones showed deficiencies of minerals. Pigs were also quite small, with long and slender limbs. Few piglet bones had traces of rachitis. Most of the horse bone fragments derived from small-sized and middle-aged horses, although two fragments had belonged to a larger type. Dog bones belonged to some smaller dogs, but most of them indicated larger, wolf-like dogs. Cats had the same body build as modern cats and fowls were smaller as it is characteristic to the Medieval Period, according to Saks (1991a, 1–3).

Excavations in 1991

Archaeological investigations became necessary in summer of 1991, when a water pipeline trench was excavated just beside the church and the medieval town wall. About 15 m^2 were excavated archaeologically. A thin Early Medieval cultural layer from the 13th century could be related to the cultural layer found already in 1990. Above that cultural layer there was a thick filling that could also be related to the similar filling found in 1990 – probably deposited there during the end of the 13th or in the first half of the 14th century. The function of the area in the Middle Ages has remained unclear – there is no cultural layer formed on top of the filling or it could have been removed during the war period in the second half of the 16th century. From the second half of the 15th century to the beginning of the Livonian War the area belonged to a Fransiscan monastery. In the first half of the 16th century there were extensive earthworks carried out – deep timber framed waste-pits were dug and those were covered with intensive cultural layer. In the 17th century there was also some earthwork and then the area became a part of cemetery that functioned till the end of the 18th century. (Valk 1993a)

In total 363 animal bone specimens were collected. Most of the bones derived from the 16th to the 17th centuries' cultural layer. Some (28 sp.) bones came also from the 13th century layer, representing cattle, sheep / goat, pig and fowl, but this assemblage is too small for the comparisons. Therefore I left the 13th century material out from the subsequent analysis and studied only the material from later period (fig. 52).

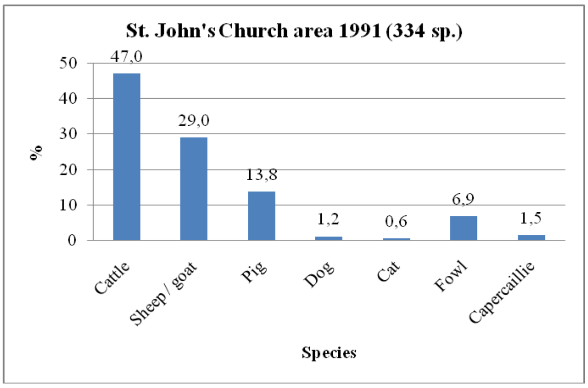
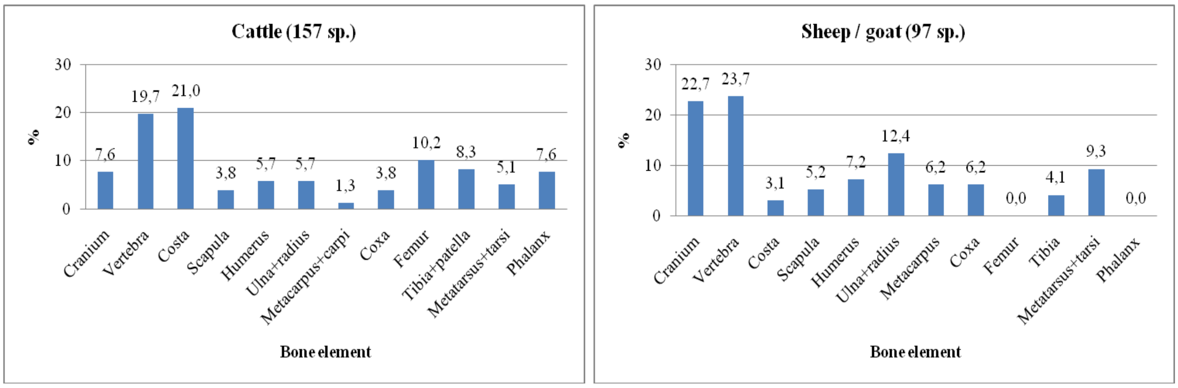
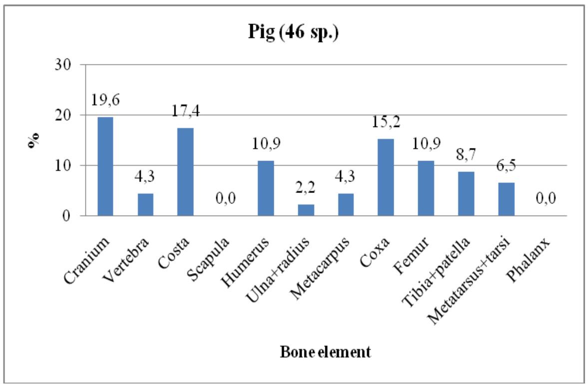
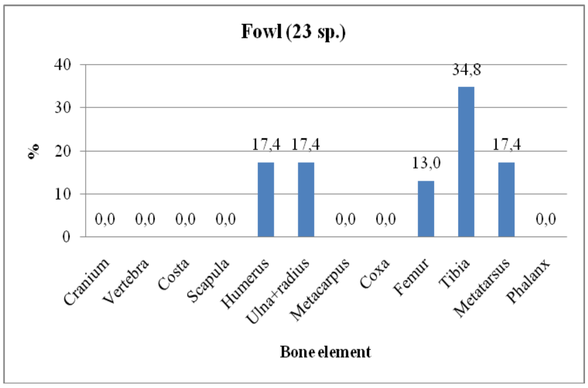


Figure 52. *The distribution of bone specimens from St. John's Church area by species.*







Figures 53–56. *The distribution of cattle (Bos primigenius* f. *taurus), sheep / goat (Ovis ammon* f. *aries / Capra ibex* f. *hircus), pig (Sus scrofa* f. *domestica) and fowl (Gallus gallus* f. *domesticus) bone specimens from St. John's Church area by bone element.*

According to Saks (1991b), the bones were very fragmented, except cattle carpals, tarsals and phalanges and specimens from dogs', cats' and fowls' tubular bones. Most of the cattle bones belonged to adult animals. Cattle were smaller, but sheep were close to the same size as modern breeds. Most of the pigs were slaughtered young. Fowls were again quite small size. On two cattle tarsals there were anchylosis and one cock's metatarsal was also pathological (Saks 1991b).

5.2.4. Pikk Street 1991

The heating pipeline trench excavated in the summer of 1991 (fig. 1: 8) was a continuation to the trench in the St. John's Church area investigated in 1990. Approximately 90 m^2 were archaeologically excavated. Earlier cultural layers from the 13th and 14th centuries were very well preserved. As in the church area, the early layers were covered with some filling and the late medieval period was represented quite poorly. The time of the Livonian War and some time after that in the late 16th and 17th centuries show again intensive life activity in the area. (Valk 1993b)

During the bone analysis no distinction between different time periods were made, so I present the material as one assemblage from the 13th to the 17th century. Altogether 3042 bone specimens were collected, whereof 98.5% were identified by E. Järv and P. Saks (Valk 1993b).

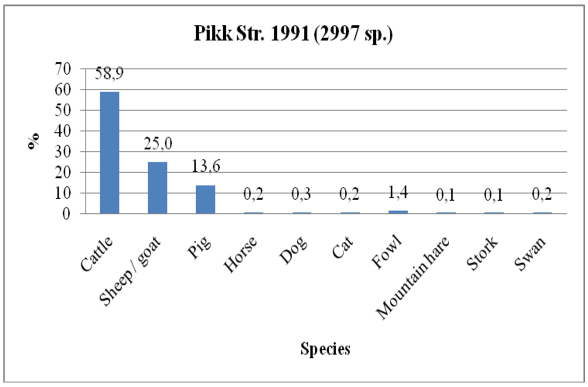
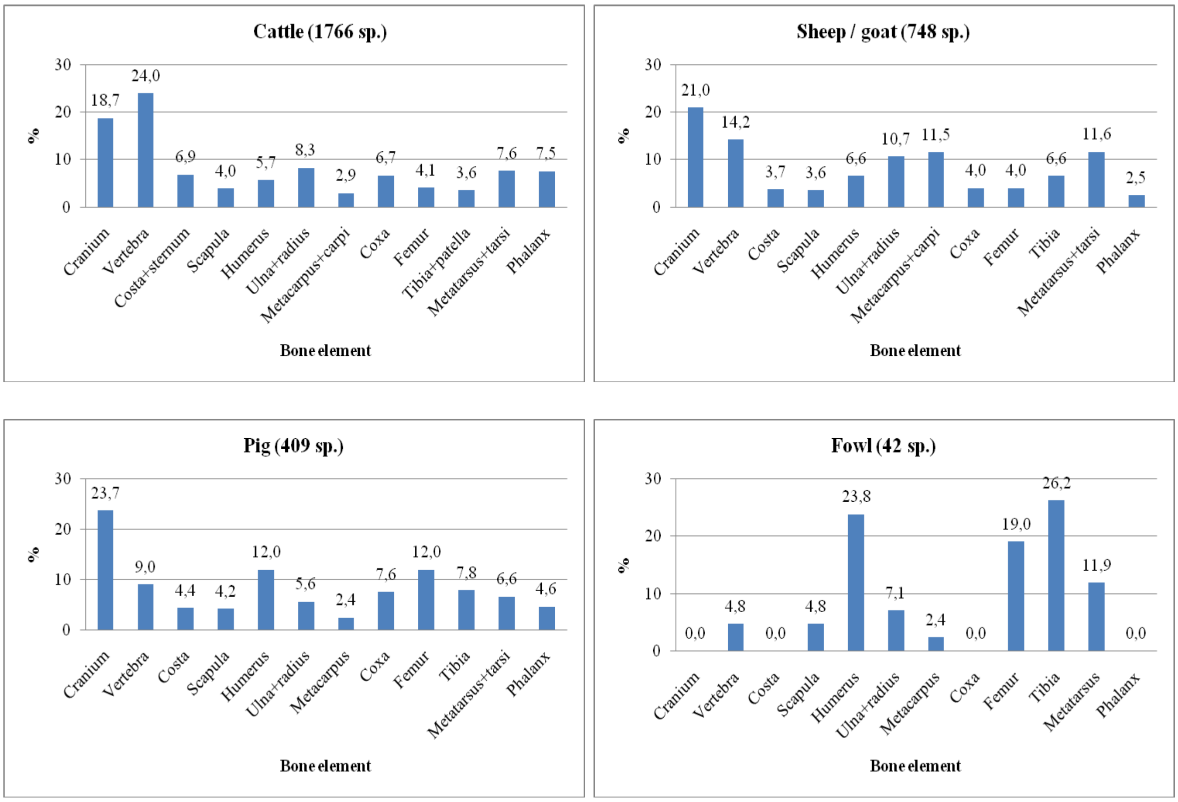


Figure 57. *The distribution of bone specimens from Pikk Street by species.*

Cattle exceeds other species greatly, followed by sheep / goat and pig. Compared to previous sites, wild birds like stork (*Ciconia sp.*) (2 sp.) and swan (*Cygnus sp.*) (5 sp.) were found (fig. 57).



