IRON AGE ANIMAL HUSBANDRY, HUNTING, FOWLING AND FISHING ON VOORNE-PUTTEN (THE NETHERLANDS)

Wietske Prummel
Biologisch-Archaeologisch Instituut, Groningen, Nederland

ABSTRACT: Faunal remains from Iron Age farms on Voorne-Putten have been studied. Animal husbandry, especially the rearing of cattle, was the most important source of food of animal origin. The farms could have been self-sufficient as regards meat and milk, and may even have produced some surplus.

KEYWORDS: Iron Age, Voorne-Putten, animal husbandry, hunting, fowling, fishing.

1. INTRODUCTION

Since 1968 many Iron Age sites have been discovered in the district of Voorne-Putten, that consists of the former islands Voorne and Putten (fig. 1) (Wind, 1970). Many of these sites have been excavated by the Bureau Oudheidkundig Onderzoek van Gemeentewerken Rotterdam (B.O.O.R.). Most of them were single farmhouses, varying from 4-5 m in width and from 10-20 m in length. Three phases of habitation have been discerned: phase 1, c. 725-525 BC (Early Iron Age), phase 2, c. 425-200 BC (Middle Iron Age) and phase 3, c. 200-25 BC (Late Iron Age) (van Trierum, 1986b; van Trierum et al., 1988: pp. 23-38). Individual farms were probably inhabited for several decades. Presumably most contemporaneous farms were situated at some distance from one another (van Trierum, pers. comm.).

During phase 1 the conditions for habitation were still rather poor. The sites of this phase were inhabited for shorter periods than those of phase 2, and therefore are more difficult to recognize in the soil (van Trierum, 1986a) (fig. 2). The sites of phase 2 were inhabited for relatively long periods. They left thick layers of habitation remains, which are easily recognizable (fig. 3; van Trierum, pers. comm.). The relative scarcity of sites of phase 3 (fig. 4) is still unexplained (van Trierum, pers. comm.). The conditions for habitation during phase 3 would have been fairly good.

The absence of sites of phase 1 and 2 in the western half of Voorne-Putten (figs 2 and 3) may be fortuitous. Remains of Iron Age habitation in the western half are to be expected at deeper levels than in the eastern half. Moreover fewer recent building and exploration activities have been carried out in the western half than in the eastern half (van Trierum, pers. comm.). The central peat area of Voorne-Putten, in between the present-day places Brielle (B), Rockanje (R), Hellevoetsluis (H) and Geervliet (west of Spijkenisse, S) (figs 2-4), was not inhabited during the Iron Age (van Trierum, pers. comm.).

P.J.A. van Mensch studied the faunal remains from 8 of these sites. His results have not been published, but are summarized in appendix 2 of this paper. The faunal remains from 19 other Iron Age sites are discussed in this paper.

2. THE GEOGRAPHICAL AND VEGETATIONAL BACKGROUND

In the Iron Age Voorne-Putten was largely covered with peat, belonging to the Holland-peat formation. This peat started to grow after the Late Neolithic behind the then closed beach ridges of the west coast of the Netherlands. During the Late Neolithic and Early Bronze Age river-banks and levees in this peat area were still habitable (Louwe Kooijmans, 1986; Bakels, 1986; van Trierum, 1986a; Prummel, 1987a). In the later phases of the Bronze Age the peat area was presumably not inhabited because of wet conditions (Hallewas & van Regteren Altena, 1980: fig. 2; van Trierum, 1986a).

The growth of peat was interrupted about 1500 BC, when the Dunkirk 0 transgression phase started (van Staalduinen, 1979). During this phase clay and sand were deposited locally. Peat growth recovered c. 1000 BC, but was interrupted again about 750 BC, due to the Dunkirk Ia transgression phase. After drainage of the peat by still existing gullies of Dunkirk 0 or by gullies of Dunkirk Ia (van Heeringen, 1986), the peat became habitable. The first Iron Age habitation phase started, culturally belonging to the Early Iron Age (fig. 2). This phase lasted from the end of the 8th century BC until the end of the 6th century BC (both of these are ultimate dates) (van Trierum, 1986b: p. 67).

Peat growth started again at the end of phase 1 and continued until the end of the 5th century BC. Then, after drainage by gullies of Dunkirk Ib, a second phase of Iron Age habitation started, phase 2, belonging to the Middle Iron Age (fig. 3). This phase began before the end of the 5th century BC and ended about 200 BC (van Trierum, 1986b: p. 69). After phase 2, marine sediments of the Dunkirk I transgression phase (clay and sand) were deposited on large parts of Voorne-Putten (fig. 4). On top of these sediments habitation remains have been found of phase 3, of the Late (Pre-Roman) Iron Age (fig. 4). This phase is dated from c. 200 BC until the last quarter of the first century BC (van Trierum, 1986b: p. 69).

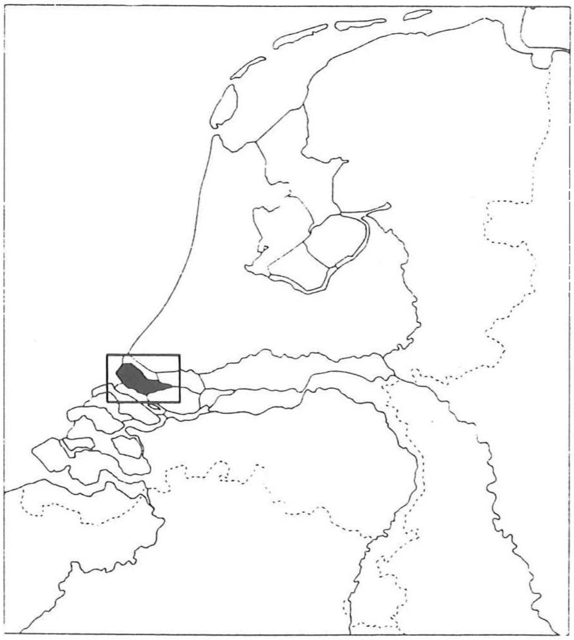

Fig. 1. Map of the Netherlands showing the situation of Voorne-Putten (black); the area is shown enlarged in figures 2-4.

The landscape of Putten during habitation phases 1 and 2 was a peat landscape. The peat showed elevations and depressions. Most sites were situated on an elevation (van Trierum, 1986b: e.g. figs 13, 15 and 20). The depressions probably provided some drainage of the peat. The sites of phase 3 are situated on top of the Dunkirk I deposits, that were laid down on parts of Voorne-Putten (van Trierum, 1986b: fig. 18). On account of this difference in geological situation, different vegetation types prevailed in the surroundings of the sites of the three Iron Age phases.

The vegetation during phase 1 and 2 mainly consisted of three components: 1) swamps with some open water, the wooded parts being dominated by alder and willow; 2) moist heath of *Erica* and grasses, with shrubs of bog-myrtle, *Myrica gale*, this heath being passable (Bakels, 1986); and 3) forests on mineral subsoil such as river banks, in which various tree species including oak (*Quercus*) and elm (*Ulmus*) occurred. This is the driest vegetation type. The extent and localization of these vegetation types are currently being studied (Brinkkemper, in prep.). The heath would have been suitable for animal husbandry. Arable farming on a small scale was only possible on mineral and drier parts of the landscape (Brinkkemper, in prep.).

During phase 3, the river banks and former riverbeds of the Dunkirk I deposits were wooded with oak, hazel, ash, maple, apple and some other trees (Bakels, 1986: p. 1). The sites of this phase were limited to the Dunkirk I deposits and thus situated in this vegetation type. This relatively dry type of vegetation would have been suitable for animal husbandry. This part of the landscape was also suitable for arable farming, and on a larger scale

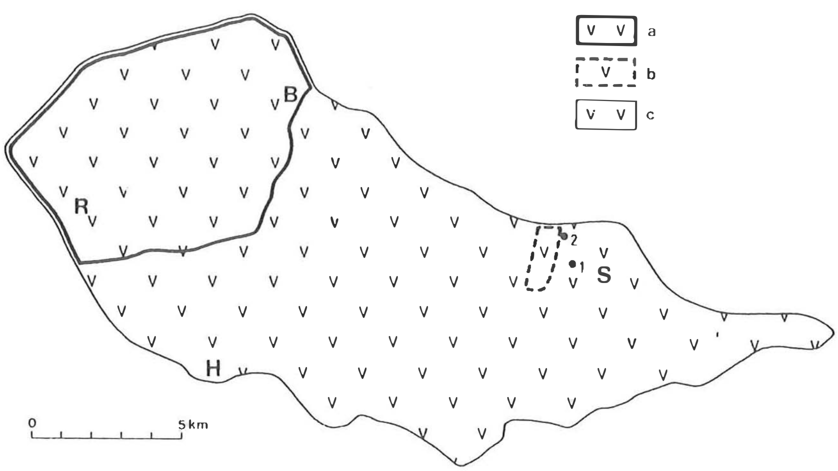

Fig. 2. Palaeogeographical situation of Voorne-Putten during Iron Age phase 1, c. 700-500 BC (after van Staalduinen, 1979; Hallewas & van Regteren Altena, 1980, and van Trierum, pers. comm. on the distribution of Dunkirk 0 deposits). a. distribution of Dunkirk 0 deposits; b. possible distribution of Dunkirk 0 deposits; c. Holland peat; S. Spijkenisse; H. Hellevoetsluis, R. Rockanje; B. Brielle; the sites belonging to this phase that have been studied archaeozoologically are: 1. 17-35; 2. 10-69.

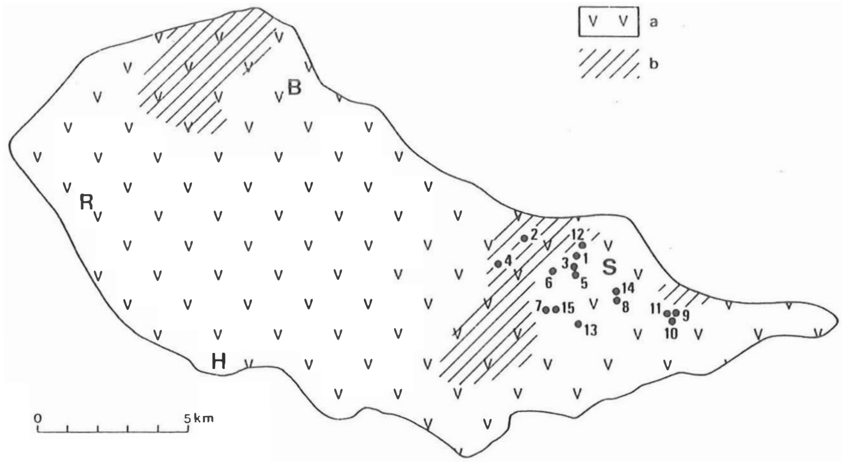

Fig. 3. Palaeogeographical situation of Voorne-Putten during Iron Age phase 2, c. 400-200 BC (after van Trierum, 1986b). a. Holland peat; b. areas with Dunkirk I gullies, that were or became active during phase 2; S. Spijkenisse; H. Hellevoetsluis; R. Rockanje; B. Brielle; the sites belonging to this phase that have been studied archaeozoologically are: 1. 17-35 (also phase 1 and 1 or 2); 2. 10-74; 3. 17- 34; 4. 17-40; 5. 17-51; 6. 17-55; 7. 17-56; 8. 18-06; 9. 18-28; 10. 18-29; 11. 18-30; 12. 10-28; 13. 17-14; 14. 18-50; 15. 17-18.

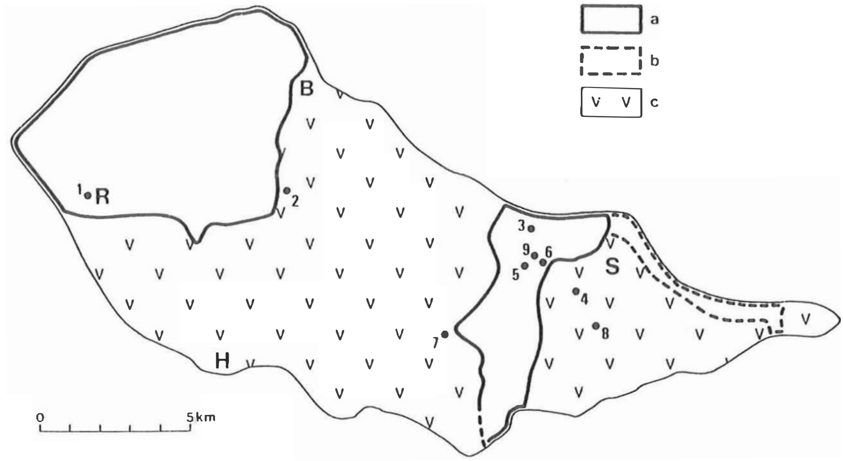

Fig. 4. Palaeogeographical situation of Voorne-Putten during Iron Age phase 3, c. 200-25 BC (after van Staalduinen, 1979; Hallewas & van Regteren Altena, 1980; van Trierum, 1986b). a. Distribution of Dunkirk I deposits; b. possible distribution of Dunkirk I deposits; c. Holland peat; S. Spijkenisse; H. Hellevoetsluis; R. Rockanje; B. Brielle; the sites belonging to phase 3 that have been studied archaeozoologically are: 1. 08-06; 2. 09-08; 3. 10-110; 4. 17-23; 5. 17-41; 6. 17-44; 7. 17-22; those belonging to phase 2 or 3: 8. 17-33; 9. 17-36.

than in phases 1 and 2 (Brinkkemper, in prep.). The landscape outside the Dunkirk I sedimentation area was covered with peat, that was most probably not inhabited at all (van Trierum, pers. comm.).

3. THE SITES STUDIED ARCHAEOZOOLOGICALLY

As was stated in the introduction, P.J.A. van Mensch studied in the 1970's and 1980's the faunal remains from 8 Iron Age sites from Voorne-Putten. His unpublished results are summarized in appendix 2. M. Seeman identified remains of perch and Cyprinidae from site 17-30 (phase 1) (see van Trierum, 1986a).

I myself studied nineteen other sites. Most of these were inhabited during only one of the three phases. Site 17-35 was occupied during phase 1 as well as phase 2 (van Trierum, 1986b: fig. 7a). It was abandoned in the interval between phase 1 and 2. Only a certain proportion of the faunal remains could be ascribed to either phase 1 (table 1) or phase 2 (table 2), while the rest have been attributed to phase 1 or 2 (table 4) (see also appendix 1). The sites 17-33 and 17-36 were inhabited in phase 2 and/or in phase 3 (table 5) (van Trierum, pers. comm.) (tables 1-3 and appendix 1).

The state of preservation of the faunal remains varied. That of the bones of the sites of phase 1 (fig. 2) was rather poor, probably because of the peat cover on top of the habitation levels (see above). The Dunkirk I clay sediments on top of the habitation levels of phase 2 would have ensured good preservation conditions for the bones of the sites of that phase (fig. 3). This may explain the generally better condition of faunal remains from phase 2, although locally worse conditions prevailed. The state of preservation of the faunal remains from the sites of phase 3 (fig. 4) varied too. Generally, it was comparable to that of phase 2. A number of sites of phase 3 lay above the average groundwater level.

One of the sites that I studied belonged to phase

1, 11 to phase 2 and 6 to phase 3 (figs 2-4). These numbers are in accordance with the numbers of the sites demonstrated archaeologically: few of phase 1, many of phase 2, rather few of phase 3 (compare figs 2-4 and section 1).

4. THE ANIMAL SPECIES BRED OR CAUGHT

4.1. The animal species represented by bones

The numbers of bones identified to species and the numbers of unidentified bones from the 19 sites that I studied are listed in appendix 1. In tables 1-6 these numbers are summarized for each phase and for all phases together. A total of 42 bones was found in phase 1, of which 24 could be identified. Cattle (figs 6-14), sheep (figs 15-16), mallard (fig. 23) and sturgeon (fig. 24) have been identified (table 1). Seeman found in site 17-30 (phase 1) remains of perch, *Perca fluviatilis*, and of unidentified Cyprinidae (van Trierum, 1986b). Van Mensch identified 5 remains of cattle and 3 of horse for phase 1 (site 10-69); 24 were unidentifiable (appendix 2).

