FARMING ON THE BANKS OF THE RIVER AA

THE FAUNAL REMAINS AND BONE OBJECTS OF PADDEPOEL 200 B.C.-250 A.D.

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CONTENTS

1. INTRODUCTION*

In the 19th and 20th century, in the course of the levelling of the dwelling mounds (Dutch: *wierden* or *terpen*) in the coastal area in the north of the Netherlands for agricultural reasons, a great number of ancient remains, including many bones, were found. Dutch archaeozoology started with the investigation of these *terp* finds (Clason, 1977). Most of this research was published per species: dog by Schoor (1887), Van Giffen (1913b; 1927) and Keller (1918); cattle by L. Broekema (1908; 1909a) and C. Broekema (1910); horse by L. Broekema (1909b) and Labouchère (1927); sheep by L. Broekema (1910) and Reitsma (1932); pig by L. Broekema (1912) and Reitsma (1935). Van Giffen's doctoral thesis *Die Fauna der Wurten* (1913a) dealt with the game mammals which had been found. His proposed second volume on domesticated animals has never appeared. Roes (1963) described bone and antler objects found in the *terpen.* Bakker (1931) and Clason (1970a) produced summaries.

Most of these studies were concerned with random material from several *terpen* and periods, with the emphasis on skulls. Before 1945 no thought was given to describing the faunal complex of an excavation in its entirety. This is regrettable since much of our knowledge of the *terp* period is based on these excavations. During the few post-war *terp* excavations the bone material was indeed collected where possible, but, so far, it has not been intensively studied (Clason, 1962; 1970b). The present paper presents a qualitative and quantitative description of the material from the settlements of Paddepoel, and a comparative discussion of the results.

2. EXCAVATION

During the preparatory work for the building of the Paddepoel extension scheme of the city of Groningen, three clusters of small, clay-covered *terpen* situated on the west bank of the river Aa (fig. 1) were found, as was also a small graveyard more to the north. The small *terpen*, which were excavated by the Biologisch-Archaeologisch Instituut (B.A.I.) under the supervision of Van Es (1970), date from 200 B.C.-250 A.D. The small graveyard was an Early Medieval one.

The habitation of the small Paddepoel *terpen* occurred partly in transgression phases. From time to time clay was deposited by floods. These, however, were not sufficiently serious to permanently dislodge the inhabitants. It was only the post-Roman transgression of about 250 A.D. (Dunkirk II) that terminated this habitation (Roeleveld, 1974). The little graveyard was established in the sixth century A.D. The area was obviously inhabited again by that time. The botanical remains from the excavation (Van Zeist, 1974) show that the *terpen* were situated in an area with salt marsh vegetation (*Juncetum gerardii* association), quite a distance from the sea, in the neighbourhood of the little rivers Aa and Hunze. The environment must have been slightly brackish, with fresh water rapidly counterbalancing any marine influences.

The three clusters of small *terpen* were called Paddepoel I, II and III, respectively. The two *terpen* of Paddepoel I were situated on a bend in the former course of the river Aa (fig. 1). There had been three or four phases of habitation, starting with a *Flachsiedlung* (settlement directly upon the old landsurface). The two *terpen* of Paddepoel II were situated c. 700 m to the north-west of Paddepoel I. The three residential nuclei of Paddepoel II had all been raised three times. In the most north-easterly nucleus, a three-aisled house was found which had been rebuilt several times. Small granaries were also discovered in Paddepoel II. The site Paddepoel III was situated a little to the north of Paddepoel II. It consisted of three *terpen.* The greater part of its most easterly section of the site has been excavated. It was possible to distinguish three phases in a continuous habitation. The first two phases were *Flachsiedlungen.* The house in the south-eastern corner and its successors occupied the same position in the last two phases. A second house was built alongside it during the final phase. The incomplete floor-plans show three-aisled houses and possible granaries here, too. The small Early Medieval graveyard, named Paddepoel IV, produced few bones, although there was a farm there later in the Middle Ages.

The excavations were carried out with a machine which removed successive layers of 20 cm, after which each level was shaved and measured. Bones were collected during this process. Settlement traces were dug out to a depth of 20 cm each time with bones and other finds being collected.

* Tables 31-40 have been reproduced as microfiches (1:D5-G13;2;3) in an envelope attached to the rear cover of this volume.

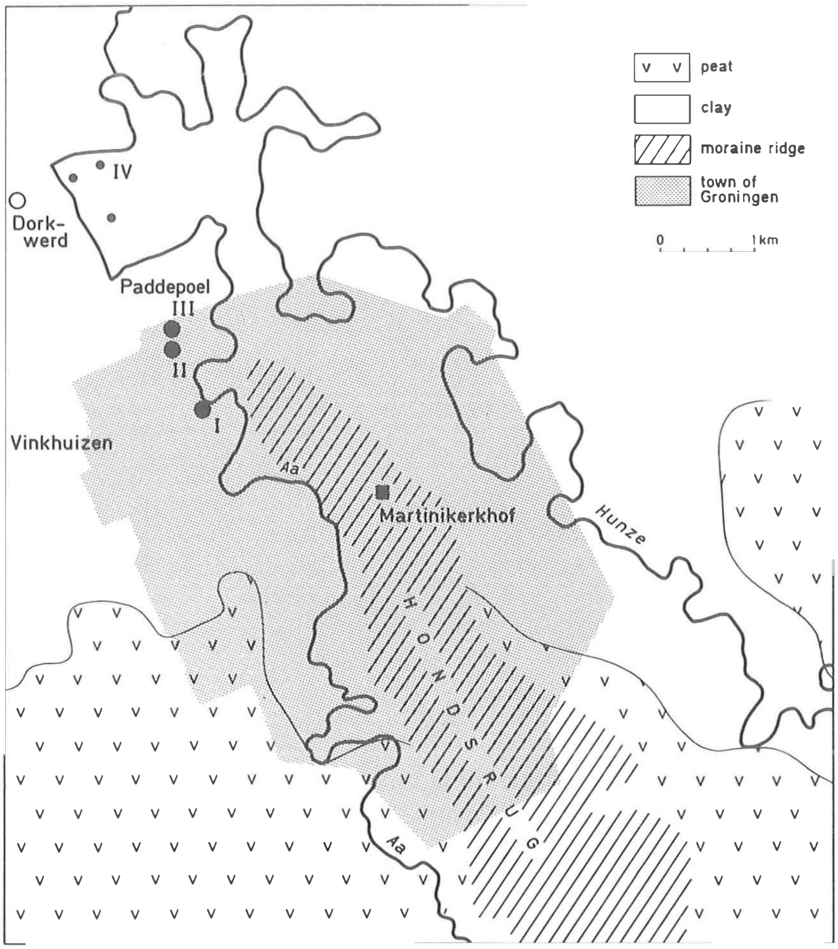

Fig. 1. The location of the four find sites Paddepoel I, II, III and IV in relation to the rivers Hunze and Aa at the period of their habitation. Drawing after Van Zeist (1974: fig. 2).

3. MATERIAL AND METHODS

During the excavation the bone fragments that were visible to the naked eye were collected. Due to this method small bones and bone fragments may have been overlooked.

In a number of excavations, sieving yielded additional information, particularly concerning small mammals, birds and fish (Clason *et al.*, 1978; 1979; Prummel, 1980; 1983). It is, therefore, to be regretted that no sieving was carried out in Paddepoel. During the 1983 excavation campaign of the Heveskesklooster *terp* in north-east Groningen, I assisted in the collecting of the faunal material. In the course of this work samples of several archaeological features were processed by sieving. The results for the oldest inhabited level (tentatively dated c. 50 B.C.-c. 300 A.D.) were slight, so that it remains questionable whether sieving would have produced much useful additional information in Paddepoel.

The bones were cleaned and given find numbers which were prefixed by an indication of the find-site (PP I, PP II, *etc.*). The find numbers are shown on the plans of Van Es (1970). There was a total of 2308 bone fragments including 65 which had lost their numbers. Any bone fragments which could be combined were glued together. The bones are in the collection of the Archaeozoological department of the Biologisch-Archaeologisch Instituut.

The bone fragments were measured with callipers accurate to 0.1 mm. Circumferences were measured with a piece of string and the values then read off from a mm scale. The measurements were taken in accordance with Von den Driesch (1976). The bones were weighed on a letter-scale.

The identifications, measurements, weights, ages, find numbers and other particulars were recorded on a 'floppy disc' in the 'Knocod' code as proposed by Uerpmann (1978) with some modifications customary at the B.A.I., and then

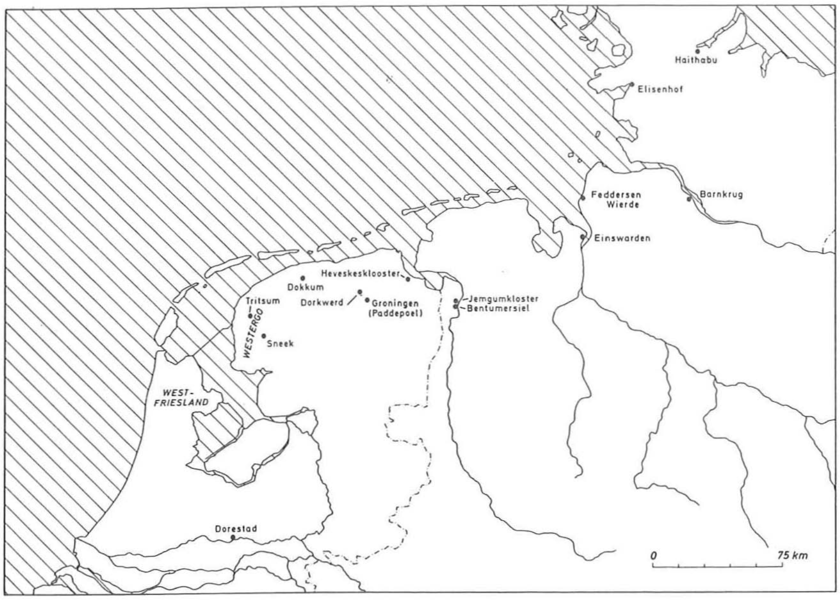

Fig. 2. The coastal area of the Netherlands and West Germany, showing the excavations to which reference is made in the text. Drawing J.M. Smit.

processed at the Computer Centre of the State University of Groningen. The information was processed by means of three programs, one for numbers, one for measurements and one for ages (Prummel, 1980; 1983). For the dog skulls, measurements different from the Knocod ones were taken. These measurements, like those of the small number of domestic fowl remains, were processed by hand. All measurements are given in tables 31-40.

The material from the four find-sites was considered separately and collectively and there proved to be no conspicuous differences between Paddepoel I, II and III. Since they were close together in time and space, these three complexes will be described collectively. Paddepoel IV must be excluded on these grounds. Nothing further was done with the unnumbered bones. The particulars noted for the bones studied were worked out by hand in the absence of a program for processing them. The 43 bones which had been conserved by a plastic strengthening material, Archeo-derm, Filoform B.V., were omitted, because the effect of this material on the weight is not known. Of these bones 35 were from Paddepoel III. Bone tools were first counted as bone fragments and subsequently discussed in chapter 9. For comparison of the Paddepoel data with those of other excavations (fig. 2), statistical tests of Siegel (1956) and Blalock (1960) were used.

4. THE DOMESTICATED MAMMALS

4.1. Cattle (*Bos taurus* Linnaeus, 1758)

4.1.1. *Numerical data*

The Paddepoel I, II and III excavations yielded 676, 404 and 516 fragments of cattle bones, respectively. In addition, there were 37 bone fragments from Paddepoel IV and 51, including 14 teeth, without a number. Table 1 shows the distribution of the numbers and weights over the various skeletal elements for Paddepoel I, II and III, combined. It is obvious from these numbers that the skeletal elements are not present in the same proportions as in a complete skeleton. These differences may be the result of the method of excavation, the degree of fragmentation and the state of preservation of the bones, and/or of human and animal activity.

A comparison with the Feddersen Wierde results is difficult because Reichstein (1973a) used the minimum numbers of individuals method which is less suitable for quantification of the material (Clason, 1972; Prummel, 1980; 1983). Nevertheless, Reichstein's results broadly agree with those for Paddepoel.

The measurements for the bone fragments are shown in tables 31, 39 and 40.

Table 1. The distribution over the skeletal elements of the bone fragments of cattle of Paddepoel I, II and III, combined. The numbers and number percentages, weights (g) and weight percentages, and average weights (g) are given. The weights of the preserved bones are omitted.

	Number	Percentage	Weight	Weight percentage	Average weight
Horn core or antler	17	1.065	826	1.078	48.6
Skull with horn core or antler	25	1.566	2095	2.734	83.8
Part of skull	92	5.765	3635	4.744	39.5
Loose maxillary tooth	60	3.759	1391	1.815	23.2
Fragment of mandible	175	10.965	10390	13.558	59.4
Loose mandibular tooth	38	2.381	636	.830	16.7
Maxillary or mandibular tooth	12	.752	46	.060	3.8
Hyoid	3	.188	16	.021	5.3
Scapula	120	7.519	10581	13.807	88.2
Humerus	69	4.323	5354	6.986	77.6
Radius	62	3.885	2395	3.125	38.6
Ulna	19	1.190	507	.662	26.7
Radius and ulna	14	.877	1827	2.384	130.5
Carpus	4	.251	35	.046	8.8
Metacarpus 3 + 4	100	6.266	6706	8.750	67.1
Pelvis	66	4.136	3655	4.769	55.4
Femur	67	4.198	2941	3.838	43.9
Patella	4	.251	73	.095	18.3
Tibia (tibiotarsus)	84	5.263	5531	7.217	65.8
Astragalus	33	2.068	1140	1.488	34.5
Calcaneus	24	1.504	834	1.088	34.8
Tarsus (remaining)	8	.501	180	.235	22.5
Metatarsus 3 + 4	104	6.516	7323	9.555	70.4
Tarsometatarsus	1	.063	7	.009	7.0
Metapodial of main axis	5	.313	55	.072	11.0
Phalanx 1, anterior/posterior	27	1.692	435	.568	16.1
Phalanx 2, anterior/posterior	10	.627	101	.132	10.1
Phalanx 3, anterior/posterior	8	.501	78	.102	9.8
Fragment of long bone	4	.251	53	.069	13.3
Atlas	8	.501	420	.548	52.5
Axis	6	.376	150	.196	25.0
Cervical vertebra	19	1.190	368	.480	19.4
Thoracic vertebra	33	2.068	936	1.221	28.4
Lumbar vertebra	26	1.629	917	1.197	35.3
Sacrum	14	.877	536	.699	38.3
Caudal vertebra	2	.125	26	.034	13.0
Indeterminate vertebra	2	.125	36	.047	18.0
Rib	231	14.474	4402	5.744	19.1
Total	1596		76637		48.0

Table 2. The heights of the withers for cattle calculated with the coefficients suggested by Von den Driesch *et al.* (1974, partly after Matolcsi) for Paddepoel I, II and III. For the metapodia, the average for cow and bull was taken since the sex ratio is unknown.

Type of bone	Coefficient	Number	Average height of the withers (cm)	Minimum height of the withers (cm)	Maximum height of the withers (cm)	Standard deviation (cm)
Humerus	4.14	1	105.4			
Radius	4.30	1	103.8			
Metacarpus	6.15	21	107.1	96.7	115.6	4.76
Femur	3.23	1	96.9			
Tibia	3.45	1	106.4			
Metatarsus	5.45	13	108.5	100.4	114.3	4.27

4.1.2. *Size and shape of the cattle*

It is accepted that the length and width of the long bones bear a linear correlation to the height and width of the whole animal. Consequently, attention will be paid here to the following three aspects: 1. the length of the long bones and, related to this, the height of the withers; 2. the width of these bones; and 3. the ratio between these two, i.e. the allometry of these bones.

From the length of the long bones and from the length of the metapodia estimates of the height of the withers can be made by means of multiplication factors. The most useful factors were proposed by Von den Driesch et al. (1974, partly after Maltolcsi). With the metapodia, no difference was made between bulls, oxen or cows, since nothing definite could be said about the distribution of the sexes in Paddepoel (4.1.5.). The results (table 2) are for Paddepoel I, II and III combined. In Paddepoel IV it was not possible to take any length measurements of long bones.

Table 2 shows that the heights of the withers which were calculated from metapodia, work out higher than those calculated from long bones, although there are far fewer measurements of the long bones in consequence of the high degree of fragmentation. The same was observed by Prummel (1980; 1983), both for Dorestad and in the literature. She came to the conclusion that the coefficients for the long bones which were determined by Maltolcsi (1970, quoted by Von den Driesch *et al.*, 1974) for 11 Hungarian steppe cattle were either unreliable, since based on too few data, or are not applicable to western European cattle.