Figures 58–61. *The distribution of cattle (Bos primigenius* f. *taurus), sheep / goat (Ovis ammon* f. *aries / Capra ibex* f. *hircus), pig (Sus scrofa* f. *domestica) and fowl (Gallus gallus* f. *domesticus) bone specimens from Pikk Street by bone element.*

Most numerous skeletal element for cattle is vertebra. Different parts of limbs are represented quite equally, although in the case of hind limbs the lower extremities are more abundant than in case of the front limbs. Among sheep / goat bones the predominance of lower extremities is clearly seen. In case of fowls, as usual, most fragments derive from wings and legs.

According to Järv and Saks (1991), the bones were quite fragmented. Most of the cattle specimens derived from up to five years old individuals. Lack of caudal vertebrae and porous surface of single horncores indicate a disturbance in mineral metabolism. Also, in case of 5% of cattle bone specimens there occurred anchylosis of tarsal bones. Sheep and goats were almost the same size as in the beginning of the 20th century. Pig bones belonged mostly to young animals with slender body build and long cranium. Fowls were again small sized, according to Järv and Saks (1991).

5.3. The castle area

The Teutonic Order castle in Viljandi has been excavated several times in 1878–1879, 1939, 1996, 1998–1999, 2000–2004 and 2007, but in the present thesis I use the animal bone material of 13 046 specimens only from the three years research excavations of 2001–2003 (fig. 1: 9), because these bones have been identified by E. Järv.

Excavations in 2001

The excavation area in 2001 was all together 28 m^2. The plots were situated near the northern wing of the convent building, by the castle chapel and revealed layers from the 16^{th} and 17^{th} centuries (Haak 2001). The site could be interpreted as a so called bell tower or sacristy and based on a find of the helmet fragment, the sacristy cellar could be interpreted as a wareroom for some military equipment (verbal, Haak 2010). All together 528 bone specimens from this period were collected and identified (Järv 2002).

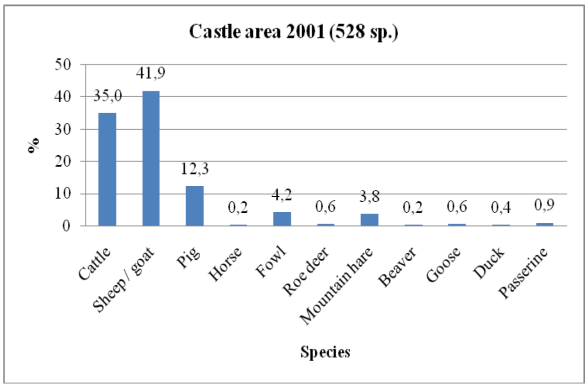
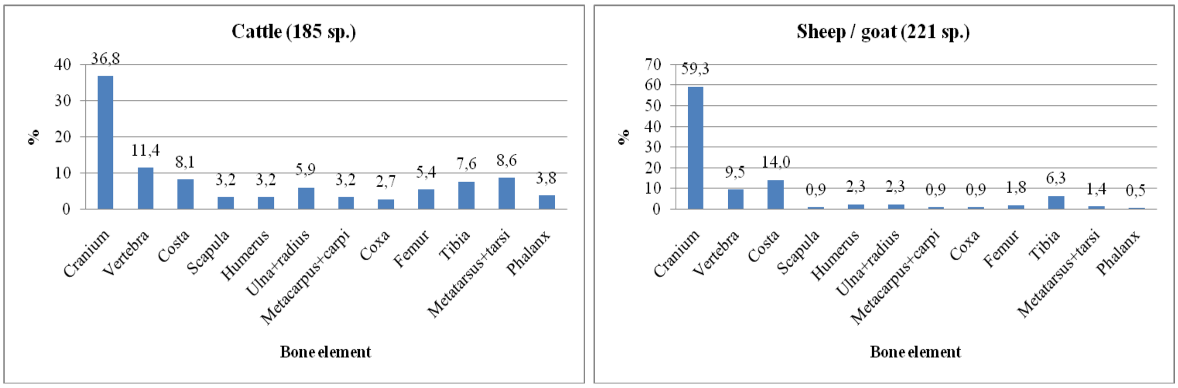
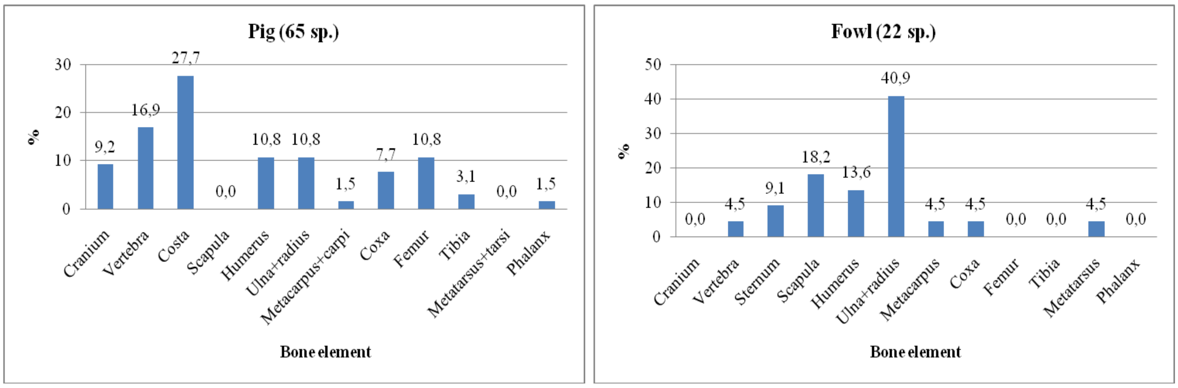


Figure 62. *The distribution of bone specimens from the castle area by species.*

The castle area differs from the town and suburb with its dominance of sheep / goat bones. Also game like roe deer (3 sp.) and beaver (*Castor fiber*) (1 sp.) are represented (fig. 62).





Figures 63–66. *The distribution of cattle (Bos primigenius* f. *taurus), sheep / goat (Ovis ammon* f. *aries / Capra ibex* f. *hircus), pig (Sus scrofa* f. *domestica) and fowl (Gallus gallus* f. *domesticus) bone specimens from the castle area by bone element.*

Most of the cattle and sheep / goat fragments derive from cranii, while other body parts are in great minority. Pigs, on the other hand, are represented with quite equal proportions between cranii, vertebrae and limbs.

Excavations in 2002

In 2002 the three excavation plots were situated in the first outer bailey (21.5 m^2) and in the staircases leading into the cellars of the eastern wing of the convent building and the sacristy part just next to these (respectively 12 m^2 and 25 m^2) (Haak & Pärnamäe 2004). From the medieval layers, dating to the end of the 13th to the beginning of the 17th century, 3321 animal bone specimens were found and identified by E. Järv (2003).

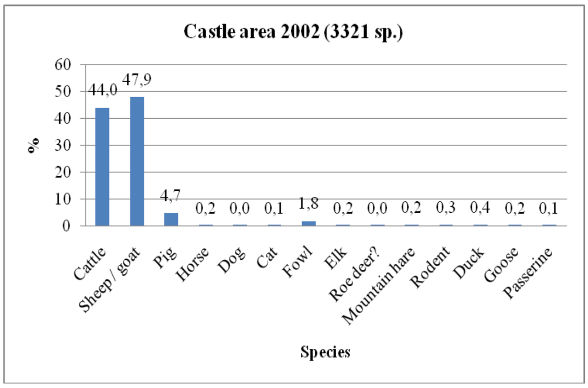
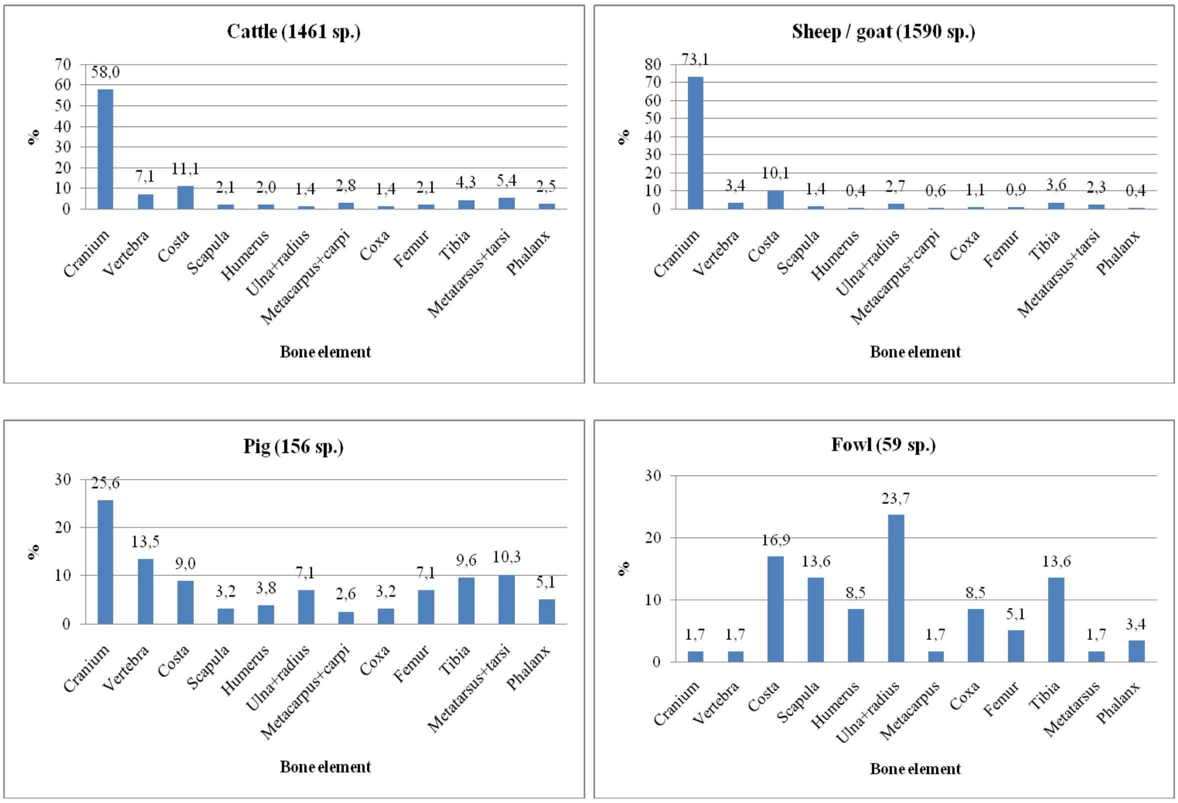


Figure 67. *The distribution of bone specimens from the castle area by species.*

As seen in figure 67, the interval between sheep / goat, cattle and other species is obvious. Although the diversity of species is quite large, most of them are represented only by few specimens.



