ANIMAL BONES FROM A PRE-ROMAN IRON AGE COASTAL MARSH SITE NEAR MIDDELSTUM (PROVINCE OF GRONINGEN, THE NETHERLANDS)

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ABSTRACT: A study was made of the animal bone remains from the pre-Roman Iron Age settlement site of Middelstum-Boerdamsterweg, occupied approximately between the 6th and the 4th/3rd centuries BC. Abundant remains of cattle were found, as well as smaller quantities of bones of sheep, pig, horse and dog, while wild animal species, including grey seal, red deer, wild duck and sea eagle, were represented by very small numbers of bones.

KEYWORDS: Iron Age, Middelstum-Boerdamsterweg, northern Netherlands, animal bones, coastal marsh site, *terp* settlement.

1. INTRODUCTION

In the years 1970-1973 large-scale excavations were carried out by the Biologisch-Archaeologisch Instituut (B.A.I.), University of Groningen, near the village of Middelstum, which lies about 15 km north of the city of Groningen, in the northern Netherlands (see fig. 1). The excavation area, situated on the west side of the road known as the Boerdamsterweg, had been the site of clay-winning operations carried out in 1969 by a local brick-making company. It had turned out that at this spot there was hardly any clay present that was suitable for industrial exploitation; instead the area was found to consist of earth containing abundant potsherds and animal bones, indicating the former presence here of an occupied site, probably a settlement on a (low) dwelling mound (in Dutch: a *terp* or *wierde*). Such dwelling mounds are characteristic of the marine clay area of the provinces of Groningen and Friesland in the northern Netherlands, and in the adjacent part of the coastal region of northern Germany. The Middelstum-Boerdamsterweg site (henceforth called the Middelstum-Bw site) had been covered over by younger clay deposits as a result of marine transgressions post-dating the occupation, and had therefore disappeared from view until it was discovered quite by chance.

A total area of 5-6 hectares was excavated by the B.A.I., under the direction of J.W. Boersma. A brief description of the excavation is given by Boersma (1983). Some further details of the results of the excavation and a discussion of the function of the site are presented by van Gijn and Waterbolk (1984) and by Waterbolk (1988). Flint tools from the Middelstum-Bw site have been described by Boersma (1988) and Stapert (1988). A study of the plant remains from the Middelstum-Bw site has been made by van Zeist (1989). Although the interpretation of the site as presented by Boersma (1983) is provisional, sufficient information has been obtained to enable us to trace the overall development of the settlement at this spot. It was found that the settlement had been situated on levees along the southern side of a former tidal creek that flowed in a NW direction through the excavation area. At the time when the site was occupied it lay in the area of extensive salt marsh along the north coast of the Netherlands, bordering the shallow waters of the Wadden Sea (it was not until the Middle Ages that dikes were first built in this region, permitting reclamation of the land and permanent settlement). In post-glacial times, this area of extensive salt marsh emerged around 600 BC, after the Dunkerque IA transgression phase (Roeleveld, 1974). It was then that the area became accessible for human occupation for the first time, and the Middelstum-Bw site appears to have been one of the earliest occupied sites in the coastal marshes. A number of ^{14}C dates have been obtained for the site (see Lanting & Mook, 1977), but it is not possible to convert all of these ^{14}C dates into reliable absolute dates (Boersma, 1988). At the time when it was occupied, the site lay close to the estuary of the former river Fivel, that flowed from the higher sandy area of Drenthe (situated further south) northwards into the Wadden Sea (see Kooi, 1988: fig. 1).

