Developments in Animal Husbandry and Food Supply in Roman Germania Inferior

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The Roman province of Germania Inferior is characterized geographically by the river Rhine—the border of the Empire—and the forts along it. From the north-west to the south-east, there are significant differences in landscape and type of rural habitation. Whether these differences are also noticeable in animal husbandry forms the subject of this article. Are there any differences in species proportions and slaughter ages between the western and eastern parts of the province, and between urban, military, and rural sites? What does this say about farming and food supply? After presenting an overview of the zooarchaeological data from Germania Inferior, I shall discuss in detail one civitas—the civitas Batavorum, with the best known zooarchaeological dataset within the province. What changes in species proportions and cattle size can be detected over time from this civitas? Is there evidence for inter- and intra-site variability and changes in butchery methods? This article’s further aim is to demonstrate what kind of questions a synthetic overview of zooarchaeological datasets can address.

Keywords: animal husbandry, Roman period, Germania Inferior, Netherlands, Germany

INTRODUCTION

Animal husbandry in the Roman period not only produced meat, but also raw materials for industry and transport animals in the form of cattle and horses. It has long been recognized that animal husbandry changed during the Roman period, but only detailed studies of different regions can reveal whether these changes were the same or not throughout the Roman Empire. This paper focuses on the province of Germania Inferior, located on the northern border of the Empire. This region was incorporated into the Empire in the late first century BC, although the province was only formally established sometime between AD 82 and 90 (Willems & Van Enckevort, 2009: 25, 75). Roman occupation lasted until the late fourth century AD. The province is typified by a strong military presence, with a series of forts situated along the river Rhine. The Rhine formed a convenient transport route for goods. Within the province, there are significant differences in landscape: from the coastal dunes, peat, and river delta in the Central Netherlands to the sandy and loessic soils of the south-eastern Netherlands, to the river plain in the part of the province that is now in modern Germany. Settlements ranged from military camps to large towns. Two main types of rural site can be distinguished: villae, which were agrarian businesses producing food for the urban and military market and which are mainly found in the eastern part of the province; and small clusters of farms, which may also have produced a surplus of food, but on a much
smaller scale. The latter are dominant in the western part of the province. The presence of imported goods on indigenous sites is a strong indication that local people were active participants in economic networks.

My first aim is to outline broad trends in animal husbandry in Germania Inferior. Were there differences in species proportions and slaughter ages between urban, military, and rural sites, and between the western and eastern parts of the province? If so, what does this say about food supply or dietary preference? By investigating differences between types of site and in animal exploitation, it is possible to establish to what extent animal husbandry and food supply were influenced by environmental factors, farmers’ choices, and consumer demand. By examining whether animal exploitation (i.e. slaughter ages) was focused on meat or secondary products, it is possible to discover the relative importance of industry and the degree of specialization in food production.

My second aim is to add more detail and time depth by discussing one civitas, the civitas Batavorum, a region for which an excellent zooarchaeological dataset exists. Are there any changes in species proportions over time, and between urban, military, and rural sites? Is there any inter- and intra-site variability in species proportions, and if ‘yes’, what does this say about relative specialization? Do cattle show an increase in size, and if so, when does this take place? Developments in cattle size will be discussed since they reflect changes in the social perception of livestock, changes in economic aims (intensification of meat output or more traction power), know-how of cattle breeding, and economic networks. I will further briefly discuss changes in butchery methods, since this provides information on changes in the perception of animals and technology.

My third aim is to demonstrate what kinds of questions can be addressed in a synthetic overview of zooarchaeological datasets. These questions include: To what extent do environmental factors influence animal husbandry? What is the relationship between site type and meat consumption? Do we find evidence for variation—reflecting different agrarian specialization—between contemporary rural sites in a given cultural region?