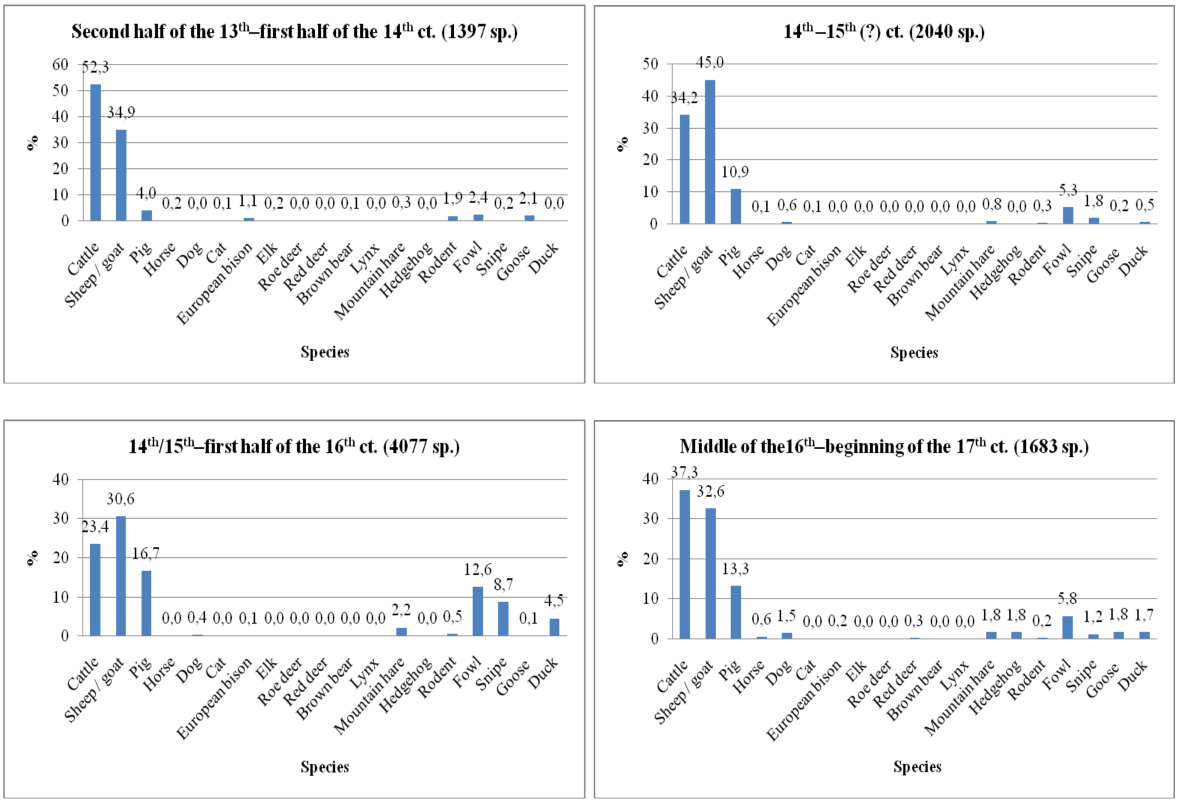
Figures 68–71. *The distribution of cattle (Bos primigenius* f. *taurus), sheep / goat (Ovis ammon* f. *aries / Capra ibex* f. *hircus), pig (Sus scrofa* f. *domestica) and fowl (Gallus gallus* f. *domesticus) bone specimens from the castle area by bone element.*

The dominance of cattle and sheep / goat cranium fragments is remarkable. According to Järv (2003, 2–3), the bones were quite fragmented. In case of cattle most of the metapodials had also been fractured, showing the culinary usage even of fatty bone marrow from the lower extremities. Cattle were mostly adults, with withers' heights of about one meter. Sheep and goats, on the other hand, were slaughtered before maturing. Pigs were as well slaughtered before maturing, but already when they had gained their maximal body size. Fowls were typically small, as reported by Järv (2003, 2–3).

Excavations in 2003

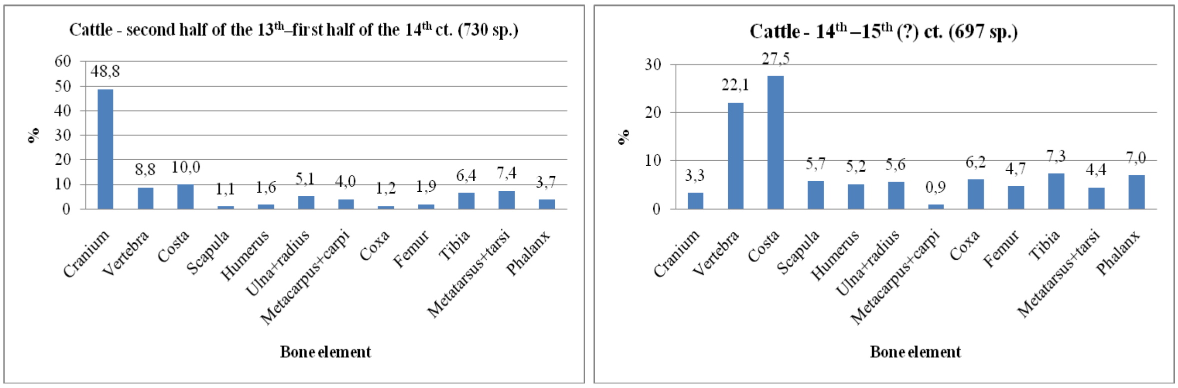
In 2003, the excavation plots were located by the southeastern corner of the main castle (25 m^2) and by the northeastern corner of the first outer bailey (8 m^2). In addition, archaeological supervision was carried out during the removal of construction debris between the northern wing of the Convent Building, and the building north of it at the first outer bailey. (Haak & Pärnamäe 2003, 2004)

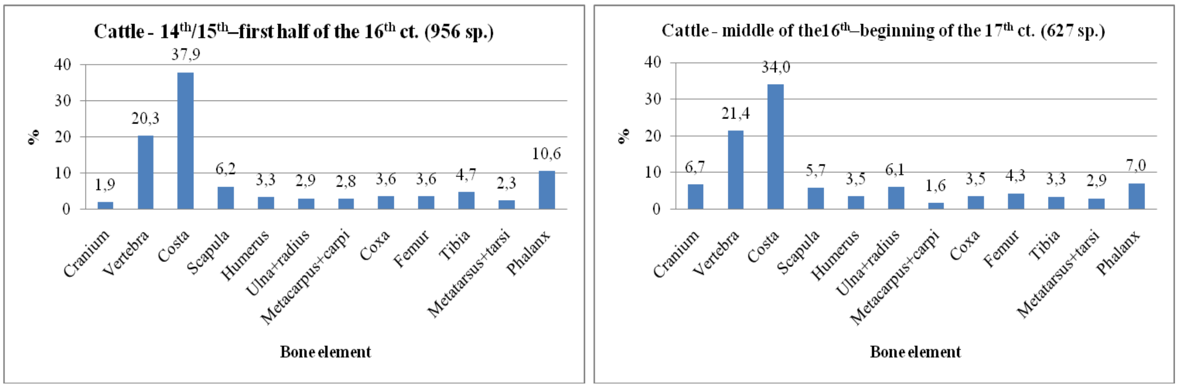
Animal bones collected from the sites were numerous – altogether 9199 specimens. Only two fragments derived from the first half of the 13th century and are not considered in my analysis. Bones from Medieval and Post-Medieval Times were distinguished into four periods: 1) the second half of the 13th to the first half of the 14th century (1397 sp.); 2) from the 14th to the 15th (?) century (2040 sp.); 3) from the 14th / 15th to the first half of the 16th century (4077 sp.); 4) from the mid-16th to the beginning of the 17th century (1683 sp.). (Järv 2005)



Figures 72–75. *The distribution of bone specimens from the castle area by species, by four time periods.*

Again, as characteristic to the castle area, sheep / goat bone specimens outbalance the cattle. Pigs and different birds have also been numerous in the human's meals. Due to the great bone assemblage, the species diversity is also most plentiful (fig. 72–75). In addition to elk (4 sp.), roe deer (1 sp.) and mountain hare (139 sp.) there are also other game like European bison (*Bison bonasus*) (25 sp.), red deer (*Cervus elaphus*) (5 sp.), brown bear (2 sp.), lynx (*Lynx lunx*) (1 sp.) and, further, hedgehog (*Erinaceus europaeus*) (30 sp.). Hedgehog bones are probably stray find, because based on the number of composition of different bone elements they could derive from one individual. Among bird bones domestic fowl has been most numerous, followed by snipe (*Gallinago sp.*), duck (family *Anatidae*) and goose.





Figures 76–79. *The distribution of cattle (Bos primigenius* f. *taurus) bone specimens from the castle area by bone element, by four time periods.*

If to look at the time periods separately (fig. 76–79), one can see a great difference within the distribution of cattle's cranii, vertebrae and costae: in the first period fragments of skull form almost half of the specimens, while vertebrae and costae are represented quite moderately; in other periods it is vice versa. According to Järv (2005, 2), most of the cattle were quite small – even with smaller withers' heights than one meter, but there were also very large bovids that probably were bisons.