The sites of phase 2 that I studied yielded 1,704 bones, of which 934 could be identified to species. Dog (fig. 19), horse, pig (fig. 17), cattle, sheep, beaver (fig. 22), fox (fig. 20), red deer (fig. 25), heron and sturgeon were represented by bones in sites of this phase (table 2 and appendix 1). Bird species other than heron could possibly be represented in the material, as three bird bones remained unidentified (table 2). Van Mensch identified 675 bones of phase 2 (site 10-18, 17-14, 18-50, 17-18 and 18-30). He identified dog, horse, cattle, sheep/goat, pig, red deer and roe deer (appendix 2). The find of roe deer was a shed antler.

The sites of phase 3 that I studied yielded 41 bones, of which 28 could be identified. Cattle, sheep/goat, mute swan and sturgeon were represented by bones (table 3). Van Mensch identified remains of horse, cattle, sheep/goat and pig in site 17-22 (appendix 2). Two ossa opercularia from this site that he had left unidentified proved to be of *Abramis brama*, bream, of the Cyprinid family.

Site 17-35 was inhabited in phase 1 and in phase 2. A proportion of the bones, 135, could have come from either of these phases. Among these bones dog, pig, cattle, sheep, beaver, otter (fig. 21) and sturgeon were identified. The 18 pig bones came from the same spot, and probably originated from the same young pig (table 4).

The sites 17-33 and 17-36 were inhabited during phases 2 and 3. A total of 163 bones have been found in these sites, of which 118 could be identified. Among these bones dog, horse, pig, cattle, sheep, sturgeon and thin-lipped or thick-lipped grey mullet have been identified (table 5).

Sheep were definitely kept on Voorne-Putten in the Iron Age. No bones in the material listed in tables 1-5 showed the features that are characteristic for goat (Prummel & Frisch, 1986). Therefore it is

Table 1. Frequencies of faunal remains from phase 1 (site 17-35, partly). N: number of remains of each species; weight: the weight in g of the remains of each species; % dom: percentage of total domestic mammals; % idf: percentage of total remains identified; indet: remains that could not be identified.

Species	N	% dom	% idf	weight	% dom	% idf
Bos taurus (cattle)	19	86.4	79.2	277	93.6	92.6
Ovis aries (sheep)	1	4.6	4.2	6	2.0	2.0
Ovis/Capra (sheep/goat)	2	9.1	8.3	13	4.4	4.3
Total domestic mammals	22		91.7	296		99.0
Anas platyrhynchos (mallard)	1		4.2	1		0.3
Acipenser sturio (sturgeon)	1		4.2	2		0.7
Total identified	24			299		
Indet, size cattle/horse	9			32		
Indet, size sheep/goat/pig	9			8		
Total unidentified	18			40		
Identified + unidentified	42			339		
% identified			57.1			88.2

Table 2. Frequencies of faunal remains from phase 2 (sites 10-74, 17-34, 17-35 (partly), 17-40, 17-51, 17-55, 17-56, 18-06, 18-28, 18-29, 18-30). N: number of remains of each species; weight: the weight in g of the remains of each species; % dom: percentage of total domestic mammals; % idf: percentage of total remains identified; indet: remains that could not be identified.

Species	N	% dom	% idf	weight	% dom	% idf
Canis familiaris (dog)	12	1.3	1.3	469	3.0	3.0
Equus caballus (horse)	5	0.5	0.5	530	3.4	3.4
Sus domesticus (pig)	69	7.5	7.4	795	5.0	5.0
Bos taurus (cattle)	683	73.9	73.1	13,129	83.5	83.0
Ovis aries (sheep)	12	1.3	1.3	102	0.6	0.6
Ovis/Capra (sheep/goat)	143	15.5	15.3	708	4.5	4.5
Total domestic mammals	924		98.9	15,733		99.5
Castor fiber (beaver)	3		0.3	35		0.2
Vulpes vulpes (fox)	1		0.1	20		0.1
Cervus elaphus (red deer)	1		0.1	18		0.1
Total wild mammals	5		0.5	73		0.5
Ardea cinerea (heron)	1		0.1	2		0.0
Aves, unidentified (indet bird)	3		0.3	1		0.0
Total birds	4		0.4	3		0.0
Acipenser sturio (sturgeon)	1		0.1	4		0.0
Total identified	934			15,813		
Indet, size cattle/horse	435			1,381		
Indet, size sheep/goat/horse	183			190		
Indet, size unknown	152			110		
	770			1,681		
Identified + unidentified	1,704			17,494		
% identified			54.8			90.4

assumed that the bones listed in these tables as 'sheep/goat' were actually of sheep, and that goat was absent.

Domestic cats were not kept on Voorne-Putten in the Iron Age (tables 1-5 and appendix 2). In this respect this area is no exception, as domestic cat is absent from all Dutch Iron Age sites studied up until now. Bones of domestic cat have only been found in sites dating from after the beginning of the Christian era.

Remains of domestic fowl, *Gallus gallus domesticus*, were absent in the Iron Age sites studied by van Mensch (appendix 2) and me (tables 1-5). Presumably domestic fowl was absent or at most very scarce in the Netherlands in the Iron Age. Sites without bones of domestic fowl include: Achthoven (van Mensch, 1975), Stevenshofjespolder I, Boschen Gasthuispolder and Wassenaar-ter Weer (van Heeringen, 1982), Stevenshofjespolder IV (van Heeringen, 1984), Assendelft (Seeman, 1987; van Wijngaarden-Bakker, 1988), Spanjaardsbergje, Vlaardingen-Old People's Home and Vlaardingen-Broekpolder (Clason, 1967B), Culemborg and Driel (Clason, 1980), Tritsum and Haaren (Clason, pers. comm.), Paddepoel (Knol, 1983). The only Iron Age site with a single bone of domestic fowl is Amsterdamse Waterleidingduinen (Clason, 1967B: table 18). The Romans introduced domestic fowl into the Netherlands or promoted domestic fowl breeding on large scale (Prummel, 1987c).

4.2. Numbers of remains and bone weights

The proportions of numbers of remains (N) and bone weights (weight) vary considerably from phase to phase (tables 1-5). For example, the proportion of the number of remains of cattle varies between 36% (phase 3, table 3) and 79% (phase 1, table 1). However, the proportions may be biased by the small sample sizes, especially in the case of phases 1 and

Table 3. Frequencies of faunal remains from phase 3 (sites 08-06, 09-08, 10-110, 17-23, 17-41, 17-44). N: number of remains of each species; weight: the weight in g of the remains of each species; % dom: percentage of total domestic mammals; % idf: percentage of total remains identified; indet: remains that could not be identified.

Species	N	% dom	% idf	weight	% dom	% idf
Bos taurus (cattle)	10	71.4	35.7	107	92.2	69.9
Ovis/Capra (sheep/goat)	4	28.6	14.3	9	7.8	5.9
Total domestic mammals	14		50.0	116		75.8
Cygnus olor (mute swan)	1		3.6	2		1.3
Acipenser sturio (sturgeon)	13		46.4	35		22.9
Total identified	28			153		
Indet, size cattle/horse	4			16		
Indet, size sheep/goat/pig	8			8		
Indet, size unknown	1			1		
Total unidentified	13			25		
Identified + unidentified	41			178		
% identified			68.3			86.0

Table 4. Frequencies of faunal remains from phase 1 or 2 (site 17-35, partly). N: number of remains of each species; weight: the weight in g of the remains of each species; % dom: percentage of total domestic mammals; % idf: percentage of total remains identified; indet: remains that could not be identified.

Species	N	% dom	% idf	weight	% dom	% idf
Canis familiaris (dog)	1	1.0	1.0	37	1.9	1.8
Sus domesticus (pig)*	18	18.6	17.8	75	3.8	3.7
Bos taurus (cattle)	58	59.8	57.4	1,786	90.2	89.0
Ovis aries (sheep)	2	2.1	2.0	7	0.4	0.3
Ovis/Capra (sheep/goat)	18	18.6	17.8	74	3.7	3.7
Total domestic mammals	97		96.0	1,979		98.6
Castor fiber (beaver)	1		1.0	9		0.4
Lutra lutra (otter)	1		1.0	5		0.2
Total wild mammals	2		2.0	14		0.7
Acipenser sturio (sturgeon)	2		2.0	14		0.7
Total identified	101			2,007		
Indet, size cattle/horse	31			131		
Indet, size sheep/goat/pig	2			2		
Indet, size unknown	1			1		
Total unidentified	34			134		
Identified + unidentified	135			2,141		
% identified			74.8			93.7

* 18 bones (skull, mandibula, 4 cervical vertebrae, 5 thoracic vertebrae, 4 ribs, humerus, ulna and astragalus) from one and the same spot: site 17-35, number 538; as far as could be ascertained, all from (a) young pig(s) (younger than 12 months): possibly all 18 bones from the same individual.

3. Therefore it is not possible to ascertain any differences between the three Iron Age as regards the exploitation of animals by the farmers of these periods.

The identification rate was low: between 55 and 75% of the bones from the various phases could be identified (tables 1-5). The fragmentary state of the bones (see section 5.4) and the poor state of preservation of some of the bones account for these low identification rates. The identified remains constituted between 86 and 96% of the total bone weights (tables 1-5). This means that many of the larger fragments could be identified, whereas most of the small fragments were unidentifiable (compare figs 6-17 and fig. 18). Van Mensch identified 52% of the remains that he studied (appendix 2). This figure is comparable to the identification rates for numbers of remains in tables 1-5 (N.B. van Mensch did not weigh his material).

Remains of domestic mammals were the most numerous. They made out between 50 and 99% of the identified remains, with an average of 97.3% (tables 1-6). In terms of bone weight the proportion of domestic mammals was even higher: 76-99.8% (with an average of 99.3% for the three phases). If we add the quantities for the unidentified remains (n = 880, weight = 2,039 g, for the three phases together) to those for the domestic mammals, assuming that most of the unidentified remains come from bones of this group, then the average proportion becomes 98.5% of the number of remains and 99.3% of the bone weight. The sites studied by van Mensch had nearly the same proportions for domestic animals as the sites of table 6: 99% of the identified remains (appendix 2).

Remains of sturgeon were rather common: they amounted to 1.5% of the number of identified remains from the three phases together (table 6). They seem to be especially common in phase 3 (table 3), but here we need to be cautious because of the small sample size. The absence of remains of sturgeon in the sites studied by van Mensch is very striking, because of the characteristic shape and structure of sturgeon bones (appendix 2).

Thin-lipped or thick-lipped grey mullet (table 5), bream (appendix 2) and possibly other Cyprinidae, and perch (see van Trierum, 1986b) were found in small numbers. No sieving took place on the Iron Age sites on Voorne-Putten. Sieving could have yielded larger numbers of bones of fish and birds.

Wild mammal remains amounted to 0.6% of the number of identified remains for the three phases together (table 6). This proportion is nearly identical to that in the sites studied by van Mensch (0.5%) (appendix 2). He did not find any bird remains, while bird bones accounted for 0.5% of the number

Table 5. Frequencies of faunal remains from phase 2 or 3 (sites 17-33 and 17-36). N: number of remains of each species; weight: the weight in g of the remains of each species; % dom: percentage of total domestic mammals; % idf: percentage of total remains identified; indet: remains that could not be identified.

Species	N	% dom	% idf	weight	% dom	% idf
Canis familiaris (dog)	1	0.9	0.8	16	0.4	0.4
Equus caballus (horse)	2	1.7	1.7	364	10.2	10.2
Sus domesticus (pig)	3	2.6	2.5	29	0.8	0.8
Bos taurus (cattle)	90	77.6	76.3	2,981	83.3	83.2
Ovis aries (sheep)	6	5.2	5.1	51	1.4	1.4
Ovis/Capra (sheep/goat)	14	12.1	11.9	136	3.8	3.8
Total domestic mammals	116		98.3	3,577		99.8
Acipenser sturio (sturgeon)	1		0.8	7		0.2
Liza ramada/Chelon labrosus (thin-/thick-lipped grey mullet)	1		0.8	1		0.0
Total fish	2		1.7	8		0.2
Total identified	118			3,585		
Indet, size cattle/horse	33			141		
Indet, size sheep/goat/pig	9			15		
Indet, size unknown	3			3		
Total unidentified	45			159		
Identified + unidentified	163			3,744		
% identified			72.4			95.8

of identified remains from the sites that I studied (table 6).

4.3. The frequencies of the domestic mammals

About three-quarters of all bones of domestic mammals were cattle bones (between 60 and 79% for the individual phases, and 73% for the average of the three phases; tables 1-6). Van Mensch (appendix 2) found a slightly higher proportion of cattle bones: 81% of the number of bones of domestic mammals (appendix 2).

Sheep is in second place among the domestic mammals: between 8 and 18% of the bones of domestic mammals (with an average of 17%) are sheep or sheep/goat bones (tables 1-6). Van Mensch found a lower proportion (on average 7%) of sheep bones among the bones of domestic mammals (appendix 2). The reason for the differences in proportions of cattle and sheep between table 6 and appendix 2 is uncertain. Biological or cultural causes are rather improbable, because a) the kinds of environment of the sites studied by van Mensch and by myself were the same and b) the sites of each phase were culturally identical (van Trierum, 1986b). These differences in proportions are therefore most probably fortuitous.

Table 6. Frequencies of faunal remains from phases 1-3, 1 or 2 and 2 or 3 combined (consolidation of tables 1-5). N: number of remains of each species; weight: the weight in g of the remains of each species; % dom: percentage of total domestic mammals; % idf: percentage of total remains identified; indet: remains that could not be identified.

Species	N	% dom	% idf	weight	% dom	% idf
Canis familiaris (dog)	14	1.2	1.2	522	2.4	2.4
Equus caballus (horse)	7	0.6	0.6	894	4.1	4.1
Sus domesticus (pig)	90	7.7	7.5	899	4.1	4.1
Bos taurus (cattle)	860	73.3	71.4	18,280	84.2	83.6
Ovis aries (sheep)	21	1.8	1.7	166	0.8	0.8
Ovis/Capra (sheep/goat)	181	15.4	15.0	940	4.3	4.3
Total domestic mammals	1173		97.3	21,701		99.3
Castor fiber (beaver)	4		0.3	44		0.2
Vulpes vulpes (fox)	1		0.1	20		0.1
Lutra lutra (otter)	1		0.1	5		0.0
Cervus elaphus (red deer)	1		0.1	18		0.1
Total wild mammals	7		0.6	87		0.4
Ardea cinerea (heron)[1]	1		0.1	2		0.0
Cygnus olor (mute swan)[2]	1		0.1	2		0.0
Anas platyrhynchos (mallard)[3]	1		0.1	1		0.0
Aves (bird, indet)	3		0.2	1		0.0
Total (wild) birds	6		0.5	6		0.0
Acipenser sturio (sturgeon)[4]	18		1.5	62		0.3
Liza ramada/Chelon labrosus (thin-/thick-lipped grey mullet)[5]	1		0.1	1		0.0
Total fish	19		1.6	63		0.3
Total identified	1205			21,857		
Indet, size cattle/horse	512			1701		
Indet, size sheep/goat/pig	211			223		
Indet, size unknown	157			115		
Total unidentified	880			2039		
Total	2085			23,896		
% identified			57.8			91.5

1) a coracoid; 2) a lumbal vertebra; 3) a scapula; 4) 14 dermal plates, 2 spina pinnae pectoralis, a fulcral bone and a keratohyale; 5) an operculum.

Pig accounts for c. 8% of the bones of domestic mammals (table 6 and appendix 2). Horse bones were slightly more numerous in the sites studied by van Mensch (appendix 2) than in those that I studied (tables 1-6). Dog bones were slightly more numerous in the sites that I studied (tables 1-6) than in those studied by van Mensch (appendix 2) (1.2 against 0.7%). The differences in proportions of horse and dog are considered to be fortuitous.

The remains of domestic mammals of table 6 and appendix 2 together show the following proportions for the three phases: cattle 75%, sheep(/goat) 15%, pig 8%, horse 1% and dog 1%. These proportions are rather approximate, and represent average values for the three phases. This averaging was necessary in view of the small sample sizes.

5. ASPECTS OF ANIMAL HUSBANDRY

5.1. The size and shape of the domestic animals

A general measure of the size of domestic mammals is the height at the withers, that is usually calculated by multiplying the length of a bone with a factor obtained by the study of modern material (von den Driesch & Boessneck, 1974).