**Materials and Methods**

The research area is the province of Germania Inferior, but it excludes the civitas Tungrorum as this is covered by Fabienne Pigière’s article in this issue (Figure 1). A rough west-east division is used when analysing and discussing the data here. The western part of the province covers the civitates Cananefatium, Batavorum, and Frisiavonum and lies between the towns of Voorburg and Nijmegen. The eastern part of the province covers the civitates Traianensis and Ubii and lies between the towns of Nijmegen and Bonn. A recent article (Groot & Deschler-Erb, 2015) describes the differences between the datasets from the eastern and western Central Netherlands, so they are not discussed here. Apart from this geographical division, the data are analysed by type of site, distinguishing between military, urban, and rural sites. Military and urban sites provide evidence for consumption of animal products in the first place, but indirectly also for production. In rural sites, evidence for production dominates but is also mixed with evidence for consumption. The available zooarchaeological data are not spread evenly over the province: there is a strong bias towards the western part (mostly the Central Netherlands; see Table 1). There is also a bias towards rural data (Table 1), but this bias is due to the
fact that most of the dataset comes from the Netherlands, with very few rural sites in Germany having been analysed and published. Within the rural data, there is a further bias: small farmsteads dominate in western Germania Inferior, while villae form the main type of rural settlement in eastern Germania Inferior. Because of the

**Figure 1.** Map of north-western Europe showing the province of Germania Inferior, the civitas Batavorum, and the western and eastern parts of the province as discussed in this article. The southern half of the province, the civitas Tungrorum, is not considered in this article.

**Table 1.** Zooarchaeological dataset used in this study.

<table>
<thead>
<tr>
<th>Area</th>
<th>n military assemblages</th>
<th>n urban assemblages</th>
<th>n rural assemblages</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Netherlands, west</td>
<td>14</td>
<td>12</td>
<td>28</td>
<td>54</td>
</tr>
<tr>
<td>Central Netherlands, east</td>
<td>11</td>
<td>15</td>
<td>63</td>
<td>89</td>
</tr>
<tr>
<td><strong>Total western Germania Inferior</strong></td>
<td><strong>25</strong></td>
<td><strong>27</strong></td>
<td><strong>91</strong></td>
<td><strong>143</strong></td>
</tr>
<tr>
<td>South-eastern Netherlands</td>
<td>–</td>
<td>2</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Germany</td>
<td>11</td>
<td>11</td>
<td>2</td>
<td>24</td>
</tr>
<tr>
<td><strong>Total eastern Germania Inferior</strong></td>
<td><strong>11</strong></td>
<td><strong>13</strong></td>
<td><strong>7</strong></td>
<td><strong>31</strong></td>
</tr>
</tbody>
</table>

*Note: Due to limits of space, I refer to previous publications for a list of sites and references for sites from western Germania Inferior: Groot, 2016; Groot & Deschler–Erb, 2015, 2016. Sites from eastern Germania Inferior are listed in the appendix.*
small size of the dataset for the eastern part of the province, it is not possible to analyse developments over time there. Such developments will be discussed in more detail for the western part of the province.

To understand the relative importance of different livestock species, percentages were calculated for the main domestic mammals (cattle, sheep or goat, and pig). The percentages were calculated on the basis of the Number of Identified Specimens. Although of lesser importance as a meat provider, horse is included in this study, as it will become clear that this species played an important economic role in the western part of the province. The percentage is calculated out of the total Number of Identified Specimens for the three main domestic animals and horse. Chicken was introduced in the area under study during the Roman period; it therefore reflects the influence of the Roman diet, and the extent to which this was adopted by local people. The percentage of chicken is calculated out of the total Number of Identified Specimens for the three main domestic animals and chicken.

To allow for comparison between the two parts of the province and to investigate changes over time, percentages were grouped by region and type of site, and the mean and standard error calculated.

Analysing slaughter ages of cattle, sheep/goat, and pig involved consulting many different publications using different methods of ageing (tooth eruption and wear, epiphyseal fusion or both, and different methods within these basic methods), for which raw data were not always available. The solution used in this and previous articles (Groot & Deschner-Erb, 2015, 2016) is to group assemblages into three broad categories of exploitation: mainly (61 per cent and above) young animals slaughtered, mainly adult animals slaughtered, and finally a roughly equal mixture (between 40 and 60 per cent) of young and adult animals. While this does not provide detailed mortality profiles, it does reveal broad trends in exploitation patterns. For cattle, ‘young’ means younger than 3–4 years and ‘adult’ older than 3–4 years; for sheep and goat, ‘young’ means younger than 2–3 years and ‘adult’ older than 2–3 years; and for pig, ‘young’ means younger than 2–3 years and ‘adult’ older than 2–3 years.

Bone measurements were used to study changes in the size of cattle. Not only were cattle the most important animal in the Roman economy, but it is the only species for which the biometric dataset is large enough for analysis. Nevertheless, changes in cattle size were only investigated for the Central Netherlands, since there are few published data for Germany and the south-eastern Netherlands. The logarithmic scale index (LSI) method, where the log of a measurement is compared with the log of a standard (Meadow, 1984, 1999; Uerpmann, 1990), was used to make the most of the available datasets.