Consequently, in a comparison between Paddepoel and other excavations, only heights of the withers calculated from metapodia were considered. By means of the *t* test (Blalock, 1960), the Paddepoel heights of the withers were compared

Table 3. Using the *t* test on the heights of the withers calculated from the metacarpalia and metatarsalia of cattle as found in Paddepoel, Tritsum (Clason, unpubl.) and Feddersen Wierde (Reichstein, 1973b). For the last-mentioned, the variance was calculated from the 95 % confidence interval given by Reichstein (1973b). The lengths and standard deviations were multiplied by 6.15 for metacarpalia and by 5.45 for metatarsalia. The resulting heights of the withers were tested with the *t* test (level 0.05).If an F test showed a significant difference between the variances, model 2 of the *t* test was chosen, otherwise model 1 was chosen (Blalock, 1960, pp. 172-6).

Heights of the withers (cm) calculated from metacarpalia

Excavation	n	Variance	Average height of the withers
Paddepoel	21	22.65	107.1
Feddersen Wierde	918	8.13	108.6
Tritsum	14	13.84	109.5

The *t* test on the heights of the withers calculated from the metacarpalia

Comparison	F	Model chosen	*t*	Degrees of freedom	Significant difference
Paddepoel-Feddersen W.	2.785	2	1.405	20	no
Paddepoel-Tritsum	1.636	1	1.544	33	no
Tritsum-Feddersen W.	1.702	1	1.165	930	no

Heights of the withers (cm) calculated from metatarsalia

Excavation	n	Variance	Average height of the withers
Paddepoel	13	18.19	108.5
Feddersen Wierde	590	22.31	109.7
Tritsum	10	62.88	109.9

The *t* test on the heights of the withers calculated from the metatarsalia

Comparison	F	Model chosen	*t*	Degrees of freedom	Significant difference
Paddepoel-Feddersen W.	1.226	1	0.906	601	no
Paddepoel-Tritsum	3.457	2	0.480	14	no
Tritsum-Feddersen W.	2.818	2	0.075	9	no

with those from Feddersen Wierde (Reichstein, 1973a; 1973b), and Tritsum (table 3). The last-mentioned were calculated from Clason's data (unpublished) for Tritsum III-VI (300 B.C.-100 A.D.). There is no significant difference between Paddepoel and either Tritsum or Feddersen Wierde, nor between Feddersen Wierde and Tritsum. From the results we may tentatively conclude that the cattle in the *terp* region between 300 B.C. and 250 A.D. had an average height of the withers of 107-110 cm. In Sneek (0-300 A.D.) the only measurable metatarsus (Clason, 1962) gave a height of the withers of 114.45 cm. This is within the range of Paddepoel (table 2).

Zawatka & Reichstein (1977) came to the conclusion that the lengths of the metacarpalia and, consequently, the heights of the withers from Bentumersiel, a non-agrarian settlement with a strong representation of Roman import materials in northern Germany, do not differ significantly from those of Feddersen Wierde and Early Medieval Haithabu in Schleswig-Holstein. The average heights of the withers for Early Medieval Dorestad (Prummel, 1983) were, calculated from metacarpus: 116,3 cm (s = 6.041 cm), and from metatarsus: 115.9 cm (s = 4.751 cm). For Late Medieval Dokkum, Van Gelder-Ottway (1979) found an average height of the withers of 122 cm, calculated from metacarpus and/or metatarsus. With the same method of calculation, she found an average height of the withers of 126 cm for 16th/17th century Groningen (Van Gelder-Ottway, 1976/77). Apparently the height of the withers of the cattle increased in the course of time.

The greatest distal width of both metacarpus and metatarsus give indirect information concerning the width of the animal. In the literature on Feddersen Wierde only the greatest distal width of metacarpus could be found. Table 4 is the result of testing Paddepoel, Tritsum and Feddersen Wierde with the *t* test. The distal width of the Feddersen Wierde metacarpus does not differ significantly from the Paddepoel value. That of Tritsum differs from those of both Paddepoel and Feddersen Wierde. The distal width of the Paddepoel metatarsus differs from that of Tritsum. Tritsum, therefore, does not conform. This may have been caused by a difference in measuring methods. There are two shapes of metapodia. One

Table 4. Results of the *t* test of the greatest distal width of the metacarpalia of cattle as found in Paddepoel, Tritsum (Clason, unpubl.) and Feddersen Wierde (Zawatka & Reichstein, 1977), and of the *t* test of the greatest width of the metatarsalia of cattle as found in Paddepoel and Tritsum. For the *t* test (level 0.05) used, see table 3.

Greatest distal width metacarpalia (mm)

Excavation	n	Variance	Average distal width
Paddepoel	31	15.28	52.2
Feddersen Wierde	115	2.67	51.2
Tritsum	22	10.32	49.1

The *t* test on the greatest distal width metacarpalia

Comparison	F	Model chosen	*t*	Degrees of freedom	Significant difference
Paddepoel-Feddersen W.	5.72	2	1.370	16	no
Paddepoel-Tritsum	1.48	1	3.001	51	yes
Tritsum-Feddersen W.	3.865	2	2.928	10	yes

Greatest distal width metatarsalia (mm)

Excavation	n	Variance	Average distal width
Paddepoel	27	13.02	46.2
Tritsum	22	16.69	48.6

The *t* test on the greatest distal width metatarsalia

Comparison	F	Model chosen	*t*	Degrees of freedom	Significant difference
Paddepoel-Tritsum	1.281	1	2.137	47	yes

has its greatest width distally on the suture at the level of the epiphyses. The other has its greatest width distally at the condyle. In the present study, measurements were taken after Von den Driesch (1976) so that the greatest width was always measured. Duerst (1926) gave both possibilities as two separate measurements. Clason (pers. comm.) always took the measurement at the suture of the epiphyses. Reichstein's measuring method at Feddersen Wierde is unknown. At Paddepoel no quantitative record of the two shapes was made, but I have the impression that the shape with the greatest width at the condyle was predominant. It is doubtful, however, whether there were considerable differences in measuring methods. With large numbers they might well average out. With small numbers, a difference in the sex ratio can produce a large difference in the average distal width.

For Dorestad, Prummel (1983: table 65) calculated an allometrical equation by means of which, independent of length, the metacarpus widths from different find-sites could be compared. For the group of cow, ox and bull, combined, this equations as follows: $y_c = 0.00087 \cdot x^{2.12}$ with: y_c = calculated width in mm; x = the greatest length in mm.

This equation enables us to compare the *terp* cattle with the Early Medieval Dorestad cattle. If the calculated width (y_c) differs from the observed width (y_0), the difference is length independent. The results for Paddepoel and three other contemporaneous coastal settlements are shown in table 5.

It appears from the table that the cattle in the *terp* region were, independent of length, wider than the cattle in Dorestad, as Prummel (1980) had already proved for Feddersen Wierde. As long as no other allometrical equations have been worked out, it remains uncertain whether the differences found between y_c and y_0 are mutually comparable. Consequently, the allometry of Paddepoel cannot be compared with that of Feddersen Wierde on the basis of the formula used here. The establishment of an allometrical equation necessitates large numbers of bones of which both the length and the width are available.

Table 5. The average greatest length, using Prummel's (1980; 1983) allometrical equation for Dorestad the width calculated from it (y_c), the observed width (y_o) and the difference between y_c and y_o for Cattle of Paddepoel, Feddersen Wierde (Reichstein 1973b), Tritsum (Clason, unpubl.) and Bentumersiel (Zawatka *et al.*, 1977). If the difference between y_c and y_o is zero, the animals are of the same relative size as those of Dorestad. All sizes given in mm.

Excavation	Average length	n	y_c	y_o	n	y_o-y_c
Paddepoel	174.2	21	48.98	52.16	31	3.18
Feddersen Wierde	174.2	115	49.04	51.20	115	2.16
Tritsum	178.0	14	51.34	49.07	22	2.27
Bentumersiel	177.2	29	50.85	53.60	51	2.75

Zawatka *et al.* (1977) found that the cattle in Bentumersiel and Feddersen Wierde were thickset compared with those from Haithabu. Those from Bentumersiel were even more thickset than those from Feddersen Wierde. No allometrical comparison between Paddepoel and the much later bone fragments from Dokkum and Groningen (Van Gelder-Ottway, 1976/77; 1979) was carried out in view of the extremely small numbers of metapodia found during those excavations.

The cattle from Paddepoel, Feddersen Wierde and Tritsum were fairly similar in size. Whether these animals were of the same size as those brought by the earliest inhabitants from the sandy soils of Drenthe (c. 500 B.C.) remain doubtful. Examination of material from the earliest settlers of the *terpen* area from Middelstum (550-200 B.C.) and early Tritsum (from 500 B.C.) will be necessary to answer that question.

4.1.3. *Age distribution and age at slaughter*

There are two methods for determining the age at which an animal died. The first is based on an estimate of the age at which the epiphyses sutures fuse; the second is based on the state of the teeth.

By means of the ages program, the degree to which the epiphyses sutures were fused in the various skeletal elements was determined. The age at which the epiphyses sutures fuse was taken from the table of epiphyses fusing (Clason, 1980, after Reichstein). Due to the small numbers, the method of Chaplin (1971) and Prummel (1980; 1983) of working with categories was followed. Table 6 shows the numbers and percentages of the unfused epiphyses sutures and, consequently, of the animals that died before the age of fusion. It is likely that small foetal bones and small, attractive, intact bones such as phalanges and calcani obscure the picture to some extent; the former because they are perhaps more easily overlooked, the latter

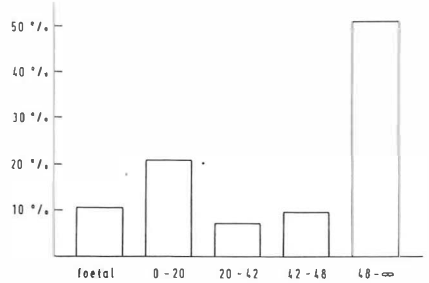

Fig. 3. The percentages of cattle killed between the ages indicated; ages expressed in months and determined on the basis of the fusion of the epiphyses (table 6). Drawing J.M. Smit.

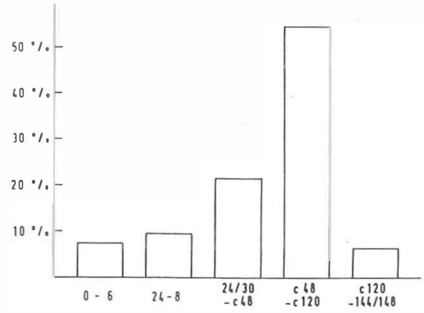

Fig. 4. The percentages of cattle killed between the ages indicated; ages expressed in months and determined on the basis of the condition of the teeth (table 7). No information was available for the period of 6-24 months. Drawing J.M. Smit.

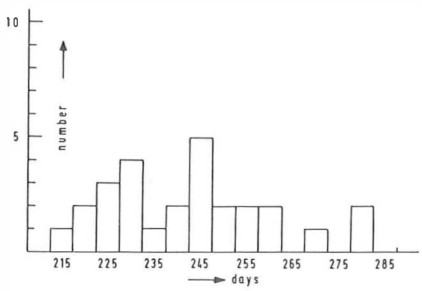

Fig. 6. The distribution of the numbers of foetal bone fragments of cattle (all specimens combined) over the ages in days after conception (table 8). Drawing J.M. Smit.

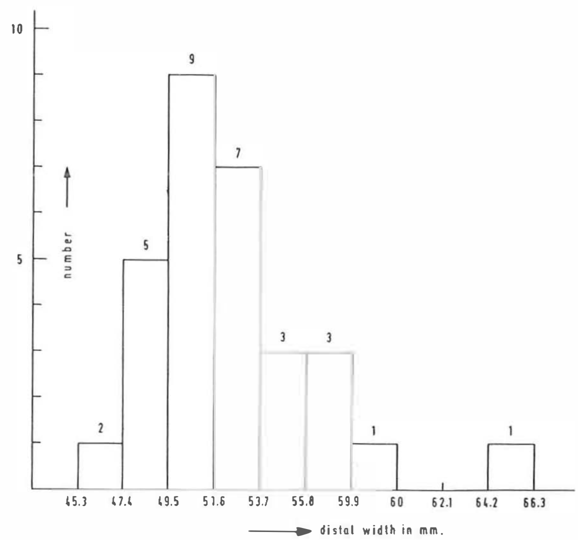

Fig. 7. The distribution of the greatest distal width (in mm) of metacarpus of cattle in Paddepoel I, II and III combined (n = 31). Drawing J.M. Smit.

Table 6. Percentages of fused and unfused epiphyses of the long bones of cattle in Paddepoel I, II and III, indicating the percentages of cattle that died before and in between the age categories mentioned. In brackets the percentages without calcaneum; see text.

Age in months and type of bone	Unfused epiphyses died before the age indicated n	%	Fused epiphyses died after the age mentioned n	%	% died in between indicated and previous ages
Foetal					
Metacarpus p	11		50		
Metatarsus p	2		57		
Total	13	10.8	107	89.2	10.8
12-20					
Humerus d	11		26		
Radius p	16		27		
Phalanx 2 p	1		7		
Total	28	31.8	60	68.2	21.0
20-24					
Phalanx 1 p	1	4.2	23	95.8	–
24-30					
Tibia d	8		20		
Metacarpus d	9		41		
Metatarsus d	20		33		
Total	37	28.2	94	71.8	–
36-42					
Calcaneum	0		14		
Femur	9	(39.1)	14	(60.9)	(7.3)
Total	9	33.3	28	66.6	–
42-48					
Ulna p	2		5		
Humerus p	14		9		
Radius d	14		5		
Femur d	6		11		
Tibia p	8		16		
Total	44	48.9	46	51.1	9.8
After 48 months		100.0		0.0	51.1

because they are conspicuous. With the small number of data this circumstance affects table 6 so materially that a number of intervals had to be omitted in figure 3. The figure shows the percentages of animals, based on table 6, which died in between the categories. Apparently, after a peak in the slaughter durve during the first 18 months, most of the animals were slaughtered after their fourth year. In the first four years 48.9 % were died. This figure should be corrected for the inclusion of foetal bones (see 4.1.4.). Foeti, of course, will have been stillborn, not slaughtered. The foetal death-rate was approximately 10.8 %, so that 48.9-10.8 % = 38.1 % were slaughtered in the first four years.

Table 7. The condition of the teeth of cattle (numbers and percentages) observed in Paddepoel I, II and III, with the ages after Habermehl (1975). There are no criteria for 6-24 months and consequently nothing can be said about this period.

Age	Description of teeth	Number	%
Younger than 5-6 months	1st molar absent	4	
5-6 months	1st molar erupting	3	
	1st molar in place but not in wear	3	
Total first 6 months		10	7.5
24-28 months	3rd molar erupting	4	
	premolar erupting	5	
	3rd molar in place but not in wear	4	
Total		13	9.7
2/2½-c. 4 years	3rd molar slightly worn	20	
	premolar slightly worn	3	
	unknown (pre)molar slightly worn	6	
Total		29	21.6
c. 4-10 years	3rd molar moderately worn	47	
	premolar moderately worn	2	
	2nd molar moderately worn	1	
	unknown (pre)molar moderately worn	23	
Total		73	54.5
c. 10-12/14 years	3rd molar heavily worn	7	
	unknown (pre)molar heavily worn	2	
Total		9	6.7

A second age indicator is the state of the teeth. The replacement and eruption of teeth and the degree of wear are evidence of the age. This information was always determined by means of that tooth which most accurately indicated the age. For example, if the first and third molars were present, it was the latter that was described. In addition, the degree of wear was determined for any detached third molars from lower and upper jaws and for other (pre)molars which were not further identifiable. The wear was graded 'slight', 'moderate' and 'heavy' (after Uerpmann, 1978). This description was incorporated into the Knocod code. The information on the age and the eruption and wear of teeth was derived from Habermehl (1975). It appears that 38.8 % were killed after four years (table 7; fig. 4). Since few foetal jaw fragments were found, no corrections for foeti were necessary. It appears that only 6.7 % were killed after the age of 10 years. Most of the animals were apparently killed between their fourth and tenth year.