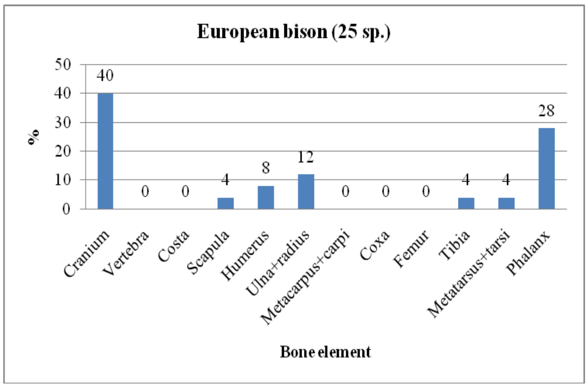
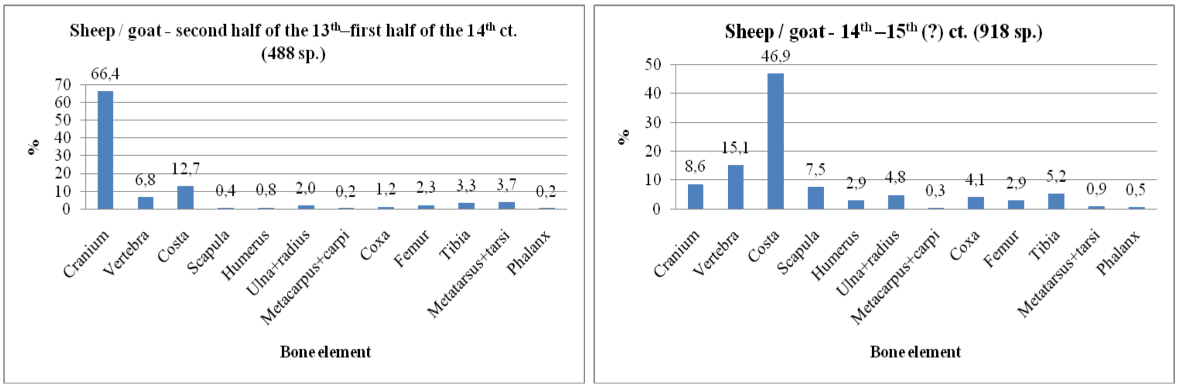
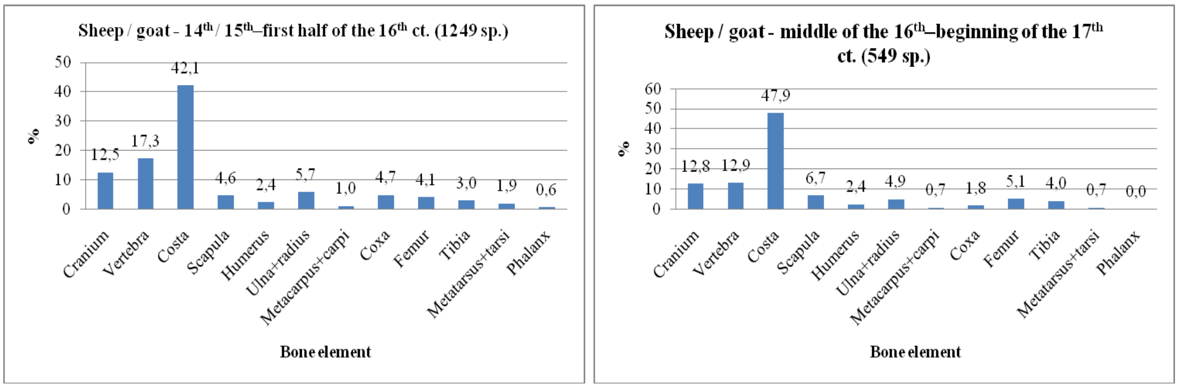


Figure 80. *The distribution of European bison (Bison bonasus) bone specimens from the castle area by bone element.*

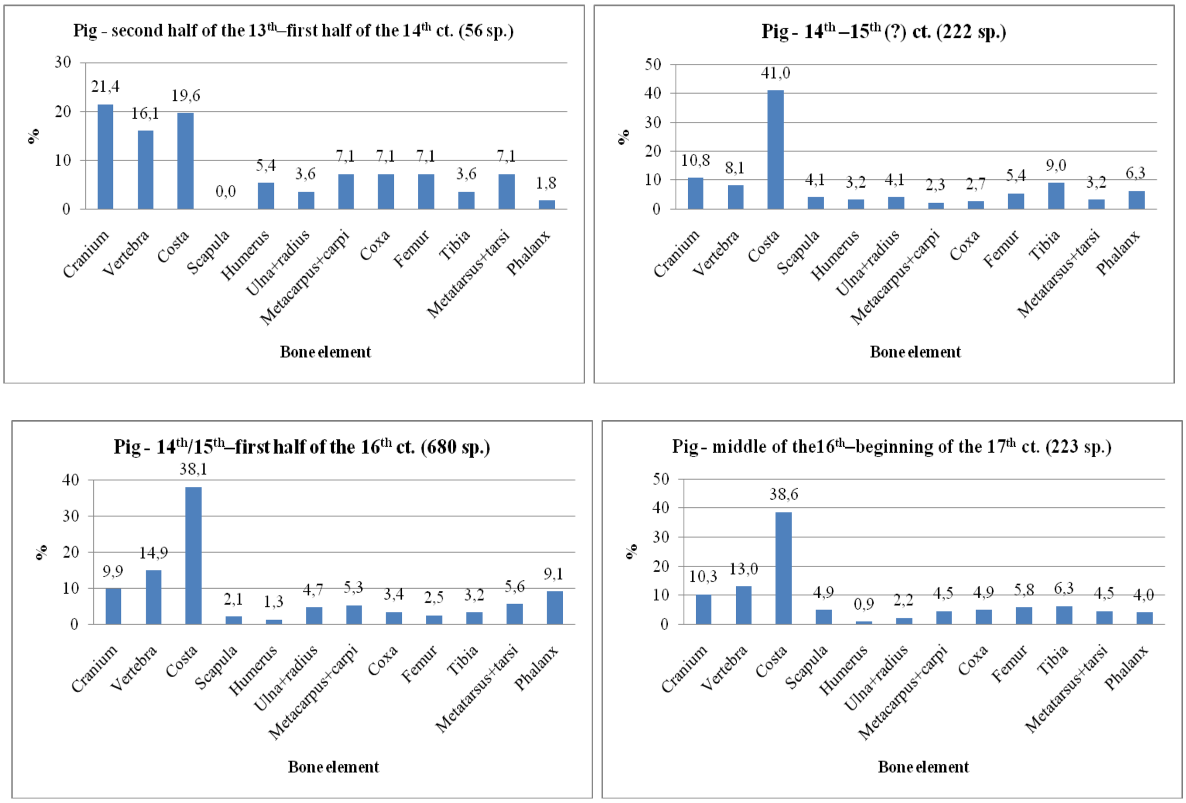
Bisons lived in Southern Estonia at the end of the first millenium AD, but in Latvia and Lithuania they were more abundant and inhabited the areas for a longer time period (Paaver 1965). So the bison bones in Viljandi most likely derive from import from southern areas, although it could also be possible, that the animals migrated for a short time to Southern parts of Estonia even during the Middle Ages (verbal, Lõugas 2010).





Figures 81–84. *The distribution of sheep / goat (Ovis ammon* f. *aries / Capra ibex* f. *hircus) bone specimens from the castle area by bone element, by four time periods.*

In case of sheep / goats the distribution of body parts is quite similar to cattle (fig. 81–84): again, in the first period skull fragments form more than a half of all bone specimens, while in the later periods the most numerous bone element is costa. According to report by Järv (2005, 2), sheep and goats were slaughtered young, even in the age of four months or up till 18 months.



Figures 85–88. *The distribution of pig (Sus scrofa* f. *domestica) bone specimens from the castle area by bone element, by four time periods.*

There were only 17 horse bones in the castle material from the excavations of 2003, mostly derived from costae and vertebrae. Ten horse bone specimens from the middle of the 16th to the beginning of the 17th century carried clear cut marks, proving the consumption of horse flesh, remarks Järv (2005, 2).

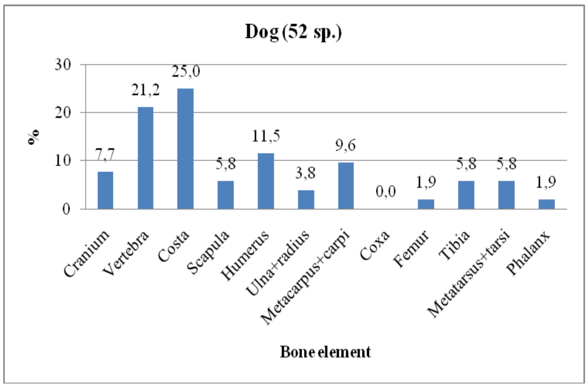


Figure 89. *The distribution of dog (Canis lupus* f. *familiaris) bone specimens from the castle area by bone element.*

According to Järv (2005, 2), most of the bones belonged to small-sized dogs and only from the 16th to the 17th century layers there were few specimens of larger, wolf-sized dogs.

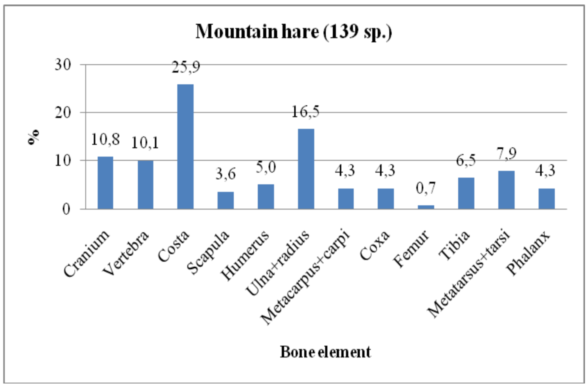
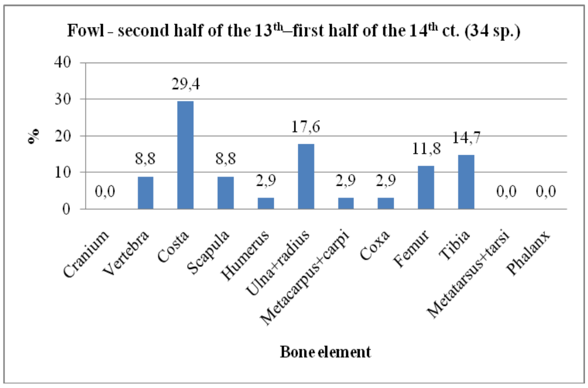
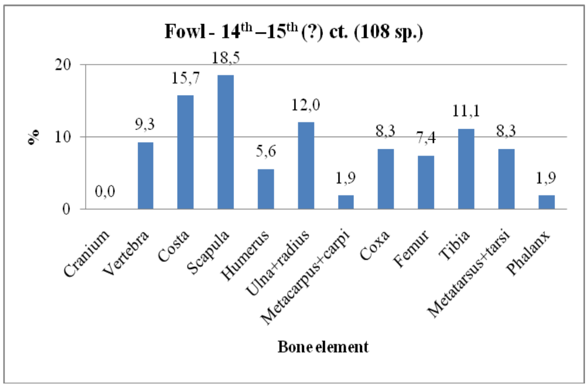
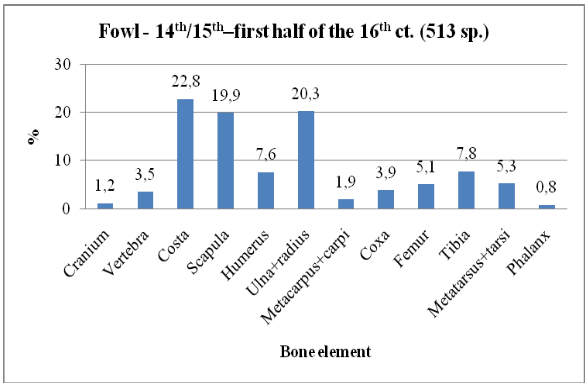
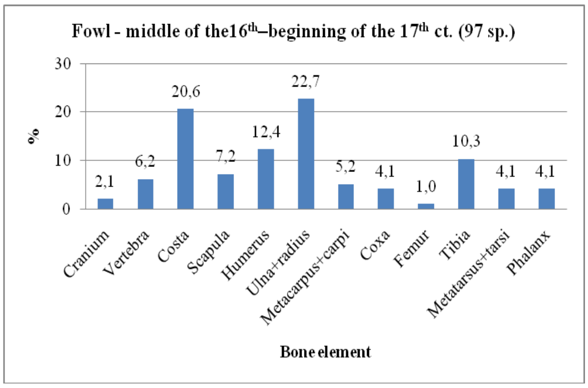