The standard consists of the mean for measurements taken for Late Iron Age cattle from Geldermalsen-Hondsgemert, a rural site in the Central Netherlands. Only post-cranial measurements were included. To maximize the dataset, I did not exclude post-cranial measurements that may continue growing post-fusion (Popkin et al., 2012: 1780).

To establish the statistical significance of any differences observed in the dataset for species proportions, the Mann-Whitney U test was used; statistical significance was concluded for p-values lower than 0.05.

**Results**

**Germania Inferior: broad trends**

The mean proportions for the main meat providers, i.e. cattle, sheep/goat, and pig,
show a strong reliance on cattle, which is most pronounced in urban sites (west: 84 per cent; east: 87 per cent; Table 2; Figures 2 and 3). Mean proportions for cattle in military and rural sites are similar within the western area (military: 67 per cent; rural: 68 per cent) and eastern part (military: 46 per cent; rural: 45 per cent), but differ between these areas, with higher proportions of cattle in the western part; these differences are statistically significant (Table 3). Proportions of sheep/goat are highest in rural and lowest in urban sites, and for military and rural sites, higher in the eastern part of the province (although this is only statistically significant for the military sites). Pig shows higher mean proportions in the eastern part of the province (statistically significant for military and rural sites), and within the western and eastern parts, proportions are highest in the military sites and lowest in the urban sites.

The mean proportion of horse is low on military and urban sites in both the western and eastern parts of the research area, as well as in the rural sites in the eastern part (Table 4). For the rural sites in the western part, the mean proportion is much higher, and this difference is statistically significant when compared to all other groups (p < 0.005). This high proportion of horse in the western part of the province will be discussed when we look at the civitas Batavorum. Proportions of horse in military and urban sites do not show a statistically significant difference between the western and eastern parts, or when compared to each other.

The proportion of chicken is generally very low, but there are some exceptions (military sites in the Netherlands: Velsen and Nijmegen Castra, and villae in the south-eastern Netherlands: Hoogeloon and Maasbracht 2). The western and eastern parts of the province show no differences in mean proportion of chicken for military and urban sites (Table 4). However, there is a statistically significant difference for rural sites (p < 0.005): the mean for the eastern part is considerably higher than that for the western part.

The exploitation of cattle could be compared for the two parts of the province

**Table 2.** Mean percentage and standard error per species for the western and eastern parts of Germania Inferior, all phases combined.

<table>
<thead>
<tr>
<th></th>
<th>West</th>
<th>East</th>
</tr>
</thead>
<tbody>
<tr>
<td>Military sites</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NISP cattle-sheep/goat-pig</td>
<td>39,366</td>
<td>22,568</td>
</tr>
<tr>
<td>Mean percentage</td>
<td>67.2</td>
<td>11.7</td>
</tr>
<tr>
<td>Standard error</td>
<td>3.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Urban sites</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NISP cattle-sheep/goat-pig</td>
<td>39,043</td>
<td>66,412</td>
</tr>
<tr>
<td>Mean percentage</td>
<td>84.1</td>
<td>8.6</td>
</tr>
<tr>
<td>Standard error</td>
<td>1.8</td>
<td>1.2</td>
</tr>
<tr>
<td>Rural sites</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NISP cattle-sheep/goat-pig</td>
<td>44,561</td>
<td>1724</td>
</tr>
<tr>
<td>Mean percentage</td>
<td>67.9</td>
<td>24.2</td>
</tr>
<tr>
<td>Standard error</td>
<td>1.3</td>
<td>1.3</td>
</tr>
</tbody>
</table>
and by type of site. In the eastern part of the province, more assemblages show an emphasis on adult cattle (Figure 4). Rural assemblages more often have a preponderance of young cattle than military and urban assemblages. An emphasis on adult cattle is most common in urban sites, and least common in rural sites.

As for cattle, there is a stronger focus on adult sheep and goats in the eastern part of the province (Figure 5). Exploitation is quite variable in both parts, with 53 per cent (west) and 44 per cent (east) of assemblages concentrating on young sheep/goats and the rest on either adults or a range of ages. Urban sites display the strongest specialization on young animals, although it has to be taken into account that the sample size is small.