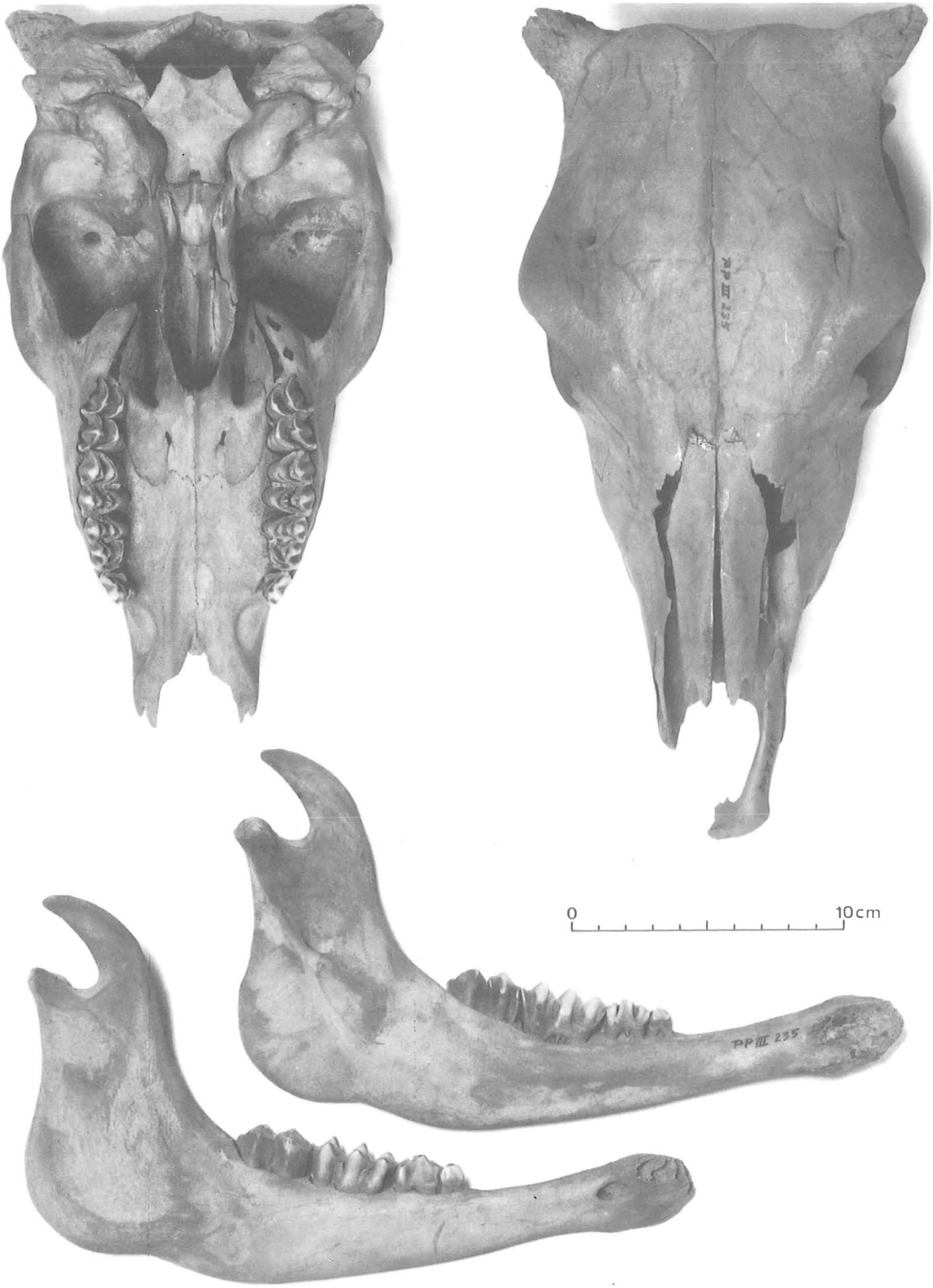

Fig. 5. The skull of a calf found in Paddepoel III. View from above and below. In the left-hand photo the left-hand nasale is missing. N.B. All the sutures are still unfused. Below the lower jaw belonging to this calf. The suture is not yet fused.

On the basis of fusion of the epiphyses sutures it was determined that 38.1 % were killed after four years. On the basis of the state of teeth 38.8 % were killed after four years.

To recapitulate, it may be said that, after a peak in the slaughter curve during the first 18 months, no new extensive slaughtering took place until after the fourth year. Most of the cattle had been slaughtered before their tenth year. This agrees to a certain extent with Reichstein's (1972) results for Feddersen Wierde: after a slaughter peak of 17 % for calves (up to six months), most of the slaughter (61.3 %) took place after three years. For Dorestad, Prummel (1983) found a death-rate approaching the 60 % mark after three and a half to four years. She found no peak in the death-rate of calves. Reichstein (1972) suggested that more calves were slaughtered in production areas, such as Feddersen Wierde, than in consumption areas, such as trading settlements. Prummel (1983) pointed out that later Reichstein apparently subscribed to a different opinion concerning Haithabu, ascribing a high calf slaughter to a high level of prosperity which would permit the eating of veal (Reichstein *et dl.*, 1974). It is possible that a peak in the calf death-rate is not always recognised because of differences in the degree of preservation. Perhaps the small, brittle calf bones decompose more rapidly, which might be the explanation of their absence in Dorestad. The calves in Paddepoel probably died natural deaths. No traces of chopping or cutting were found on the bones. I do not know if there were such traces on the calf bones in Feddersen Wierde or in Haithabu. In Sneek (0-300 A.D.) a conspicuous number of calf bones were found too (Clason, 1962).

4.1.4. *Foetal and calf remains*

The Paddepoel excavation yielded a fair number of remains of foeti and calves, *viz.* a total of 136 foetal bones and 61 bones of young calves. These amounted to 8 and 3.6 %, respectively, of the total number of cattle bone fragments found. One reason for the number of foetal bone fragments being so large is that in Paddepoel III a fairly intact skeleton of one particular foetus was found (23 bone fragments, find number PP III 268; vertebrae and skull were missing). Figure 5 shows a calf skull and a lower jaw. Although this animal did survive for a short time, the bone sutures had not yet fused and the horn cores had not yet developed.

Habermehl (1975) produced a table in which the greatest length between the epiphyses of long bones was correlated with the age of the foetus, expressed as the length of the pregnancy in days. The table was based on Regli's work on Swiss cattle (Simmentaler and Freiburger cattle breeds) and Bünger's work on black German cattle. Their results agreed up to the age of 230 days, after which the black German cattle remained somewhat smaller. Recent cattle have a greater height of the withers than the value found at Paddepoel, and it is, therefore, doubtful to what extent this

Table 8. The greatest length between the epiphyses of long bones of foetal bones from cattle (Paddepoel I, II and III). Also given the age of the foetus expressed as the length of the pregnancy in days (after Habermehl, 1975).

Type of bone	Length (mm)	Age in days after conception	Find number
Humerus	89.6	225	I - 104
	98.0	235	I - 59
	91.4	225	I - 115
	107.5	245	III - 288
	108.6	250	III - 268
	99.3	225	I - 43
	109.9	250	II - 172
	105.4	250	II - 150
Radius	99.8	240	III - 129
	104.4	240	III - 143
	107.4	245	I - 114
	108.7	250	III - 268
	109.0	250	II - 182
	121.8	270	I - 57
Ulna	135.3	250	III - 268
Metacarpus	109.0	230	III - 137
	110.0	230	II - 175
	125.5	245	II - 125
	97.7	215	III - 253
	107.3	240	III - 268
Femur	129.3	255	I - 114
	129.4	255	I - 93
	132.4	260	III - 197
	137.7	265	III - 268
Tibia	131.4	245	II - 161
	131.7	245	III - 311
	140.1	250	III - 268
	143.0	260	II - 164
	159.9	280	I - 97
	131.1	245	I - 29
Metatarsus	121.6	240	III - 268
	115.0	230	II - 191
	114.7	230	I - 88
	106.5	220	I - 87
	108.7	220	II - 261
	122.4	240	III - 268

table is valid for Paddepoel. It was used, however, in the determination of the age of the measurable bones (table 8). The nine measurable bones of the Paddepoel III 268 foetus produced an age of 247.49 days (standard deviation 7.49 days). Figure 6 shows graphically the results for all the bone fragments combined. If Habermehl's table is fully valid for the *terp* cattle, the foeti were in the 7th, 8th or 9th month. It is doubtful whether any significance should be attached to the two peaks in the graph; it is possible that the foetal death-rate was somewhat higher in certain months but the small numbers may have been responsible for this result, too. If we assume that the height of the withers of the Paddepoel foeti, like that of the adult animals, was less than that of modern cattle, this means that the foeti died shortly before or after birth.

4.1.5. *The sexes*

Several authors (including Prummel, 1980; 1983) determined the ratio of the sexes by means of the distal width of the metacarpus. Bulls have wider metacarpi than cows. If both are represented in the find complex, a distribution graph of the width should show two peaks. Figure 7 vaguely suggests two peaks but the numbers are too small to justify conclusions about the sex ratio.

4.1.6. *About the horns*

There are no indications of hornless cattle in Paddepoel, though they were found elsewhere in the *terp* region (Broekema, 1908; Clason, 1962; 1970a).

A horn was found in Paddepoel III (find number PP III 221; fig. 8). This was rather unusual. The possibility of the horn's being a later intrusion would appear to be slight (Van Es, 1970: plan XVII; find book).

4.1.7. *Colouring*

No hairs were collected in Paddepoel. We have scarcely any information about the colouring of *terp* cattle. Van Giffen (1913a) reported a red-haired calf from the *terp* of Eenumer Hoogte.

4.1.8. *Pathologies*

The only evidence of pathologies was found in one rib fragment which had been fractured and had healed again.

4.1.9. *Slaughtering methods*

It is possible to say something about the method of slaughtering cattle and the preparation of beef by studying any traces of cutting and of dog bites. Quantification of such matters would perhaps require greater numbers than the Paddepoel ones (table 9). If the position (e.g. distal or proximal) is also taken into consideration, the numbers are even smaller. Nevertheless, something can be said, based also on the fragmentation of the bones. There were, on the whole, few traces of gnawing.

Firstly, it is notable that the ribs were rarely intact (generally it was a quarter or a half rib that was found) and that there was a high percentage of cutting marks. Scarcely any gnawing marks were found, so that the ribs were obviously not of any interest to dogs. Chunks of meat were perhaps cooked with the bone and the ribs picked clean. With lumbar vertebrae it was noticeable that the *processus transversi* had been struck off (fig. 9). In this way, the meat was divided into

Table 9. The occurrence of cutting and gnawing marks on bone fragments of cattle, in Paddepoel I, II and III and the unnumbered bone fragments

Name of skeletal element	Total number	With cutting marks		With bites	
		n	%	n	%
Skull	120	12	10.0	0	0.0
Mandible	69	18	26.1	5	7.2
Scapula	126	7	5.6	3	2.4
Humerus	72	4	5.6	8	11.1
Metacarpus	102	13	12.7	17	16.7
Pelvis	67	4	6.0	0	0.0
Femur	69	2	2.9	1	1.5
Tibia	86	11	12.8	4	4.7
Metatarsus	109	16	14.7	8	7.3
Phalanx 1	27	3	11.1	1	3.7
Atlas	8	3	37.5	0	0.0
Axis	6	0	0.0	0	0.0
Cervical vertebra	19	4	21.0	0	0.0
Thoracic vertebra	33	12	36.4	0	0.0
Lumbar vertebra	27	12	44.4	0	0.0
Sacrum	14	4	28.6	0	0.0
Caudal vertebra	2	0	0.0	0	0.0
Rib	232	29	12.5	1	0.4

two pieces, with the spinal column being detached to be dealt with separately. There were many traces of cutting on the vertebrae, but no traces of gnawing. Long bones which were rich in marrow were generally smashed to pieces. The small number of these with cutting marks possibly resulted from the high degree of fragmentation making these marks on the edges less conspicuous. In view of the gnawing marks, these bones were certainly of interest to dogs, the humerus having apparently been a particular favourite.

Complete skulls of adult cattle were not found; except for one half skull, they turned up in fragments. These fragments can be divided into two groups; with and without horn cores. The detached horn cores will have been a by-product of the processing of the skin and the horns after slaughter. The other fragments will have resulted from the removal of the brains. No dog bites were found on skull fragments. Complete lower jaws were more numerous, but, even so, often broken. The vertical ramus was struck off the horizontal ramus. Many cutting traces and a fair number of dog bites were found on them.

The metapodia cannot have been of much culinary use to man. The cutting marks on them must have been a sign of the great economic value of cow hides, even the pieces around the legs being used. Moreover, the strong and conveniently sized metapodia were often used for all sorts of purposes (see chapter 9). The metapodia which were thrown away by human beings were eagerly picked clean by dogs. This also applies to phalanx 1. No marks were found on phalanxes 2 and 3, but not many of these bones were found.

Nine bone fragments displayed traces of burning or were even completely calcined. They had apparently been hanging over a fire and had subsequently fallen into it. It is not impossible that the small burnt pieces were occasionally overlooked by the excavators.

4.2. Horse (*Equus caballus*, Linnaeus, 1758)

4.2.1. *Numerical data*

Although many horse remains occur in the *terpen*, our knowledge concerning this species is not yet extensive. Many bones are highly fragmented because the horse was used for human consumption. Paddepoel I, II, III and IV yielded 108, 46,

Table 10. The distribution over the skeletal elements of the bone fragments of horse of Paddepoel I, II and III, combined. The numbers and number percentages, weights (g) and weight percentages, and average weights (g) are given. The weigh't of preserved bones are omitted.

	N	%	Weight	Weight %	Average weight
Part of skull	6	2.520	219	1.531	38.0
Loose maxillary tooth	26	10.924	981	6.856	37.7
Fragment of mandible	13	5.463	1405	9.819	108.1
Loose mandibular tooth	18	7.563	475	3.320	26.4
Maxillary or mandibular tooth	3	1.261	27	.189	9.0
Scapula	10	4.202	940	6.570	94.0
Radius	6	2.521	745	5.207	124.2
Ulna	3	1.261	124	.867	41.3
Radius & ulna	2	.840	47	.328	23.5
Carpus	1	.420	6	.042	6.0
Metacarpus 3+4	12	5.042	600	4.193	50.0
Pelvis	20	8.404	1966	13.741	98.3
Femur	10	4.202	916	6.402	91.6
Tibia (tibiotarsus)	14	5.882	1539	10.756	109.9
Astragalus	1	.420	75	.524	75.0
Calcaneus	2	.840	61	.426	30.5
Tarsus (remaining)	2	.840	18	.126	9.0
Metatarsus 3+4	21	8.823	2043	14.279	192.5
Other metatarsus	1	.420	2	.014	2.0
Phalanx 1, anterior/ posterior	7	2.941	334	2.334	47.7
Phalanx 2, anterior/ posterior	10	4.202	219	1.531	21.9
Phalanx 3, anterior/ posterior	6	2.521	186	1.300	31.0
Atlas	5	2.101	405	2.831	81.0
Axis	4	1.681	362	2.530	90.5
Cervical vertebra	3	1.261	116	.811	38.7
Thoracic vertebra	1	.420	15	.105	15.0
Lumbar vertebra	5	2.101	96	.671	19.2
Sacrum	1	.420	27	.189	27.0
Rib	25	10.504	359	2.509	14.4
Total	238		14308		60.1

48 and 3 bone fragments, respectively. One scapula fragment was unnumbered.

Table 10 shows the distribution of the numbers and weights of the various skeletal elements for Paddepoel I, II and III, combined. It can be seen that a remarkable number of detached teeth were found. Perhaps this is because teeth are more readily picked up than other pieces of bone of equal size.

The measurements for the bone fragments are shown in tables 32, 39 and 40.

4.2.2. *Size*

Von den Driesch *et al.* (1974) gave two methods for the determination of the height of the withers of the horse: Kiesewalter's method with coefficients determined by the greatest lateral length of the long bones, and Vitt's method with size categories determined by the greatest length of a number of skeletal elements. The latter, the most commonly used method, was applied for the present study, too.

In Paddepoel the length of two metacarpi and five metatarsi were measurable. Table 11 gives the heights of the withers after Vitt. Most of the animals belonged to Vitt's 'small' (*kleine*) category of horses, with a height of the withers of 120-128 cm. No measurements of horse bones from Feddersen Wierde are known. We have four measurements from Tritsum at our disposal (Clason, pers comm.): two metacarpi (greatest lengths 217.5 and 220.0 mm, respectively) and two metatarsi (greatest lengths 259.5 and 251.5 mm, respectively). On the basis of the metacarpi, these horses belong to Vitt's 'small' category, and on the basis of the metatarsi to his 'slightly built' (*kleinwüchsige*) category. These bones, however, were from rather widely different periods respectively Tritsum II (500-400 B.C.) and Tritsum VII (0-100 A.D.) so that no conclusions can be drawn from this.

Prummel (1979b) tested Labouchère's theory (1927) about the development of the Dutch horse against finds from more recent excavations. Labouchère examined skulls from the *terp* region and found two types. Type B, which occurred before the Migration period, height of the withers (calculated by Prummel, after Vitt) 132.4 cm, and type A, which occurred after the Migration period, height of the withers (calculated by Prummel, after Vitt) 142.6 cm. He also found an intermediate type Labouchère postulated that, during the Migration period, the ancient, small horse was partly supplanted by a larger, imported horse and that the later Dutch breeds of horses descended from the intermediate type. Prummel found that the finds from the post-1927 excavations did not contradict this theory. The Paddepoel horses were even slightly smaller than Labouchère's type B, but do not contradict his theory either. It would perhaps be wiser not to pronounce an opinion on Tritsum.

Prummel (1979b) established an allometrical equation for the metacarpus and metatarsus of horse of the Roman Iron Age:

for metacarpus $y = 0.024\ x^{1.34}$
for metacarpus* $y = 0.0015\ x^{1.77}$
x = the greatest length and y the calculated smallest width of the shaft.