From the excavation of the Middelstum-Bw site it is evident that three phases of occupation can be

discerned:

Phase	Approximate date
1	6th century BC
2	5th century BC
3	4th/3rd century BC

The earliest phase (1) is represented by three spatial concentrations (1a, 1b and 1c) of structures within the excavation area, all of which were built directly on the marsh surface, thus constituting a so-called *Flachsiedlung*. The eastern concentrations 1 a and 1b are represented by a large 'granary' and by a well-built farmhouse with a few small 'granaries', respectively. The western concentration 1c is represented by a few simply built small houses and a few small 'granaries'; these small houses appear to have annexes which may have been used for penning livestock, for example. The concentration 1c subsequently developed into a low *terp* (dwelling mound), of about 1 hectare in extent, that represents phases 2 and 3 of the settlement. During phase 2 a large number of 'granaries' are present around the perimeter of the *terp*, while a few small, simple houses are situated around a well in the centre of the *terp*. At this stage the *terp* is surrounded by a circular ditch, that is connected with a more extensive system of ditches around the *terp*. No traces of any buildings have remained from phase 3, on account of soil disturbance and poor conditions for preservation. The occupation comes to an end in the 4th/3rd century BC, probably as a result of marine flooding during the Dunkerque IB transgression. Simplified ground-plans of the settlement sites in phases 1 and 2 are shown in figures 2 and 3, respectively.

In the course of the excavation animal bone material was collected by hand. Unfortunately no sieving was carried out. Much of the bone material came from a stratified context and could thus be attributed specifically to phase 1, 2 or 3.

2. METHOD

The animal bone material from the Middelstum-Bw site was sorted according to phase. A high proportion of the bones came from a clearly stratified context (i.e. attributable to phase 1, 2 or 3), while a substantial proportion came from a roughly stratified context (phases 1-2, 2-3, 1-3). Some other animal bone material had been collected from an unstratified context (isolated finds) during the excavation. All of these categories of bones were examined and identified as far as possible with reference to the comparative collection of skeletal material at the B.A.I.

The animal bones from a clearly stratified context (phases 1, 2 and 3) were studied in detail: data were recorded from each separate identified bone or bone fragment according to the 'Knocod' system for processing data on faunal remains from archaeological sites, as developed by Uerpmann (1978) and modified for use at the B.A.I. by W. Prummel. Measurements of these bones were taken whenever possible, using conventional hand-operated callipers, according to the manual of von den Driesch (1976).

The other categories of animal bones, from a roughly stratified or unstratified context, were examined and identified as far as possible, but were not included in the detailed data processing.

A small number of human bones were identified among the bone material. These were set aside and are disregarded here.

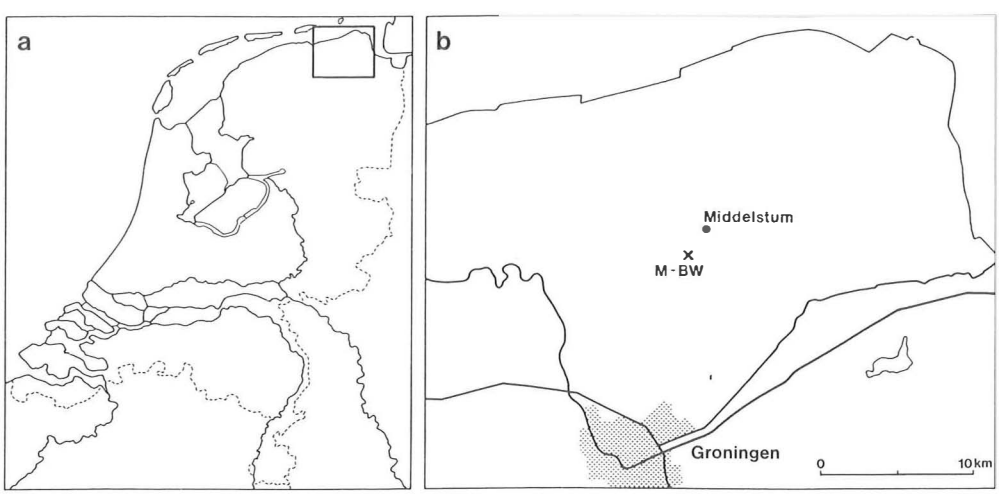

Fig. 1. Location of the site of Middelstum-Bw site.

Fig. 2. Ground-plan of Middelstum-Bw site in phase 1 (after Boersma, 1983: fig. 1).

3. RESULTS

3.1. General remarks

A total quantity of 265.3 kg of animal bone material was obtained from the excavation at the Middelstum-Bw site, of which 56% (by weight) came from a clearly stratified context (i.e. from phase 1, 2 or 3; see table 1).