Figure 90. *The distribution of mountain hare (Lepus timidus) bone specimens from the castle area by bone element.*

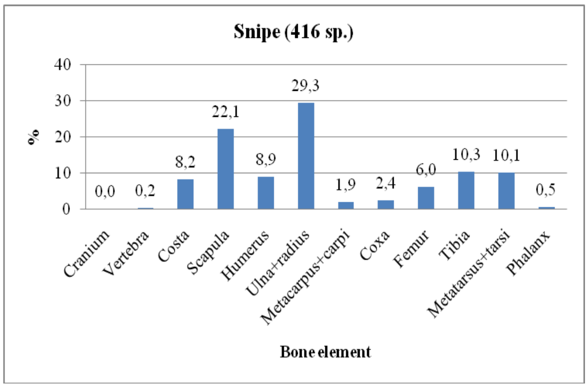


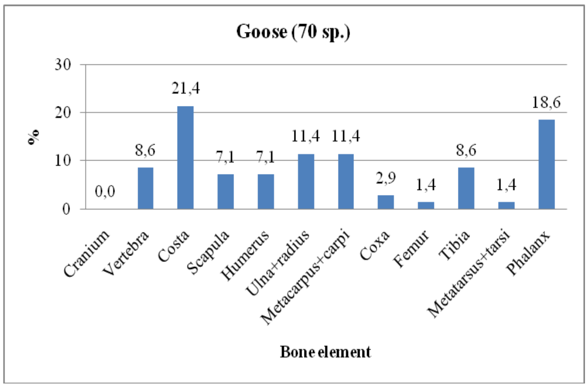


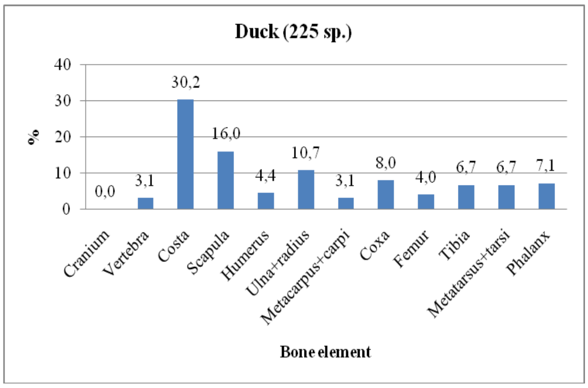




Figures 91–94. *The distribution of fowl (Gallus gallus* f. *domesticus) bone specimens from the castle area by bone element, by four time periods.*







Figures 95–97. *The distribution of snipe (Gallinago sp.), goose (Anser sp.) and duck (family Anatidae) bone specimens from the castle area by bone element.*

Chapter 6. Animal consumption in Viljandi: discussion

The material concerned in the present work is quite limited and its character is dependent on the locations of the excavation areas. Bone assemblages from nine sites in Viljandi do not necessarily represent the animal consumption and meat supply for the whole town during the Middle Ages, but still give a valuable information about the life and subsistence in the past. This is not an easy task to compare the sites because of their different excavation techniques, level of preservation, bone assemblage sizes and processes of identification. Also the chi-squared test showed that the sites are very different and therefore not possible to compare (app. V: 1–4). So, the patterns I found in the results could derive from the methodology and perhaps not reflect the original pattern of livestock supply (c.f. O'Connor 2003, 78). Nevertheless, these nine sites yield quite considerable amount of bones and represent three different areas of the town (app. III). Therefore, I can describe them, find some tentative differences and similarities and point out some interesting phenomena regarding the town of Viljandi.

6.1. General concepts of urban assemblages

The supply of meat to Viljandi was a part of wider agricultural economy and therefore animal bones found in the towns cannot tell us much about the real composition of herds, where the animals came from. Although some animals were kept inside the town and in the suburban areas as well, the main site of animal production was still the farm and the town was mostly the site of consumption, as suggested by O'Connor (2003, 80). Thus, to understand the animal husbandry and consumption as a whole, the rural areas are essential to include into the research. However, some reflections of the herd are also possible to give using the urban bone assemblages, e.g. a dairy herd typically consists of adult cows and calves, whereas a herd being raised primarily for meat might consist largely of young castrated males, as these will grow faster than intact males or females (O'Connor 2003, 80). So, if the urban bone assemblages include mostly specimens from mature cattle, then it could be assumed that the herd where the animals derived from, was basically a dairy herd. My source material represents a selection of animals brought into the town and their body parts from different farms and herds.

Excavation sites in the suburban and town areas represent mostly the medieval street layers, in some places with a smithy, iron processing site and craft. My main source material represents the suburban smithy and a tavern site as well, whereas at the church area there has been a possible market place. Thus, the bone material I studied is not related to any definite household or workshop and cannot be connected to the certain consumers of the meat. Therefore I cannot make any particular assumptions on social situations in the town, but I can only have a general overview.

As I cannot relate the bones to any household, it is also harder to tell, whether the bones form the waste of butchery, kitchen or craftsmanship. Butchery waste mostly consists of less meaty body parts like cranium and lower extremities. Kitchen waste or refuses from meals usually form of more meaty body parts like vertebrae and upper extremities, but bones used for marrow (like metapodials) belong here as well. Craftsmanship waste is indicated by raw material, half-ready products and fragments with processing marks on them.

I base my discussion on the general concept, referring to O'Connor (2003, 80), that animals were brought to the town alive, since it is the easiest way to transport animals, especially large cattle. Therefore the bone material in the suburb and in the town must include both the butchery and the kitchen waste, while the processed bones, as also in my research, can be less abundant. Once the animals had reached the town, they were slaughtered and butchered to different degrees. Questions like where was it done and by whom, could show, were the animals were slaughtered and chopped by a professional or not (O'Connor 2003, 80). However, town's people were skilled to kill animals and butcher the carcasses themselves too. In small-scale Post-Medieval urban systems in northern Finland and Sweden, for example, it was common that people bought animals alive from a butcher and these were then slaughtered at home, either by the butcher or the purchasers (Puputti 2009, 34). I cannot transmit this interpretation to Viljandi's material, since there is no evidence of professional butchers in Viljandi discovered so far, and I did not specially focus on cut marks during my research. I can tell at least that it could be one possible hypothesis.

The difference in various consumption of animals is an indicator of social and cultural differences at one certain time period, but also during the changes over time. When an animal was slaughtered, its carcass was utilized in many different ways. The degree of intensity of utilizing the carcasses shows how much potential resource a human community felt it could afford to waste (O'Connor 2003, 81). Differences in utilizing the meat in different parts of the town could indicate to economic differences. Also, if some particular skeletal elements were very heavily utilized, then those elements might be missing from the bone assemblage and could have survived as processed artifacts instead (O'Connor 2003, 81). In some sites of Viljandi, for example, there is a relative interval between more numerous metapodials and less numerous phalanges. Since these bones are part of lower extremities and therefore considered as butchery waste, they both should be equally present in the material. But if phalanges are missing, it could indicate a recovery bias, since phalanges are much smaller than metapodials. However, it could also be a possible indication of using phalanges for other purposes, e.g. making toys for children, which was quite common in the Middle Ages. Therefore phalanges may be absent in the food waste assemblage.

During the Middle Ages animals were smaller, meaning that they gave less meat than in some other periods of history. Also, the consumption of different species and body parts has changed throughout the times and some patterns that might appear in the diagrams, could be hard to interpret, just because it seems unusual for a 21st century researcher. Here some help from the written sources could be gained, in order to study dietary traditions of medieval people. Historical documents are also essential to be included in the studies, because sometimes they can provide a totally different outcome compared to the bone assemblages, and therefore collaboration with historians is necessary (c.f. Albarella 1999).

Although I did not make any special investigations of the pathologies and issues of animals' health in Viljandi, we can presume that most of the animals reached Viljandi on hoof, and those animals who died by disease or accident in the farm are not represented in the urban material (O'Connor 2003, 80). That could be the case with my bone material also and it could be the reason why there are only few signs of pathologies among the tavern and smithy bone material.

6.2. Consumed species and their body parts in Viljandi

There are two important sets of data in my work: species and skeletal element. It seems that the distribution within those is quite usual for medieval towns. The chi-squared test shows the lack of homogeneity in the distribution of cattle, sheep / goat and pig bone specimens in all the sites (app. V: 1–4), but based on a simple observation they still seem quite similar. Although there are little differences between individual sites, all the bones derive from both butchery and kitchen waste. In the discussion I mostly rely on my main source material – the tavern and smithy site, since it is the only assemblage, where I analyzed the individual features of the animals.

Cattle

As already mentioned in chapter 6.1, the cattle herds could have been kept for milking and / or for meat. In both cases older individuals were kept for breeding, e.g. maintaining the herd. In Viljandi's tavern, it seems that most of the consumed cattle meat derived from dairy herds, with mature animals slaughtered after reaching 4–5 years (fig. 3, 4). But it also indicates that people ate older animals in the tavern and that meat from young animals was not available or was maybe too costly. Out of male cattle most were probably oxen, although they did not appear clearly in the diagrams of sexual distribution (fig. 5–8). Oxen, as well as cows, were usually used as draught animals and bulls were kept only for breeding purposes. Cattle hides were also useful. In the tavern's material there are cutting marks on 62% of the mandibles, that most probably indicate the skinning procedure (Puputti 2009, 32) and maybe even a tannery nearby (Tourunen 2008, 46), although any tannery pits have not been found so far.

The only assemblage which could show something about the importance of cattle during the Middle Ages in Viljandi, is the one from Munga Street. There the importance of cattle has increased from the 14th to the beginning of the 17th century and at the same time the consumption of sheep / goats has decreased. However, since these results are based only on one bone assemblage that is not very large, it cannot be generalized to the whole town. A different pattern appears in the castle area (2003), where cattle was the most numerous species in the first period from the 13th to the 14th century and in the last period from the 16th to the 17th century, but seemed to have lost its significance for some time in the intermediary periods, when sheep and goats were dominating instead (fig. 72–75).