If we compare the calculated and the observed narrowest width of the shaft (table 12) found for

Table 11. The heights of the withers of horse for Paddepoel I, II and III determined by means of Vitt's method (Von den Driesch *et al.*, 1974)

Type of bone	Excavation	Greatest length (mm)	Height of the withers (cm)	Size
Metacarpus	III	197.2	128-120	*kleine*
Metacarpus	III	209.6	136-128	*klein wüchsige*
Metatarsus	I	261.2	144-136	*mittel wüchsige*
Metatarsus	I	244.6	128-120	*kleine*
Metatarsus	III	242.7	128-120	*kleine*
Metatarsus	II	232.0	128-120	*kleine*
Metatarsus	I	215.3	120-112	*sehr kleine*

Table 12. Calculated and observed width of metapodia of horse in Paddepoel I, II and III. The calculated width was calculated from Prummel's formula as mentioned in the text (Prummel, 1979b)

	Calculated width of the shaft	Observed width of the shaft
Metacarpus	28.53 mm	29.3 mm
	30.97 mm	30.5 mm
Metatarsus	24.98 mm	29.1 mm
	23.07 mm	23.2 mm
	25.33 mm	26.8 mm
	28.45 mm	29.9 mm

* In Prummel (1979b) misprinted as $y = 0.015\ x^{1.77}$.

Paddepoel, we see that they are very similar. This means that for Paddepoel the horses were not length-independent thickerset or more slender than Dutch Roman iron age horse, which agrees with Prummel's observations. She concluded that in the Netherlands the horses from Roman Iron Age, both native as well as military Roman sites up to and including the Carolingian period were of the same relative width.

4.2.3. *The distribution and age at slaughter*

The ages at which the horses found had been killed can be determined from the fusion of the epiphyses sutures or from the condition of the teeth.

It was possible to make a total of 84 observations on the epiphyses sutures in 15 different skeletal elements. On the basis of the ages at which the epiphyses sutures in the various skeletal elements fuse (grouped after Prummel, 1983) the percentages of animals killed before and within certain age limits were calculated (table 13). With the reservation that small numbers were involved, it can be said that almost 20 % were killed during the first 15 months. Approximately 64 % survived the first three and a half years. There was, therefore, a fairly high death-rate among foals, after which most of the animals lived longer than three and a half years. This agrees with the results found for cattle.

Again, because of the small numbers, little can be said on the basis of the teeth. Moreover, there is no correlation between Uerpmann's (1978) Knocod code and Habermehl's (1975) study on the age of domesticated animals. Observations can be made on five of the 13 lower jaw fragments:

a. In one jaw the first molar was not present. According to Habermehl, the molar or premolar erupts after about a year.

b. In another jaw the third milk molar was moderately to heavily worn. According to Habermehl the premolars are replaced at the age of about two and a half years.

c. In another jaw the first incisor or canine was in place but not worn. According to Habermehl the canine is replaced at about four years.

d. In another jaw the third molar was moderately worn.

e. In another jaw the third molar was moderately worn.

No age can be concluded from the last two observations. In addition there are 18 teeth, 10 of which were slightly worn and eight moderately worn. In Habermehl's opinion, it is not possible to draw any conclusions from these. He did suggest a correlation between age and the length measurement of a tooth, including the root. This length measurement was not incorporated into the Knocod program. Still, in an attempt to reach some conclusion, some lower jaw teeth were examined. The greatest lengths of these, including the roots, were 58, 70, 80, 80, 80, 80 and 84 mm. If we compare this with Habermehl (1975: p. 47), the age can be estimated to be approximately ten years.

To summarise, it may be tentatively stated that there was a rather high death-rate among foals, after which most of the horses were killed between the ages of three and a half and ten years, the

Table 13. Percentages fused and unfused epiphyses for horse in Paddepoel I, II and III, indicating the percentages of animals which died before and in between the age categories mentioned

Age in months and type of bone	Unfused epiphyses died before the age indicated		Fused epiphyses died after the age indicated		% died in between indicated and previous age
	n	%	n	%	
Foetal					
Metacarpus p	0		9		
Metatarsus p	1		14		
Total	1	4.2	23	95.8	4.2
1st week					
Phalanx 1 d	0		5		
Phalanx 2 d	0		7		
Total	0	0.0	12	100.0	0.0
12-15 months					
Metacarpus d	1		3		
Metatarsus d	1		9		
Phalanx 1 p	1		5		
Phalanx 2 p	2		6		
Total	5	17.9	23	82.1	17.9
15-18 months					
Radius p	1	100.0	0	0.0	–
24 months					
Tibia d	4	80.0	1	20.0	–
42 months					
Radius d	1		4		
Ulna p	0		1		
Femur p	0		2		
Femur d	0		2		
Tibia p	2		2		
Total	3	21.4	11	78.6	13.9
After 42 months		100.0		0.0	64.0

majority probably nearer ten. The age at slaughter indicates that they must have also been used for other purposes than consumption.

4.2.4. *The sexes*

The presence or absence of canines is an indicator of the sex of a horse since mares usually lack a canine. Five of the lower jaw fragments contained, teeth, but only one of these had a canine. Such small numbers do not justify any conclusions.

4.2.5. *Pathologies*

Two of the bones were deformed. The one (fig. 10: right) was a fusion of the astragalus with the calcaneus; the other (fig. 10: left) was a number of tarsal bones fused with the metatarsus. Both were found in Paddepoel III and had, perhaps, belonged to lame animals.

4.2.6. *Slaughtering methods*

As was the case with cattle, we checked with horse how many bone fragments displayed cutting marks or dog bites. The results are shown in table 14. Compared with the cattle, the metapodia showed few cutting marks. In my opinion, no further conclusions are justified because of the small numbers.

Table 14. The occurrence of cutting and gnawing marks on bone fragments of horse in Paddepoel I, II and III

	Total number of	With cutting marks		With dog bites	
		n	%	n	%
Scapula	10	–	–	1	10.0
Radius	6	1	16.6	–	–
Ulna	3	1	33.3	–	–
Metacarpus	12	–	–	2	16.6
Pelvis	20	1	5.0	–	–
Tibia	14	2	14.3	1	7.1
Metatarsus	21	1	4.8	–	–
Calcaneus	2	–	–	1	50.0
Phalanx 1	7	–	–	3	42.9
Phalanx 2	10	1	10.0	–	–
Axis	4	1	25.0	–	–
Atlas	5	1	20.0	–	–
Rib	25	1	4.0	–	–

The high degree of fragmentation indicates consumption. No large skull fragments were found. Reichstein (1973a) also found evidence for the consumption of horse meat in Feddersen Wierde. Labouchère (1927: p. 53) was of the opinion that the horse bones from the *terpen* did not display any marks that would indicate that marrow had been extracted. This is probably a consequence of the fact that he mostly examined skulls in collections and did not study an entire faunal complex. There is a possibility that, in the pre-Christian era, a religious feeling was attached to eating horse meat. At least, in 732, Pope Gregory III, through Bonifatius, forbade the consumption of horse meat (Rau, 1968; Slob, quoted by Prummel, 1980: p. 230).

4.3. Sheep (*Ovis aries*, Linnaeus, 1758)

4.3.1. *Numerical data*

The osteological difference between sheep and goat is very slight. With the aid of the criteria of Boessneck *et al.* (1964) and Boessneck (1969), 25 bone fragments, including eight scapulae and five humeri were ascribed to sheep. Two horn cores could be ascribed to goat. With 204 fragments it was not possible to decide whether they were sheep or goat bones. Paddepoel I, II, III yielded 9, 12 and 3 bone fragments of sheep, 0, 1 and 1 of goat and 116, 37 and 37 of sheep/goat respectively. Table 15 shows the numbers and weights of the sheep, goat and sheep/goat remains for Paddepoel I, II and III, combined. The 11 unnumbered bone fragments and the four fragments of Paddepoel IV were left out of consideration in the calculation of the size and age at slaughter of the sheep. Since only two horn cores of goat were found, it may be assumed that most, if not all, of the sheep/goat bone fragments originated from sheep. Sheep and sheep/goat, therefore, were dealt with together.

The measurements for the bone fragments are shown in table 33, 35, 39 and 40.

4.3.2. *Size of the sheep*

From five sheep and six sheep/goat skeletal elements it was possible to calculate a height of the withers (table 16). Teichert's coefficients were used for this (Von den Driesch *et al.*, 1974). It should

Table 15. Distribution over the skeletal elements of the bone fragments of sheep, goat and sheep/goat of Paddepoel I, II and III, combined. The numbers and number percentages, weights (g) and weight percentages, and average weights (g) are given.

Sheep	N	%	Weight	Weight %	Average weight
Horn core	1	4,167	51	8.947	51.0
Skull with horn core	1	4.167	84	14.737	84.0
Scapula	8	33.333	216	37.895	27.0
Humerus	5	20.833	90	15.789	18.0
Femur	3	12.500	49	8.596	16.3
Calcaneus	2	8.333	7	1.228	3.5
Metatarsus 3+4	2	8.333	54	9.474	27.0
Phalanx 1, ant./post.	1	4.167	2	.351	2.0
Atlas	1	4.167	17	2.982	17.0
Total	24		570		23.8

Goat	No.	Weight	Average weight
Horn core	1	18	18
Skull with horn core	1	146	146
Total	2	164	82

Sheep/goat	N	%	Weight	Weight %	Average weight
Part of skull	4	2.105	24	.904	6.0
Loose maxillary tooth	1	.526	5	.188	5.0
Fragment of mandible	26	13.684	479	18.048	18.4
Loose mandibular tooth	11	5.789	40	1.507	3.6
Hyoid	1	.526	2	.075	2.0
Scapula	9	4.737	79	2.977	8.8
Humerus	8	4.211	128	4.823	16.0
Radius	12	6.316	175	6.594	14.6
Ulna	2	1.053	8	.301	4.0
Metacarpus 3+4	8	4.211	97	3.655	12.1
Pelvis	15	7.885	280	10.550	18.7
Femur	12	6.316	164	6.179	13.7
Tibia (tibiotarsus)	32	16.842	672	25.320	21.0
Astragalus	2	1.053	7	.264	3.5
Metatarsus 3+4	21	11.053	296	11.153	14.1
Metapodial of main axis	2	1.053	31	1.168	15.5
Fragment of long bone	4	2.105	29	1.093	7.3
Atlas	2	1.053	12	.452	6.0
Axis	2	1.053	37	1.394	18.5
Thoracic vertebra	3	1.579	11	.414	3.7
Lumbar vertebra	5	2.632	42	1.583	8.4
Rib	6	3.158	31	1.168	5.2
Sternus	1	.526	4	.151	4.0
Skeletal element unknown	1	.526	1	.038	1.0
Total	190		2654		14.0

Table 16. Heights of the withers calculated with Teichert's coefficients Von den Driesch *et al.*, 1974) for both sheep and sheep/goat. For Paddepoel I, II and III.

Sheep	
Scapula	Coefficient 4.22 Greatest length (height along the spine) 136.7, 147.2 and 149.5 mm Height of the withers 57.69, 62.12 and 63.09 cm Average height of the withers 60.96 cm (standard deviation 2.88 cm), n = 3
Calcaneus	Coefficient 11.40 Greatest length 53.5 mm Height of the withers 60.99 cm
Metatarsus	Coefficient 4.54 Greatest length 138.8 and 172.2 mm Height of the withers 63.02 and 78.18 mm Average height of the withers 70.59 cm (standard deviation 12.87 cm), n = 2
All the bones combined	Average height of the withers 64.18 cm (standard deviation 6.52 cm) n = 5
Sheep/goat	
Radius	Coefficient 4.02 Greatest length 156.5 and 165.9 mm Height of the withers 64.8 cm (standard deviation 2.67 cm), n = 2
Tibia	Coefficient 3.01 Greatest length 210 mm Height of the withers 63.21 cm
Astragalus	Coefficient 22.68 Greatest lateral length 25.5 and 28.1 mm Height of the withers 57.8 and 63.7 cm Average height of the withers 60.8 cm (standard deviation 4.17 cm), n = 2
Metatarsus	Coefficient 4.45 Greatest length 144.5 mm Height of the withers 65.60 cm
All the bones combined	Average height of the withers 63.32 cm (standard deviation 2.81 cm) n = 6
Sheep and sheep/goat together	
All the bones combined	Average height of the withers 63.13 cm (standard deviation 3.55 cm), n = 11

be noted, however, that results from small bones such as astragalus and calcaneus are always slightly less reliable than those from larger bones. Averaging all the heights of the withers together gives an average height of the withers of 63.13 cm (standard deviation 3.55 cm). For Tritsum III-VI Clason (pers. comm.) took 16 length measurements from which a height of the withers could be calculated (table 17). The average height of the withers was 64.18 cm (standard deviation 2.68

Table 17. Heights of the withers calculated with Teichert's coefficients (Von den Driesch *et al.*, 1974) of sheep/goat for Tritsum III-VI (300 B.C.-100 A.D.). The measurements were provided by Clason

Sheep/goat	
Metacarpus	Coefficient 4.89 Greatest length 133.5, 134.5, 134,0, 139.5 and 121.5 mm Height of the withers 65.28, 65.77, 65.53, 68.22 and 59.41 cm Average height of the withers 64.84 cm (standard deviation 5.95 cm) n = 5
Tibia	Coefficient 3.01 Greatest length 212.5 mm Height of the withers 63.96 cm
Calcaneus	Coefficient 11.40 Greatest length 57.0 mm Height of the withers 64.98 mm
Astragalus	Coefficient 22.68 Greatest lateral length 25.5 mm Height of the withers 57.83 cm
Metatarsus	Coefficient 4.54 Greatest length 146.0, 146.0, 139.0, 140.0, 136.0, 146.0, 137.5 and 146.5 mm Height of the withers 66.28, 66.28, 63.11, 63.56, 61.74, 66.28, 62.42 and 66.51 cm Average height of the withers 64.50 cm (standard deviation 1.91 cm) n = 8
All the bones combined	Average height of the withers 64.18 cm (standard deviation 2.68 cm) n = 16

cm). Since an F test showed that the variances do not differ significantly, Paddepoel was tested against Tritsum with the first model of the *t* test (Blalock, 1960: pp. 72-75). The *t* was 0.843, so that there was no significant difference (level 0.05). Broekema (1910) gave some length measurements of metapodia from which the height of the withers can be calculated. For metatarsus, the height of the withers was 63.8 cm (n = 13, s = 2.4585), for metacarpus it was 62.2 cm (n = 8, s = 2.6644). These measurements were not tested since the *terp* and period of origin of these metapodia are unknown. In Sneek two measurements of metatarsus gave a height of the withers of 64.5 and 68.3 cm (Clason, 1962). Both Sneek and Broekema's height of the withers are within the range of Paddepoel (table 16).

It is interesting to compare the results from Paddepoel and Tritsum with those from German research. The height of the withers calculated from all the long bones for the sheep from Early Medieval Elisenhof was 64.9 cm (n = 92), for those from Feddersen Wierde 62.6 cm (n = 328) (Reichstein *et al.*, 1974: p. 39). Since no standard deviation was given, these heights could not be tested against those of Paddepoel or Tritsum. They did give the average lengths, with deviations, of metatarsi and metacarpi. These were used to calculate the height of the withers and standard deviation for Feddersen Wierde and Elisenhof (tables 18a and 19a).

The heights of the withers from Paddepoel and Tritsum have been tested against those calculated from metatarsi and metacarpi from Feddersen Wierde (table 18b) and Elisenhof (table 19b). Paddepoel differs not significantly from Feddersen Wierde. Tritsum differs only significantly from Feddersen Wierde with the heights of the withers calculated from metatarsus. Maybe this was due to the small number of Tritsum. Paddepoel and Tritsum both differ significantly from Elisenhof (table 18b). Reichstein *et al.* (1974) found that the Eisenhof sheep were significantly larger than those from Feddersen Wierde. A possible conclusion would appear to be that the early *terp*

Table 18a. The greatest lengths of metacarpus and metatarsus of sheep in Feddersen Wierde (Reichstein, 1974) and the resulting height of the withers. Heights of the withers calculated with Teichert's coefficients (Von den Driesch *et al.*, 1974)

Metacarpus n = 146	Greatest length 140.2 ± 0.68 mm Resulting calculated standard deviation 4.178 mm Height of the withers 63.65 cm; standard deviation 2.04 cm
Metatarsus n = 144	Greatest length 128.1 ± 0.57 mm Resulting calculated standard deviation 3.490 mm Height of the withers 62.64 cm; standard deviation 1.53 cm

Table 18b. Tests of the heights of the withers of sheep/goat from Paddepoel and Tritsum III-VI with the heights of the withers from Feddersen Wierde calculated from metacarpi and metatarsi. For the *t* test (level 0.05) used, see table 3

Comparison	F	Model chosen	*t*	Degrees of freedom	Significant difference
Padd.-Fedd.W. metacarpus	3.016	2	0.458	11	no
Padd.-Fedd.W. metatarsus	5.371	2	0.434	10	no
Tritsum-Fedd.W. metacarpus	1.714	1	0.839	160	no
Tritsum-Fedd.W. metatarsus	3.052	2	2.194	16	yes

Table 19a. The greatest lengths of metacarpus and metatarsus of sheep in Elisenhof (Reichstein & Tiessen, 1974) and the resulting height of the withers. Height of the withers calculated with Teichert's coefficients (Von den Driesch *et al.*, 1974)

Metacarpus n = 30 greatest length 134.6 ± 1.36 mm
Resulting calculated standard deviation 3.737 mm
Height of the withers 65.82 cm; standard deviation 1.83 cm

Metatarsus n = 29 greatest length 145.5 ± 1.42 mm
Resulting calculated standard deviation 3.834 mm
Height of the withers 66.06 cm; standard deviation 1.71 cm

Table 19b. Tests of the heights of the withers of sheep/goat from Paddepoel and Tritsum III-VI with the heights of the withers of sheep from Elisenhof calculated from metacarpi and metatarsi. For the *t* test (level 0.05) used, see table 3

Comparison	F	Model chosen	t	Degrees of freedom	Significant difference
Padd.-Elisenh. metacarpus	3.772	2	2.209	10	yes
Padd.-Elisenh. metatarsus	4.326	2	2.544	12	yes
Tritsum-Elisenh. metacarpus	2.144	2	2.133	23	yes
Tritsum-Elisenh. metatarsus	2.459	2	2.463	23	yes

sheep (Paddepoel, Tritsum and Feddersen Wierde) were slightly smaller than those in Early Medieval Elisenhof.