On account of the extreme degree of fragmentation of the bone material, a large proportion was unidentifiable. The total number of identified bones for the separate phases 1, 2 and 3 amounted to 2560, whereas the corresponding number of unidentified bone fragments was c. 1200, accounting for 7% of the total weight (see table 2).

The distribution of identified animal bones according to species in terms of numbers and in terms of weight for the separate phases 1, 2 and 3 is shown in tables 3 and 4. From these tables it can be seen that in all three phases cattle represent by far the most abundant species, while the other animal species occur in much lower percentages. Among the rest of the bone material, from a roughly stratified or unstratified context, the same pattern of species distribution was found to prevail, with cattle clearly predominating. Also the unidentified bone material of all the categories of bone material undoubtedly comes from cattle for the most part, in

Table 1. Middelstum-Bw. The weights of animal bone material from the excavation.

Phase	Weight (kg)	Percentage
Clearly stratified context		
1	50.62	
2	41.26	
3	57.00	
Total	148.88	56%
Roughly stratified context		
1-2	22.75	
2-3	15.00	
1-3	34.45	
Total	72.20	27%
Unstratified context		
	44.25	17%
Total weight	265.33	

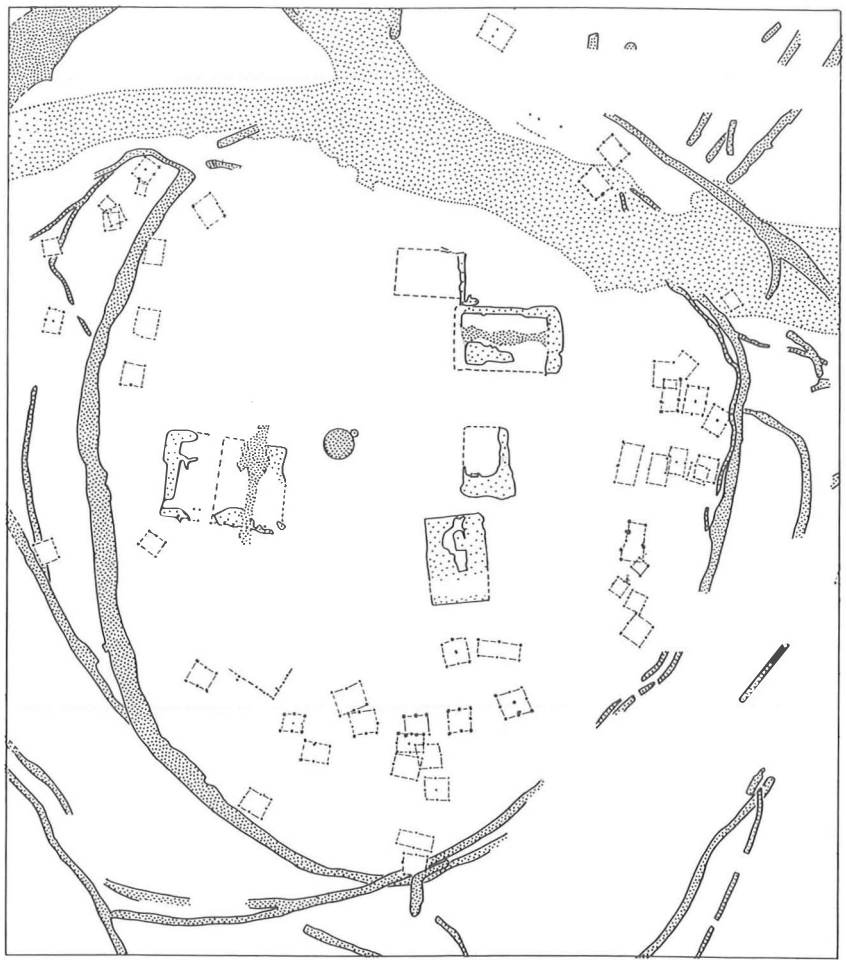

Fig. 3. Ground-plan of Middelstum-Bw site in phase 2 (after Boersma, 1983: fig. 2).