Only four cattle bones were sufficiently complete to permit the measurement of their maximum length: a metacarpus from site 17-34, phase 2, (187.5 mm), a metacarpus from site 17-22, phase 3, (184 mm), a metatarsus from site 17-34, phase 2, (211 mm) and a metatarsus from site 17-55, phase 2, (197 mm) (the last value was estimated). The factors of Von den Driesch & Boessneck (1974) gave values of height at the withers of 1.15 m, 1.13 m, 1.15 m and 1.07 m, respectively.

The regression equations of van Wijngaarden-Bakker & Bergström (1988) gave, for the same maximum lengths of metacarpus and metatarsus, values for the height at the withers of 1.12 m, 1.11 m, 1.12 m and 1.06 m, respectively. These results are nearly identical to those obtained by using the factors given by von den Driesch & Boessneck (1974).

Unfortunately, the metapodia are rather unreliable indicators for the height at the withers. Prummel (1983: pp. 171-174) found that cattle metapodia gave higher values for height at the withers than humerus, radius, femur and tibia from the same site, and presumably the same cattle population. Bartosiewicz (1984; 1987) found that of the bones of the foreleg only the radius is a good bone for the estimation of height at the withers in archaeozoological practice. He considers humerus and metacarpus as less suitable for the estimation of the height at the withers. Van Wijngaarden-Bakker & Bergström (1988) consider the metapodia to be less suitable indicators for the height at the withers, too.

For the maximum length of 206.2 mm of a horse metacarpus from site 17-36, phase 2/3, the table of Vitt (von den Driesch & Boessneck, 1974: table 2) gave a height at the withers of between 1.28 and 1.36 m. This was a rather small horse, that was, however, typical for the Iron Age. During and after the Roman period an increase in size of horses has been demonstrated in the Netherlands (Prummel, 1979).

The factors of Teichert (von den Driesch & Boessneck, 1974: table 6) gave for a sheep radius from site 17-34, phase 2, with a maximum length of 138.8 mm, a height at the withers of 0.56 m, and for a sheep calcaneus of 52.1 mm a height at the withers of 0.59 m. Von den Driesch & Boessneck (1974: pp. 339-340) warn that the factors for calcaneus and astragalus may give erroneous heights at the withers, because of the small size of these bones. No maximum lengths of bones of pig were available for estimation of the height at the withers of pig.

The Iron Age cattle on Voorne-Putten had horns. At least, a few cattle horn cores have been found (table 18). It is not certain whether the sheep had horns. No sheep horn cores have been found, but the sheep crania were poorly preserved.

5.2. The age at death of the domestic animals

For section 5.2 only data from the sites that I studied have been used. Two kinds of data on the age at death were available in the material: data on the eruption, replacement and wear of teeth and data on the fusion of the epiphyses. The age criteria of Habermehl (1975) have been used.

5.2.1. *Cattle*

Phase 2. A total of 139 bones of cattle gave information on the age at death of cattle in phase 2 (tables 7 and 8). Nine of these were of foetuses in the last quarter of gestation or of calves that died at birth (Prummel, 1987b; 1988). The cause of these foetal or neonatal deaths is unknown.

The teeth and epiphyses indicate that of the cattle that survived birth only 8% died in their first year (table 7, age limit 2.t; table 8, age limit 2.e). About 30-40% died in the second, the third or the first half of the fourth year. This is deduced from age limits 7.t in table 7 and 5.e in table 8, that indicate that at the age of 36-42 months 50% and 43% of all individuals had been killed, respectively. As the relation between tooth wear and age is uncertain, the age data of teeth and epiphyses cannot strictly be correlated with each other for the ages older than 3 years (table 7, age limits 8-10.t). Data from teeth and epiphyses both indicate that no cattle grew very old (the unfused vertebral epiphyses indicate that no cattle reached the age of 9 years). I estimate that c. 25% of all cattle died between 3-3$^1/_2$ and 4$^1/_2$ years, and c. 35%

Table 7. Teeth age data of cattle in phase 2, maxilla and mandibula combined, with the proportions of cattle killed during each age phase and the cumulative proportions of cattle killed during and before each age phase.

Age limit	Criterion	Age in months	Number of jaws	Killed during	before
				%	%
Age phase exactly known					
1.t	M1 erupting	4-6	2	5.0	-
2.t	M1 erupted	7-14	1	2.5	5.0
3.t	M2 erupting	15-18	-	-	7.5
4.t	M2 erupted	19-24	1	2.5	7.5
5.t	M3 erupting	25-28	4	10.0	10.0
6.t	P2-4 erupting	29-34	2	5.0	20.0
7.t	end of eruptions	36	10	25.0	25.0
8.t	M3 moderately worn	>36	-	-	50.0
9.t	M3 distinctly worn	>>36	20	50.0	50.0
10.t	M3 extremely worn	>>>36	-	-	100.0
Total			40	100.0	
Age phase roughly known					
M3/P2-4 not yet erupting		<25-28	4	14.0 *	
Total number of tooth data				44	

* This percentage is the fraction of all tooth data that originate from cattle slaughtered before the age of 25-28 months, namely 100 (4+2+1+1)/44.

Table 8. Age data of epiphyses of cattle in phase 2 (information on the ages of fusion from Habermehl, 1975).

Limit	Age in months	Number fused	%	Number unfused	%	Total
1.e	7-10	7	100	-	-	
2.e	12-20	23	92	2	8	
3.e	20-24	10	91	1	9	
4.e	24-30	20	91	2	9	
5.e	36-42	4	57	3	43	
6.e	42-48	3	33	6	67	
7.e	9 years	-	-	5	100	
Total		67		19		86

Epiphyses fusing at age limit:
1.e: scapula d (4 fused) and pelvis-acetabulum (3 fused); 2.e: humerus d (6 fused, 1 unfused), radius p (10 fused, 1 unfused) and phalanx II p (7 fused); 3.e: phalanx I p (10 fused, 1 unfused); 4.e: tibia d (7 fused, 1 unfused), metacarpus d (3 fused), metatarsus d (6 fused) and metacarpus or metatarsus (4 fused, 1 unfused); 5.e: femur p (1 fused, 1 unfused) and calcaneus p (3 fused, 2 unfused); 6.e: ulna p and d (no data), humerus p (1 fused, 2 unfused), radius d (1 unfused), femur d (1 fused, 1 unfused) and tibia p (1 fused, 2 unfused); 7.e: vertebral epiphyses (5 unfused) (p: proximal, d: distal).

between $4^1/_2$ years and at most 9 years old (an average age at death of 6 years is assumed) (table 9.A).

Meat of calves (0-1 years) and yearlings (1-2 years) was hardly eaten on Voorne-Putten in phase 2 of the Iron Age (table 9.A). The bones of cattle that died in their first or second year, c. 20% of the total, probably originate from animals that died naturally. Mass slaughter of cattle (45%) occurred at ages between 2 and $4^1/_2$ years, i.e. of animals that had produced progeny 1-3 times. The last 35% of slaughtered cattle were killed between $4^1/_2$ and c. 6 years. In conclusion, most cattle were slaughtered after they had produced enough progeny to ascertain the continuity of the herd, and before the meat would become too tough. A decrease of milk production and of traction power, especially in the case of oxen, could be other reasons for slaughtering older cattle.

Kill-off patterns like that of table 9.A give the age composition of the slaughtered cattle. It does not give directly the age composition of the living cattle herd. That kind of information would be quite helpful if we wanted to estimate the amount of meat and milk available for human consumption. The age

Table 9. Approximate percentages of cattle of phase 2 killed in various age phases (A), life table of cattle (B) and life expectation (C).

A. Kill-off pattern of cattle in phase 2 (consolidation of tables 7 and 8).

Age phase	% of cattle slaughtered (estimates)
0-1 year	c. 10
1-2 year	c. 10
2-3 $^1/_2$ year	c. 20 (c. 13% in year 3, c. 7% in year 4)
3 $^1/_2$ - 4 $^1/_2$ years	c. 25 (c. 13% in year 4, c. 12% in year 5)
4 $^1/_2$ - c. 6 years	c. 35 (c. 23% in year 5, c. 12% in year 6)

B. Life table of Iron Age cattle of phase 2. X: the number of cows or bulls (or oxen) that survived birthday B; Y: the number of cows or bulls that died between birthday B and birthday B + 1; Z: proportions of cattle killed between birthday B and birthday B + 1 (from table 9.A); L: proportions of the various year groups of living cattle shortly after the birth of new offspring.

B birthday (years)	X cows	Y cows	X bulls	Y bulls	Z %	L %
0 (birth)	100	10	20	10	10	25
1	90	10	20	10	10	23
2	80	13	26	13	13	20
3	67	20	40	20	20	17
4	47	35	70	35	35	12
5	12	12	24	12	12	3
6	0	-	0	-	-	-
	396	100	396	100	100	100

C. Mean expectation of life in years for cattle of phase 2 at birth (B = 0) and at their 1st, 2nd, 3rd, 4th and 5th birthday. Way of calculation: subtract half a year from the sum of the numbers of cattle reaching the same or a higher birthday divided by the number of individuals reaching the same birthday. E.g.: the mean life expectancy for each of the 100 cows or bulls at birth is [(100 + 90 + 80 + 67 + 47 + 12) / 100] - 0.5 = 3.46 years; the mean life expectancy for a cow or bull at its 5th birthday is (12 / 12) - 0.5 = 0.5 year (method after Kratochvíl et al., 1986).

Birthday (years)	Mean life expectancy in years
0	3.46
1	2.79
2	2.08
3	1.38
4	0.76
5	0.50

composition of the living herd (life table) can be constructed from the kill-off pattern if the maximum age of the cattle is known or can be estimated (Prummel, 1983; Kratochvíl et al., 1986).

In table 9.B the life table for 100 new-born cows and 100 new-born bulls/oxen of Iron Age phase 2 has been constructed. The cattle are assumed to have attained maximum ages of about six years (table 9.A). The cattle population is assumed to be stable, not increasing or decreasing, with identical kill-off patterns for cows and bulls/oxen (as no data on the sex of the cattle were available, I assumed identical patterns for cow and bull/oxen). The number of 100 new-born female and male cattle has been chosen for convenience of calculation.

Table 9.B shows that each year c. 206 cows (those older than two years: 80 + 67 + 47 + 12) were available to supply the 200 calves that had to replace those cattle that were slaughtered or that died in some other way. This number would be high enough, because we assume that a cow delivered on average one calf per year. If some cows were kept a few years longer than the maximum of 6 years supposed or if fewer females than males were slaughtered at the younger age phases, then the breeding perspectives were even better. These factors would result in an increase of the population, but would be counterbalanced by the presence of some infertile cows.

The age composition of the living herd shortly after the birth of the new offspring was: 0 year old: 25%, 1 year old: 23%, 2 years old: 20%, 3 years old: 17% old, 4 years old: 12% and 5 years old: 3% (table 9.B, column L). Two-thirds of the live cattle were of ages younger than 3 years (25 + 23 + 20%).

Table 10. Age data for cattle from phase 1, phase 3, phase 1/2 and phase 2/3 (p: proximal, d: distal; for age phases see tables 7 and 8).

	Age phase	Number
Phase 1		
teeth data	2.t	1
	<25-28 months	1
epiphyses	2.e	1 fused (phalanx II p)
	3.e	1 fused (phalanx I p)
Phase 3		
teeth data	foetal	1
epiphyses	4.e	1 unfused (metatarsus d)
	5.e	1 fused (femur p)
Phase 1/2		
teeth data	5.t	1
	6.t	1
	8/9.t	3
	< 25-28 months	2
epiphyses	1.e	1 fused (scapula d)
	2.e	2 fused (radius p, phalanx II p)
	4.e	2 fused (tibia d, metatarsus d)
		1 unfused (metacarpus or metatarsus d)
	5.e	1 fused (calcaneus p)
	6.e	1 fused (radius d)
Phase 2/3		
teeth data	4.t	3
	8/9.t	8
	<25-28 months	2
	neonates	2
epiphyses	1.e	1 fused (scapula d)
		1 unfused (pelvis-acetabulum)
	4.e	1 fused (tibia d)
		2 unfused (tibia d, metacarpus d)
	5.e	2 unfused (femur p, femur d)
	7.e	2 unfused (vertebral epiphyses)

A cow or bull that survived birth had a mean life expectancy of 3.5 years (table 9.C). On their first birthday they could expect to live on average another 2 years and 9 months; on their fifth birthday they could expect to live on average another 0.5 year.

Phase 1, 3, 1/2, 2/3. Age data for cattle in the phases 1 and 3 were scarce (table 10). Very roughly they show the same pattern as the kill-off pattern for cattle in phase 2: few cattle were killed at young ages, most at rather advanced ages. The same holds for the age data for cattle from either phase 1 or 2, and either phase 2 or 3 (table 10).

5.2.2. *Sheep*

Phase 2. Tables 11 and 12, that combine the age data of teeth and epiphyses of sheep and sheep/goat from phase 2, indicate that in phase 2 most sheep died before or around the age of 2 years (teeth: 73% before or around 2 years: table 11, age limit 7.t; epiphyses: 75%: table 12, age limit 3.e). The teeth age data show that many of these sheep died in the first year after birth (table 11, limit 3.t). About 25% of all sheep died in the second year of their life (65 - 45%, table 11, 6.t minus 3.t). The oldest sheep probably died younger than 4-5 years old, as no vertebral epiphyses have been found fused. At that age these epiphyses fuse.

If we draw conclusions on the kill-off pattern of sheep we have to keep in mind that the number of age data for sheep was rather low: 21 fusion data and 18 tooth data were available. Table 13.A presents a consolidated kill-off pattern that may hold roughly for the sheep of phase 2. The errors around these percentages are estimated to be 10-20%.

On the basis of the kill-off pattern of table 13.A, the hypothetical life table for sheep in phase 2 has been constructed (table 13.B). This kill-off pattern has been differentiated as regards age and sex in the following way: 70% of the rams were killed between c. 6 months and their first birthday; 30% of rams were kept alive for breeding. The ewe lambs were kept alive to become pregnant at the end of the first year or in their second year. Ewes and breeding rams were kept for reproduction for 4 years and then slaughtered. Decreasing growth rates and milk supplies, birth problems, diseases etc. may have been reasons killing the sheep.

The maintenance of the herd of sheep would have been endangered if many ewe lambs were among the 35% of sheep killed as lambs. I assume that each ewe produced on average one lamb with each delivery. Modern ewes mature at 5-10 months, depending on the breed. Iron Age sheep were probably late maturing, at an age of, say, not less than 10 months. As gestation in sheep extends over about 5 months, first-year deliveries probably did not occur in the Iron Age sites on Voorne-Putten.

The hypothetical life table of sheep (table 13.B), that was constructed for 100 new-born ewes and 100 new-born rams on the basis of the kill-off pattern in table 13.A, with an assumed maximum age of 4 years for both sexes, revealed that annually 205 ewes of ages over 1 year were available to replace the 200 sheep that were killed each year (table 13.B: 100+70+35). They could have produced these new offspring if no diseases, infertility, etc. occurred. If some gestations were twins, the maintenance of the sheep herd was more safely ensured. But twins would not have been very numerous in the presumably unimproved Iron Age sheep of Voorne-Putten. For instance, the German Heath sheep (*Heidschnukke*), has only a number of 95 lambs born out of 100 pregnant ewes (Haring et al., 1980: p. 191).

Table 11. Teeth age data of sheep(/goat) from phase 2, maxilla and mandibula combined, with the percentages of sheep(/goat) killed during each age phase and the cumulative percentages of sheep(/goat) killed during and before each age phase.

Age limit	Criterion	Age in months	Number of jaws	Killed during %	before %
Age phase exactly known					
1.t	M1 erupting	3	1	7	-
2.t	M1 erupted	4-8	2	13	7
3.t	M2 erupting	9	4	27	20
4.t	M2 erupted	10-17	2	13	47
5.t	M3, P2-4 erupting	18-24	-	-	60
6.t	end of eruptions	c. 24	2	13	60
7.t	M3 moderately worn	>24	-	-	73
8.t	M3 distinctly worn	>>24	4	27	73
9.t	M3 strongly worn	>>>24	-	-	100
Total			15	100	
Age phase roughly known					
M3/P2-4 not yet erupting			<18-24	3	67*
Total number of tooth data				18	

* This percentage is the fraction of all tooth data that originate from sheep (/goat) slaughtered before the age of 18-24 months, namely 100 (3+1+2+4+2)/18.