Prummel (1983: table 67) examined the heights of the withers calculated from metacarpi and metatarsi from several Early Medieval find-sites. In Dorestad, Haithabu and Elisenhof, the heights of the withers turned out to be greater than those in Hamwih (in Southern England) and Feddersen Wierde. The average height of the withers of the 13th-16th century Dokkum sheep was c. 65 cm, that of the 16th and 17th century Groningen sheep c. 66 cm (van Gelder-Ottway, 1976/77; 1979). This shows that, in general, sheep became larger in the course of time.

4.3.3. *Age distribution and age at slaughter of the sheep*

The age determination on the basis of the fused/unfused epiphyses are shown in table 20, grouped after Prummel (1983). The age at which epiphyses fuse was derived from Habermehl (1975). Due to the small numbers, no percentages were calculated for two of the periods in table 20. It appears that 20 % of the animals were slaughtered as early as during their first four months. In the following year, nearly 40 % were slaughtered. Thirty per cent of the animals lived longer than three and a half years.

Table 20. Percentages of fused and unfused epiphyses for sheep and sheep/goat in Paddepoel I, II and III, indicating the percentages of animals which died before and in between the age categories mentioned

Age in months and type of bone	Unfused epiphyses died before the age indicated n	%	Fused epiphyses died after the age indicated n	%	% of animals killed between indicated and previous ages
Foetal					
Metacarpus p	0		6		
Metatarsus p	0		11		
Total	0	0.0	17	100.0	–
3-4 months					
Humerus d	2		5		
Radius p	0		3		
Total	2	20.0	8	80.0	20.0
7-10 months					
Phalanx 1 p	0		1	100.0	–
15-20 months					
Tibia d	5		7		
Metacarpus d	2		1		
Metatarsus d	7		2		
Total	14	58.3	10	41.7	38.3
36-42 months					
Calcaneus p	1		1		
Ulna p	2		0		
Femur p	3		0		
Total	6	85.7	1	14.3	–
c. 42 months					
Humerus p	2		0		
Tibia p	6		2		
Radius d	1		4		
Femur d	7		1		
Total	16	69.6	7	30.4	11.3
After c. 42 months		100.0		0.0	30.4

Habermehl (1975) was also the source for the age determination on the basis of the teeth. He gives information on the eruption of teeth. He reports that Weinberg & Sharow did not consider it justified to give an indication of age based on wear. In one of his tables (pp. 122-123), however, he did use information derived from Behr. On the basis of this table, Uerpmann's (1978) des-

Table 21. Age estimates on the basis of teeth for sheep and sheep/goat together for Paddepoel I, II and III and for the unnumbered fragments. The ages are after Habermehl (1976). The ages derived from wear have been roughly grouped on the basis of Habermehl although the latter writes that some authors are of the opinion that wear is not a clear indicator of age

Age	Description	N	%
3 months	M1 erupting	3	
9 months	M2 in place but not in wear	1	
18 months	M3 erupting	2	
	Milk premolar slightly or moderately worn	5	
first 18 months		11	35.5
24-36 months	(Pre)molar not worn	3	
36-48 months	(Pre)molar slightly worn	2	
	Premolar slightly worn	1	
	M2 slightly worn	1	
24-48 months		7	22.6
48-72 months	(Pre)molar moderately worn	2	
72-96 months	M2 moderately worn	2	
	M3 slightly worn	1	
96-120 months	M3 moderately worn	6	
48-120 months		11	35.5
After 120 months	(Pre)molar heavily worn	1	
	M3 heavily worn	1	
After 120 months		2	6.5

criptions of the teeth in the Knocod code were given certain dating. On the basis of the teeth, 64.5 % of the sheep lived longer than 18 months (table 21).

If the ages determined on the basis of epiphyses sutures and the teeth are compared with each other, it appears that the former are lower than the latter. Three reasons may be put forward to explain this. First of all, these determinations are based on small numbers *viz.* 57 epiphyses sutures and 31 teeth. Moreover, it appeared that Silver (1969) found older ages for the fusing of the epiphyses sutures and Habermehl was uncertain about the wear determinations, so that the results could perhaps be somewhat closer together. In conclusion, it can be assumed that by the age of one and a half years about 50 % had been slaughtered.

Reichstein *et al.* (1974: p. 37) found that '. . *altere bis sehr alte Tiere (über 2.5 Jahre)*' (older to very old animals, over 2.5 years of age) accounted for 48 % in Feddersen Wierde (n = 962) and 42 % in Elisenhof (n = 455). They connected this with the keeping of sheep for the wool and pointed out that in both *terpen* archaeological finds points to the processing of wool. In Paddepoel too there was archaeological evidence for processing of wool (Van Es, 1970). Woollen fabrics were found in other *terpen* in the Netherlands (Schlabow, 1974).

Table 22. The occurrence of cutting and gnawing marks on bone fragments of sheep and sheep/goat for the whole of Paddepoel

Type of bone	N	With cutting marks n	With cutting marks %	With gnawing marks n	With gnawing marks %
Humerus	17	–	–	2	11.8
Radius	12	–	–	3	25.0
Pelvis	17	1	5.9	1	5.9
Metatarsis	11	1	9.1	4	36.4
Rib	6	1	16.7	1	16.7

4.3.4. *The sexes*

With reference to Boessneck *et al.* (1964) one epistropheus could be ascribed to an ewe and three pelvis fragments to a ram. Other sex determinations could not be made.

4.3.5. *Slaughtering methods*

There were few cutting marks and traces of gnawing (table 22). The bones of pelvis and skulls were highly fragmented.

4.3.6. *The Drenth heath sheep and the Frisian milch sheep*

Four horn cores of sheep/goat and sheep were found. There were no indications of hornless sheep. Consumption of the brains will be the reason that the skulls were highly fragmented.

Reitsma (1932) came to the conclusion that there were heavily-horned rams and both horned and hornless ewes in the *terp* period. These constituted a single breed, the *terp* sheep. On the basis of skull examination, he found great similarities with the Drenthe heath sheep. He held that the latter were descended from the *terp* sheep. In the light of present-day opinion on immigration from the

Drenthe plateau (Waterbolk *et al.*, 1976) and the continuous habitation of Drenthe (as was demonstrated for Peelo: Bardet *et al.*, 1983), it must be thought more likely that the *terp* sheep, in a possibly somewhat modified form, is the same as the Drenthe heath sheep of the Iron Age. The present-day Drenthe heath sheep is also descended from the latter.

In Reitsma's opinion, the Frisian milch sheep is not descended from the Drenthe heath sheep. There is a possibility that a careful study of the botanical differences mentioned in the chapter on the faunal spectrum (chapter 8) might yet produce evidence for the evolution of different breeds. On the other hand, mention can be made of Halbertsma's opinion (1975: pp. 212 ff.) that there was also possible immigration from West-Friesland to the Frisian area of Westergo. Perhaps the Frisian milch sheep originated there. Further research on this point would be desirable, a drawback being that since it is difficult enough to separate the post-cranial bones of sheep and goat, it will be even more difficult to differentiate those of different breeds of sheep.

4.4. Goat (*Capra hircus*, Linnaeus, 1758)

Two horn cores found in Paddepoel II and III could be ascribed to goat. The measurements for these are shown in table 34. It is possible that there are goat remains among the sheep/goat bones. One of the two horn cores had been struck off. In Feddersen Wierde it was possible to ascribe seven horn cores to goat, but no other skeletal elements. In Dorestad, a great many horn cores were found in the harbour, but no post-cranial elements. This suggests that skins, complete with horn cores, were imported to Dorestad (Prummel, 1983). It is possible that this occurred in the *terp* region, too.

Goat will have been of little significance among the livestock in the *terpen*, a conclusion already drawn by Broekema (1912), Van Giffen (1913a), Clason (1970a) and Reichstein (1972).

4.5. Pig (*Sus scrofa*, Linnaeus, 1758)

4.5.1. *Numerical data*

Pig was of little significance in Paddepoel. The natural environment was probably not very suitable for pig husbandry. Paddepoel I, II and III produced 13, 4 and 2 bone fragments, respectively. No pig remains were found in Paddepoel IV. The distribution per skeletal element for these 19 finds is shown in table 23. The measurements for the bone fragments are shown in table 36.

Table 23. The numbers and weights (g) of the bone fragments of pig per skeletal element, for Paddepoel I, II and III combined

	N	Weight	Average weight
Part of skull	4	169	42.3
Loose maxillary tooth	1	2	2.0
Fragment of mandible	4	182	45.5
Loose mandibular tooth	1	1	1.0
Scapula	2	40	20.0
Ulna	1	14	14.0
Metacarpus 4	1	9	9.0
Femur	1	6	6.0
Astragalus	1	9	9.0
Calcaneus	1	15	15.0
Phalanx 2, posterior	1	3	3.0
Rib	1	8	8.0
Total	19	458	24.1

4.5.2. *Size of the pig*

The height of the withers of pigs can be determined on the basis of the greatest lengths of a number of bones Only two measurements were available, from an astragalus and a calcaneus. Coefficients suggested by Teichert (quoted by Von den Driesch *et al.* 1974) were used. The heights of the withers calculated from small bones are always somewhat unreliable because of the effect of a small measuring error. The heights of the withers found were 37.4 mm 17.9 = 66.9 cm for the astragalus, and 76.9 mm 9.34 = 71.8 cm for the calcaneus. These heights are in reasonable agreement with Teichert (1970) who established a height of the withers of 70-75 cm for German pigs from the Roman period and with Prummel (1983) who compared various medieval settlements. It was not possible to determine a height of the withers for Tritsum. In Feddersen Wierde the domestic importance of pig was greater, but no data on size could be found in the literature.

4.5.3. *Age distribution and age at slaughter*

One lower jaw belonged to a young animal. The

M1 was present, and the M2 still rattled inside the jaw, so that, according to Habermehl (1975) the animal must have been between 8 and 13 months old. The age for a late-maturing breed was taken, as did Prummel (1983) for Dorestad. Another jaw fragment with a few milk teeth, and a milk tooth found separately, must have belonged to two eight-month old animals. A small piece of upper jaw contained an M1 which had erupted but did not yet show any wear. This animal must have been about eight months old, but Habermehl gave no indications for age on the basis of wear. A piece of upper jaw with an M3 must have been from an approximately two-year old animal.

Where it was possible to make observations on epiphyses sutures it was found that these were fused. These were a metacarpus, a calcaneus and a rear phalanx 2.

4.5.4. *The sexes*

Judging from the canines found, two lower jaw fragments and a separately found canine belonged to a boar.

4.5.5. *Slaughtering methods*

Although no cutting marks were found, the bones were highly fragmented, particularly the skulls, which amounted to half of the finds. A dog had gnawed one scapula. The blades of both the scapulae that were found were broken.

4.6. Dog (*Canis familiaris*, Linnaeus, 1758)

Much had already been written on the *terp* dog before the Second World War. At that time various prehistoric breeds were distinguished and their origin was a frequent topic of discussion (Schoor, 1887; Van Giffen, 1913b; 1927; Keller, 1918). At present it is assumed that the dog is descended from the wolf, *Canis lupus* Linnaeus, 1758 (Clason, 1977). The pre-war view was that three breeds of dogs occurred in the *terpen*, *viz.* the so-called peat dog *Canis palustris*, the bronze dog *Canis matris optimae* and an intermediate breed *Canis intermedius*. Later research has confirmed that it is probable that three forms did occur in the *terpen*.

Paddepoel I, II and II produced 4, 7 and 9 bone fragments, respectively. No dog remains were found in Paddepoel IV. These 20 bone fragments,

Table 24. The numbers and weights (g) of the bone fragments of dog per skeletal element, for Paddepoel I, II and III combined

	N	%	Weight	Weight %	Average weight
Part of skull	7	35.0	623	62.738	89.0
Fragment of mandible	6	30.0	301	30.312	50.2
Humerus	2	10.0	25	2.618	13.0
Pelvis	1	5.0	31	3.122	31.0
Metatarsus 3	1	5.0	3	.302	3.0
Metatarsus 4	1	5.0	2	.201	2.0
Rib	1	5.0	6	.604	6.0
Penis bone	1	5.0	1	.101	1.0
Total	20		993		49.7

included four almost complete skulls, two skull fragments and seven lower jaws (table 24). The measurements for the bone fragments are shown in table 37.

Five of the bone fragments from Paddepoel II (find number 174), *viz.* a skull, lower jaw, a metatarsus 3, a metatarsus 4 and a penis bone, can be assigned to a single male dog. The dog was found in a ditch at the lowest level of the excavation. Van Es (1970) could not find much to say about this layer. The find book reported: '12-8-1964 174 sherds from Paddepoel II ditch' (compare Van Es, 1970: map XI level e). It follows, therefore, that the dog must date from the earliest period of Paddepoel II. The skull had been smashed in at the forehead, and was therefore fragmented. On the left lower jaw an exostosis at the bottom of the ramus can be seen. There were notches at the bottom of the right-hand side of the lower jaw, and also on the top of the skull. It is possible that the skin of this dog had been used.

The lower jaw and the fragment of upper jaw of Paddepoel III 140 belong together. In the lower jaw of Paddepoel I 114 the P4 is missing. The alveolus had closed later. Since this jaw has quite a sheen it must have been handled often and may have served as a memento or an amulet. The skull of Paddepoel II 197 consisted only of an occiput, the entire facial part was missing. In the skull of Paddepoel III 210 the occiput had been damaged. One skull bore the number 'PP III stray'. This had obviously been found separately on the dump of the excavation so that its exact find spot was no longer known. Its appearance certainly indicates a prehistoric find. The skull had been smashed in above the eye socket. The skull of Paddepoel III 333 displayed no clear signs of having been struck.

From the above the impression is obtained that the dogs were generally killed, possibly when they were old or sick. The cutting marks may be indications of utilisation of the skin. No signs of human consumption were found.

Not much can be said about the age of the dogs found. The distal epiphyses sutures of the metatarsi of dog PP III 174 were fused, so that it must have been older than five months (Habermehl, 1975).

On the basis of the measurements of the four skulls there is no point in drawing conclusions from allometrical formulae such as those which were established for Haithabu (Wendt, 1978) or Utrecht (Kersten, 1979).

Heinrich (1974) studied the dogs of Feddersen Wierde. He stressed the great diversity in size, both of the dogs of Feddersen Wierde and of modern dog breeds. Wendt (1978) and Heinrich (1974) found a tendency to breed slender dogs in Haithabu and Feddersen Wierde, respectively.

5. DOMESTICATED BIRDS

5.1. Domestic fowl (*Gallus gallus domesticus*)

Remains of two hens were found. Paddepoel I yielded one humerus. In Paddepoel III, a well of the second phase of habitation produced five small bones, presumably from one bird, *viz.* two humeri, a breast-bone, a pelvis and a tarsometatarsus. The breast-bone has an exostosis on the crest. The numbers and weights are shown in table 25, the measurements in table 38.

Other remains of domestic fowl of the *terp* period have been discovered (Clason, 1970a; 1979).

Table 25. The number, weights (g) per skeletal element for domestic fowl for Paddepoel I and II combined.

	Number	Weight	Average weight
Humerus	3	9	3.0
Pelvis	1	12	12.0
Tarsometatarsus	1	4	4.0
Sternus	1	7	7.0
Total	6	32	32.0
	12	64	4.0

6. WILD MAMMALS

The hunting of big game was of no importance to the *terp* inhabitants of Paddepoel. It is difficult to make any comment on the hunting of small game mammals and birds or on the fishing. No little bone of small game mammals, wild birds or fish were found but there is no guarantee that they were not there to be found. But also those of large wild mammals and large birds are scarce or absent. The four bone fragments which were found had presumably all been worked.