Table 2. Middelstum-Bw. The relative proportions of identified and unidentified bones for the separate phases 1, 2 and 3.

	Phase 1	Phase 2	Phase 3	Total	Overall percentage
Identified bones					
Number	911	680	969	2560	68%
Weight (g)	46,395	38,715	53,300	138,410	93%
Unidentified bones					
Number	c. 500	c. 200	c. 500	c. 1200	32%
Weight (g)	4225	2550	3700	10,475	7%

view of the size and appearance of these bone fragments.

The distribution of skeletal parts identified for each animal species represented in the separate phases 1, 2 and 3 is shown in tables 5-7 respectively.

It is presumed that most of the animal bone material represents butchery refuse, certainly in the case of cattle, sheep/goat and pig. To what extent the extreme fragmentation of the bone material is due to butchery techniques (the deliberate smashing of bones) or to cooking processes is uncertain. Cut marks were found to be present on a small number of cattle bones, and on a few bones of sheep/goat. Traces of burning were observed very occasionally, notably on bones of cattle, sheep/goat and grey seal.

The measurements that could be taken of animal bones for phases 1, 2 and 3 are given in the Appendix, at the end of this article.

3.2. Cattle (*Bos taurus*)

As we have seen, cattle represent by far the most abundant species in all three phases of the settlement. All of the bovine remains were identified as domesticated cattle. Nearly all parts of the bovine skeleton were represented in all three phases (see tables 5-7).

The remains of cattle skulls show no evidence of the presence of any hornless or polled cattle. The horn cores fall into the categories of short horned and medium horned cattle as defined by Armitage and Clutton-Brock (1976) on the basis of horn core length. For all three phases the better preserved horn cores exhibited curvature and slight upward torsion, indicating that they probably came from cows (Armitage & Clutton-Brock, 1976). A few distinctly large fragments of bases of horn cores probably came from bulls. Occasionally distinct cut marks could be seen near the base of the horn core, indicating that the horn had been purposely removed.

Most of the cattle bones were from adult or subadult animals (although it must be remembered that differential preservation probably accounts for some over-representation of these older age categories). To get an idea of the age distribution of the cattle represented by the bone remains, we can ascertain the age at the time of death for the mandibulae, loose teeth and the long bones with epiphyses, on the basis of age data given by Habermehl (1975). These data are presented in tables 8 and 9, for phases 1, 2 and 3. It can be seen from these tables that during all three phases subadult/adult animals (2 years and older) account for a much higher proportion of the bones than younger animals.

The withers heights of the cattle from phases 1, 2

Table 3. Middelstum-Bw. The distribution of animal bones in terms of numbers of identified bones for each species for the separate phases 1, 2 and 3. * = including the incomplete skeleton of one individual, consisting of 33 bones; ** = the incomplete skeleton of one individual.

Species	Phase 1	Phase 2	Phase 3	Total	Percentage of total
Cattle	814	548	869	2231	87
Sheep	8	42*	9	59	2
Sheep/goat	37	31	46	114	4.5
Pig	19	4	8	31	1
Horse	24	21	24	69	2.5
Dog	7	32**	10	49	2
Grey seal	1	-	-	1	< 1
Red deer	-	1	2	3	< 1
Wild duck	1	-	1	2	< 1
Sea eagle	-	1	-	1	< 1
Total	911	680	969	2560	

Table 4. Middelstum-Bw. The distribution of animal bones in terms of weight of identified bones for each species for the separate phases 1, 2 and 3. Weight in g.

Species	Phase 1	Phase 2	Phase 3	Total	Percentage
Cattle	42,320	33,710	48,350	124,350	90%
Sheep	220	390	205	815	< 1%
Sheep/goat	440	520	695	1,655	1%
Pig	375	135	170	680	< 1%
Horse	2,915	3,405	2,680	9,000	6.5%
Dog	110	485	405	1,000	< 1%
Grey seal	10	-	-	10	< 1%
Red deer	-	60	790	850	< 1%
Wild duck	5	-	5	10	< 1%
Sea eagle	-	10	-	10	< 1%
Total				138,410	

Table 5. Middelstum-Bw. The distribution of skeletal elements identified for each animal species in phase 1.