Table 12. Age data of epiphyses of sheep(/goat) from phase 2 (information on the ages of fusion from Habermehl, 1975).

Limit	Age in months	Number fused	%	Number unfused	%	Total
1.e	3-4	5	100	-	-	
2.e	5-10	2	100	-	-	
3.e	15-24	1	25	3	75	
4.e	36-42	2	40	3	60	
5.e	c. 42	2	100	-	-	
6.e	4-5 years	-	-	3	100	
Total		12		9		21

Epiphyses fusing at age limit:
1.e: humerus d (5 fused); 2.e: scapula d (1 fused), pelvis-acetabulum (1 fused); 3.e. tibia d (1 fused, 3 unfused); 4.e: femur p (1 fused), calcaneus p (1 fused, 3 unfused); 5.e. humerus p (1 fused), tibia p (1 fused); 6.e: vertebral epiphyses (3 unfused).

Nearly half of the living sheep herd consisted of first-year lambs (table 13.B, L: 44.4%). The high mortality of (presumably) male lambs at the end of the first year accounted for the fact that second-year sheep constituted only about 29% of the whole herd. The age composition of sheep differs considerably from that of cattle (table 9.B: L), where calves make up only 25% of the total herd. The difference is caused by the younger average kill-off age in sheep than in cattle.

The average life expectancies of first-year ewes and rams in this hypothetical life table were quite different: a ewe that survived birth could expect to live for on average 2.55 years, a first-year ram on average 0.95 year (= $11^1/_2$ months). On their first birthday a ewe could expect to live another 1.55 year on average, the few rams another year. On their second birthday both sexes could expect to live another year. After 3 years, at the third birthday, ewes and rams could expect to live only another half-year (± 0.5 year), on average.

The sex of the adult sheep can be deduced from the pelvis (Boessneck et al., 1964; Prummel & Frisch, 1986). Two pelves of adult ewes indicate that at least some ewes reached full maturity. No pelves of male adult sheep have been found. Although the number of adult pelves is small, they do not contradict the supposition expressed in table 13.B that female sheep preponderated among the adult sheep.

Table 13. Approximate percentages of sheep of phase 2 killed in various age phases (A), life table of sheep (B) and mean life expectancy of ewes and rams at different ages (C).

A. Kill-off pattern of sheep (consolidation of tables 10 and 11)

Age phase	% of sheep slaughtered
first year	c. 35
second year	c. 25
third and fourth year	c. 40 (c. 20% in each)

B. Life table of ewes and rams of Iron Age phase 2. X: the number of ewes or rams that survived birthday B; Y: the number of ewes or rams that died between birthday B and birthday B + 1; Z: proportions of sheep killed between birthday B and birthday B + 1 (from table 13.A); L: proportions of the various year groups of living sheep shortly after the birth of new offspring.

B birthday (years)	X ewes	Y ewes	X rams	Y rams	Z %	L %
0 (birth)	100	0	100	70	35	44.4
1	100	30	30	20	25	28.9
2	70	35	10	5	20	17.8
3	35	35	5	5	20	8.9
4	0	-	0	-	-	-
	305	100	145	100	100	100

C: Mean life expectancy in years for ewes and rams of phase 2 at birth (B = 0) and at their 1 st, 2nd, 3rd, 4th and 5th birthday. For way of calculation see section of table 9.C.

Birthday (years)	Mean life expectancy in years ewes	rams
0 (birth)	2.55	0.95
1	1.55	1.00
2	1.00	1.00
3	0.50	0.50

Table 14. Age data for sheep from phase 1, phase 1/2 and phase 2/3 (p: proximal, d: distal; for age phases see tables 12 and 13).

	Age phase	Number
Phase 1		
epiphyses	3.e	1 unfused (metacarpus d)
Phase 1/2		
teeth data	1.t	1
epiphyses	2.e	1 unfused (scapula d)
	6.t	1 unfused (vertebral epiphysis)
Phase 2/3		
teeth data	6.t	1
	7/8.t	3
epiphyses	1.e	1 fused (radius p)
	2.e	3 fused (1 scapula d, 2 pelvis-acetabulum)
	5.e	1 fused (radius d)

Phase 1, 3, 1/2, 2/3. The age data of sheep in phase 1 were very scanty (table 14). Therefore no conclusions on the kill-off patterns for sheep in this phase can be drawn. The same holds for the age data for sheep from either phase 1 or 2, and either phase 2 or 3 (table 14). From phase 3 no age data for sheep are present. The age data for sheep in table 14 show about the same pattern as the kill-off pattern for sheep in phase 2: some jaws and epiphyses are from sheep that died at rather young ages, others from sheep that died somewhat older.

5.2.3. *Pig*

Because of the small numbers of data on the age at death of pig in the various phases, these are presented together in tables 15 and 16. In the keys of these tables it is indicated which age data originate from which Iron Age phase. A total of 24-45% of the pigs were killed in their 1st and 2nd year of life (table 15, age limit 5.t: 25%, 6.t: 45%; table 16, age limit 2.e: 25%). The high percentage for the first year alone (25%) in table 16 (1.e) may be biased by the small number of epiphyses. Therefore, I estimate that about 10% of the pigs were killed at ages under 1 year (table 17).

About 15% of all pigs died in their second year (table 15: 5.t - 2.t), and about 20% around their 2nd birthday (table 15, 6.t) (table 17). The other 55% of pigs died older than 24 months. At what exact ages they died is unknown, but as heavily worn molars have not been found (tooth wear is correlated with age), the maximum ages were probably not very high. A tibia that was proximally fused indicates that atleastone pig was killed when it was olderthan $3^1/_2$ years. As no fused vertebral epiphyses have been found there is no indication that pigs survived the age of 7 years (table 16).

The fact that so many pigs died at ages around and older than 24 months strongly suggests that the Iron Age pig took a long time to reach its full size and weight. As the fertility of pig is high in comparison with that of cattle and sheep (at least one, and possibly two multi-piglet litters a year, Lauwerier, 1983), the maintenance of the pig herd would not have been problematical, even if most full-grown pigs (boars and sows) were slaughtered shortly after they reached their full size. Probably the sows gave birth once or twice and were then slaughtered at ages around 2 years or older. Boars may have been castrated. Hogs are easier to handle, and castration does not damage meat production, but may even improve it.

Seven mandibles or loose canines gave information on the sex of pig. Five, two mandibles and three loose canines, were of adult boars or hogs and two other mandibles were of adult sows, proving that both sexes are represented in the adult pigs. The

Table 15. Teeth age data of pig for all Iron Age phases together, maxilla and mandibula combined, with the percentages of pig killed during each age phase and the cumulative percentages of pig killed during and before each age phase.

Age limit	Criterion	Age in months	Number of jaws	Killed during %	before %
Age phase exactly known					
1.t	M1 erupting	4-6	-	-	-
2.t	M1 erupted	6-10	2	10	-
3.t	M2 erupting	10-12	-	-	10
4.t	P2-4 erupting	12-16	1	5	10
5.t	M3 erupting	16-24	2	10	15
6.t	end of eruptions	24	4	20	25
7.t	M3 moderately worn	>24	1	5	45
8.t	M3 distinctly worn	>>24	10	50	50
9.t	M3 extremely worn	>>>24	-	-	100
Total			20	100	

N.B. All jaws with age limit 2.t, 4.t, 5.t, 6.t and 7.t are from phase 2; 9 of limit 8.t are from phase 2, 1 of phase 2/3.

Age limit	Criterion	Age in months	Number of jaws	Killed during %	before %
Age phase roughly known					
P2-4 not erupted		<16-24	1	18*	
P2-4 erupted		>12-16	1	82**	
Total number of tooth data				22	

* This percentage is the fraction of all tooth data that originate from pig slaughtered before the age of 16-24 months, namely 100 (1+2+1)/22.
** This percentage is the fraction of all tooth data that originate from pig slautered after 12-16 months, namely 100 (1+2+4+1+10)/22.
N.B. The two jaws with roughly known age phase are from phase 1/2.

Table 16. Age data of epiphyses of pig for all Iron Age phases together (information on the ages of fusion from Habermehl, 1975).

Limit	Age in months	Number fused	%	Number unfused	%	Total
1.e	12	3	75	1	25	
2.e	24	1	100	-	-	
3.e	c. 42	1	25	3	75	
4.e	4-7 years	-	-	1	100	
Total		5		5		10

N.B. epiphyses fusing at age limit
1.e: humerus d (1 fused, phase 2; 1 unfused, phase 1/2); radius p (1 fused, phase 2); phalanx II p (1 fused, phase 2); 2.e: phalanx I p (1 fused, phase 2); 3.e: tibia p (1 fused, phase 2); humerus p (1 unfused, phase 1/2); ulna p & d (1 unfused at both ends, phase 1/2); fibula p (1 unfused, phase 2/3); 4.e: vertebral epiphyses (1 unfused, phase 1/2).

Table 17. Approximate percentages of pigs of all Iron Age phases killed in various age phases (consolidation of tables 15 and 16).

Age phase	% of pigs slaughtered
first year	c. 10
second year	c. 15
c. 24 months	c. 20
third year	c. 5
older than third year, younger than 7 years	c. 50

larger number of mandibles or canines of boars may be accidental, as boar canines are much more conspicuous than those of sows.

5.2.4. *Horse*

A metacarpus 3 from phase 2/3, that was fused distally, came from a horse that was evidently older than 12-15 months at the time of death (Habermehl, 1975). A skull of a young horse, with the deciduous premolars still in the jaw, was found in phase 2. This horse must have died at an age younger than 2 years. The number of bones with data on the age at death is too small to construct a kill-off pattern for horse.

5.2.5. *Dog*

A mandible from phase 1/2 was of a dog that died at an age older than 6-12 months. A dog humerus that was fused distally was found in phase 2/3. This means that the dog to which this humerus belongs was older than 5-8 months when it died (age data: Habermehl, 1975). These two bones are of dogs that died at adult ages, after the replacement of the milk teeth.

5.3. The distribution of the bones over the skeleton

There are various possible reasons to account for an uneven distribution of the remains of a species over its skeleton. The three most important of them are: 1) parts (e.g. hindquarters, carcasses without head and feet or hides with part of the skull and the feet) have been imported; 2) parts of the skeleton have been used in some way (e.g. for artefact production) and therefore removed from the site; and 3) the waste bone of the different parts of the skeleton has been discarded in different places.

An even distribution is an indication that the animals were butchered at the site and that the bones

Table 18. Distribution of the mammalian faunal remains over the skeleton; No.: number of remains; for cattle, pig and sheep+sheep/goat the classes after Spennemann's method are given. Phase 1, 2 and 3 together. sh/go: sheep/goat.

Skeletal element	cattle		pig		sheep	sh/go	sheep+sh/go		horse	dog	beaver	red deer	fox	otter
	No.	Class	No.	Class	No.	No.	No.	Class	No.	No.	No.	No.	No.	No.
Os cornu/antler	4	2	-	-	-	-	-	1	-	-	-	1	-	-
Cranium	79	4	8	3	1	1	2	2	1	1	-	-	1	-
Maxilla	82	4	11	4	-	25	25	4	1	-	1	-	-	-
Mandibula	154	5	37	5	-	45	45	5	1	4	2	-	-	1
loose teeth max. or man.	5	2	1	2	-	-	-	1	-	-	-	-	-	-
Os hyoides	2	2	-	1	-	-	-	1	-	-	-	-	-	-
Atlas	7	2	2	2	-	-	-	1	-	-	-	-	-	-
Epistropheus (Axis)	2	2	-	1	-	-	-	1	-	-	-	-	-	-
Vertebrae cervicales	13	3	4	3	-	3	3	2	-	2	-	-	-	-
Vertebrae thoracicae	24	3	5	3	-	4	4	3	-	1	-	-	-	-
Vertebrae lumbales	15	3	1	2	-	9	9	3	-	1	-	-	-	-
Os sacrum	1	2	-	1	-	-	-	1	-	-	-	-	-	-
Vertebrae caudales	-	1	-	1	-	-	-	1	-	-	-	-	-	-
Vertebrae unidentified	8	2	-	1	-	-	-	1	-	-	-	-	-	-
Costae	63	4	4	3	-	15	15	4	-	2	-	-	-	-
Sternum	-	1	-	1	-	-	-	1	-	-	-	-	-	-
Scapula	18	3	4	3	3	2	7	3	-	1	-	-	-	-
Humerus	44	4	3	3	6	4	10	3	1	1	-	-	-	-
Radius	33	3	1	2	3	12	15	4	-	-	-	-	-	-
Ulna	11	3	2	2	-	2	2	2	-	-	1	-	-	-
Carpalia	7	2	-	1	-	-	-	1	-	-	-	-	-	-
Metacarpus	31	3	-	1	3	2	5	3	1	-	-	-	-	-
Pelvis	26	3	-	1	-	5	5	3	1	-	-	-	-	-
Femur	54	4	-	1	2	14	16	4	-	-	-	-	-	-
Patella	1	2	-	1	-	-	-	1	-	-	-	-	-	-
Tibia	52	4	2	2	1	22	23	4	-	1	-	-	-	-
Fibula	-	-	1	2	-	-	-	-	-	-	-	-	-	-
Talus (Astragalus)	15	3	2	2	-	3	3	2	-	-	-	-	-	-
Calcaneus	19	3	-	1	-	6	6	3	-	-	-	-	-	-
other Tarsalia	5	2	-	1	-	-	-	1	-	-	-	-	-	-
Metatarsus	42	4	-	1	2	6	8	3	1	-	-	-	-	-
Metapodia	10	2	-	1	-	-	-	1	-	-	-	-	-	-
Phalanx I	15	3	1	2	-	1	1	2	-	-	-	-	-	-
Phalanx II	12	3	1	2	-	-	-	1	-	-	-	-	-	-
Phalanx III	5	2	-	1	-	-	-	1	-	-	-	-	-	-
Sesamoid	1	2	-	1	-	-	-	1	-	-	-	-	-	-
Total	860		90		21	181	204		7	14	4	1	1	1

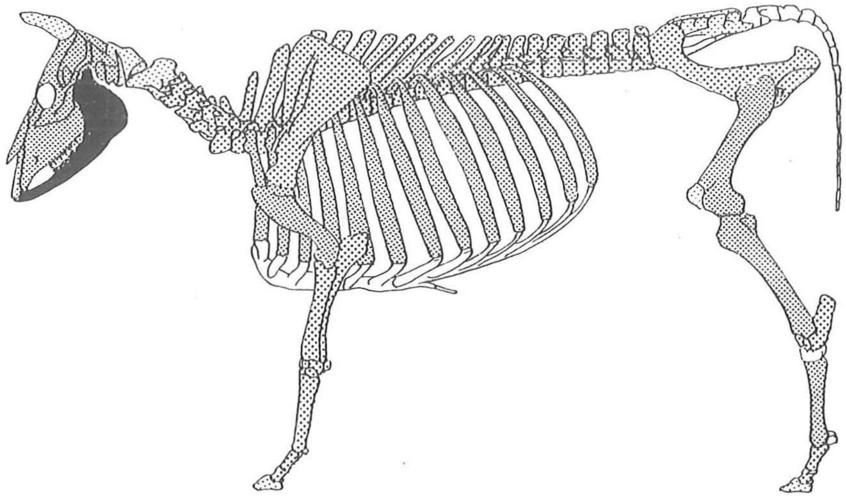

Fig. 5. Voorne-Putten, Iron Age. Distribution of the identified remains of cattle over the skeleton. Five frequency classeshave been used: white: no fragments; light shade: 1-10 fragments; middle shade: 11-38 fragments; dark shade: 39-86 fragments; black: 87-154 fragments (for the calculation of the class limits, see Spennemann, 1985).

were discarded together. Table 18 shows that this situation was the case in the Iron Age sites of Voorne-Putten for cattle, sheep and pig. The remains of these species were evenly distributed over the skeleton. In table 18 the data are presented together. The distributions for the various phases showed basically the same pattern as in this table.

The distribution of the cattle remains over the skeleton is illustrated after the method of Spennemann (1985). The bones of skull, vertebral column, shoulder and pelvic girdle, foreleg and hind leg are well-represented in the faunal remains of cattle: the frequency classes 3 and 4 are the most common ones in these parts of the body. The mandibula is the best represented skeletal element of cattle (class 5). The upper jaw, maxilla, is well represented too. These high frequencies will partly be due to the generally good preservation of teeth (quite a lot are loose teeth) (fig. 5).