It should not come as a surprise that there is a strong emphasis on young animals among pigs in both parts of Germania Inferior and in all site types (Figure 6). Unlike cattle and sheep, pigs cannot be kept for milk, traction, or wool. The exploitation of pigs for meat is most pronounced in the eastern part, and more in urban sites than in military and rural sites.

To summarize, cattle were the main meat provider in Germania Inferior. The reliance on cattle is strongest in urban sites; for military and rural sites, proportions are much higher for the western part of the province. In both western and eastern parts, the proportions of sheep and goat are highest in rural sites and those of pig are highest in military sites (and also in rural sites in the eastern area). Overall, the proportions of sheep or goat and especially pig are higher in the eastern part of the province. The mean proportion of horse is similar in most types of site, except for rural sites in western Germania Inferior, where it is considerably higher than anywhere else. Although the proportion of chicken is highest in rural sites in eastern Germania Inferior, it is still low, with 3 per cent. Slaughter ages of cattle show a stronger emphasis on adult animals in the eastern part of the province; in both parts, a focus on young cattle is found more often in rural sites and least often in urban sites. For sheep and goat, the emphasis on adult animals is stronger in eastern Germania Inferior; for pig, the opposite is the case.
The civitas Batavorum

We have observed general differences in species proportions and livestock exploitation between military, urban, and rural sites, as well as differences between the western and eastern parts of Germania Inferior. By taking the civitas Batavorum as a case study, we can see whether this smaller region fits the broad patterns...
established for the province of Germania Inferior as a whole. The dataset from the civitas Batavorum also allows us to add time depth; this will help us establish whether the patterns observed are constant or change over time.

Figure 7 clearly shows that cattle are the dominant species in all periods and types of site. The proportion of cattle increases during the Middle Roman period (AD 70–270); for rural sites, it increases even further in the Late Roman period. On rural sites the proportion of sheep/goat decreases over time, while that of horse increases in the Middle Roman period and that of pig in the Late Roman period. The proportion of pig in military and urban sites decreases in the Middle Roman period. Proportions of horse are high for Middle Roman rural sites and the Late Roman military site of Nijmegen.

When describing broad trends, the variation between individual sites is overlooked. Figure 8 shows species proportions for several assemblages from six rural sites dating to the period AD 70–200. In some cases differences can be explained by a difference in date, but contemporary sites also show variation. The first four assemblages in Figure 8 are contemporary (c. AD 70–150), as are Tiel-Oude Tielseweg phase 4 (OTW4) and Kesteren-De Woerd phase d (KEWd) (c. AD 110–170). Cattle are the main species in all but one assemblage, and proportions of pig are generally low (less than 10 per cent), while

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**Figure 4.** Slaughter ages of cattle by region and type of site. Percentages out of the number of assemblages for which age data were available. Western Germania Inferior: 13 military, 14 urban, and 38 rural assemblages. Eastern Germania Inferior: 4 military, 8 urban, and 3 rural assemblages.
proportions of sheep/goat and horse vary greatly.

Figure 9 illustrates the variation between different military sites. While not all date to the same period, and some differences can be explained by differences in chronology, some contemporary sites also show differences. For instance, the assemblage from the watchtower Utrecht-LR39 has a much higher proportion of sheep/goat and lower proportion of pig than the assemblage from the castra in Nijmegen (NCAS). Cattle are dominant in all sites, except for two assemblages from the Augustan military camp in Nijmegen (NAK/NAT), where pig is the dominant species. High proportions of pig are found elsewhere on early military sites, and can probably be explained by a self-sufficient food supply of the Roman army in the earliest occupation phase (Thijssen, 1988: 64; Cavallo et al., 2008: 74, 76, 78; Deschler-Erb & Groot, in prep.).

Even within sites, there is variation in species proportions, which in rural sites is likely to reflect differences in animal husbandry and thus economic differentiation between households. A previous study examined animal bones at the level of individual households in three rural settlements (Groot, 2011, 2012). Although the samples were mostly small, a similar pattern was found in several sites and different phases. All households had high proportions of cattle, but some households also showed a relatively high proportion of...
sheep, while others showed a relatively high proportion of horse (Figure 10). The households with high proportions of horse have been connected to veterans from the Roman army, since more military gear and horse gear was found in or near these houses; furthermore, some houses had construction elements associated with the Roman army. This has led me to conclude that veterans from the Roman army initiated and maintained the economic specialization in horse breeding found in the civitas Batavorum, using their existing connections in the army to sell their horses.