6.1. Red deer (*Cervus elaphus*, Linnaeus 1758)

Two antler fragments were found in Paddepoel I. One (find number PP I 73) is smooth and gives the impression of having been used for some purpose. Nothing can be said about the other (PP I 38). It is only a small fragment.

6.2. Roe deer (*Capreolus capreolus*, Linnaeus 1758)

An antler fragment was found in Paddepoel III (PP III 208). The extremity of the fork displays cutting marks, which points to an attempt to make a tool of it (fig. 11).

6.3. Whale (Cetaceae)

Paddepoel III yielded a fragment of bone of a whale which could not be further identified. It was possibly used as a scraper (fig. 11).

7. MOLLUSCS (MOLLUSCA)

Although molluscs were probably not collected, one specimen of painter's mussel, *Unio pictorum* Linnaeus, 1758, was found. The left valve (height 29 mm, breadth c. 50 mm) was nearly intact. The right valve consisted only of a fragment of the hinge. Almost the entire periostracum was still present.

The find book reported find number 32: 'mussel shell from a groove below blue layer exact position unknown, see profile B'. Profile B (Van Es, 1970: plan V) reveals that find 32 was discovered in naturally silted clay below the second land surface.

The shell was found adjacent to a ditch running towards an old bed of the river Aa. Painter's mussel occurs in stagnant and sluggishly flowing water (Janssen *et al.*, 1965), an environment which is likely to have existed in the ditch and in the Aa.

8. THE FAUNAL SPECTRUM

The faunal spectrum of the individual Paddepoel find-sites, the unnumbered bone fragments combined, and the Paddepoel I, II and III excavations combined are shown in numbers and percentages in table 26, in weights and percentages in table 27. These tables also show the percentages of bone fragments identified. The identification percentage lies between 92 and 99 % for numbers and is nearly 100 % for weight. This is because unidentified fragments are often small. Most of the unidentified fragments are in the size range of red deer to domesticated cattle. These are likely to have been fragments of cattle or horse.

There is a possibility that small bone fragments are under-represented (chapter 3). The absence of remains of fish and small game and the small number of chicken bones may point in that direction. The following domesticated animals were found in Paddepoel I, II and III: cattle, horse, sheep, goat, dog, pig and chicken. Paddepoel IV yielded only cattle, horse and sheep/goat. This find-site differs in geographical location and date from the other three, and only a few bone fragments (46 specimens) were found. Consequently, most of our attention was directed to the first three find-sites.

There is no great difference in faunal spectrum between Paddepoel I, II and III so that they were treated as a single complex (tables 26 and 27).

Game was not significant (table 28). The finds consisted of two antler fragments of red deer, an antler fragment of roe-deer and a worked piece of bone from a whale. It is possible that these pieces had been imported as raw material or artefacts from elsewhere. This small proportion of game is all the more remarkable because of the close vicinity of the Hondsrug (fig. 1). The

Table 26. The faunal spectra, in numbers and percentages, of Paddepoel I, II, III, IV, the unnumbered bone fragments, all the bone fragments combined, and Paddepoel I, II and III combined

Paddepoel excavation	I		II		III		IV		Un-numbered		All fragments combined		I, II, III	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Total number of finds	1007		520		669		46		65		2308		2197	
Identified	929		511		660		44		63		2207		2100	
Domestic hen	1	0.1			5	0.8					6	0.3	6	0.3
Dog	4	0.4	7	1.4	9	1.4					20	0.9	20	1.0
Horse	108	11.6	46	9.0	84	12.7	3	6.8	1	1.6	242	11.0	238	11.3
Pig	13	1.4	4	0.8	2	0.3					19	0.9	19	1.0
Sheep	9	1.0	12	2.3	3	0.5			1	1.6	25	1.1	24	1.1
Goat			1	0.2	1	0.2					2	0.1	2	0.1
Sheep or goat	116	12.5	37	7.2	37	5.6	4	9.1	10	15.9	204	9.2	190	9.0
Cattle	676	72.8	404	79.1	517	78.3	37	84.1	51	81.0	1685	76.3	1597	76.0
Red deer	2	0.2									2	0.1	2	0.1
Roe deer					1	0.2					1	0.04	1	0.1
Whales					1	0.2					1	0.1	1	0.1
Unidentified	78		10		9		2		2		101		97	
No size assignment	1	1.3									1	1.0	1	1.0
Wild boar-size to red deer, small cattle-size	35	44.9	7	70.0	5	55.6					47	46.5	47	48.5
Red deer-size to domestic cattle-size	42	53.8	3	30.0	4	44.4	2	100.0	2	100.0	53	52.5	49	50.5
Percentage identified at Paddepoel excavation		92.3		98.1		98.7		95.7		96.9		95.6		95.6

Table 27. The faunal spectra, in weights (g) and percentages, of Paddepoel I, II, III, IV, the unnumbered bone fragments, all the bone fragments combined, and Paddepoel I, II and III combined

Paddepoel excavation	I		II		III		IV		U numbered		All fragments combined		I, II, III	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Total weight	25770		33395		37307		3131		1824		101417		96472	
Identified	25307		33327		37240		3113		1802		100852		95937	
Domestic hen	2	0.0			30	0.1					32	0.	32	0.
Dog	101	0.4	307	0.9	585	1.6					993	1.0	993	1.0
Horse	4862	19.2	3183	9.6	6263	16.8	190	6.1	54	3.0	14552	14.4	14308	14.9
Pig	231	0.9	159	0.5	68	0.2					458	0.5	458	0.5
Sheep	161	0.6	335	1.0	74	0.2			39	2.2	609	0.6	570	0.6
Goat			18	0.1	146	0.4					164	0.2	164	0.2
Sheep or goat	1168	4.6	769	2.3	717	1.9	102	3.3	377	20.9	3133	3.1	2654	2.8
Cattle	18838	74.3	28556	85.7	29302	78.7	2821	90.6	1332	73.9	80849	80.2	76696	79.9
Red deer	7	0.0									7	0.	7	0.
Roe deer					27	0.1					27	0.	27	0.
Whales					28	0.1					28	0.	28	0.
Unidentified	400		68		67		8		22		565		535	
No size assignment	2	0.4									2	0.3	2	0.4
Wild boar-size to red deer, small cattle-size	105	26.3	35	51.5	27	40.3					167	29.6	167	31.2
Red deer-size to domestic cattle size	293	73.3	33	48.5	40	59.7	8	100.0	22	100.0	396	70 1	366	68.4
Percentage identified at Paddepoel excavation		98.5		99.8		99.8		99.8		98.8		99.4		99.5

Table 28. The ratio of domesticated animals to wild animals in Paddepoel I, II, III, Paddepoel I, II and III, IV, unnumbered and all fragments combined. The weight ratio and the numbers ratio are both given

Number ratio	Domesticated animals		Wild animals	
	n	%	n	%
Paddepoel I	927	99.8	2	0.2
Paddepoel II	511	100.0	0	0.0
Paddepoel III	658	99.7	2	0.3
Paddepoel I, II & III	2096	99.8	4	0.2
Paddepoel IV	44	100.0	0	0.0
Unnumbered fragments	63	100.0	0	0.0
Combined	2203	99.8	4	0.2

Weight (g) ratio	Domesticated animals		Wild animals	
		%		%
Paddepoel I	25363	99.97	7	0.03
Paddepoel II	33327	100.0	0	0.0
Paddepoel III	37185	99.9	55	0.1
Paddepoel I, II & III	95875	99.9	62	0.1
Paddepoel IV	3113	100.0	0	0.0
Unnumbered fragments	1802	100.0	0	0.0
Combined	100790	99.9	62	0.1

species of game found agree completely with the game spectrum as found by Van Giffen (1913a) in the *terp* region. The insignificant role of game in the *terp* region was also found in Sneek (Clason, 1962) and in Germany (Nobis, 1955; Zawatka *et al.*, 1977).

The order of importance of the domesticated animals of the early *terp* period in Paddepoel (200 B.C.-250 A.D.) is as follows: cattle was the most important (76 %), followed by horse (1 %) and sheep (sheep and sheep/goat combined 10 %); pig was of scarcely any significance (c. 1 %) and goat of even less; dog and chicken were both represented by a figure of 1 %. Comparison with other *terp* research shows that there are differences as well as similarities which will be discussed per species (table 30; also Nobis, 1955). The number of bones found in Sneek is too little for comparison (table 30; Clason, 1962).

Van Giffen demonstrated the great importance of cattle as early as 1913 (Van Giffen, 1913a). The cattle provided meat, milk, traction, skins, manure and bone.

Table 29. The numbers and percentages of identified bone fragments of the large domesticated animals as found at Bentumersiel and Jemgumkloster (Zawatka *et al.*, 1977: table 2), Feddersen Wierde (Reichstein, 1973: table 1), Tritsum, periods III-VI (Clason, unpubl.), Sneek (Clason, 1962) and Paddepoel I, II and III, combined

	Bentumersiel		Jemgumkloster		Feddersen Wierde		Tritsum III-VII		Sneek	Paddepoel I, II & III	
	n	%	n	%	n	%	n	%	n	n	%
Cattle	3480	70.4	316	67.2	28017	63.2	1404	74.2	87	1597	76.4
Sheep/goat	337	6.8	48	10.2	6238	14.1	363	19.2	30	216	10.3
Pig	295	6.0	55	11.7	2245	5.1	36	1.9	0	19	0.9
Horse	819	16.6	49	10.4	6254	14.1	51	2.7	5	238	11.4
Dog	12	0.2	2	0.4	1580	3.6	38	2.0	39	20	1.0
Total	4943	100.0	470	99.9	44334	100.1	1893	100.0	161	2090	100.0

Table 30. The comparison of the faunal spectrum of Paddepoel III before the Roman period with that of Paddepoel III after the Roman period. On the basis of Van Es (1970 and pers. comm.) it was determined which find numbers were certain and which were likely to have belonged to phase 1 (pre-Roman); the others were considered to be Roman. The faunal spectrum applies to the large domesticated animals, sheep, goat and sheep/goat being combined

	Certain pre-Roman		Likely pre-Roman		Total pre-Roman		Roman		Totals including 9 bone fragments could not be assigned to a phase	
	n	%	n	%	n	%	n	%	n	%
Horse	3	6.3	18	10.1	21	9.2	63	15.1	84	12.9
Cattle	42	87.5	145	81.5	187	82.7	323	77.3	517	79.2
Sheep/goat, sheep, goat	1	2.1	12	6.7	13	5.8	26	6.2	41	6.3
Pig	1	2.1			1	0.4	1	0.2	2	0.3
Dog	1	2.1	3	1.7	4	1.8	5	1.2	9	1.4
Total	48		178		226		418		653	

It is difficult to distinguish bone fragments of sheep and goat. Only two horn cores could be ascribed with certainty to goat; 24 bone fragments definitely originated from sheep. It may be assumed that nearly all the sheep or goat bone fragments came from sheep. Sheep and sheep/goat combined are taken to represent the proportion of sheep. Reichstein (1975) demonstrated that differences in vegetation are reflected in a difference in the ratio between sheep and cattle in various settlements in the German *terp* region. More sheep were kept in brackish areas than in areas with fresher water. A lower sheep percentage was found in Feddersen Wierde than in Elisenhof. Behre (quoted by Reichstein, 1975) found that four halophytes, *Limonium vulgare, Puccinellia maritima, Salicornia europaea* and *Spergularia marginata*, occurred in Elisenhof which were scarce or absent from Feddersen Wierde. The first three of these were not present in Paddepoel, either, but were present in Tritsum (Van Zeist, 1974). Tritsum is a *terp* which was situated closer to the sea. It is thought that this *terp* was continuously inhabited from 500 B.C. to 200 A.D. (Waterbolk, 1961). Clason (pers. comm.) has examined a small proportion of the bone fragments collected. Her figure for sheep is 19.2 % (table 29), which is double the figure for Paddepoel. Therefore, also in the Dutch *terp* region sheep husbandry appears to have been of more importance in brackish areas than in fresh water areas. In addition to these botanical differences, Prummel (1979a) mentions another possibility. The liver fluke, a dangerous parasite for sheep, cannot flourish in brackish areas because of the absence of its intermediate host, the dwarf pond snail (*Lymnea (galba) truncula*ta Müller, 1774). There are no observations of the little dwarf pond snail from the *terp* period, but probably no attention has ever been paid to the matter. The dwarf pond snail does not occur near the sea. Sheep will have provided the *terp* inhabitants with meat, wool, milk, manure and skins.

In many early *terpen* the proportion of horse bones is remarkably high. This was found in

Germany as well as in Paddepoel, e.g. Feddersen Wierde (Reichstein, 1973a), Jemgumkloster and Bentumersiel (Zawatka *et al.*, 1977), Barnkrug and Einswarden (Nobis, 1955). In Tritsum (pers. comm.), Sneek (Clason, 1962) and Elisenhof (Reichstein, 1972), the horse was of less importance, maybe due to the botanical differences, mentioned above. The *terp* inhabitants will have used the horses for their meat and as riding animals.

The question arises whether the presence of the Romans in the area south of the Netherlands had any effect on the keeping of horses. This point was looked into for Paddepoel III. Table 31 shows the faunal spectra of: 1. certainly pre-Roman, 2. possibly pre-Roman, and 3. Roman Paddepoel III. From this table it appears that the proportion of horse remains is greatest in Roman Paddepoel III. An X^2 test on two independent samples (Siegel, 1956: pp. 104-111) for the proportion of horse in certainly pre-Roman and Roman times did not produce a significant difference (X^2 = 2.078; p = 0.05). A test of certainly pre-Roman and possibly pre-Roman remains combined, against Roman remain' produced a weakly significant difference (X^2 = 3.826; p = 0.05). On these grounds it is doubtful whether the Roman presence in the south had any effect on horse-breeding in Paddepoel.

The insignificance of pig will have been connected with the absence of forests. Nobis (1955) showed that in *terpen* situated closer to wooded areas higher numbers of pig bones were found. It is unlikely that the Paddepoel farmers took their pigs across the river Aa to herd them on the Hondsrug. This little river may have formed the border, and the people of Paddepoel may not have been allowed to go there with their livestock. The insignificance of pig in the *terp* period had also been established by Broekema (1912), Van Giffen (1913a), Reitsma (1935) and Clason (1962; 1970a). The pigs were probably fed on scraps and kept for their meat.

Goat was unimportant, as was also found in Germany (Reichstein, 1972). Because of the slight osteological difference between goat and sheep, goat may be under-represented but, with the exception of two horn cores, all the bone fragments identified to species belonged to sheep. As has been previously remarked, bone fragments ascribed to sheep or oat were counted as sheep.

Dogs will have been used as watch-dogs and for hunting vermin.

Not much can be said about the keeping of poultry. Clason (1970a) reported finds of eggs from the *terpen.*

Cat was not found. Tritsum VI (of the year 0) yielded one cat (Clason, pers. comm.). In the *terp* Kimswerd, two skeletal elements of a cat were found in layers dating from 350 B.C.-c. 50 A.D. (Milojković *et al.*, 1984). Nobis (1955) reported a cat in Tofting in the 2nd-3rd century A.D. The cat was introduced into the Netherlands by the Romans. One of the oldest finds is from the Roman settlement of Valkenburg (Clason, 1967). Cat was possibly still rare in the north at the time of the Paddepoel settlement.

9. BONE OBJECTS

Bone is a very suitable material from which to make objects. It is strong, easily worked, is sometimes ready for use without a great deal of work, and is nearly always amply available. Right up to the 20th century bone was much used, e.g. for the making of buttons, napkin-rings, *etc.* The *terp* inhabitants made good use of the possibilities offered by bone (Roes, 1963). Compared with what is known from other *terpen*, the Paddepoel finds are scanty. It is unfortunately often difficult to establish the function of the objects recovered; sometimes unfinished specimens were found. All the objects found will be discussed below, even if their function is unknown.

Scrapers, possibly used for scraping hides clean, were an conspicuous object. Seven of them with curved edges had been made from fragments of cattle ribs (fig. 12a). It is probable that the piece of whale bone from Paddepoel III (fig. 11) also served as a scraper. A burnt edge can be seen on its left-hand side.

Two possible spindle-whorls have been made from the caput of a cattle femur (fig. 12b). A hemisphere had been sawn off the caput and a hole drilled through it. One was found in Paddepoel II in the latest excavation layer (number PP II 35). The other was found in the second phase of Paddepoel III (number PP III 208). All three find-sites also yielded earthenware spindle-whorls (Van Es, 1970). A spindle-whorl was used with a stick as a spinning top for the spinning of wool and, possibly, flax. Recently Schoenmaker (1983) gave an other possibility for these objects: *oesdop.* This is a Frisian word for a part of the harness. It links the trace with the harness.