The absence of tail vertebrae may be due to the small size of these bones. They may have been overlooked. Another reason for their absence could be that the tail had been fed to dogs. No remains have been found of sternum and the connecting elements between sternum and ribs. These elements are of calcified cartilage, that is less resistant to decay than bone. This may account for the absence of these elements.

The even distribution of cattle bones over the skeleton means: 1) that the complete carcasses were butchered at the sites; 2) that no joints or partial carcasses were imported or exported; 3) that bone waste had been consistently discarded in the same way for the various parts of the body.

The remains of sheep/goat and pig had almost the same distribution over the skeleton as those of cattle (table 18). Therefore figure 5 may be taken as an example for the distributions of the pig and sheep and sheep/goat remains as well.

In conclusion, cattle, pigs and sheep were slaughtered at the farms. No joints of meat or carcasses were imported or exported. The waste disposal was essentially the same for all parts of the body. Horse and dog were too poorly represented to permit any conclusions on the distribution of the skeletal elements over the skeleton (table 18).

5.4. The degree of fragmentation of the bones

5.4.1. *Cattle, sheep and pig*

The Iron Age material from Voorne-Putten was extremely fragmented. The average weight of a fragment amounted to c. 11.5 g (identified and unidentified remains) (table 6). An average Iron Age cattle bone from Voorne-Putten weighed 21.3 g, an average pig bone 10.0 g and an average sheep or sheep/goat bone 5.5 g (table 6). This much greater average weight of a cattle bone fragment is what one would expect in view of the much larger size of cattle. The degree of fragmentation, that is the number of fragments into which a complete bone broke up, is rather constant for the three species (figs 6-17).

Few complete bones have been found. Most of these are of foetuses or neonatals (figs 6, 8, 9). The other bones of cattle, pig and sheep/goat probably all came from animals that were killed for their meat. In this respect the low proportion of bones with distinct cut marks is amazing. Only 31 bones (1.5%) showed clear cut marks (e.g. figs. 6.d, 12.a, 13.c, 14.a&b, 17.f). These were found on bones of cattle, pig, sheep and on unidentified fragments. The criterion that I used for a cut mark is as follows: a groove on

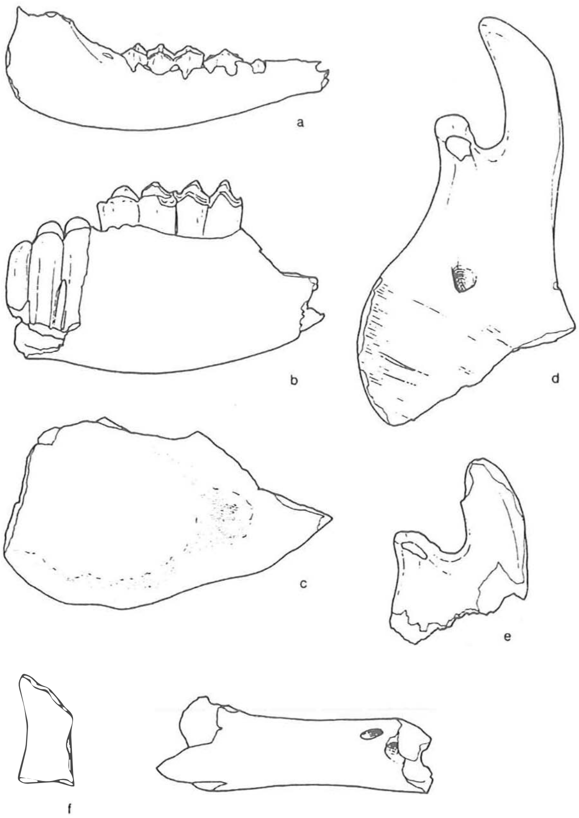

Fig. 6. Cattle mandibles. a. nearly complete right mandible of an almost full-grown foetus (17-34/319); b-g. examples of (sub)adult cattle mandible fragments: b. part of the corpus (17-55/LV1); c. bottom half of ramus (17-55/LV2); d. ramus with clear cuts; the ramus has been cut from the corpus (17-34/322); e. upper half of ramus (17-34/LV1); f. part of ramus under the articular surface with the skull (17-55/LV1); g. symphysis and diastema (17-34/775). Scale 1:3.

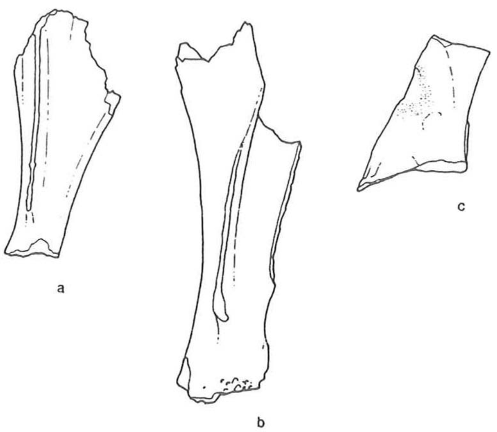

Fig. 7. Cattle scapula fragments. a. foetal scapula (10-74/3); b. distal half of left scapula, with gnaw marks on the distal end (10-74/3); c. distal end of scapula, collum part (17-55/LV2). Scale 1:3.

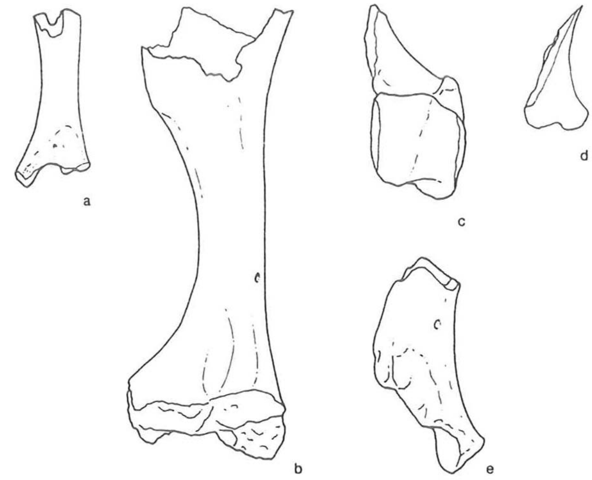

Fig. 8. Cattle humeri. a. humerus of a foetus (proximally damaged) (17-34/543); b. distal 3/4 of right humerus, distally unfused (17-34/308); c. distal end of a left humerus, lateral half (17-34/536); d. part of distal end, just above the trochlea (17-23/292); e. part of the distal half of the shaft of left humerus (17-34/221). Scale 1:3.

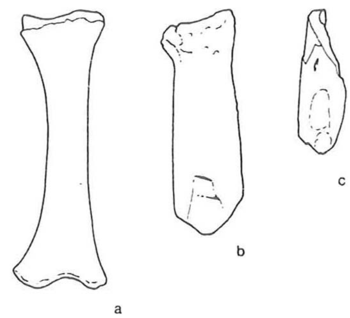

Fig. 9. Cattle radii. a. right radius of a foetus or neonatus of cattle (17-35/605); b-c. examples of (sub)adult cattle radius fragments; b. half of proximal end of right radius (10-74/3); c. middle part of the shaft of a left radius, posterior aspect (calcined) (17-34/550). Scale 1:3.

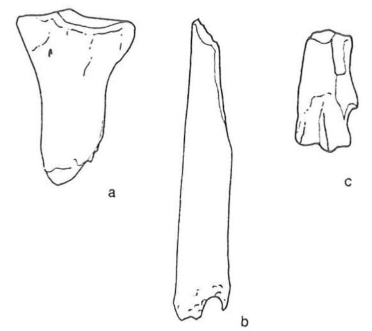

Fig. 10. Cattle metacarpals. a. proximal end of right metacarpus, longitudinally split (17-34/512); b. distal half of shaft, longitudinally split, distally with gnaw marks on distal end (17-35/27); c. half of distal end (17-34/512). Scale 1:3.

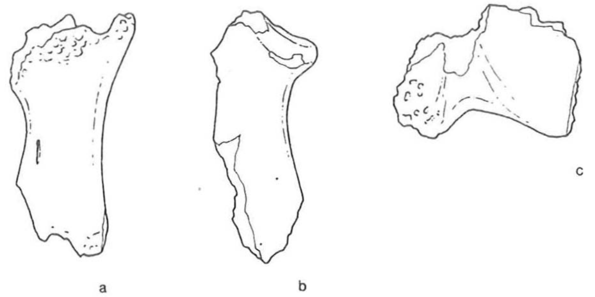

Fig. 11. Cattle pelves. a. ilium fragment of a right pelvis with gnaw marks (10-74/5); b. part of right ischium (17-34/494); c. parts of fused left and right ischia, with gnaw marks (10-74/5). Scale 1:3.

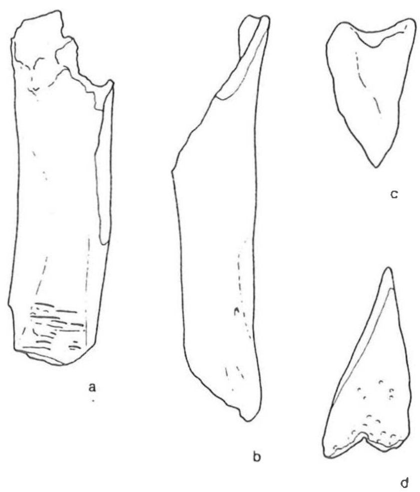

Fig. 12. Cattle femurs. a. proximal half of the shaft of a right femur, with cuts (10-74/5); b. middle part of a right cattle femur (below, the fossa supracondylaris, a good distinguishing feature for femur) (17-34/352); c. fragment from proximal half of femur shaft with trochanter minor (17-34/326); d. fragment from distal half of shaft, with gnaw marks (17-34/344). Scale 1:3.

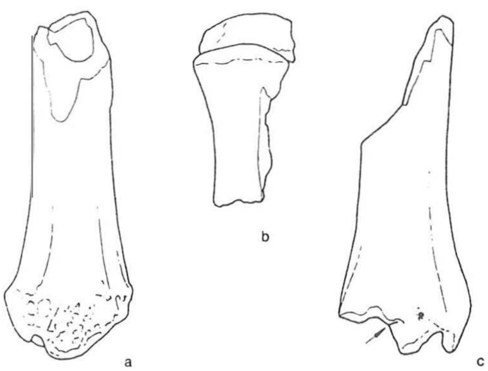

Fig. 13. Cattle tibiae. a. distal half of left tibia, with gnaw marks (17-34/379); b. proximal end of left tibia, longitudinally split, with loose proximal epiphysis (17/34/505); c. distal half of tibia with a distinct cut (arrow) (17-34/415). Scale 1:3.

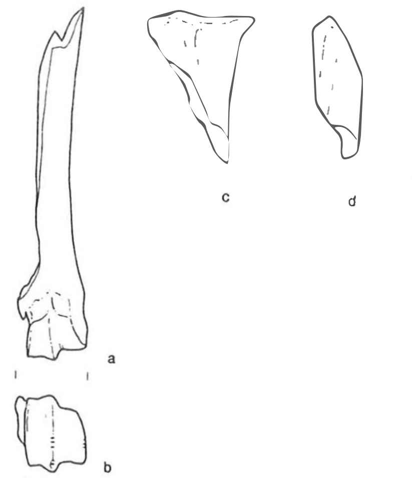

Fig. 14. Cattle metatarsals. a, b. distal half, longitudinally split, with distinct cuts on the distal aspect of the articular surface (b) (17-34/291); c. fragment of proximal end of right metatarsus, longitudinally split (17-34/532); d. fragment from the middle of the shaft, anterior aspect, with the groove that is characteristic of the metatarsus (17-34/292). Scale 1:3.

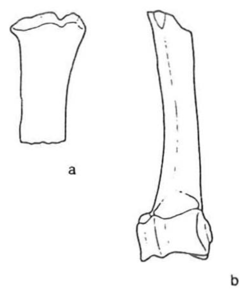

Fig. 15. Sheep bones. a. proximal one-third of left radius (17-34/291); b. distal two-third of right humerus (17-34/774). Scale 1:3.

a bone that showed the same colour as the bone itself (to distinguish such marks from recent injuries, e.g. those caused by excavation implements).

However, we have to realize that the tools that were used to divide the carcass were probably rather crude in the Iron Age. A rude chopper would have been used for this purpose. A blow with a chopper on a joint would have been enough to divide e.g. a foreleg from an upperleg (Rixson, 1988). These blows result in rough fracturing of the bone, that can not be distinguished from unintentional fractures. So, although hardly any distinct marks indicative of portioning have been found on the bones, without doubt the division of the carcass into large portions was accomplished by chopping. Further division may have occurred by further chopping and cutting. The removal of cooked meat from the bone could have resulted in cut marks as well. After cooking and the consumption of the meat additional fractures

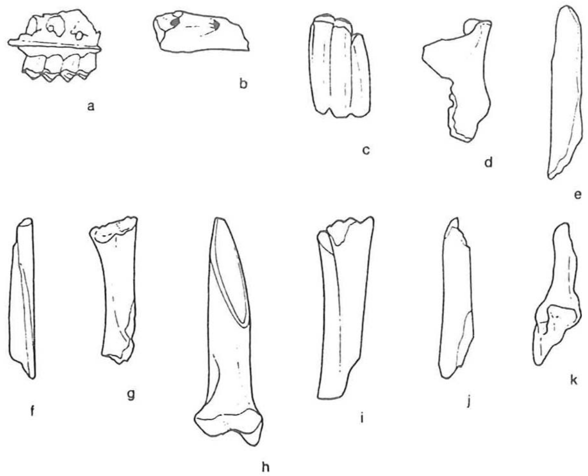

Fig. 16. Sheep(/goat) bones. a. fragment of left maxilla, medial aspect, with milk premolars (17-34/543); b. rostral one-third of left mandible (17-34/536); c. third molar of mandibula (17-34/543); d. fragment of ramus (17-34/497); e. fragment of shaft of left radius (17-34/344); f. fragment of shaft of metacarpus (17-34/390); g. left ischium (17-34/39); h. distal half of left femur, distal epiphysis unfused (17-34/543); i. proximal half of shaft of right tibia (10-74/3); j. fragment from distal half of shaft of left tibia (17-34/548); k. fragment of right calcaneus (17-34/543). Scale 1:3.

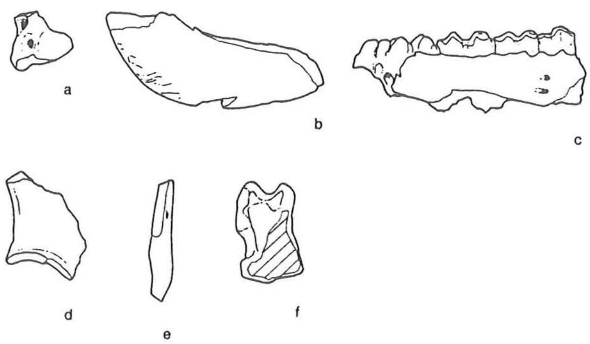

Fig. 17. Pig bones. a. left lacrimale (part of the skull) (17-34/387); b. basal part of ramus of mandible (17-34/548); c. fragment of right mandible with the fourth premolar and the three molars (age at least 20 months) (17-34/280); d. proximal part of right ulna (17-34/313); e. fragment of the proximal half of the posterior wall of the shaft of a right tibia, with a foramen nutriticum (17-34/777); f. left calcaneus, with a cut mark (shaded) (17-34/326). Scale 1:3.

may have occurred during waste removal, burial in the soil, and at the excavation.

Figures 6-17 illustrate the size and shape of the fragments of the skeletal elements of cattle, sheep (goat) and pig, as far as they could be identified to species. The figures are slightly biased, because for these illustrations I intentionally selected fragments that are identifiable from a two-dimensional drawing. Smaller fragments than those illustrated could be identified as well. The size and shape of the unidentified remains are illustrated by figure 18.

Figures 6-17 demonstrate that nearly all zones of the mandibula and the long bones of cattle, sheep(/goat) and pig are represented by fragments. Fragments that lack distinct features to permit their identification are among the unidentified bones. This point was also mentioned by Bonifay (1986: p. 13). Another factor that determines why remains are left unidentified is their relative size: the smaller a fragment is with respect to the complete skeletal element, the smaller is the chance that it contains a distinct feature.