Two third-century assemblages from Ulpia Noviomagus consist almost entirely of cattle bones and deviate from the other urban assemblages. They reflect the large-scale processing of cattle by professional butchers, an activity that is typical for Roman towns. The activities carried out at the two sites differ: one site shows evidence for initial butchery and processing of the head, while the second shows evidence for either further butchery or glue making (Groot, 2016).

As in many other regions of the Roman Empire (e.g. Teichert, 1984; Dobney et al., 1996: 31–33; Lepeiz, 1996; Peters, 1998; Schlumbaum et al., 2003; Schibler & Schlumbaum, 2007; Albarella et al., 2008; Valenzuela et al., 2013; Colominas et al., 2014), cattle increased in size in the civitas Batavorum during the Roman period. Data from the rural sites show that the most significant increase in width and length measurements took place in the Middle Roman period (AD 70–270) (Figures 11 and 12). Bones from urban
and military sites show a similar size increase (Groot, 2016), but the data from these sites are less plentiful.

Food processing, such as butchery, also changed during the Roman period. Evidence for professional Roman butchers in towns has been described for different parts of the north-western Empire (e.g. Maltby, 1989; Oueslati, 2005; Seetah, 2006), but butchery in the countryside has received less attention. In the civitas Batavorum, an increase in chopping marks compared to cut marks has been observed on rural sites (Groot, 2016). There are three explanations for this: first, new technology became available, in the form of cleavers, which have been found on several rural sites; before the Roman period, all butchery was carried out with knives. Second, the change in butchery methods may also have come from the experience of rural people in the army or in towns, where they observed a faster and more efficient way of butchering cattle. Third, the change in butchery practices reflects a changing perception of livestock: dismembering a carcass with knives goes hand in hand with the butcher knowing the individual animal, whereas chopping up a carcass is generally done by people unfamiliar with the animals.

**DISCUSSION**

The province of Germania Inferior as a whole shows a strong reliance on cattle for meat, especially when the much larger size of cattle compared to sheep/goat and pig is considered. While this was already
noted by King (1999) in his review of the Roman Empire, he looked at a much larger area (Germania Inferior, Germania Superior, Raetia, and Noricum). The dominance of cattle is most pronounced on urban sites. Species proportions for urban sites show little difference between the western and eastern parts of the province, while military and rural sites show marked differences between the two regions. The military sites show a much stronger reliance on cattle in western Germania Inferior, with fewer sheep/goat and pig. The rural sites also show much higher proportions of cattle in the western part of the province, while the rural sites in eastern Germania Inferior have higher proportions of pig. These differences in species proportions can be explained in various ways. First, environmental factors may have played a role: the river delta and coastal zone of western Germania Inferior is more suitable for keeping cattle than for keeping pigs. Second, animal husbandry in this region traditionally relied strongly on cattle, with this species playing an important economic and cultural role (Roymans, 1999; Van Dijk & Groot, 2013). Third, rural settlement in the eastern part of the province consisted of villae, and may have been better able to cater for urban and military customers than the small-scale farmsteads of western Germania Inferior. Finally, the higher proportions of pig in the eastern part of the province may reflect a more ‘Roman’ taste. This last

Figure 8. Species proportions of cattle, sheep/goat, pig, and horse for assemblages from six rural sites in the civitas Batavorum, dating to AD 70–200. Site codes: OTW3: Tiel-Oude Tielseweg phase 3 (Groot, 2008); KEWc: Kesteren-De Woerd phase c (Zeiler, 2001); DRK2: Druten-Klepperheuvel phase 2 (Lauwerier, 1988); PHW3.2: Tiel-Passewaaijse Hogeweg phase 3.2 (Groot, 2008); PHW4: Tiel-Passewaaijse Hogeweg phase 4; OTW4: Tiel-Oude Tielseweg phase 4; KEWd: Kesteren-De Woerd phase d; TMK: Tiel-Medel Krommewei (Van Dijk, 2008); EWK2: Ewijk-Keizershoeve phase 2 (Van Dijk, 2012a).
explanation also applies to the greater proportion of chicken found in rural sites in the eastern part of the province; it is likely that a more ‘Roman’ diet was consumed in the villae.