The bones of cattle from Viljandi could be attributed mostly to mixed waste, i.e. both butchery and kitchen waste. It seems that more specimens which derived from meal refuses, were among suburban Lossi Street material and in the St. John's Church area, including Pikk Street. Somewhat more butchery waste probably came from the Munga Street assemblage. One discovery that should be emphasized is the abundance of cranium fragments, especially from castle area. From the excavations of 2001 and 2002 fragments of cranii formed approximately half of all the specimens. This is a typical butchery waste and the castle might have had its own deliveries, its own butcher and a large kitchen. From the 2003 year excavations, where the distinction between four time spans could be made, an interesting pattern appeared that indicates to a different use of the same area: in the first period fragments of cranii formed almost half of all the bones, but in later periods the cranium fragments were almost missing, instead vertebrae and costae were dominating. It could be assumed that people did not eat meat from the heads, especially in the castle. Although, the way cranii were fractured – the mandibles were broken at the angles, indicates on their consumption as food source (Järv 2003, 2). So they could have used the tongues and facial muscles to make, for example, sausages and meat jelly. Thus, fragments of cranium could derive both from butchery and kitchen waste. In the assemblages of Tartu Street, church area (1990) and Pikk Street, there were relatively more hind limb bones, especially metatarsals and this could be a sign of bone work. In some sites there were more phalanges than metatarsals, indicating to a good archaeological recovery, because in the complete cattle skeleton there are six phalanges for every metapodials (app. II).

Sheep and goats

Sheep and goats were second numerous species in the material. Since their bones are much smaller than cattle bones, in the sites where the recovery has been poor, they tend to be under-represented (c.f. Albarella 1999, 868). The biggest interval between cattle and sheep / goats was in the suburban tavern site (table 1) and in the Lossi Street inside the town (fig. 37). In general sheep tend to be more frequent in rural sites and cattle in towns. According to Albarella (1999, 868), in the later Middle Ages in England sheep abundance increased – a change possibly connected to the expansion of land devolved to pasture and to the increasingly flourishing wool market. However, there might be regional differences and these interpretations might not apply to Medieval Livonia.

The distinction between sheep and goat bone fragments is complicated, but it seems that most of the fragments among the material belong to sheep. In the tavern material a reliable picture of these two species may be based on the distinction of metacarpals, where more than half of the specimens derive from the sheep (fig. 11). In sheep husbandry, as in the case of cattle, the main goal was unlikely to have been their meat (Albarella 1999, 868) and therefore wool production might have been quite important in the stock-breeding in Viljandi's hinterland as well. In the tavern site those small ungulates seemed to have been raised for wool and dairy, but also for meat, because half of them were killed before maturing (fig. 13). The tavern material also shows that a skin processing workshop could have been nearby – the indications of this are quite large amount of metapodials and phalanges and chopped goat horns (fig. 12; c.f. Wigh 2001, 87). Possible dominance of bucks (fig. 15) could also indicate to this craftsmanship.

Based on the assemblage from Munga Street in the town area, the importance of sheep and goats decreased during the 14th to the beginning of the 17th century and at the same time the consumption of cattle increased (fig. 41). In the castle area sheep and goats were dominating all the time, except in two periods distinguished at the excavations in 2003: the first period from the second half of the 13th to the first half of the 14th century and in the last period from the mid-16th to the beginning of the 17th century. Then cattle was the dominant species instead (fig. 72–75). However, in the last period sheep and goats might have been more abundant also, because they are almost as numerous as cattle and since smaller bones tend to be under-represented, there could be some recovery bias.

Sheep and goat bones were also mixed waste, although it seems that in the town area they formed mostly butchery waste and in the castle area more of kitchen waste. Most frequent body parts were cranial, vertebral and costal. In the suburb and in the town area there were quite a lot of lower extremities also and as in the case of cattle, metatarsals were for some reason more numerous, i.e. in suburban Lossi Street site (fig. 31) and in church area (fig. 48, 54). Phalanges, on the other hand, were not that numerous, indicating a recovery bias, i.e. in the church area (1990) (fig. 48) and in Pikk Street (fig. 59). In the castle area the body part distribution is very similar to that of cattle: most of the specimens derive from cranii, while other body parts are in great minority (fig. 64, 69). A different pattern appears from the 2003 assemblage, where parts of crania form more than half in the first period, but later the fragments of costae become abundant instead (fig. 81–84).

Pigs

Pig was the third numerous species in Viljandi's bone material. Although pig bones can be under-represented in the material, since getting into butchering waste more rarely than other artiodactyls (Maldre 1997a, 101), and they tend to decay more easily because of a high fat content, it is still rather certain that pigs did not outbalance the abundance of sheep and goats. Pigs were kept only for meat and majority of them were slaughtered as soon as they had gained their maximum body weight (Järv 2005, 2).

Based on the data from Munga Street, the importance of pig in medieval Viljandi has been roughly constant, although a little diminishing in the 16th century (fig. 41). Despite the limited assemblages, E. Iregren (verbal, 2010) has offered one possible interpretation for this kind of pattern: when the town was founded, there were more pigs consumed, but as the town grew, the less gardens and grazing lands were available inside the town and therefore pig consuming decreased. Also, in time there could have appeared some regulations for the waste, and loose pigs that were very common to medieval towns, did not find that much food any more (verbal, Iregren 2010). One evidence for breeding pigs in Viljandi, actually quite common for medieval towns, is a skeleton of a two-week old piglet found from one of the earliest waste pits in the church area (1990) (Valk 2004, 424). Most probably the piglet had died of natural causes and was dumped in a pit. In the castle area, however, the situation of pig bone abundance is opposite to the town: bone assemblage from the excavations of 2003 reveals a relative increase in pig bones through four time periods from the second half of the 13th to the beginning of the 17th century (fig. 72–75).

Pig bones from Viljandi occur mostly as mixed waste as well, although there seems to be some more specimens from kitchen waste. Most of the fragments derive from cranii, except from suburban Tartu Street, where most are from limbs (fig. 28). Also numerous are vertebrae and costae, followed by upper extremities. In some sites all parts of the limbs are represented quite equally. From the bone assemblage of castle area 2003 the distribution of body parts is very similar to those of sheep / goats at the same site: in the first period pig's cranii together with vertebrae and costae are most numerous, but in the following periods there are quite few cranium fragments, vertebrae and costae are dominating instead (fig. 85–88).

Horses

Horse bones were not numerous, but still in considerable amount. The majority of them comes from the suburban tavern site (table 1, app. III), where 41% of the fragments carry cut marks. Therefore horse flesh was consumed, although in small quantities. It could be related to poorer periods, when there was lack of food in the town. In Viljandi there could be some evidence for that from Munga Street, where horse was totally absent in the first period from the 14th to the beginning of the 16th century, but became as common as pig in the third period in the second half of the 16th century (fig. 41). H. Valk (1990, 26) has stated another hypothesis for this phenomenon: the presence of horse bones in the layers from the time of the Livonian War, second half of the 16th century could indicate that then Viljandi was a habitat for the Muslim Tartar warriors, who were traditional horse meat consumers. In that time the Tartarian troops were involved in the Russian Czar army and they acted also in Livonia (verbal, Valk 2010). The time of Livonian War could be a reason for consuming horse meat even in the castle area, where ten horse bones with cut marks were dated to this rough period. Although horse meat was not normally consumed, the animal could still be utilized in different ways. When a horse died or had to be killed because of sickness, injury or old age, it could have been used for bone processing, skinning (Tourunen 2008, 108) or for other possible purposes.

Dogs and cats

Although my work focuses mainly on domesticates used for meat supply, there were other functions for animals in a town also. Dogs and cats were likely to be kept as pets, to control the spread of rats and mice and dogs were most probably used also as guard animals (c.f. Albarella 1999, 872). Although there might have been quite a lot of dogs and cats running around medieval Viljandi, they rarely ended up in the butchery or kitchen waste. However, there are some bones in those waste assemblages also that could give some general ideas about the utilization of these species in medieval Viljandi.

From the waste pits in the earliest layers of the church area (1990) there were three dog skeletons found (Valk 2004, 424). That is the reason why the number of dog specimens from the site is quite numerous, represented mostly with vertebrae and costae, followed by metatarsals (fig. 46, 50). Most probably those dogs were deceased pets. There are no direct evidence from Viljandi, i.e. cut marks and the abundance of metatarsals, but in the Middle Ages the skinning of dogs was quite common and their pelts were used for making gloves (Albarella 1999, 873). Butchery marks on dog bones could show that they were eaten occasionally, they could have been used to feed other dogs, or the marrow fat could be exploited for cosmetic or other uses (Albarella 1999, 873). In the tavern material I did not study the cut marks that precisely, but a fact that there were cut marks on 18 dog bone specimens (table 1), could be explained by either way. Also, from the castle area 2003 there were relatively more dog bones from the period of the Livonian War (fig. 75) – it could be explained with eating dogs at that time or with the larger utilization of dog pelts.

Cat fur was very important in the Middle Ages and it seems, that the best quality skins came from young cats (Albarella 1999, 872; Hatting 1990). In Viljandi, most of the cat bones derive from the town, especially from the church area 1990 (app. III, fig. 46). Besides the dog skeletons also one from a cat was found from one of the waste pits (Valk 2004, 424). Since the bones belonged to a young individual, the interpretation of using this individual for skinning would be most probable. Studying the cut marks on these specimens could give more knowledge about the purpose of breeding cats in town.

Birds

More than half of the bird bones belong to domestic fowl, represented mostly by parts of limbs. For duck and goose there is no specification, were they domesticated or not, so I cannot treat them as domestic nor as wild birds. In the suburb, besides the fowl, there are also single fragments of goose, duck and passerine (*Passeriformes*). In the town area there are additionally a few specimens of goose, capercaillie (*Tetrao urogallus*), and quite extraordinarily, few swan and stork specimens from the Pikk Street (app. III; fig. 57). In England, most of the wild bird bones have been found from sites of high status (castles) and not from towns or rural sites of lower status (Albarella & Thomas 2002, 23). Swan has been especially associated with the aristocracy and could have been kept in the parks (Albarella & Thomas 2002, 25). The wild birds did not represent a staple element of the medieval diet or of the food economy and therefore their bones are not abundant among the zooarchaeological material, but they may be a significant source material for studying economic, social and symbolic elements of medieval society (Albarella & Thomas 2002, 24).

The majority of the bird bones come from the castle area: 85% of all fowl specimens and almost all of the other bird species (app. III). It could be explained with different excavation methods: only in the castle area sieving was employed and that effects the recovery of smaller bones. Also, the largest bone assemblages were collected from the castle. However, the relative distribution of the castle species still indicates to a bigger importance of bird consumption in the castle than in the other parts of the town. If to look at the assemblage from 2003, it is seen, that the relative abundance of fowl has grown during the Middle Ages. But also, general consumption of birds has grown in the two last periods of the 14th / 15th to the beginning of the 17th century (fig. 72–75). How can this be interpreted in Viljandi, is hard to say. But for example, historical and archaeological sources of England suggest that the upper classes increased the consumption of wild birds in the later periods, because if meat became more available for the people of lower status, then the higher class needed to manifest and differentiate itself with new ways (Albarella & Thomas 2002, 36). The second numerous bird species in the castle is snipe and it appears only there (app. III; fig. 72–75). Almost all of the duck and goose bones derive also from the castle. Based on a more frequent appearance of goose metacarpals and phalanges (fig. 96), Järv (2005, 2) has interpreted that geese wings could have been used for sweeping.