Skeletal element	Cattle	Sheep	Sheep/ goat	Pig	Horse	Dog	Grey seal	Wild duck
Antler	-	-	-	-	-	-	-	-
Horncore	23	-	-	-	-	-	-	-
Skull	28	-	-	1	1	1	-	-
Mandibula	137	-	2	5	4	2	-	-
Dentes	80	-	-	1	-	-	-	-
Hyoid	-	-	-	-	-	-	-	-
Atlas	4	-	-	-	-	-	-	-
Epistropheus	5	-	-	-	-	1	-	-
Other vertebrae	32	-	-	1	-	-	-	-
Ribs	39	-	3	-	-	-	-	-
Sternum	-	-	-	-	-	-	-	-
Scapula	53	-	4	-	-	-	-	-
Humerus	68	2	2	4	3	-	-	1
Radius	38	1	3	-	3	-	-	-
Ulna	8	-	1	-	-	1	1	-
Radius + ulna	1	-	-	-	-	-	-	-
Carpals	-	-	-	-	-	-	-	-
Metacarpals	47	-	1	-	1	-	-	-
Pelvis	41	-	4	-	2	-	-	-
Femur	39	4	4	6	1	-	-	-
Patella	1	-	-	-	-	-	-	-
Tibia	44	-	11	-	1	1	-	-
Astragalus	23	-	-	-	-	-	-	-
Calcaneus	15	1	-	1	1	1	-	-
Other tarsals	8	-	-	-	1	-	-	-
Metatarsals	56	-	2	-	3	-	-	-
Metapodials (indet.)	8	-	-	-	-	-	-	-
Phalanx (I,II or III, fore- or hind-limb)	16	-	-	-	3	-	-	-
Totals	814	8	37	19	24	7	1	1

Table 6. Middelstum-Bw. The distribution of skeletal elements identified for each animal species in phase 2. * = Including the incomplete skeleton of one individual, consisting of 33 bones; ** = the incomplete skeleton of one individual.

Skeletal element	Cattle	Sheep	Sheep/ goat	Pig	Horse	Dog	Red deer	Sea eagle
Antler	-	-	-	-	-	-	1	-
Horncore	14	2	-	-	-	-	-	-
Skull	62	7	2	-	1	-	-	-
Mandibula	76	2	7	1	3	-	-	-
Dentes	45	2	-	-	2	-	-	-
Hyoid	1	-	-	-	-	-	-	-
Atlas	5	1	-	-	-	-	-	-
Epistropheus	-	-	-	-	-	-	-	-
Other vertebrae	32	5	1	-	-	13	-	-
Ribs	52	1	2	-	-	8	-	-
Sternum	-	-	-	-	-	-	-	-
Scapula	38	3	2	-	1	2	-	-
Humerus	40	4	1	1	-	2	-	-
Radius	16	4	3	1	1	1	-	-
Ulna	5	-	-	-	-	1	-	1
Radius + ulna	4	-	-	-	-	-	-	-
Carpals	1	-	-	-	-	-	-	-
Metacarpals	25	2	2	-	-	1	-	-
Pelvis	20	-	-	1	2	-	-	-
Femur	18	1	2	-	1	2	-	-

Table 6 (continued).

Skeletal element	Cattle	Sheep	Sheep/ goat	Pig	Horse	Dog	Red deer	Sea eagle
Patella	3	1	-	-	-	-	-	-
Tibia	29	2	6	-	3	1	-	-
Astragalus	9	1	-	-	2	-	-	-
Calcaneus	7	-	-	-	1	-	-	-
Other tarsals	2	-	-	-	-	-	-	-
Metatarsals	25	3	3	-	2	1	-	-
Metapodials (indet.)	6	1	-	-	-	-	-	-
Phalanx (I,II or III, fore- or hind-limb)	13	-	-	-	2	-	-	-
Totals	548	42*	31	4	21	32**	1	1

Table 7. Middelstum-Bw. The distribution of skeletal elements identified for each animal species in phase 3.