5.4.2. *Horse and dog*

The inhabitants of the Iron Age farms seem to have dealt quite differently with the skeletons of horse than with those of cattle, sheep and pig. This must be a consequence of the much greater average weight of a horse bone, c. 128 g. The horse fragments were proportionally larger than those of cattle, pig and

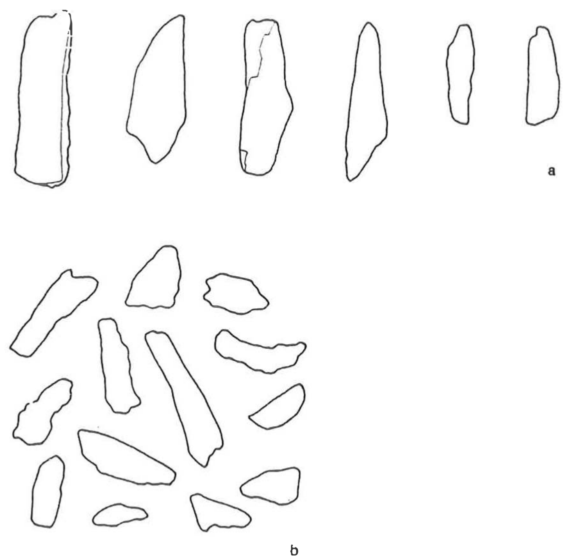

Fig. 18. Unidentified fragments of bone. a. cattle-size; b. sheep/pig-size. Scale 1:3.

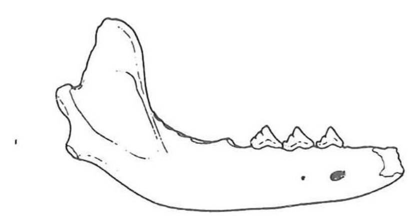

Fig. 19. Right mandible of dog, lateral aspect (17-34/343) (phase 2). Scale 1:3.

sheep. One of the seven bones of horse was complete: a metacarpus 3. A cut mark was found on a distal part of a humerus. This suggests that horse meat was eaten. The fragmentation of the horse bones was less extreme than that of the bones of cattle, sheep and goat.

The dog bones were relatively well preserved. Among them were nearly complete skulls and mandibles. Therefore, I conclude that the inhabitants of the Iron Age farms on Voorne-Putten did not eat dog meat.

5.5. The state of health of the domestic animals

No pathologies, like healed fractures, bone growths caused by ulcers, etc. have been found. This means that the domestic animals were reasonably healthy, or at least did not have diseases that leave traces on the bones. But we have to keep in mind that few diseases leave traces on the skeleton.

The foetal and neonatal cattle bones that have been found indicate that the Iron Age farmers suffered losses as a result of abortions and still-born calves.

5.6. The size and composition of the livestock herds

Archaeozoological material from a site gives information on the relative contributions of the various animal species to the food of animal origin consumed by the inhabitants of the site. The bone weight is supposed to be a good estimate of the relative contribution of a particular animal species to the diet. Taking into account differences in size of the species, we can estimate the composition of the herd. Life tables have been constructed on the basis of the age at death (see section 5.2).

The numbers of remains of domestic animals that are found at a site do not directly reflect the numbers of livestock that once lived there. At any site many bones will disappear in the course of time. We can expect a relation to exist between the number of animals once living at a site and the number of remains found on excavation, but very little is known about this. Also the duration of inhabitation will influence the number of faunal remains. Unfortunately, for most sites the duration of inhabitation is unknown.

The size of the farmhouse, and especially of the part of the building used for housing animals, may give information on the number of animals that could be stalled, and thus on the maximum size of the livestock herd at a given moment. Information on the number of individual stalls in the byre is available from four Iron Age farms on Voorne-Putten. These are:

- Site 10-69 (phase 1), 6 stalls of 1.6 m width and 1.0 m depth;
- Site 17-30 (phase 1), 6-7 stalls of c. 1.7 m width and 1.6-1.7 m depth (see van Trierum et al., 1988: p. 28);
- Site 17-35 (phase 1), at least 7 stalls of 1.6-1.8 m width and c. 1.7 m depth and one large stall of 3 m width and c. 1.7 m depth;
- Site 10-28 (phase 2) with 6 stalls of 1.6 m width and 1.6-1.8 m depth (van Trierum, pers. comm.).

The animal housing part of a fifth site, 17-34 (phase 2) probably had an area of 60-68 m^2. The individual stalls could not be counted, but there was room for 10-12 of them, a much larger number than in the four farms mentioned above.

On the basis of the information on the number of stalls hypothetical models have been made for the size and composition of the livestock herds of the Iron Age farms on Voorne-Putten. Models were developed for a small farm, with a stable part of 6 stalls and for a larger house, with a stable part of 10 stalls.

Starting-points for these models were:

a. All domestic animals had to be housed in winter or at night to protect them against bad weather and predators.

b. An average stall could house 2 cattle or horses, or 3 sheep or pigs.

Two ways of filling the stalls with cattle, horse, sheep and pig have been used in constructing the models, one with equal numbers of stalls for cattle and horse as those for sheep and pig, the other with about 80% of the stalls for cattle and horse and 20% for sheep and pig. In this way a total of 4 models have been made, two for the small farm (table 19: 1 and 2), and two for the big farm (table 19: 3 and 4).

The second way of filling the stalls is according to the proportions of these species in the faunal remains (tables 2 and 6), with a correction for the difference in average age (animals that live longer need the stalls longer than animals that die earlier). The average age of a living cow or bull (or ox) was 1.77 year (table 9.B: L), that of a living sheep 0.87 year (table 13.B: L), that of a pig was probably about the same as that of a sheep (from table 17).

Average meat and milk yields for human consumption have been calculated for the 4 models. The numbers of newborn animals and animals slaughtered have been estimated on the basis of the kill-off-patterns described in section 5.2. These calculations are based upon these assumptions:

1. The small farm, model 1 and 2, had 6 inhabitants, the large one, model 3 and 4, had 8 inhabitants.

2. A cattle carcass provided on average 100 kg of meat.

3. A sheep carcass delivered on average 20 kg of meat.

Table 19. Hypothetical size and composition of the livestock herd of Iron Age farms from Voorne-Putten: model 1 and 2, a small farm with six stalls, model 3 and 4 a large farm with ten stalls. Ind. = individual.

Model	1	2	3	4
Total number of stalls	6	6	10	10
Number of stalls for cattle and horse	3	5	5	8
Number of stalls for sheep and pig	3	1	5	2
Approximate numbers of animals				
Number of cattle	5	9	9	14
Number of horse	1	1	1	2
Number of sheep	7	2	12	4
Number of pigs	2	1	3	2
Number of yearly offspring				
Calves	2	3-4	3-4	4-7
Lambs	3-5	1-2	8-10	2-3
Piglets	4	2	8	4
Number of animals yearly slaughtered				
Cattle	1	2-3	2-3	3-5
Sheep	2-3	1	6-8	1-2
Pig	2	1	6	2
Meat yield for human consumption, yearly in kg				
Cattle (100 kg/ind.)	100	200-300	200-300	300-500
Sheep (lambs 10 kg/ind., ewes/rams 20 kg/ind.)	30-40	20	60-100	10-30
Pig (piglets 10 kg/ind., adult pigs 20 kg/ind.)	30	10-20	60-100	20-30
Total kg of meat yearly	160-170	230-340	320-500	330-560
Total kg of daily meat	0.44-0.47	0.63-0.93	0.88-1.37	0.90-1.53
Total number of heads	6	6	8	8
Total meat/day/head in g	73-78	105-155	110-171	113-192
Number of milk-giving animals				
Cows	1-2	3-4	3-4	4-5
Ewes	2	1	4-5	2-4
Estimated yearly milk yield for human consumption in kg				
Cows, 100 kg each	100-200	300-400	300-400	400-500
Sheep, 50 kg each	100	50	200-250	100-200
Total milk in kg	200-300	350-450	500-650	500-700
Total milk/day in kg	0.55-0.82	0.96-1.23	1.37-1.78	1.37-1.92
Total number of heads	6	6	8	8
Total milk/head/day in g	91	160-205	171-223	171-240

4. A piglet carcass delivered on average 10 kg of meat, an adult pig 20 kg of meat.
5. Each year a cow gave not more than 100 kg of milk for human consumption.
6. Each year a ewe gave 50 kg of milk for human consumption.

These estimates are on the conservative side, the real values possibly being somewhat higher. The smaller sources of meat have not been incorporated in the models. These include the meat of wild mammals, birds, fish and horse. The contributions of these smaller sources of meat would have made the menu more varied.

Model 2, 3 and 4 show daily rations of meat and milk that would have been sufficient. The daily rations of model 1 would definitely have been deficient in the long run. The proportions of meat of cattle, sheep and pig in model 1 and 3 do not fit in with the proportions for these species in the faunal remains: too little meat of cattle, too much of sheep and pig (compare with the proportions for these species in table 2 and 6). The models 2 and 4, in which 80% of the stall area was used by cattle and horse, and 20% by sheep and pig, fit in well with the proportions of the species in the faunal remains. These models are supposed to represent the small and the large Iron Age farms on Voorne-Putten, respectively.

The small farm had about 9 cattle: 2 calves, 2 yearlings, 2 animals of two years old and 3 of three, four and five years old, respectively. Every year three of four cows produced a calf. Some calves died at foetal or neonatal stages (see section 5.2.1). Because of these losses, not more than 2-3 cattle could be slaughtered annually. These were mainly old cows or bulls/oxen. The numbers of sheep and pigs were low: two sheep and one pig. Each year a few lambs and pigs were born. I estimate that every year one sheep and one pig was slaughtered.

The larger farm, with ten stalls, had about 14 cattle (table 19, model 4). The approximate age distribution of the living cattle was: 3 calves, 3 yearlings, 3 of two years old, 2 of three years old, 2 of four years old and 1 of five years old. Each year 4-5 calves were born, of which a few died peri- or neonatally. At most 3-5 cattle could be slaughtered annually. Some 4-5 cows gave milk for human consumption. The farm had 4 sheep and 2 pigs. Each year 2-3 lambs were born, while 1-2 sheep and 2 pigs were slaughtered every year.

Both farms could have produced some surplus. This is shown by the amounts of meat and milk available for each inhabitant (table 19, models 2 and 4). These surpluses may have been used for the acquisition of goods that were not produced on the farm, or were not produced in sufficient quantities, or were not available in the vicinity. Many imported goods have been demonstrated (van Trierum et al., 1988: p. 25). A surplus could have been exported in the form of living calves, lambs or piglets.

Another reason why living animals left the farms could have been the necessity to prevent inbreeding. The rather small herds would have been threatened by inbreeding if there was no regular input of fresh blood. Therefore I assume that a regular exchange of breeding animals existed between the farms.

Now that we have estimated the size of the herds, we may try to assess the area of pasture that was necessary to maintain them. I assume that the densities of cattle and sheep did not exceed the numbers of one head of cattle or horse or two sheep per hectare (100 x 100 m) of pasture, that had to provide the winter-fodder too. With this condition, the small farm would have needed 11 ha for their cattle and sheep, and the larger farm 18 ha. No extra areas have been calculated for the few pigs, as these live largely on waste.

This pasture was definitely not the meadow with a few grass and clover species that we know nowadays. Herbs, shrubs and trees would have been eaten by the Iron Age cattle and sheep. Obviously, the landscape of Voorne-Putten was most suitable for cattle in the Iron Age. Sheep farming would have been restricted by the liver-fluke and pig farming by the scarcity of woods. To protect the livestock against predators like wolves the animals would have been herded by a herdsman, probably accompanied by a dog. This may have been a major reason for keeping dogs on the farms.

The area used for arable farming is estimated as half of the area used for pasture. This proportion is based on the figures of Slicher van Bath, who found a ratio of $1:1^1/_2$-$1^3/_4$ between arable and pasture of good quality (1960: p. 30). This proportion gives areas of arable of $5^1/_2$ ha for the small farm and 9 ha for the large farm.

The total areas used for animal and plant husbandry would be $16^1/_2$ ha for the small farm and 27 ha for the large farm. These figures are only rough estimates. If these areas were situated regularly around the farms, they would fit within circles with a radius of 229 m for the small farm and 293 m for the large farm. These radii represent the greatest distances from the farms to their fields and the pastures. Hunting, fowling and fishing were probably practised to some extent outside the areas used for herding and cultivation.

6. ASPECTS OF HUNTING, FOWLING AND FISHING

The wild animal species demonstrated in the faunal remains of the Iron Age sites on Voorne-Putten have been mentioned in section 4.1 (see also tables 1-6 and appendix 2).

6.1. Age at death of the wild animals

The evidence for the age at death of the wild animals is rather scarce. A proximally fused ulna of beaver from phase 1/2 (site 17-35) belonged to an adult individual, this being deduced from the fact that the proximal epiphysis of ulna fuses in the second winter of life (Iregren & Stenflo, 1982). The bird remains originated from adult individuals.

6.2. The consumption of meat of wild animals

The meat of beaver and otter could have been eaten. Especially the tail of beaver is known to be a delicacy. However, these species will not have been im-

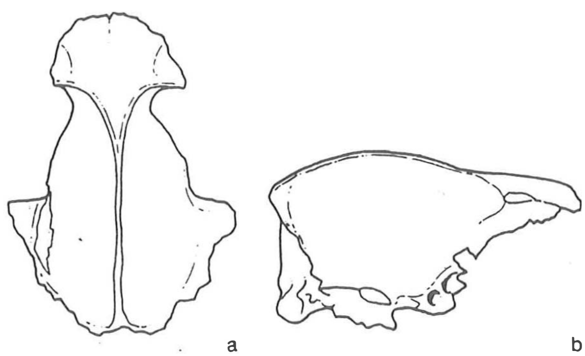

Fig. 20. Cranium of fox, *Vulpes vulpes*. a. dorsal aspect (17-34/310); b. right aspect (phase 2). Scale 1:2.

portant meat suppliers, as the numbers of remains are very small. Red deer meat would have been eaten occasionally on the farms of Voorne-Putten. The only remains of this species are an astragalus (talus) from site 10-28 (phase 2), identified by van Mensch (appendix 2), and an antler fragment with marks of antler processing (see section 6.3). This object could have been made from a shed antler of a red deer that was not necessarily eaten at all.

The birds and fish were certainly caught for their meat, as is confirmed by the fact that some of the bones from these species are broken.

Fig. 21. Left mandible of otter, *Lutra lutra*, lateral aspect (17-35/VK13) (phase 1/2). Scale 1:2.

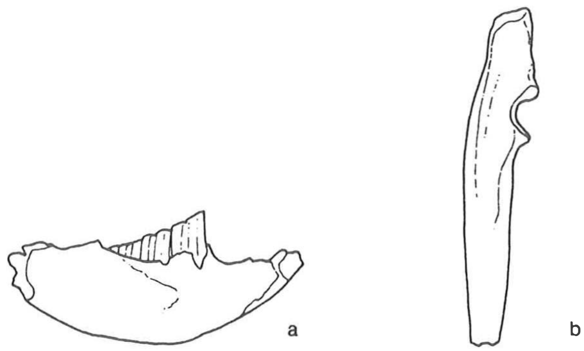

Fig. 22. Beaver, *Castor fiber*. a. right mandible (17-34/280) (phase 2); b. left ulna (17-35/6) (phase 1/2). Scale 1:2.

6.3. The wild fauna of Voorne-Putten in the Iron Age

The presence of roe deer, *Capreolus capreolus*, and red deer, *Cervus elaphus*, on Voorne-Putten during the Iron Age can not necessarily be concluded from the few bones of these species (table 6 and appendix 2): a shed antler is the only find of roe deer, while there were only two finds of red deer, a worked fragment of antler and an astragalus. The antler fragments could have been imported. The red deer astragalus is the only indication that deer lived on Voorne-Putten during the Iron Age. Bones of roe and red deer are absent in the Iron Age sites of Vlaardingen (Old People's Home and Broekpolder (Clason, 1967B)) on the north bank of the Meuse, although these sites had the same type of vegetation (N.B. the references used in section 6.3 are mentioned the first time a site is discussed).