Wild mammals

From 279 wild mammal specimens 88% derive from the castle, 8% from the suburb and only 4% from the town area. The percentage of wild animals in medieval Viljandi is very low and could be explained with general trends of that time, common to whole Europe: during late medieval period only people with higher status had the permission to hunt and consume wild animals and although there are no specific written sources concerning this matter in Viljandi, it still could be assumed that this practice was applied there also (verbal, Haak 2010). But yet, there are few game bones also from the suburban area, which is considered as an area for lower class and for people who dealt with dangerous or unpleasant activities – like iron processing and butchering. In the town, on the contrary, there are much less game specimens. So, apparently, they could have served some game meat in the tavern, but since the number of fragments is so small (table 1), its amount was probably insignificant.

Mountain hare is the most numerous game species in all three areas of the town. But the most interesting is the presence of bison, found throughout the Middle Ages in the castle area, but only from the excavations in 2003 (fig. 72–75). Bison bone elements, mostly limbs and cranium indicate that the parts were not imported, but butchered and consumed at the site (fig. 80). Since there were no more bisons in Estonia at that time period, it could be assumed that castle inhabitants used to go for hunting in southern areas in time to time (verbal, Lõugas, 2010). In general the abundance of game is quite low. This could be explained with little consumption in general, but also, wild animals' waste could have been treated differently and therefore they do not appear in the assemblages. For example, only one brown bear phalanx among the tavern material could be an indication of the skinning at the kill site in the woods or that the remains might have been handled outside the town (Puputti 2009, 49). Few elk antlers could have been brought there just for processing and only six specimens from a mountain hare (table 1) could just be a stray find.

6.3. Social situation in the suburb, in the town and in the castle of Viljandi

Social differences are characteristic to medieval towns. In Viljandi the castle is associated with the largest share of the highest status, while in the town there were different social classes. In the suburbs, which had some rural characteristics, lived usually people from the lower social classes and also the ones dealing with dangerous or unpleasant activities. In the studied material only a few aspects indicate to those spatial differences in Viljandi. Temporal differences related to the social situation in the town, however, could not be drawn at all.

Comparison between the two suburbs (app. III, V: 1) is difficult, since the bone assemblages derive from quite different places. The tavern and smithy site is related to quite certain activities, mainly being a tavern for the town's people, but also for travelers and guests of the town. Other three sites in the northern suburb near the Tartu gate, however, do not represent any definite households. The common feature of all suburban sites is that they yielded a mixed waste from butchering and kitchen, consisting mainly of cattle, sheep, goat and pig bones. The biggest difference is the relatively bigger abundance of cattle and horse bones in the tavern and smithy site. According to the bone material the tavern offered mostly meat from old cattle, while meat from younger animals derived from sheep, goats and pigs. Quite extraordinary is the relatively big consumption of horse meat in the tavern compared to the rest of the town. It could be related to the site location in the suburb, belonging to a poorer area of the town and therefore serving even horse meat. This could also explain, why evidence of consuming game is almost missing in the tavern. However, in the town area there were even less wild animals – only few specimens of mountain hare and elk.

In four sites of the town centre (app. III, V: 2) there was also mixed waste, although the butchery waste could be somewhat more dominating. Horse and game bones were very rare. Birds, in the other hand, were more abundant than in the suburb, including even rare and high status indicating species like capercaillie, swan and stork. This is the main difference with the suburb, but in general there are no clear differences between these two areas based on the source material studied in the present work.

Castle (app. III, V: 3) as the place for socially higher inhabitants contrasted most with other parts of the town. Although there was butchery waste in the castle as well, a little more seem to derive from the kitchen. Castle inhabitants tended to consume more sheep and goat meat and also a lot of birds of different species. Horse bones were very rare. A relatively much bigger abundance of game bones and also a richness of species in the castle clearly indicates social differences between the three areas in Viljandi.

Conclusions

Viljandi was fairly important Estonian small town during the Middle Ages, belonging to the Hanseatic League and being a location for one of the mightiest castles of the Livonian Order. The history of the town is poorly known, since there are only a few written sources preserved from this period. Thus the archaeological evidence, including animal bones, is very important. The analysis of the bone material is essential to get information about the animals themselves, but also about their relationship with humans.

To study animal consumption in medieval Viljandi, I used the source material of almost 27 000 bone specimens. Bones derived from nine sites in different parts of the town and represented three different areas: the suburb, the town and the castle. My main source material, the bones I identified myself, derives from the excavations of Sports Centre construction, representing a suburban tavern and smithy site from the 14^{th} to the 16^{th} century. Although the studied assemblages were very different and therefore difficult to compare, the zooarchaeological analysis still gave some initial results about the animal consumption in medieval Viljandi.

The questions I addressed to my source material were mostly economy oriented. Main concern was the meat supply in the town. For that I mainly analyzed the distribution of species and animals' body parts. Most of the animals were probably raised in the farms in rural areas, although some animals, especially pigs, were kept inside the town as well. Three main domesticates were cattle, sheep / goat and pig. Because of the dominance of those species most of my results concern straightly them. The superiority of cattle was very clear in the suburb and in the town, but in the castle sheep and goats were most numerous instead. All bones represented mostly a mixed waste from butchery, kitchen and craftsman processing. Distinction between these categories was impossible to make, since the material could not be related to any definite household, but derived mostly from street layers, filling soils and homogeneous cultural layers dated to extensive time periods. In addition to meat, animals were also utilized for getting milk, wool, hides, horns and bones for processing.

Conclusions about sex distribution, age at death and animals' size were possible only based on the tavern and smithy site material. Most of the cattle had been kept for milking, since they were slaughtered mostly as matured animals. While sheep and goat bones were not distinguished, it is hard to say, which species was more abundant. It seems that they were also kept for milking and in case of sheep, for wool, since half of the animals were slaughtered as adults. Rest of them were slaughtered before maturing, indicating to the valuation of young animals' flesh. Pigs, as very common domesticates were kept only for meat and were mostly slaughtered as soon as they reached their maximum body weight. Horse flesh was not commonly consumed in the Middle Ages, but some bones with cut marks may be an evidence of neglecting this tradition in Viljandi. Data about the dogs and cats remained very insufficient and therefore it is impossible to make any profound conclusions. Among bird bones the most common species were domestic fowl and snipe, whence the latter was consumed only in the castle. Quite special finds in the town area were the bones of stork and swan, which are considered as indicators of higher status.

Consumption of wild animals seems not to be very prevalent in Viljandi, although there were quite a lot of different species. Most common of them was mountain hare, but others like brown bear, elk, roe deer, beaver and lynx were represented as well. Most interesting was the presence of European bison and red deer, who are rather extraordinary species to be found in medieval towns in Estonia. Both of them were found only in the castle area as most of the wild animals, most likely because of the higher status of its inhabitants.

The differences between the suburb, the town and the castle were not very distinctive. Although there were some indicators of the differences in social statuses – like more game and birds and the dominance of sheep and goats in the castle – it is not enough for any conclusive interpretations.

Temporal changes in the consumption of animals were even harder to see. Only in two sites the data could be studied according to time periods. The bone assemblage from Munga Street in the town, dating from the 14th to the beginning of the 17th century, showed the increase of cattle, while the abundance of sheep and goats was decreasing. In the time of the Livonian War abundance of horse had increased as well, indicating probably to some changes in society at the war period. In the castle area there were some changes in the patterns of the consumption of main domesticates, related to the dominance of cattle in some periods and sheep / goat in others. Towards the end of the Middle Ages eating pork became more common in the castle and there was also some increase in the consumption of birds, especially domestic fowls.

To answer more questions about animal consumption in medieval Viljandi, more profound studies are necessary. It is very important to interpret the site by the archaeologist and to collect and document the animal bones as precisely as possible. The basic problem in town excavations is that they tend to be very time-limited, so the methods applied are imperfect, especially concerning animal bones. Regardless of that, animal bones have to be treated as important source material as any other. The bones should be put in precise context, dated as accurately as possible and collected and preserved carefully in order not to lose any data.

My future perspective is to continue the studies of medieval Viljandi. The bone material from there is very interesting and since there have been and will be a lot of excavations in the town, the source material improves and increases constantly. More precise identification, more accurate recording and methods together with the study of other archaeological data, historical documents, town history, mentality in medieval societies and comparison with the other towns in Estonia and neighboring countries would eventually give a clearer picture of Viljandi as one of the towns in medieval Livonia. To understand the animal husbandry and consumption as a whole, rural areas are essential to be included in the research as well. Future excavations in the areas of Viljandi's hinterlands and the analysis of those animal bones could shed some light to the meat trade and town's relationship with the farms. Also, since in the present work the focus was on the general consumption of the animals and not on the animals themselves, studies about breeds, health, shape and other individual features of the individuals forms another possible topic for the future. This includes the research of coprolites, pathologies, DNA, stable isotopes, etc.

A very important result of this thesis was my personal development. I learned the basics of zoology and osteology, I got the know-how of identifying the bones of main domesticates and introduced myself with the most common methods in zooarchaeology. I got the first experience of analyzing archaeological bone assemblages and integrating them into a larger context in order to study the history of one medieval town. On these skills and knowledge I can build my subsequent studies.