Two phalanges of horse were smooth and each had a round hole in its distal extremity (fig. 12c). There was a fragment of bone in one of these holes. Both these finds came from the second excavation level (level b) of Paddepoel I, but they were not found alongside each other. Roes (1963) mentioned a game in which cattle phalanges were used in Friesland. She concluded that the horse phalanges found in the *terpen* had been used in a game too. Van Gelder-Ottway (1979) described cattle phalanges from Medieval Dokkum. The latter had holes in them which continued to the inner cavity. Baart *et al.* (1977) described cattle phalanges dating from 14th-17th century Amsterdam, which were also used in a game. According to Roes (1963) only horse phalanges were used in the *terpen*, as in Paddepoel and Sneek (Elzinga, 1962; Clason, 1962). This was maybe an indication of the special meaning that horses had for the *terp* people (4.2.6.). After the Middle Ages cattle phalanges were used.

A smooth piece cattle rib with notches (fig. 12d) is an artefact whose function is unknown.

A very commonly used bone object is an awl. Three were found in Paddepoel (fig. 12e), made from a radius, a humerus and a cattle nasal bone (find numbers PP III 311, PP IV 296 and PP II 164, respectively). With the last-mentioned, the naturally pointed shape of the nasal bone had been utilised. Few pains had been taken to finish off the awls, so that their period of use was probably short.

A piece of astragalus of a cow displayed a spot worn very smooth (fig. 13). Something must have rubbed against it for a long time; it may have been a pulley.

It is not clear what the functions were of a tibia and two metatarsi of sheep/goat. All three have the high polish that is characteristic of bone objects that have been handled a great deal. One metatarsus (find number PP II 192) has a proximal hole, the other has a round hole at either end. The tibia is smooth; although the proximal epiphysis was not yet fused with the diaphysis, a round hole had been made in this which continued into the diaphysis.

Two pieces of sheep/goat tibia were possibly unfinished artefacts. In one case the proximal extremity, and in the other the shaft, had been separated from the rest by chopping from three sides. The shaft may have been used for some purpose.

A total of four horse metatarsi, six cattle metatarsi and 12 cattle metacarpi were found which were very smooth (fig. 14). In some of them the ridges on the condyles had worn away. There were no smoothly worn surfaces that would point to runners, so another function had to be sought. Many of the cutting marks on the shaft were highly polished, too. With a binocular microscope it appears that scratches perpendicular to the longitudinal axis predominated. Two possible uses are known. One, in weaving, was mentioned briefly by Herman (1902). More is known about the other use, in the tanning of leather. Barthel (1969) described in detail the use of long, strong bones, such as metapodia and radii, in tanning. With these bones the tanning fluid was squeezed out of the pores of the hide and fat pressed into the hide to produce waterproof and soft leather. These bones were scratched cross-wide, unlike runners on which length-wise scratches were visible. Both weaving and the tanning of leather were probably practised in Paddepoel. Three scrapers and a smooth cattle metatarsus found together (PP III 218) and three smooth metapodia and a scraper (PP II 175) perhaps point to the use of leather.

The plans (Van Es, 1970) were consulted to see if any significance could be attached to the distribution of the tools. Scrapers and smooth metapodia were found in all three excavations. Different artefacts were often found together, e.g. the above-mentioned find numbers PP III 218 and PP II 175. Most of the objects were found adjacent to or in a ditch or pit which was usually situated near a dwelling place. Because of the small numbers, little more can be said about their distribution. One Medieval awl (PP IV 296) was situated near a grave but it is doubtful if there was any connection.

10. HUMAN SKELETAL REMAINS

The skeletons found in the small Early Medieval graveyard in Paddepoel IV were examined by Van Vark (1970). The *terpen* of the early *terp* period yielded three skull fragments and a lower jaw.

Figure 15b shows, below right, a fragment of the right hand *os parientale.* It came from a ditch in Paddepoel II (find number PP II 160; Van Es, 1970: plan XVI, section A^a/A^b). The figure shows, below left, a fragment mainly of the left hand *os parientale*, with still unfused sutures, originating from a young person. It was found in Paddepoel III (PP III find number 244) adjacent to a ditch in the lowest excavation level (Van Es, 1970: plan

XIX level d, A^a 17). The skull in the middle came from the same spot. It is the *calva* of an elderly person. It consists of the *os frontale* and both the *os parientales.* In the front the *calva* had been cut just below the eyebrow bows. At the back the *calva* had been cut at the upper part of the *sulcus lambdoidea.* Between these two points the *calva* was cut circular so that a big cup remains. The edge is unregular and damaged by fire (fig. 16). Vaguely some cutting marks can be seen along the edge. This worked skull belongs to the group of rondelles described by Brongers (1967; 1968). It is a large specimen and closely resembles the Garnwerd one, which was a part of a rondelle (Brongers, 1968). Figure 17 shows a lower jaw which was found in a ditch in Paddepoel III (find number 223, Van Es, 1970: plan XX, section G' Ad). The high polish indicates that the jaw was handled a great deal or worn for a long time. The double foramen on the right-hand side is peculiar (plate XXI). It is clear that the skull had a special meaning for the *terp* people.

These finds do not give direct evidence of the method of disposing of the dead in the early *terp* period. Halbertsma (1954) insists that they were buried, but Waterbolk *et al.* (1976) drew parallels with the higher-flying sandy soils and postulated cremation in unpretentious funeral pyres during the early *terp* period.

The exceptional skeletal remains would then point to sacrifice, murder or relics. The four random Paddepoel finds do not point clearly to burial; moreover, a new town development was built there after the excavation. Any graveyard which had been there can hardly have been overlooked. Two of the finds were rarities. It can fairly safely be assumed that the deceased inhabitants of Paddepoel were cremated, but direct evidence for this, was not available.

11. SUMMARY

During the 1964 excavation of small *terpen* in the Paddepoel area of the city of Groningen, 2,308 bone fragments were collected. Forty-six of these came from a small Early Medieval graveyard on top of which a farmhouse had later been built. This Paddepoel IV excavation was different from the other three in time and place. Here, cattle, sheep and horse were found.

The other three find-sites, Paddepoel I, II and III, were agrarian settlements, inhabited from 200 B.C. to 250 A.D., on slightly brackish soil which in winter was occasionally flooded with seawater. The faunal spectrum consisted of cattle (76 %), horse (11 %), sheep (10 %), goat (1 %), dog (1 %), pig (1 %) and hen (1 %). Four fragments of big game were found but they are rather evidence of import than of hunting. Due to the method of collecting, it is possible that remains of small game, poultry and fish were overlooked. This fauna spectrum largely agrees with that of *terpen* such as Feddersen Wierde. The number of horse is conspicuous. In *terpen* which were situated closer to the sea, such as Tritsum and Elisenhof, the percentage of sheep bones was higher, perhaps because of the absence of liver-fluke and/or botanical differences. Closer to the sea, the percentage of horse bones is lower. No Roman influence on horse-breeding could be demonstrated. The biotope was not particularly suitable for keeping pigs.

The inhabitants of the Paddepoel *terp* probably had contact with contemporaneous settlements on the same side of the river. The *terp* of Dorkwerd and the clay-covered settlements in Vinkhuizen (Waterbolk *et al.*, 1976) were presumably inhabited at that time. It is also likely that there were contacts with people living on the Hondsrug. The river Aa was presumably their line of communication. Van Giffen *et al.* (1973) found indications of habitation during the first centuries A.D. on the Hondsrug in the centre of Groningen, at a distance of c. 2 km.

Several bone tools were found, including spindle-whorls, awls and scrapers. Highly polished metapodia were used in weaving or the tanning of leather. Four human bone fragments were found in two *terpen* of the early *terp* period. No light was shed on the method of disposal of corpses. Burial would appear to be unlikely in view of the fact that the whole area was turned upside-down for the new town development. Burial sites would certainly have been noticed and probably not have been kept secret.

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13. REFERENCES

Baart, J., W. Krook, A. Lagerweij, N. Ockers, H.H. van Regteren Altena, T. Stam, H. Stoepker, G. Stouthart & M. van der Zwaan, 1977. *Opgravingen in Amsterdam 20 jaar stadskernonderzoek.* Haarlem.

Bakker, D.L., 1931. Grepen uit de fauna onzer terpen. *Landbouwkundig tijdschrift* 43, pp. 921-928.

Bardet, A.C., P.B. Kooi, H.T. Waterbolk & J. Wieringa, 1983. *Peelo, historisch-geografisch en archaeologisch onderzoek naar de ouderdom van een Drents dorp* (= Mededelingen der K.N.A.W., afd. Letterkunde N.R. 46, 1). Amsterdam.

Barthel, H.J., 1969. Schlittknochen oder Knochengeräte. *Alt-Thüringen* 10, pp. 205-227.

Blalock Jr., H.M., 1960. *Social statistics.* New York-Toronto-London.

Boessneck, J., 1969. Osteological differences between sheep (*Ovis aries* Linné) and goats (*Capra hircus* Linné). In: D. Brothwell & E. Higgs (eds.), *Science in archaeology*, 2nd ed. London, pp. 331-358.

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.

Broekema, C., 1910. Overblijfselen van *Bos taurus primigenius* (Ruetim.) in de terpen. *Cultura* 22, pp. 475-477.

Broekema, L., 1908. Eene kleine bijdrage tot de kennis van de fauna onzer terpen. *Cultura* 20, pp. 722-724.

Broekema, L., 1909a. Verdere waarnemingen over de fauna onzer terpen in Friesland en Groningen. *Cultura* 21, pp. 57-59.

Broekema, L., 1909b. De overblijfselen van paarden in onze terpen. *Cultura* 21, pp. 1-8.

Broekema, L., 1910. De schapen der vroegere bewoners onzer terpen. *Cultura* 22, pp. 1-15.

Broekema, L., 1912. Overblijfselen van varkens uit onze Friesche terpen. *Cultura* 24, pp. 71-72.

Brongers, J.A., 1967. Protohistoric worked human skull bones in the Netherlands. *Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek* 17, pp. 29-34.

Brongers, J.A., 1968. Another rondelle from the Netherlands: Garnwerd, Groningen. *Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek* 18, pp. 263-265.

Chaplin, R.E., 1971. *The study of animal bones from archaeological sites.* London/New York.

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

Clason, A.T., 1967. Animal and man in Holland's past *Palaeohistoria* 13, pp. 1-247.

Clason, A.T., 1970a. De dierenwereld van het terpenland. In: J.W. Boersma (ed.), *Terpen — mens en milieu.* Haren, pp. 36-42.

Clason, A.T., 1970b. Preliminary report on the animal bones found at Paddepoel. *Palaeohistoria* 14, p. 287.

Clason, A.T., 1972. Some remarks on the use and presentation of archaeozoological data. *Helinium* 12, pp. 139-152.

Clason, A.T., 1977. *Jacht en veeteelt, van prehistorie tot middeleeuwen.* Haarlem.

Clason, A.T., 1979. Subfossiele vogelvondsten in Friesland. In: *Vogels in Friesland.* III. Leeuwarden, pp. 937-944.

Clason, A.T., unpubl. Archaeozoölogie. Unpubl. study guide B.A.I. (1980).

Clason, A.T. & W. Prummel, 1978. Een glimp van de Nederlandse avifauna uit het verleden. *Het vogeljaar* 26, pp. 209-217.

Clason, A.T., W. Prummel & D.C. Brinkhuizen, 1979. Vogelen en vissen. Een glimp van de Nederlandse vogelen viswereld uit het verleden. *Westerheem* 28, pp. 9-23.

Driesch, A. von den, 1976. *A guide to the measurements of animal bones from archaeozoological sites* (= Peabody Museum, Harvard Univ., Bull. 1). Cambridge.

Driesch, A. von den & J. Boessneck, 1974. Kritische Anmerkungen zur Widerristhöhenberechnung aus Längenmassen vor- und frühgeschichtlicher Tierknochen. *Säugetierkundliche Mitteilungen* 22, pp. 325-348.

Duerst, J.U., 1926. Vergleichende Untersuchungsmethoden am Skelett bei Säugern. In: E. Abderhalden (ed.), *Handbuch der biologischen Arbeitsmethoden*, Abt. 7, Teil 1. Berlin, pp. 125-530.

Elzinga, G., 1962. Nederzettingssporen van rond het begin onzer jaartelling bij Sneek. *De Vrije Fries* 45, pp. 68-99.

Es, W.A. van, 1970. Paddepoel; excavations of frustrated terps (200 B.C.-250 A.D.). *Palaeohistoria* 14, pp. 187-352.

Gelder-Ottway, S. van, 1976/77. Dierenresten uit de bouwput van de parkeergarage aan de Raamstraat uit Groningen. *Groningse Volksalmanak*, pp. 183-201.

Gelder-Ottway, S. van, 1979. Faunal remains from Dokkum. *Palaeohistoria* 21, pp. 109-126.

Giffen, A.E. van, 1913a. *Die Fauna der Wurten.* Thesis Groningen. Leiden.

Giffen, A.E. van, 1913b. Iets over terpen en den terphond. *Handelingen van het XIVde Nederlandsche Natuur- en Geneeskundig Congres gehouden te Delft op 27, 28 en 29 maart 1913*, pp. 468-481.

Giffen, A.E. van, 1927. Het oudste huisdier en de palethnologie. *Verslagen van de gewoone vergadering der afd. Natuurkunde van de Kon. Ned. Akademie van Wetenschappen* 36 (no. 10), pp. 1287-1296.

Giffen, A.E. van & H. Praamstra, 1973. *De Groninger St. Walburg en haar ondergrond* (= Verhandelingen Kon. Ned. Akademie van Wetenschappen, afd. Letterkunde N.R. 78). 2nd ed. Amsterdam.

Habermehl, K.H., 1975. *Die Alterbestimmung bei Haus- und Labortieren.* 2nd ed. Berlin/Hamburg.