Roe deer and red deer occurred in various districts of the Netherlands during the Iron Age and Roman Period, namely at the mouth of the Old Rhine (Stevenshofjespolder I (van Heeringen, 1982), Bosch-en Gasthuispolder (van Heeringen, 1982) and Achthoven (van Mensch, 1975)), on the Old Dune landscape (Spanjaardsbergje (Clason, 1967B: table 22), Amsterdamse Waterleidingduinen (Clason, 1967B: table 18) and Velsen (van Wijngaarden-Bakker, 1988)), on the northern marine clay area (Tritsum (Clason, pers. comm.), Paddepoel (Knol, 1983) and Sneek (Clason, 1962)), on the sand area (Haaren (Clason, pers. comm.)) and on the fluvial clays (Culemborg (Clason, 1980)).

These deer species are very adaptable, especially the roe deer. Both species may inhabit a wide range of habitats from dry woods to wet moorland, as long as they have a certain amount of cover (Niethammer & Krapp, 1986). I assume that roe and red deer were indeed present on Voorne-Putten in the Iron Age, but that their densities were lower than in the other districts of the Netherlands.

The elk, *Alces alces*, has not been identified in the sites of Voorne-Putten, but was found on the north bank of the Meuse, in Vlaardingen (Vlaardingen-Old People's Home) and in the fluvial clay district (Culemborg). The elk likes wet environments in summer, while in winter it needs drier habitats. The absence of elk in the sites on Voorne-Putten is probably fortuitous, although the density of the species would have been low. Van Mensch found elk remains in the Iron Age site Poortugaal (12-03) (appendix 2), that is situated 5 km east of Spijkenisse, in an environment very similar to that of the Iron Age sites on Voorne-Putten.

Beaver, *Castor fiber*, and otter, *Lutra lutra*, have identical habitats: all kinds of waters and marshes. Polechla (1985) demonstrated that otter benefits from the presence of beaver by the dams and nests that this species builds. These provide suitable habitats for otter. I consider the absence of bones of beaver and otter in the sites on Voorne-Putten studied by van Mensch (appendix 2) as a matter of chance. This may also be the reason for the absence of bones of beaver and otter in the Iron Age sites in Vlaardingen (Old People's Home and Broekpolder). In Poortugaal, van Mensch found a bone of an otter. The marshy environment on Voorne-Putten in the Iron Age would have suitable for beaver and otter.

Other districts where Iron Age remains of beaver and/or otter have been found are the mouth of the Old Rhine (Stevenshofjespolder IV (van Heeringen, 1984), Bosch- en Gasthuispolder), the Assendelft area (S'eeman, 1987; van Wijngaarden-Bakker, 1988) and the fluvial clay area (Culemborg). The absence of bones of beaver in the northern marine clay area (Tritsum, Paddepoel, Sneek) is not surprising in view of the environmental requirements of the species: light woods with shrubs along rivers and lakes or swamps. These habitats were not present in the salt marshes of the northern marine clay area. The otter could have lived there, because it tolerates brackish water.

The absence of bones of beaver and otter in the Old Dune landscape sites (Spanjaardsbergje, Amsterdamse Waterleidingduinen, Velsen) can be explained by the aridity of the area. The same may hold for Haaren, that is situated on the sand area. Otter probably lived in or visited these areas, but perhaps in smaller densities than in the wet districts at the mouth of the Meuse, the Old Rhine and the Oer IJ (the Assendelft area).

Wild boar, *Sus scrofa*, has not been identified in the Iron Age sites of Voorne-Putten (table 6, appendix 2). It was a rather common wild mammal in this area in the Neolithic: wild boar accounts for 2% of the animal remains in Hekelingen III (Prummel, 1987a). The scarcity or absence of wild boar on Voorne-Putten during the Iron Age would have been due to the scarcity of woods. The presence of wild boar has been demonstrated in some of the sites of the Old Rhine mouth (Stevenshofjespolder I and Bosch- en Gasthuispolder), in Culemborg in the fluvial area and in Haaren on the sand area.

No remains of sea mammals have been found in the Iron Age sites on Voorne-Putten (table 6 and appendix 2). Remains of these species have been identified in most sites on the Old Dune landscape and on the marine clay. Bottle-nosed dolphin, *Tursiops truncatus*, and common porpoise, *Phocoena phocoena*, have been identified in Amsterdamse Waterleidingduinen. Two other Old Dune landscape sites, Spanjaardsbergje and Velsen, yielded remains of unidentified larger Cetacea. In the marine clay sites Tritsum and Paddepoel remains have been found of a seal (Phocidae) and a whale (Cetacea), respectively.

These sites on the Old Dune landscape and the marine clay district were situated close to the sea or at a river mouth. The sites on Voorne-Putten, as well as the others along the river Meuse (Vlaardingen Old People's Home, Vlaardingen-Broekpolder), and those along the Old Rhine (Stevenshofjespolder I and IV, Bosch- en Gasthuispolder) and the Oer IJ (Assendelft) were situated further upstream, which means there would have been a smaller chance of a seal or a whale ending up there in nets or on the riverbank.

Heron, *Ardea cinerea*, mute swan, *Cygnus olor*,

Fig. 23. Scapula of mallard, *Anas platyrhynchos* (17-35/196) (phase 1). Scale 7:10.

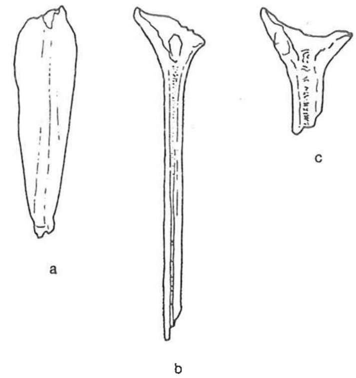

Fig. 24. Sturgeon, *Acipenser sturio*. a. fragment of dermal plate (17-36/5) (phase 2/3); b and c. fragments of spina pinnae pectoralis (both 17-35/VK13) (phase 1/2). Scale 1:3.

and mallard, *Anas platyrhynchos*, are each represented by a single bone in the Iron Age sites on Voorne-Putten (table 6). These are all species of wet habitats, that may be fresh or brackish to marine. As stated in the introduction, a freshwater environment prevailed on Voorne-Putten in the Iron Age. Heron and mallard have also been identified in the Iron Age sites in Vlaardingen (Old People's Home and Broekpolder), on the north bank of the Meuse.

Sturgeon, *Acipenser sturio*, is an anadromous fish, which means that it lives and grows in the sea, but spawns in fresh water. For that reason adult sturgeon migrate into large rivers in late spring or early summer. The species was represented by quite a lot of remains in the Iron Age sites on Voorne-Putten that I studied, together making up 1.5% of all identified remains (table 6). The sturgeon is represented in all phases, but seems to be more abundant in phase 3 (tables 1-5). Sturgeon fishing was of even more importance on Voorne-Putten during the Neolithic. Sturgeon remains formed 14% of the weight of identified remains of Hekelingen III (Prummel, 1987a).

Other Iron Age sites with remains of sturgeon are Amsterdamse Waterleidingduinen and Vlaardingen-Old People's Home. The inhabitants of the first site may have collected a stranded sturgeon from the beach. In the vicinity of the latter site natural conditions were very similar to those on Voorne-Putten.

The fact that no sturgeon have been identified in the sites on the Old Rhine (Stevenshofjespolder I and IV, Wassenaar-ter Weer, Achthoven) and Oer IJ (Assendelft, Velsen) is probably a matter of poor conditions for preservation. The sturgeon remains of the Roman castellum at Valkenburg (Clason, 1967B: table 24) demonstrate that the species entered the Old Rhine in the Roman Period. I assume they probably did this also in the Iron Age. Many sturgeon remains were found in the Roman military sites Velsen 1 and 2 (Clason, Brinkhuizen & Prummel, 1979; Brinkhuizen, 1989) (these sites should not be confused with the Iron Age sites of Velsen (van Wijngaarden-Bakker, 1988))

The scarcity of sturgeon remains in the northern marine clay area (no finds in Tritsum, Paddepoel and Sneek) is not surprising. Sturgeon spawn in large rivers as a general rule, and in this northern part of the Netherlands the rivers are rather small. No sturgeon remains have been found in Culemborg. An occasional fragment could have been present in that site, as sturgeon migrated even beyond that distance from the river mouth (Prummel, 1983).

Other fish species represented by bones in the Iron Age sites on Voorne-Putten are the thin- or the thick-lipped grey mullet, *Liza ramada* or *Chelon labrosus* (table 6), perch, *Perca fluviatilis* (identification M. Seeman, see van Trierum, 1986b), and bream, *Abramis brama*, appendix 2). Other Cyprinids could also be represented (identification M. Seeman, see van Trierum, 1986b). The bream is characteristic for the lower reaches of rivers (Ladiges & Vogt, 1965: 23). The Iron Age sites of Voorne-Putten were situated in the delta of the Meuse. The perch is a common species of fresh water. The thin- and the thick-lipped grey mullets are marine fish, that enter the river mouths in summer. From the sites of Vlaardingen-Broekpolder on the north bank of the Meuse and Stevenshofjespolder IV on the mouth of the Old Rhine, unidentified fish remains are reported, that were most probably bones of teleost fishes.

Sieving of soil in Assendelft from an Iron Age context yielded many fish remains. The majority of fish bones were of Cyprinid species. Small numbers of fragments have been found of pike, eel, perch, European catfish, cod and flounder or plaice (van Wijngaarden-Bakker, 1988).

In conclusion, the remains of the wild species in the Iron Age sites of Voorne-Putten (table 6 and appendix 2) clearly indicate the freshwater environment of Voorne-Putten, in which bream, beaver, otter, bream and perch lived. The beaver profited from the wooded banks of the gullies in the peat. The large river mouth of the Meuse was used by sturgeon as a way to reach their spawning grounds. Thin- or thick-lipped grey mullet entered this river mouth in summer. The area would have been attractive for birds too.

7. BONE PROCESSING

The Iron Age inhabitants of Voorne-Putten used antler on a small scale for the production of objects. The only object that showed distinct traces of such processing is a fragment of a red deer antler, *Cervus elaphus*, from phase 2 (fig. 25). Its shape is reminiscent of that of a basket maker's cleaver (*splijthoutje* or *spleut*), an implement used to split the stems of brambles or other twigs (Jacobs & Plettenburg, 1969: pp. 30-31; Estyn Evans, 1977: p. 127). Alternatively, this object could have been a handle or a seal.

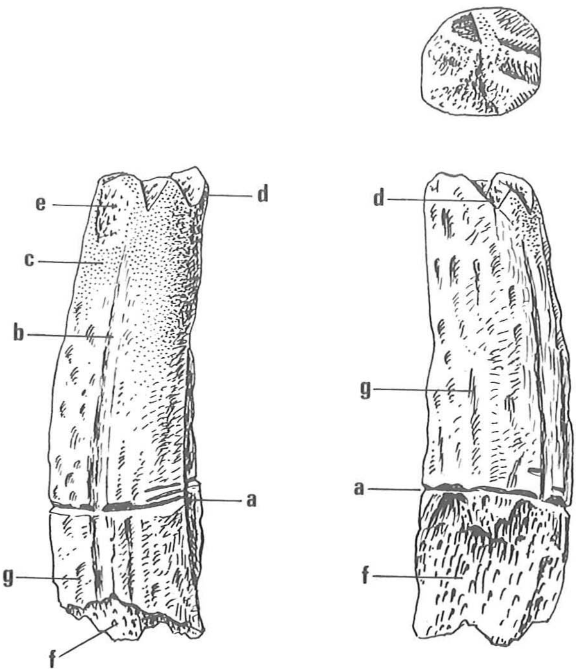

Fig. 25. Object of red deer antler, *Cervus elaphus*, from site 10-74 (phase 2), with a toothed tip and polish on sides and tip. a. cut; b. natural groove; c. gloss caused by use; d. notch; e. abrasion due to use; f. cancellous tissue of the antler (natural); g. natural surface of the antler. Scale 1:1.

No bones of domestic animals showed any traces of artefact processing or of use. Wind (1970) reported on faunal remains that had been collected during the excavation of site 08-06 (Rockanje) (these did not reach me for study). The pointed fragments of cattle long bones that Wind considered as having been purposely broken and retouched (depicted in his fig.15), are no artefacts. They are more likely to be the result of fragmentation by man due to butchering or for marrow extraction, by weathering (frost, sunshine) or by being trodden upon. The shafts of long bones tend to get broken into points (e.g. figs 8-18). Bones of domestic animals were not used for bone processing.

8. TRACES OF GNAWING AND BURNING

8.1. Gnawing

Of all bones, identified and unidentified ones, 51 (2.4%) showed tooth marks, probably made by carnivores (dogs): (e.g. figs 7, 10-13, 16). This rather low proportion is presumably due to the poor preservation of the surface of many bones. The bones have been gnawed while lying on the ground. We have to realize that the bones with tooth marks are only a proportion of all the bones once gnawed by dogs. Many of these bones would have disintegrated completely, withour leaving any traces.

8.2. Burned and calcined bone

The Iron Age sites on Voorne-Putten have a high proportion of bones showing traces of the influence of fire: 10% of all bones (217). Of these, 26 bones had black spots, while a larger number, 191 bones, had white spots or were completely white (calcined), caused by the persistent and intense influence of fire. Many of the burned or calcined fragments were unidentifiable: the fire had caused the bones to split up into many small pieces, and had deformed them (fig. 26).

This rather high proportion of bones with traces of burning indicates that many bones came into direct contact with fire. This happened after the meat had been consumed. Normal cooking of meat does not produce the high temparatures needed to burn (blacken) bones (400-500 °C) or to calcine them (400-650 °C) (Shipman et al., 1984). The burned or calcined bones must have been thrown away either into a hearth or into a rubbish pit of which the contents were set on fire.

Fig. 26. Photograph of burned bone (a) and of calcined bone (b). Scale 1:1.

9. SUMMARY

1. Animal husbandry was the most important source of meat for human consumption on the farms of the Early (phase 1), Middle (phase 2) and Late (phase 3) Iron Age on Voorne-Putten. Over 95% of the identified remains from phase 2 (n= 934) were from domestic mammals. The numbers of remains from phases 1 and 3 were too small to permit any conditions on possible differences in proportions with respect to phase 2.

2. Cattle were the most important domestic animals: more than 70% of the bones of domestic mammals were from cattle. Sheep and pigs contributed to a lesser extent to the diet. Horses and dogs were kept in very small numbers.

3. The cattle husbandry on the farms suffered losses due to stillborns or the death of neonatal calves. Veal was hardly eaten. Most cattle were slaughtered after they had reached maturity.

4. Quite a lot of sheep died in their first year of life. From this we may conclude that lamb was eaten about as often as mutton. From the few age data available for pig it may be concluded that many pigs died as piglets.

5. The reconstructed size and composition of the livestock herds of a small farm with 6 stalls and a large farm with 10 stalls suggest that the inhabitants of the small as well as the large farm had enough meat and milk for human consumption and even produced some surplus. However, the models are based on many assumptions and estimates. A possible surplus would have had to be used in the first place to acquire animals from elsewhere to prevent inbreeding. The rest could have been used to acquire goods that were not produced on the farm.

6. Hunting, fowling and fishing contributed small quantities of animal protein to the diet. The main value of these activities was the variation they brought

into the diet. Some beavers and otters were caught, probably for their fur and also for their meat. Red deer and roe deer were caught in small numbers.

7. Heron, mute swan and mallard were caught in small numbers. These species demonstrate the wet character of the environment of the farms. Sturgeon, thin- or thick-lipped grey mullet, perch and bream were caught. These fish species fit in with the location of the sites in the delta of the Meuse.

8. Bone processing has been demonstrated with certainty only by a worked fragment of antler of red deer.

9. The bones were extremely fragmented. This may be responsible for the low identification rate: 57.8% for all sites together. Of all bones 10% were burned or calcined. Another 2.4% showed traces of gnawing by dogs.

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11. REFERENCES

BAKELS, C.C., 1986. Akkerbouw in het moeras? In: M.C. van Trierum & H.E. Henkes (eds), *Rotterdam Papers* 5. Rotterdam, pp. 1-6.

BARTOSIEWICZ, L., 1984. Sexual dimorphism of long bone growth in cattle. *Acta Veterinaria Hungarica* 32, pp. 135-146.

BARTOSIEWICZ, L., 1987. Cattle metapodials revisited: a brief review. *Archaeozoologia* 1(1), pp. 47-51.

BOESSNECK, J., H.-H. MÜLLER & M. TEICHERT, 1964. Osteologische Unterscheidungsmerkmale zwischen Schaf (Ovis aries Linné) und Ziege (Capra hircus Linné) *Kühn-Archiv* 78, pp. 1-129.