The general trend in the exploitation of cattle, sheep/goats, and pigs in the province of Germania Inferior is that the focus on meat is strongest for pigs and the focus on secondary products is strongest for cattle; sheep/goats fall in the middle. This reflects the importance of cattle in industry (e.g. leather, horn) and as a source of labour. The eastern part of the province shows a stronger focus on secondary products from cattle and sheep/goat as well as a stronger emphasis on pig meat. This suggests that a more developed or specialized animal husbandry was present and that industry using animal raw materials was of greater importance. The role of cattle as transport and traction animals may also have played a greater part in this part of the province.

In the civitas Batavorum, proportions of cattle increase over time, while that of sheep/goat decreases. Wool production may have declined over time as transport networks and the importation of wool from other regions were being established. The proportion of horses increases in the Middle Roman period. Proportions of sheep/goat, and horse especially, show significant variation between and also within rural sites. This variation can be explained

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{species_proportions.png}
\caption{Species proportions on military sites in the civitas Batavorum (after Groot, 2016: fig. 6.1). Site codes: LR31: Utrecht–Leidsche Rijn 31 (Esser et al., 2007); NTP: Nijmegen–Trajanusplein (Lauwerier, 1988); NAK: Nijmegen Augustan camp (Koopmans, 1996); NAT: Nijmegen Augustan camp (Thijssen, 1988); NKP: Nijmegen–Kops Plateau (Whittaker, 2002); LR39: Utrecht–Leidsche Rijn 39 (Van Dijk, 2010); NCAS: Nijmegen Castra (Lauwerier, 1988); NCT: Nijmegen Castra (Thijssen, 1988); WDG1: Wijk bij Duurstede–De Geer 1 (Bekkema et al., 2011); MEI: Meinerswijk (Lauwerier, 1988); NIV: Nijmegen–Valkhof (Lauwerier, 1988).}
\end{figure}
by different relative specializations in certain animals or animal products. A specialization in horse breeding is typical for this region and probably related to the presence of military veterans. It is likely that a surplus of horses was sold to the Roman army. The Roman preference for pork is visible in the Early Roman period in urban and on military sites, but not in the Middle Roman period. It seems that consumers had to make do with what the local farmers were producing, and that was beef.

The main increase in cattle size takes place in the Middle Roman period. Larger cattle are desirable for two reasons. First, they could draw heavier ploughs or plough heavier soils. Arable farming seems to intensify in this period, and large cattle would have supported this (Groot, 2016). Second, larger cattle produce more meat per animal, so larger cattle can also indicate intensification of meat production. The size increase could have been achieved by crossing larger, imported cattle with the smaller, local type. Selecting larger specimens for breeding would quickly result in a population of larger animals.

Evidence for large-scale butchery and processing of cattle carcasses is found in the town of Nijmegen. Butchery practices in the countryside change during the Roman period, reflecting a change in technology and perhaps also the experience of farmers in the town or in the army.

Figure 10. Species composition for house 5 and house 10 (phase 4) at Geldermalsen-Hondsgemert. Illustration by B. Brouwenstijn (Archeologisch Centrum Vrije Universiteit Amsterdam, ACVU) (Groot, 2011: fig. 9).
CONCLUSION

Although it is possible to outline some general trends in animal husbandry, there is not one single type of animal husbandry that typifies Germania Inferior. There is a lot of variety in rural sites, but also in military sites. Urban sites seem to present the most unified picture when it comes to species proportions: cattle dominate most urban assemblages. Factors that may have determined species proportions include the possibilities or limitations of the local environment for animal husbandry, the degree of adaptation of farmers to market demand, and cultural factors such as dietary preference. In the western part of the province, environmental constraints and farmers’ choices seem to have determined supply, while in the eastern part consumer demand seems to have had a greater effect. Exploitation of livestock shows differences between the species, with the secondary products of cattle being more important than those of sheep or goat. As elsewhere in the Roman provinces, cattle size increased in Germania Inferior; this is most noticeable in the second/third centuries AD. Finally, the butchery and processing of cattle should not only be studied in Roman towns, but also on rural sites, as there is evidence in the civitas Batavorum that butchery practices in the countryside changed.