Halbertsma, H., 1954. Enkele oudheidkundige aantekeningen bij de oudste menselijke skeletten in de Friese terpen gevonden. *Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek* 5, pp. 45-49.
Halbertsma, H., 1975. Terpnamen in het licht der oudheidkunde. *Naamkunde* 7, pp. 203-235.
Heinrich, D., 1974. Die Hunde der prähistorischen Siedlung Feddersen Wierde. *Zeitschrift für Säugetierkunde* 39, pp. 284-312.
Herman, O., 1902. Knochenschlittschuh, Knochenkufe, Knochenkeitel. *Mitteilungen der anthropologischen Gesellschaft in Wien* 32, pp. 217-238.
Janssen, A.W. & F.F. de Vogel, 1965. *Zoetwatermolusken van Nederland.* Amsterdam.
Keller, C., 1918. Praehistorische Hunde aus den Terpen Hollands. *Bijdragen tot de kennis van de provincie Groningen en omgelegen streken* 2, pp. 16-22.
Kersten, A., unpubl. Honden en katten in Utrecht, middeleeuwen en subrecent. Unpubl. man. B.A.I. (1979).
Labouchère, P.C., 1927. *De geschiedenis van het Belgische trekpaard en de invloed van Indigène du Fosteau op de Nederlandsche trekpaardfokkerij.* Maastricht.
Milojković, J. & D.C. Brinkhuizen, 1984. Botten uit de terpenzool bij Kimswerd. *Helinium* 24, pp. 240-246.
Nobis, G., 1955. Die Entwicklung der Haustierwelt Nordwest- und Mitteldeutschlands in ihrer Beziehung zu landschaftlichen Gegebenheiten. *Petermanns geographische Mitteilungen* 99, pp. 2-7.
Prummel, W., 1979a. Environment and stock-raising in Dutch settlements of the Bronze Age and Middle Ages. *Palaeohistoria* 21, pp. 91-107.
Prummel, W., 1979b. The size of Dutch horses and Labouchère's theory on the origin of the Frisian horse. In: M. Kubasiewicz (ed.), *Archaeozoology.* I. Szczecin, pp. 431-438.
Prummel, W., 1980. *Vroeg-middeleeuws Dorestad, een archaeozoölogische studie.* Thesis Groningen.
Prummel, W., 1983. *Early medieval Dorestad, an archaeozoological study* (= Nederlandse Oudheden 11; Excavations at Dorestad 2). Amersfoort.
Rau, R., 1968. Brief 28, Gregorius bonifacio Z.D. 723. *Briefe des Bonifatius, Willibalds Leben des Bonifatius, nebst einigen zeitgenössischen Dokumenten* (= Ausgewählte Quellen zur deutschen Geschichte des Mittelalters, IVb). Darmstadt, pp. 100-101.
Reichstein, H., 1972. Einige Bemerkungen zu den Haustierfunden auf der Feddersen Wierde und vergleichbarer Siedlungen in Nordwestdeutschland. *Die Kunde* N.F. 23, pp. 142-156.
Reichstein, H., 1973a. Die Haustierknochenfunde der Feddersen Wierde. *Probleme der Küstenforschung im südlichen Nordseegebiet* 10, pp. 95-112.
Reichstein, H., 1973b. Untersuchungen zur Variabilität frühgeschichtlicher Rinder Europas. In: J. Matolcsi (ed.), *Domestikationsforschung und Geschichte der Haustiere.* Budapest, pp. 325-340.
Reichstein, H., 1975. Die Vegetationsverhältnisse und die relativen Haustieranteile in vor- und frühgeschichtlichen Siedlungen. In: A.T. Clason (ed.), *Archaeozoological studies.* Amsterdam, pp. 219-224.
Reichstein, H. & M. Tiessen, 1974. *Ergebnisse neuerer Untersuchungen der Haustierknochen aus Haithabu* (= Berichte über die Ausgrabungen in Haithabu 7). Neumünster.
Reitsma, G.G., 1932. *Zoölogisch onderzoek der Nederlandsche terpen. I. Het schaap.* Wageningen.
Reitsma, G.G., 1935. *Zoölogisch onderzoek der Nederlandsche terpen. II. Het varken.* Wageningen.
Roeleveld, W., 1974. *The Holocene evolution of the Groningen marine clay district* (= Suppl. Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek 24). 's-Gravenhage.
Roes, A., 1963. *Bone and antler objects from the Frisian terp-mounds.* Haarlem.
Schlabow, K., 1974. Vor- und frühgeschichtliche Textilfunde aus den nördlichen Niederlanden. *Palaeohistoria* 16, pp. 169-222.
Schoenmaker, J., 1983. Oesdoppen. In: J. Schoenmaker, T. Hermens & P. Attema (eds.), *Friese terpen en terpvondsten.*, pp. 9-10.
Schoor, W.K.J., 1887. De praehistorische honden der terpen. *De Vrije Fries* 17, pp. 115-137.
Siegel, S., 1956. *Nonparametric statistics for the behavioral sciences.* London.
Silver, I.A., 1969. The ageing of domestic animals. In: D. Brothwell & E. Higgs (eds.), *Science in archaeology.* 2nd ed. London, pp. 283-302.
Teichert, M., 1970. Grössen Veränderungen der Schweine vom Neolithikum bis zum Mittelalter. *Archiv für Tiersucht* 13, pp. 229-240.
Uerpmann, H.P., 1978. The 'Knocod' system for processing data on animal bones from archaeological sites. In: R.H. Meadow & M.A. Zeder (eds.), *Approaches to faunal analysis in the Middle East* (= Peabody Museum, Harvard Univ., Bull. 2). Cambridge, pp. 149-167.
Vark, G.N. van, 1970. A tentative investigation on the skeletal remains. *Palaeohistoria* 14, pp. 288-294.
Waterbolk, H.T., 1961. Beschouwingen naar aanleiding van de opgravingen te Tritsum, gem. Franekeradeel. *It Beaken* 23, pp. 216-226.
Waterbolk, H.T. & J.W. Boersma, 1976. Bewoning in vooren vroeghistorische tijd. In: W.J. Formsma *et al., Historie van Groningen, stad en land.* Groningen, pp. 13-74.
Wendt, W., 1978. *Untersuchungen an Skelettresten von Hunden* (= Berichte über die Ausgrabungen in Haithabu 13). Neumünster.
Zawatka, D. & H. Reichstein, 1977. Untersuchungen an Tierknochenfunden von den römerzeitlichen Siedlungsplätzen Bentumersiel und Jemgumkloster an der unteren Ems (Ostfriesland). *Probleme der Küstenforschung im südlichen Nordseegebiet* 12, pp. 85-128.
Zeist, W. van, 1974. Palaeobotanical studies of settlement sites in the coastal area of the Netherlands. *Palaeohistoria* 16, pp. 223-372.

14. KEYWORDS

Europe, Groningen, Roman Iron Age, archaeozoological investigation, settlements, animal bones, food, bone objects, human skull fragments.

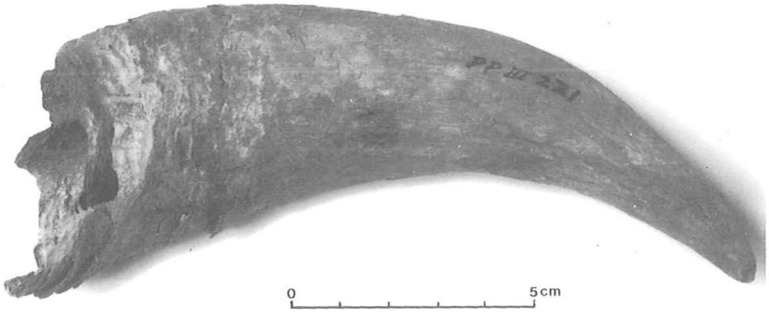

Fig. 8. The cattle horn found in Paddepoel III.

Fig. 9. Slaughtering marks on lumbar vertebrae. Left: the spinal column (find number PP III 218) where the *processus transversii* have been struck off; two unsuccessful chopping attempts are visible. Right: two separate *processus transversii* with cutting marks.

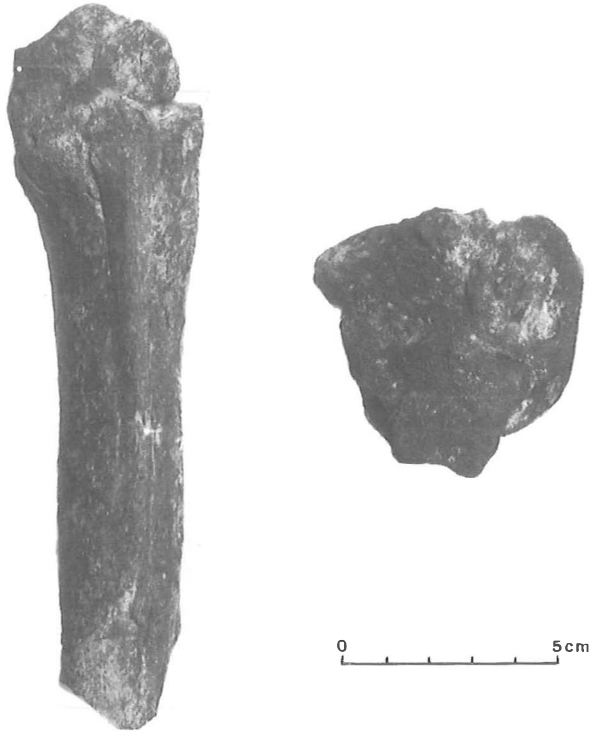

Fig. 10. Two horse bones showing deformation. Right: a right-hand astragalus, viewed from the side, fused with the calcaneus (find number PP III 253). Left: an inside view of a metacarpus, fused with tarsal bones (find number PP III 128).

Fig. 11. Above: a fragment of a bone of a whale that was probably used as a scraper. A burnt edge can be seen on the left-hand side. Below: a fragment of roe deer antler (find number PP III 208). The extremity of the fork displays cutting marks.

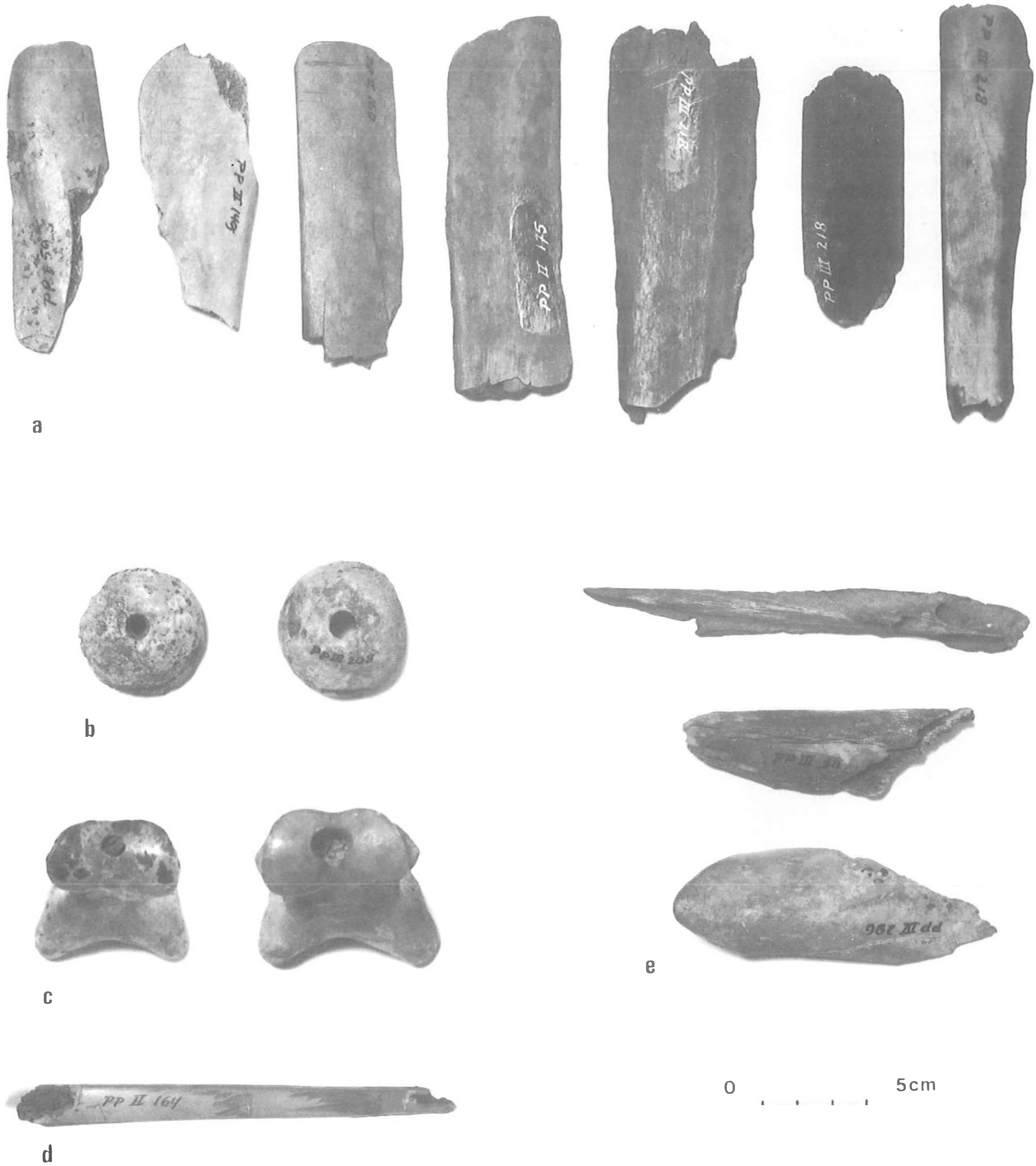

Fig. 12. a) Fragments of cattle rib with a high sheen and one or two rounded corners, perhaps scrapers; b) The two spindle whorls made from the caput of a cattle femur, photographed from above (left: find number PP I 35; right: PP III 208); c) Two phalanges I of horse which may have been used for a game (left: find number PP I 2, right: PP I 46). In the phalange (right) there is a small piece of bone in the round hole; d) Fragment of cattle rib with a smooth surface and some cuts; e) Three awls made from pieces of bones. The bones utilised are (from top to bottom): a nasal bone (find number PP II 164), a radius and a humerus of cattle.

Fig. 13. An astragalus of cattle which displays a worn patch on the left, distally (find number PP I 53).

Fig. 14. Three highly polished metapodia, used perhaps in the tanning of leather or in weaving. From left to right: two specimens of horse metatarsus and a cattle metatarsus.

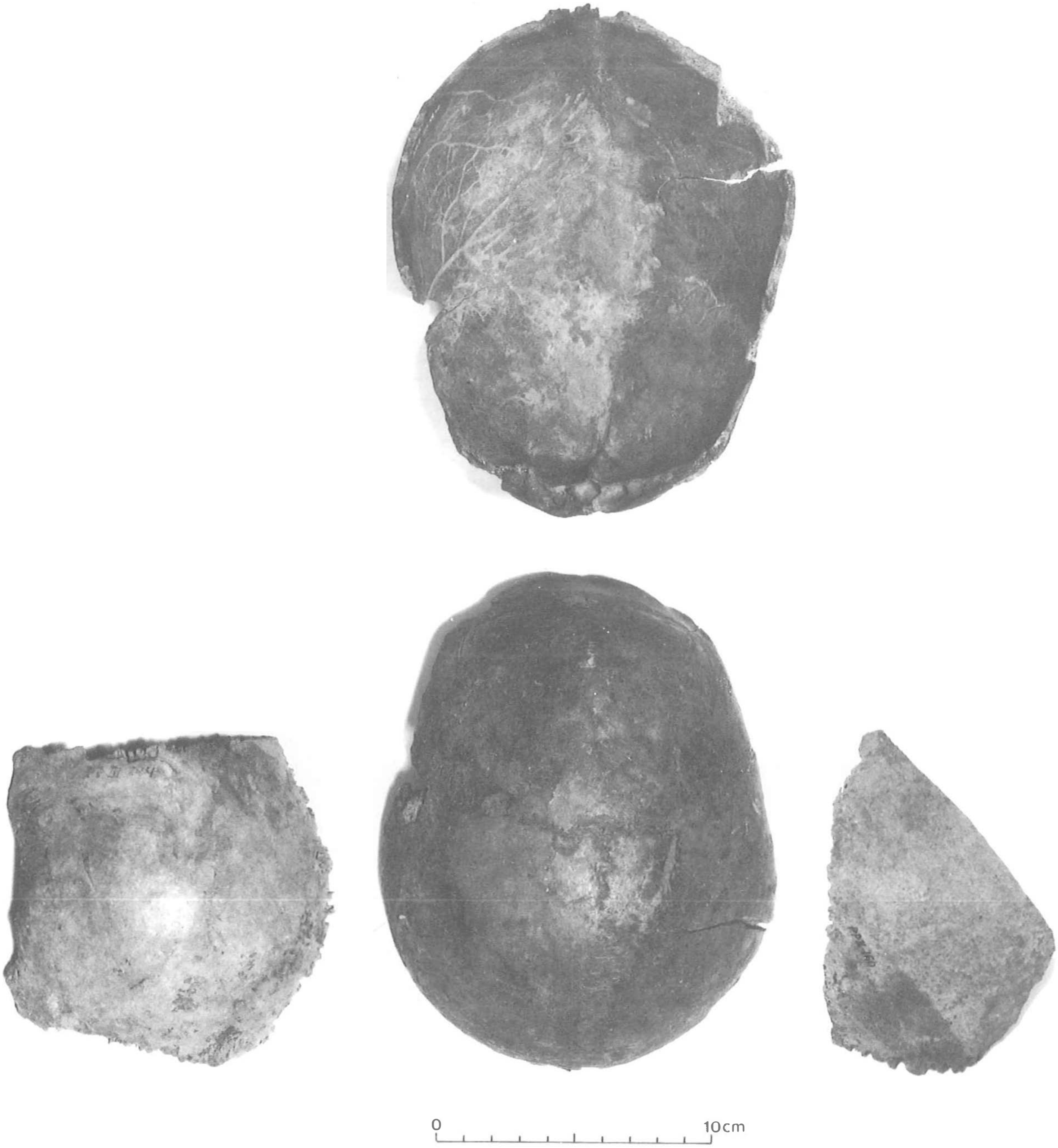

Fig. 15. Above: the inner side of the worked human skull (find number PP III 244). Below: the outer side of the three human skull fragments that were found. The skull in the middle is the worked one. From left to right: find numbers PP III 244, PP III 244 and PP II 160.

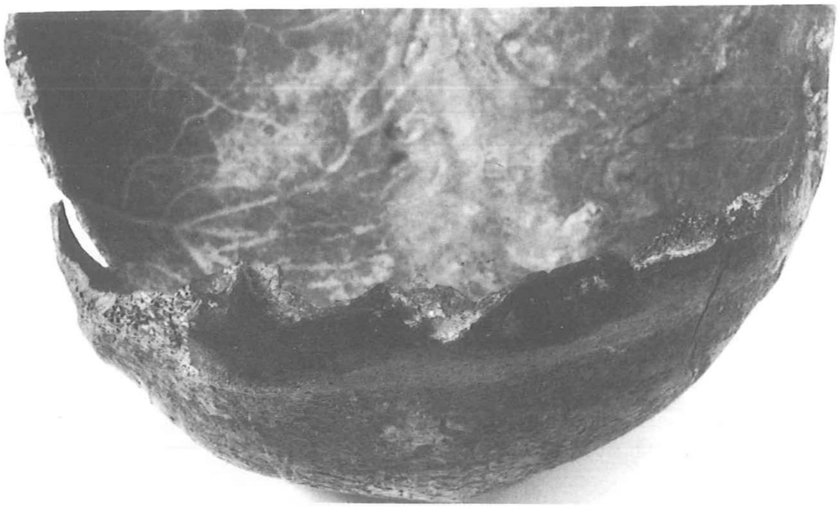

Fig.-16. A detail of the burnt edge of the worked human skull with the eyebrows in front.

Fig. 17. A detail of the highly polished human lower jaw (find number PP III 223), in which (on the left) there are two foramen instead of the usual one.