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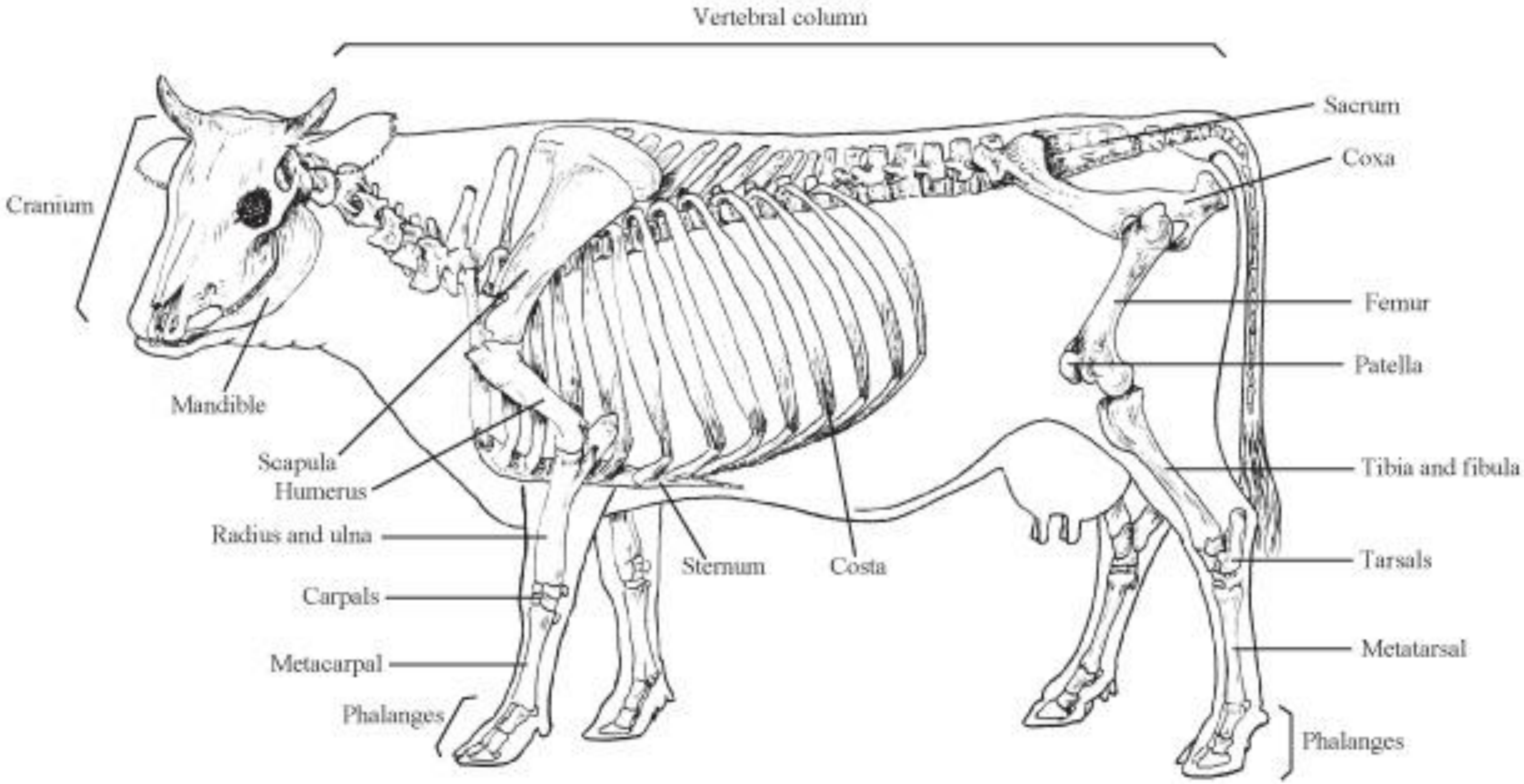
Appendixes

Appendix I: list of occurring species

Latin	English
Bos primigenius f. *taurus*	Cattle
Ovis ammon f. *aries*	Sheep
Capra ibex f. *hircus*	Goat
Sus scrofa f. *domestica*	Pig
Equus ferus f. *caballus*	Horse
Canis lupus f. *familiaris*	Dog
Felis silvestris f. *catus*	Cat
Rodentia	Rodents
Lepus timidus	Mountain hare
Bison bonasus	European bison
Capreolus capreolus	Roe deer
Alces alces	Elk
Ursus arctos	Brown bear
Castor fiber	Beaver
Cervus elaphus	Red deer
Lynx lynx	Lynx
Erinaceus europaeus	Hedgehog
Gallus gallus f. *domesticus*	Domestic fowl
Anser sp.	Goose
family *Anatidae*	Ducks
Gallinago sp.	Snipe
Passeriformes	Passerine
Tetrao urogallus	Capercaillie
Ciconia sp.	Stork
Cygnus sp.	Swan

Appendix II: skeletal elements of a cattle



Appendix III: distribution of species in Viljandi by specimens

1. Domestic species (number of specimens)

Area	Site	Layer	Cattle	Sheep / goat	Pig	Horse	Dog	Cat	Rodent
Suburb	Sports Centre 1999	14.–16.ct.	3047	912	571	314	45	6	
	Tartu Str. 1996	14.–16.ct.	76	40	31				
	Lossi Str. 2001	14.–16.ct.	235	97	80			1	
	Posti / Lossi Str. 2001	14.–16.ct. + 18.–19.ct.	696	424	230	5	3	14	
Town	Lossi Str. 1992	mid-13.–mid-16.ct.	397	131	93	20	6	25	1
	Munga Str. 1989	14.–beg.of 16.ct.	70	51	16			2	
		I half of 16.ct	56	19	5	2			
		II half of 16.ct.(+ beg.of 17.ct.)	224	35	27	26	1		
	St. John's Church 1990	II half of 13.(+ 14.–15.ct.)	1062	614	391	15	108	49	
	St. John's Church 1991	16.–17.ct.	157	97	46		4	2	
	Pikk Str. 1991	13.–17.ct.	1766	748	409	5	10	7	
Castle	Castle area 2001	16.–17.ct.	185	221	65	1			
	Castle area 2002	end of 13.–beg.of 17.ct.	1461	1590	156	5	1	3	9
	Castle area 2003	II half of 13.–I half of 14.ct.	730	488	56	3		2	27
		14.–15.ct.	697	918	222	2	12	3	7
		14./15.–I half of 16.ct.	956	1249	680	2	15		20
		mid-16.–beg.of 17.ct.	627	549	223	10	25		4
			12442	**8183**	**3301**	**410**	**230**	**114**	**68**

2. Game species (number of specimens)

Area	Site	Layer	Mountain hare	Bison	Roe deer	Elk	Brown bear	Beaver	Red deer	Lynx	Hedgehog
Suburb	Sports Centre 1999	14.–16.ct.	6		1	1	1				
	Tartu Str. 1996	14.–16.ct.	1								
	Lossi Str. 2001	14.–16.ct.	4								
	Posti / Lossi Str. 2001	14.–16.ct. + 18.–19.ct.	3				4				
Town	Lossi Str. 1992	mid-13.–mid-16.ct.									
	Munga Str. 1989	14.–beg.of 16.ct.									
		I half of 16.ct									
		II half of 16.(+ beg.of 17.ct.)									
	St. John's Church 1990	II half of 13.(+14.–15.ct.)	1			8					
	St. John's Church 1991	16.–17.ct.									
	Pikk Str. 1991	13.–17.ct.	3								
Castle	Castle area 2001	16.–17.ct.	20		3			1			
	Castle area 2002	end of 13.–beg.of 17.ct.	8		1	6					
	Castle area 2003	II half of 13.–I half of 14.ct.	4	16		3	2				
		14.–15.ct.	17	1	1						
		14./15.–I half of 16.ct.	88	5		1				1	
		mid-16.–beg.of 17.ct.	30	3					5		30
			185	**25**	**6**	**19**	**7**	**1**	**5**	**1**	**30**

3. Bird species (number of specimens)

Area	Site	Layer	Domestic fowl	Goose	Duck	Snipe	Passerine	Capercaillie	Stork	Swan
Suburb	Sports Centre 1999	14.–16.ct.	11	3						
	Tartu Str. 1996	14.–16.ct.	1							
	Lossi Str. 2001	14.–16.ct.	7		2		1			
	Posti / Lossi Str. 2001	14.–16.ct. + 18.–19.ct.	42	1	9		2			
Town	Lossi Str. 1992	mid-13.–mid-16.ct.	5							
	Munga Str. 1989	14.–beg.of 16.ct.	1							
		I half of 16.ct								
		II half of 16.(+ beg.of 17.ct.)	1							
	St. John's Church 1990	II half of 13.(+14.–15.ct.)	20	2						
	St. John's Church 1991	16.–17.ct.	23					5		
	Pikk Str. 1991	13.–17.ct.	42						2	5
Castle	Castle area 2001	16.–17.ct.	22	3	2		5			
	Castle area 2002	end of 13.–beg.of 17.ct.	59	5	13		4			
	Castle area 2003	II half of 13.–I half of 14.ct.	34	29		3				
		14.–15.ct.	108	4	11	37				
		14./15.–I half of 16.ct.	513	6	185	356				
		mid-16.–beg.of 17.ct.	97	31	29	20				
			986	**84**	**251**	**416**	**12**	**5**	**2**	**5**

Appendix IV: illustrations of pathologies from the tavern and smithy site, i.e. Viljandi's Sports Centre 1999

1. Thoracic vertebrae of a cattle (*Bos primigenius* f. *taurus*)

2. Lumbalic vertebra of a cattle (*Bos primigenius* f. *taurus*)

3. Metatarsus of a cattle (*Bos primigenius* f. *taurus*)

4. Mandible of a pig (*Sus scrofa* f. *domestica*)

5. Thoracic vertebrae of a horse (*Equus ferus* f. *caballus*)

6. Femur of a dog (*Canis lupus* f. *familiaris*)

Appendix V: the results of the chi-squared test analysis

- columns are for species: A = cattle, B = sheep / goat, C = pig
- rows are for sites
- χ^2 = chi-square
- df = degrees of freedom
- p = probability

1. **SUBURBAN AREA: 1 = Sports Centre, 2 = Tartu Str., 3 = Lossi Str., 4 = Posti / Lossi Str.**

data: contingency table

	A	B	C	
1	3047	912	571	4530
2	76	40	31	147
3	235	97	80	412
4	696	424	230	1350
	4054	1473	912	6439

expected: contingency table

	A	B	C
1	2.852E+03	1.036E+03	642.
2	92.6	33.6	20.8
3	259.	94.3	58.4
4	850.	309.	191.

χ^2= 134, df = 6, p = 0.000

2. **TOWN: 1 = Lossi Str., 2 = Munga Str., 3 = St. John's Church 1990, 4 = St. John's Church 1991, 5 = Pikk Str.**

data: contingency table

	A	B	C	
1	397	131	93	621
2	350	105	48	503
3	1062	614	391	2067
4	157	97	46	300
5	1766	748	409	2923
	3732	1695	987	6414

expected: contingency table

	A	B	C
1	361.	164.	95.6
2	293.	133.	77.4
3	1.203E+03	546.	318.
4	175.	79.3	46.2
5	1.701E+03	772.	450.

χ^2= 92.8, df = 8, p = 0.000

3. **CASTLE: 1 = castle area 2001, 2 = castle area 2002, 3 = castle area 2003**

data: contingency table

	A	B	C	
1	185	221	65	471
2	1461	1590	156	3207
3	3010	3204	1181	7395
	4656	5015	1402	11073

expected: contingency table

	A	B	C
1	198.	213.	59.6
2	1.348E+03	1.452E+03	406.
3	3.109E+03	3.349E+03	936.

χ^2= 251, df = 4, p = 0.000

4. **THREE AREAS OF VILJANDI: 1 = suburb, 2 = town, 3 = castle**

data: contingency table

	A	B	C	
1	4054	1473	912	6439
2	3732	1695	987	6414
3	4656	5015	1402	11073
	12442	8183	3301	23926

expected: contingency table

	A	B	C
1	3.348E+03	2.202E+03	888.
2	3.335E+03	2.194E+03	885.
3	5.758E+03	3.787E+03	1.528E+03

χ^2= 0.118E+04, df = 4, p = 0.000