BONIFAY, M.-F., 1986. Le materiel osseux fragmenté déterminable au paléolithique ancien: mise en évidence, catégories, histogramme (1). In: A. Aguirre & M Patou (eds), *Outillage peu élaboré en os et en bois de cervides* (= Artefacts 3). Viroinval, pp. 11-14.

BRINKHUIZEN, D.C., 1989. Ichthyo-archeologisch onderzoek: methoden en toepassing aan de hand van Romeins vismateriaal uit Velsen (Nederland). Thesis, Groningen.

BRINKKEMPER, O., in prep. Wetland farming in the area south of the Meuse estuary during the Iron Age and Roman period: an environmental and palaeo-economical study. *Analecta Praehistorica Leidensia* (also thesis, Leiden) (provisional title).

CLASON, A.T., 1962. Beenderen uit nederzettingssporen van rond het begin onzer jaartelling bij Sneek. *De Vrije Vries* 45, pp. 100-112.

CLASON, A.T., 1967. *Animal and man in Holland's past, A & B.* Groningen.

CLASON, A.T., 1980. Jager, visser, veehouder, vogellijmer. In: M. Chamalaun & H.T. Waterbolk (eds), *Voltooid verleden tijd? Een hedendaagse kijk op de prehistorie.* Amsterdam, pp. 131-146.

CLASON, A.T., D.C. BRINKHUIZEN & W. PRUMMEL, 1979. Vogelen en vissen. Een glimp van de Nederlandse vogel- en viswereld uit het verleden. *Westerheem* 28, pp. 9-23.

DRIESCH, A. VON DEN & J. BOESSNECK, 1974. Kritische Anmerkungen zur Widerristhöhenberechnung aus Längenmaßen vor- und frühgeschichtlicher Tierknochen. *Säugetierkundliche Mitteilungen* 22, pp. 325-328.

ESTYN EVAN, E., 1977. *Irish heritage.* Dundalk.

HABERMEHL, K.-H., 1975. *Die Altersbestimmung bei Haus- und Labortieren*, 2. Auflage. Berlin/Hamburg.

HALLEWAS, D.P. & J.F. VAN REGTEREN ALTENA, 1980. Bewoningsgeschiedenis en landschapsontwikkeling rond de Maasmond. In: A. Verhulst & M.K.E. Gottschalk (eds), *Transgressies en occupatiegeschiedenis in de kustgebieden van Nederland en België.* Gent, pp. 155-207.

HARING, F, C. BRÜNE, K. DEDIÉ, R. GRUHN & D SMIDT, 1980. *Schafzucht.* Stuttgart.

HEERINGEN, R.M. VAN, 1982. Een vondstcomplex uit de IJzertijd in de Stevenshofjespolder in Leiden. *Bodemonderzoek in Leiden* 5, pp. 77-88.

HEERINGEN, R.M. VAN, 1984. Nogmaals de Stevenshofjespolder in Leiden. *Bodemonderzoek in Leiden* 7, pp. 57-62.

HEERINGEN, R.M. VAN, 1986. De Late Bronstijd en Vroege IJzertijd in de Nederlandse Delta. In: M.C. van Trierum & H.E. Henkes (eds), *Rotterdam Papers* 5. Rotterdam, pp. 27-48.

IREGREN, E. & G. STENFLO, 1982. An osteological and statistical attempt to interpret seasonal occupation of dwelling sites in Northern Sweden by studying the beaver (Castor fiber L). *Pact* 7, pp. 225-234.

JACOBS, B. & H.W.M. PLETTENBURG, 1969. *De oude imkerij.* 2nd ed. Arnhem.

KNOL, E., 1983. Farming on the banks of the river Aa: the faunal remains and bone objects of Paddepoel 200 B.C.-250 A.D. *Palaeohistoria* 25, pp. 145-182.

KRATOCHVÍL, Z., Z. KUX & J. PIKULA, 1986. Age structure and reproduction of a population of Sus scrofa in Czechoslovakia. *Folia Zoologica* 35, pp. 311-324.

LADIGES, W. & D. VOGT, 1965. *Die Süsswasserfische Europas.* Hamburg/Berlin.

LAUWERIER, R.C.G.M., 1983. Pigs, piglets and determining the season of slaughtering. *Journal of Archaeological Science* 10, pp. 483-488.

LOUWE KOOIJMANS, L.P., 1986. Het loze vissertje of boerke Naas? In: M.C. van Trierum & H.E. Henkes (eds), *Rotterdam Papers* 5. Rotterdam, pp. 7-25.

MENSCH, P.J.A. VAN, 1975. Dierresten uit de polder Achthoven (gem. Leiderdorp). *Westerheem* 24, pp. 111-116.

NIETHAMMER, J. & F. KRAPP (eds), 1986. *Handbuch der Säugetiere Europas, 2/II, Paarhufer-Artiodactyla (Suidae, Cervidae, Bovidae).* Wiesbaden.

POLECHLA, P.J. Jr., 1985. More evidence of a commensal relationship between the beaver and the river otter. *IV International Theriological Congress Edmonton, Alberta, Canada,*

13-22 August 1985. Abstract No. 0498, Session S08, 2nd International Beaver Symposion.
PRUMMEL, W., 1979. The size of Dutch horses and Labouchère's theory on the origin of the Frisian horse. In: M. Kubasiewicz (ed.), *Archaeozoology* 1, Szczecin, pp. 431-438.
PRUMMEL, W., 1983. *Early medieval Dorestad, an archaeozoological study* (= Excavations at Dorestad 2. Nederlandse Oudheden 11). 's-Gravenhage/Amersfoort.
PRUMMEL, W., 1987a. The faunal remains from the Neolithic site Hekelingen III. *Helinium* 27, pp. 190-258.
PRUMMEL, W., 1987b. Atlas for identification of foetal skeletal elements of cattle, horse, sheep and pig. Part 2. *Archaeozoologia* 1(2), pp. 11-42.
PRUMMEL, W., 1987c. Poultry and fowling at the Roman castellum Velsen 1. *Palaeohistoria* 29, pp. 183-201.
PRUMMEL, W., 1988. Atlas for identification of foetal skeletal elements of cattle, horse, sheep and pig. Part 3. *Archaeozoologia* 2, pp. 13-26.
PRUMMEL, W. & H.-J. FRISCH, 1986. A guide for the distinction of species, sex and body side in bones of sheep and goat. *Journal of Archaeological Science* 13, pp. 567-577.
RIXSON, D., 1988. Butchery evidence on animal bones. *Circaea* 6, pp. 49-62.
SEEMAN, M., 1987. Faunal remains of excavations during 1978 and 1979, Assendelver Polders. In: R.W. Brandt, W. Groenman-van Waateringe & S.E. van der Leeuw (eds), *Assendelver Polder Papers* 1 (= Cingula 10). Amsterdam, pp. 91-97.
SHIPMAN, P., G. FOSTER & M. SCHOENINGER, 1984. Burnt bones and teeth: an experimental study of color, morphology, crystal structure and shrinkage. *Journal of Archaeological Science* 11, pp. 307-325.
SLICHER VAN BATH, B.H., 1960. *De agrarische geschiedenis van West-Europa, 500-1850*. Utrecht/Antwerpen.
SPENNEMANN, D.R., 1985. Vorschlag für ein neues ergänzendes System zur Präsentation zoo-archäologischer Daten. *Archäologisches Korrespondenzblatt* 15, pp. 397-403.
STAALDUINEN, C.J. VAN, 1979. *Toelichtingen bij de geologische kaart van Nederland 1 : 50.000, blad Rotterdam West (37 W)*. Haarlem.
TRIERUM, M.C. VAN, 1986a. Putten: landschap en bewoning van Prehistorie tot en met Middeleeuwen. *Westerheem* 35, pp. 50-54.
TRIERUM, M.C. VAN, 1986b. Landschap en bewoning rond de Bernisse in de IJzertijd en de Romeinse tijd. In: M.C. van Trierum & H.E. Henkes (eds), *Rotterdam Papers* 5. Rotterdam, pp. 49-75.
TRIERUM, M.C. VAN, A.B. DÖBKEN & A.J. GUIRAN, 1988. *Archaeologisch onderzoek in het Maasmondgebied 1976-1986* (= Boorbalans 1). Rotterdam, pp. 11-107.
WIJNGAARDEN-BAKKER, L.H. VAN, 1988. Zoöarcheologisch onderzoek in de west-Nederlandse delta 1983-1987. In: J.H. Bloemers (ed.), *Archeologie en oecologie van Holland tussen Rijn en Vlie* (= Studies in prae- en protohistorie 2). Assen/Maastricht, pp. 154-185.
WIJNGAARDEN-BAKKER, L.H. VAN & P.L. BERGSTRÖM, 1988. Estimation of the shoulder height of cattle. *Archaeozoologia* 2, pp 67-82.
WIND, C., 1970. Een nederzetting uit de voor-Romeinse ijzertijd te Rockanje. *Westerheem* 19, pp. 242-261.

APPENDIX 1. Voorne-Putten, Iron Age. Faunal remains in the individual sites studied by W. Prummel. n = number; w = weight.

		Phase 1 17-35		Phase 2 10-74		17-34		17-35		17-40		17-51		17-55	
		n	w	n	w	n	w	n	w	n	w	n	w	n	w
Dog	Canis familiaris	-	-	-	-	10	132	2	337	-	-	-	-	-	-
Horse	Equus caballus	-	-	-	-	1	145	1	6	1	152	1	213	-	-
Pig	Sus domesticus	-	-	3	7	63	749	1	25	-	-	-	-	2	14
Cattle	Bos taurus	19	277	49	1.098	494	9.167	44	695	12	305	4	225	58	1.270
Sheep	Ovis aries	1	6	-	-	11	92	1	10	-	-	-	-	-	-
Sheep/goat	Ovis/Capra	2	13	6	47	114	489	8	42	2	23	-	-	7	84
Beaver	Castor fiber	-	-	1	4	2	31	-	-	-	-	-	-	-	-
Fox	Vulpes vulpes	-	-	-	-	1	20	-	-	-	-	-	-	-	-
Otter	Lutra lutra	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red deer	Cervus elaphus	-	-	1	18	-	-	-	-	-	-	-	-	-	-
Heron	Ardea cinerea	-	-	-	-	1	2	-	-	-	-	-	-	-	-
Mute swan	Cygnus olor	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mallard	Anas platyrhynchos	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Bird unknown		-	1	-	2	1	-	-	-	-	-	-	-	-	-
Sturgeon	Acipenser sturio	1	2	-	-	1	4	-	-	-	-	-	-	-	-
Thin-lipped or thick-lipped grey mullet	Liza ramada/ Chelon labrosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified:															
Size of cattle		9	32	25	71	338	1.076	36	92	4	15	8	39	10	43
Size of sheep		9	8	-	-	169	174	6	4	-	-	-	-	8	12
Size unknown		-	-	-	-	81	91	60	15	-	-	-	-	4	2
Total		42	339	86	1.245	1.288	12.173	159	1.226	19	495	13	477	89	1.425

APPENDIX 1. (Cont. 1)

		17-56		18-06		18-28		18-29		18-30		Phase 3 08-06		09-08	
		n	w	n	w	n	w	n	w	n	w	n	w	n	w
Dog	Canis familiaris	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Horse	Equus caballus	-	-	-	-	1	14	-	-	-	-	-	-	-	-
Pig	Sus domesticus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cattle	Bos taurus	10	248	2	18	7	73	1	9	2	21	1	13	1	19
Sheep	Ovis aries	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sheep/goat	Ovis/Capra	3	11	1	2	1	4	-	-	1	6	-	-	-	-
Beaver	Castor fiber	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fox	Vulpes vulpes	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Otter	Lutra lutra	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red deer	Cervus elaphus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heron	Ardea cinerea	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mute swan	Cygnus olor	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mallard	Anas platyrhynchos	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bird unknown		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sturgeon	Acipenser sturio	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thin-lipped or thick-lipped grey mullet	Liza ramada/ Chelon labrosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified:															
Size of cattle		7	19	1	1	4	18	-	-	2	7	-	-	-	-
Size of sheep		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Size unknown		7	2	-	-	-	-	-	-	-	-	-	-	-	-
Total		27	280	4	21	13	109	1	9	5	34	1	13	1	19

APPENDIX 1. (Cont. 2)

		10-110		17-23		17-41		17-44		Phase 1/2 17-35		Phase 2/3 17-33		17-36	
		n	w	n	w	n	w	n	w	n	w	n	w	n	w
Dog	Canis familiaris	-	-	-	-	-	-	-	-	1	37	-	-	1	16
Horse	Equus caballus	-	-	-	-	-	-	-	-	-	-	1	197	1	167
Pig	Sus domesticus	-	-	-	-	-	-	-	-	18	75	-	-	3	29
Cattle	Bos taurus	-	-	-	-	4	25	4	50	58	1.786	9	276	81	2.705
Sheep	Ovis aries	-	-	-	-	-	-	-	-	2	7	1	1	5	50
Sheep/goat	Ovis/Capra	-	-	1	3	3	6	-	-	18	74	-	-	14	136
Beaver	Castor fiber	-	-	-	-	-	-	-	-	1	9	-	-	-	-
Fox	Vulpes vulpes	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Otter	Lutra lutra	-	-	-	-	-	-	-	-	1	5	-	-	-	-
Red deer	Cervus elaphus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heron	Ardea cinerea	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mute swan	Cygnus olor	-	-	-	-	1	2	-	-	-	-	-	-	-	-
Mallard	Anas platyrhynchos	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bird unknown		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sturgeon	Acipenser sturio	-	-	-	-	13	35	-	-	2	14	-	-	7	1
Thin-lipped or thick-lipped grey mullet	Liza ramada/ Chelon labrosus	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Unidentified:															
Size of cattle		1	7	-	-	2	8	1	1	31	131	9	42	24	99
Size of sheep		1	1	-	-	-	-	7	7	2	2	2	5	7	10
Size unknown		-	-	-	-	-	-	1	1	1	1	1	1	2	2
Total		2	8	1	3	23	76	13	59	135	2.141	23	522	146	3.216

APPENDIX 2. Voorne-Putten, Iron Age and Roman period. Faunal remains studied by P.J.A. van Mensch. Spijk.: Spijkenisse; Alb.: Alblasserdam.

		Iron Age								Roman period			
		Phase 1 10-69	Phase 2 10-28	12-03	17-14	17-18	18-30	18-50	Phase 3 17-22	25 3B	Spijk. 1973	Spijk. 1976	Alb.
Dog	Canis familiaris	-	-	5	-	1	-	2	-	-	2	18	9
Horse	Equus caballus	3	3	2	-	-	4	-	5	-	11	25	7
Pig	Sus domesticus	-	18	-	2	4	4	2	2	-	7	132	16
Cattle	Bos taurus	5	119	17	40	34	46	41	56	6	81	609	169
Sheep	Ovis aries	-	-	-	-	-	-	-	-	-	-	2	-
Sheep/goat	Ovis/Capra	-	9	2	4	5	2	1	11	8	13	311	2
Beaver	Castor fiber	-	-	-	-	-	-	-	-	-	-	8	-
Fox	Vulpes vulpes	-	-	-	-	-	-	-	-	-	-	-	1
Otter	Lutra lutra	-	-	1	-	-	-	-	-	-	-	-	-
Wild boar	Sus scrofa	-	-	-	-	-	-	-	-	-	-	-	1
Red deer	Cervus elaphus	-	2	-	-	-	-	-	-	-	-	7	2
Roe deer	Capreolus capreolus	-	-	-	-	-	1	-	-	-	-	2	1
Elk	Alces alces	-	-	6	-	-	-	-	-	-	-	1	1
Aurochs	Bos primigenius	-	-	-	-	-	-	-	-	-	-	-	4
Bird unknown		-	-	-	-	-	-	-	-	-	3	8	-
Sturgeon	Acipenser sturio	-	-	-	-	-	-	-	-	-	-	28	3
Bream	Abramis brama	-	-	-	-	-	-	-	2	-	-	-	
Baltic tellin	Macoma balthica	-	-	-	-	-	-	-	-	-	-	1	-
Unidentified		24	77	24	81	124	32	17	35	11	72	1.017	115
Total		32	228	57	127	168	89	63	111	25	189	2.169	331