Skeletal element	Cattle	Sheep	Sheep/ goat	Pig	Horse	Dog	Red deer	Wild duck
Antler	-	-	-	-	-	-	2	-
Horncore	40	-	-	-	-	-	-	-
Skull	52	-	1	-	-	1	-	-
Mandibula	135	-	10	1	1	4	-	-
Dentes	81	-	4	-	5	-	-	-
Hyoid	-	-	-	-	-	-	-	-
Atlas	5	-	2	-	-	1	-	-
Epistropheus	6	-	-	-	-	-	-	-
Other vertebrae	73	-	3	-	1	-	-	-
Ribs	73	-	5	-	-	1	-	-
Sternum	1	-	-	-	-	-	-	-
Scapula	57	5	-	-	2	-	-	-
Humerus	42	2	-	2	2	-	-	1
Radius	32	-	4	-	2	-	-	-
Ulna	8	-	2	-	-	-	-	-
Radius + ulna	-	-	-	-	-	-	-	-
Carpals	2	-	-	-	-	-	-	-
Metacarpals	55	1	2	2	-	-	-	-
Pelvis	25	-	1	-	2	1	-	-
Femur	48	1	3	-	3	1	-	-
Patella	2	-	-	-	-	-	-	-
Tibia	40	-	7	3	4	1	-	-
Astragalus	14	-	-	-	-	-	-	-
Calcaneus	13	-	-	-	-	-	-	-
Other tarsals	1	-	-	-	-	-	-	-
Metatarsals	49	-	2	-	-	-	-	-
Metapodials (indet.)	5	-	-	-	2	-	-	-
Phalanx (I,II or III, fore- or hind-limb)	10	-	-	-	-	-	-	-
Totals	869	9	46	8	24	10	2	1

and 3 have been calculated on the basis of the measurement of the maximum length of complete metatarsals and metacarpals, according to the method of Matolcsi (1970), as recommended by von den Driesch and Boessneck (1974). (Although some doubts have been expressed recently about the suitability of metapodial bones for reliable withers height estimation, the measurements of metapodials were used here because of the lack of other long bones, and to facilitate comparison with data from other sites). The figures obtained are shown in table 10. The overall mean value of estimated withers height for the Middelstum-Bw cattle works out at 112.5 cm, with a total range of values varying from 105.2 to 123.3 cm. These figures are comparable to those from other pre-Roman Iron Age sites

Table 8. Middelstum-Bw. The age distribution of mandibulae and loose teeth of cattle for the separate phases 1, 2 and 3. Age categories based on Habermehl (1975).

Age category	Phase 1	Phase 2	Phase 3	Total phases 1, 2 and 3
Age distribution of mandibulae				
Infantile	0	0	1	1
Infantile/juvenile	0	0	1	1
Juvenile	0	0	4	4
Juvenile/subadult	1	3	4	8
Subadult	2	4	1	7
Subadult/adult	9	7	14	30
Age distribution of loose teeth				
Infantile	0	0	0	0
Infantile/juvenile	0	0	2	2
Juvenile	0	0	0	0
Juvenile/subadult	5	5	3	13
Subadult	5	0	0	5
Subadult/adult	67	36	73	176

Table 9. Middelstum-Bw. The degree of epiphysial fusion of long bones of cattle for the separate phases 1, 2 and 3. Age at which fusion occurs based on Habermehl (1975). f = No. of fused epiphyses; u = No. of unfused epiphyses.