ACKNOWLEDGEMENTS

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## References


### Appendix. List of sites from eastern Germania Inferior included in this study.

<table>
<thead>
<tr>
<th>Site</th>
<th>Site type</th>
<th>Location</th>
<th>Date</th>
<th>n cattle-SG-pig</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xanten Insula 38 (2 phases)</td>
<td>urban</td>
<td>Germany</td>
<td>1st and 2nd/3rd c. AD</td>
<td>18,086</td>
<td>Müller, 1989</td>
</tr>
<tr>
<td>Xanten</td>
<td>urban</td>
<td>Germany</td>
<td>1st–3rd c., mostly 1st–2nd c. AD</td>
<td>1441</td>
<td>Waldmann, 1967</td>
</tr>
<tr>
<td>Xanten Insula 34</td>
<td>urban</td>
<td>Germany</td>
<td>late 1st c. AD</td>
<td>14,125</td>
<td>Nolde, 2008</td>
</tr>
<tr>
<td>Xanten Insula 37</td>
<td>urban</td>
<td>Germany</td>
<td>AD 75–100</td>
<td>209</td>
<td>Berke, 1995a</td>
</tr>
<tr>
<td>Xanten Räucherei</td>
<td>urban</td>
<td>Germany</td>
<td>AD 50–100</td>
<td>1942</td>
<td>Berke, 1995b</td>
</tr>
<tr>
<td>Xanten Insula 15</td>
<td>urban</td>
<td>Germany</td>
<td>second half 2nd c. AD</td>
<td>769</td>
<td>Nolde, 2012</td>
</tr>
<tr>
<td>Köln-Jahnstrasse (4 phases)</td>
<td>urban</td>
<td>Germany</td>
<td>AD 50–75; AD 75–125; AD 125–150; AD 50–225 total</td>
<td>11,735</td>
<td>Berke, 1996</td>
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<tr>
<td>Heerlen-Valkenburgerweg</td>
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<td>1st–3rd c. AD</td>
<td>56</td>
<td>Van Dijk, 2012b</td>
</tr>
<tr>
<td>Venlo-Maasboulevard</td>
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<td>20 BC–AD 230</td>
<td>1376</td>
<td>Esser et al., 2009</td>
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<tr>
<td>Asciburgium/Duisburg</td>
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<td>Germany</td>
<td>c. 12 BC–AD 89</td>
<td>1066</td>
<td>Deschler-Erb, 2007</td>
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<tr>
<td>Köln-Alteburg (6 phases)</td>
<td>military</td>
<td>Germany</td>
<td>before AD 37–AD 117</td>
<td>5581</td>
<td>Mayer, 2014</td>
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<td>Froitzheim</td>
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<td>second half 3rd c.–4th c. AD</td>
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<td>Mennerich, 1968</td>
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<td>Dormagen</td>
<td>military</td>
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<td>AD 70–4th c. AD</td>
<td>1416</td>
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<td>Mennerich, 1968</td>
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<td>Haus Bürgel</td>
<td>military</td>
<td>Germany</td>
<td>late 4th–early 5th c. AD</td>
<td>14,625</td>
<td>Stein, 2000</td>
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<td>Köln-Müngersdorf</td>
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<td>second half 1st–3rd c. AD</td>
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<td>Berke, 1991</td>
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<td>Aldenhovener Platte</td>
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<td>Germany</td>
<td>AD 70–270</td>
<td>106</td>
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<td>Hoogeloon-Kerkakkers</td>
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<td>Kooistra &amp; Groot, 2015</td>
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<td>Maasbracht (2 phases)</td>
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<td>2nd and 3rd c. AD</td>
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<td>Kooistra &amp; Laarman, 1996a</td>
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<td>Kooistra &amp; Laarman, 1996b</td>
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<td>Kerkrade-Holzkuil</td>
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<td>2nd/3rd c. AD</td>
<td>69</td>
<td>Kooistra &amp; Esser, 2005</td>
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</tbody>
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Westf. (Passauer Universitätsschriften zur Archäologie 5).
BIOGRAPHICAL NOTE

Maaike Groot is a zooarchaeologist currently based in Amsterdam. Her research focuses on animal husbandry and food supply in the Late Iron Age and Roman period in north-western Europe. A particular interest is the impact of the Roman occupation on agrarian communities. Other research interests include the use of animals in settlement rituals in Iron Age and Roman Netherlands and animal sacrifice in ancient Greece. Maaike recently finished a Marie Curie project at the University of Basel, comparing animal husbandry and food supply in the Roman Netherlands and Switzerland.

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**Stichworte:** Viehzucht, Römerzeit, Germania Inferior, Niederlande, Deutschland