Age at which fusion occurs (in modern cattle)	Epiphysis	Phases 1 f	1 u	2 f	2 u	3 f	3 u	Total phases 1, 2 and 3 f	Total phases 1, 2 and 3 u
12-15 months	Radius: prox.	23	1	16	1	13	2	52	4
15-18 months	Phal.II: prox.	0	0	3	0	1	1	4	1
15-20 months	Humerus: dist.	36	2	20	0	16	3	72	5
20-24 months	Phal.I: prox.	11	0	8	0	6	0	25	0
2-2.5 years	Tibia: dist.	12	2	10	3	9	7	31	12
	Metapodials: dist.	26	5	12	5	31	24	69	34
c. 3 years	Calcaneus: tuber c.	5	2	1	2	0	0	6	4
3.5 years	Femur: prox.	3	8	2	0	1	12	6	20
3.5-4 years	Humerus: prox.	4	2	3	0	7	3	14	5
	Tibia: prox.	2	3	6	1	4	11	12	15
	Femur: dist.	4	2	4	5	7	14	15	21
	Radius: dist.	5	6	1	1	3	3	9	10
	Ulna: prox.	2	0	0	0	1	1	3	

Table. 10. Middelstum-Bw. The estimated withers heights (in cm) of cattle for phases 1, 2 and 3, based on the maximum length measurements of metacarpals and metatarsals. The multiplication factors used are 6.15 for metacarpals and 5.45 for metatarsals (based on Matolcsi, 1970, as recommended by von den Driesch & Boessneck, 1974).

	Phases 1	2	3	Mean values for phase 1, 2 and 3 combined
Metacarpals	111.9 (range: 107.1-118.9, n = 5)	107.4 (range: 105.2-113.3, n = 4)	113.3 (range: 109.9-118.2 n = 9)	110.9 (range: 105.2-118.9, n = 18)
Metatarsals	112.2 (range: 110.7-112.9, n = 4)	111.7 (range: 111.2-112.1, n = 2)	118.1 (range: 112.3-123.3, n = 4)	114.0 (range: 110.7-123.3, n = 8)
Metacarpals + metatarsals				112.5 (range: 105.2-123.3, n = 26)

in the Netherlands (see section 4). The estimated withers heights for phase 3 at Middelstum-Bw are very slightly higher than for phases 1 and 2, but in view of the small size of the samples concerned no definitive conclusions can be drawn from this.

The cattle remains from Middelstum-Bw thus appear to represent a population of mostly adult or subadult animals, with younger animals also present. It appears that the animals were mostly slaughtered after they had attained maturity, and probably for consumption on the spot. There were no signs of greatly aged individuals, i.e. no excessive tooth wear or pathological deformities. Cut marks were present on a few cattle bones, and gnaw marks made by dogs were occasionally observed.

In all three phases of the settlement cattle are by far the most abundant species, with consistently high percentages throughout the entire period of occupation. There are no clearly discernible differences between the cattle remains from the different phases.

3.3. Sheep and sheep/goat (*Ovis aries* and *Ovis aries/Capra hircus*)

Bones of sheep and sheep/goat were present in all three phases of Middelstum-Bw (see table 3), as well as in the unstratified bone material. Some bones could be positively identified as sheep, on the basis of the distinguishing features described by Boessneck (1969). No bones could be positively identified as goat, however, so it is likely that most or all of the ovicaprid bones bones from Middelstum-Bw come from sheep. Various parts of the ovicaprid skeleton were represented in all three phases (see tables 5-7). No evidence was found of hornless animals.

If we assume that all the ovicaprid bones are of sheep, then this species is the second most abundant animal species at the site in terms of numbers of bones. It is impossible to discern any difference in the frequency of sheep or sheep/goat between the different phases, on account of the small numbers of bones identified. The sheep bones from phase 2 included the incomplete skeleton (33 bones) of one individual (subadult or adult) animal, in a relatively poor state of preservation.

Most of the ovicaprid bones appear to come from adult or subadult animals. Out of 13 mandibulae containing teeth, two were from juveniles or subadults, two from subadults and 9 from subadults or adults. The epiphysial fusion data for bones positively identifiable as sheep show a similar predominance of subadult or adult individuals (see table 11).

Table 11. Middelstum-Bw. The degree of epiphysial fusion of bones of sheep. Phases 1, 2 and 3 considered jointly. The incomplete skeleton of one individual sheep from phase 2 is excluded. The approximate ages at the time of fusion for modern sheep are based on Habermehl (1975) (after Duerst, 1926).

Approx. age at which fusion occurs (modern sheep)	Epiphysis	No. fused	No. unfused
3-4 months	Humerus: dist.	6	0
3-4 months	Radius: prox.	4	0
20-24 months	Metacarpus: dist.	1	0
c. 3 years	Calcaneus: tuber	1	0
3-3.5 years	Femur: prox.	5	0
c. 3.5 years	Humerus: prox.	1	0
c. 3.5 years	Radius: dist.	1	0
c. 3.5 years	Femur: dist.	2	0

Table 12. Middelstum-Bw. The estimated withers heights of sheep (phases 1, 2 and 3 considered jointly), based on the maximum length measurements of long bones. The multiplication factors are those given by Teichert (1975) for prehistoric and early historic sheep.

Skeletal element	(Mean) length (mm)	Multiplication factor	Estimated withers height (cm)
Scapula (n = 1)	149.2	4.22	63.0
Humerus (n = 1)	143.0	4.28	61.2
Radius (n = 1)	165.5	4.02	66.5
Metacarpus (n = 1)	128.4	4.89	62.8
Femur (n = 2)	177.6	3.53	62.7
Overall mean value			63.2

On the basis of the maximum length measurements of several complete sheep bones (one scapula, one humerus, one radius, one metacarpus and two femurs), it was possible to estimate the withers height using the multiplication factors given by Teichert (1975) for sheep in prehistoric and early historical times (see table 12). Considering all three phases jointly, the mean withers height for sheep worked out at 63.2 cm (range 61.2-66.5 cm, n=6). This figure falls within the range of values established for other pre-Roman Iron Age sites in the Netherlands (see Section 4).

Most of the ovicaprid bones from Middelstum-Bw were in a fragmentary state. On one skull fragment (from phase 2) cut marks were present, probably indicative of the intentional skinning of the animal.

3.4. Pig (*Sus domesticus*)

Small numbers of bones of pig were found in all three phases (see table 3). Various parts of the pig skeleton were represented by the bone remains. All of the pig bones evidently come from domesticated animals. Nearly all of the pig bones were in a fragmentary condition.

Among the fragments of pig mandibulae, two contain no teeth but apparently come from adult animals in view of their size; out of four mandibulae with teeth present one is from a subadult animal, while the other three are from subadult/adult pigs. The epiphysial fusion data from a total of 11 bone extremities are shown in table 13; here too a predominance of subadult/adult animals is evident.

On account of the absence of any complete long bones it was not possible to estimate any withers heights for pig.

A few chop marks are present on a mandibula fragment from phase 1.

A pig metatarsal bone with two perforations, from an unstratified context at Middelstum-Bw, is described below in section 3.11.

Table 13. Middelstum-Bw. The degree of epiphysial fusion of bones of pig. Phases 1, 2 and 3 considered jointly. The approximate ages at the time of fusion for modern pigs are based on Habermehl (1975).

Approx. age at which fusion occurs (modern pig)	Epiphysis	No. fused	No. unfused
1 year	Humerus: dist.	3	0
1 year	Radius: prox.	1	0
2 years	Metapodials: dist.	2	0
3.5 years	Humerus: prox.	0	1
3.5 years	Tibia: prox.	0	1
3.5 years	Femur: prox.	0	1
3.5 years	Femur: dist.	1	0

Table 14. Middelstum-Bw. The degree of epiphysial fusion of bones of horse. Phases 1, 2 and 3 considered jointly. The approximate ages at the time of fusion for modern horses are based on Habermehl (1975).

Approx. age at which fusion occurs (modern horses)	Epiphysis	No. fused	No. unfused
12-15 months	Metapodials: dist.	4	0
12-15 months	Phal.I: prox.	3	1
15-18 months	Humerus: dist.	2	0
15-18 months	Radius: prox.	3	0
by 2 years	Tibia: dist.	4	0
by 3.5 years	Humerus: prox.	2	0
by 3.5 years	Radius: dist.	1	0
by 3.5 years	Femur: prox.	2	0
by 3.5 years	Femur: dist.	1	0
by 3.5 years	Tibia: prox.	4	0

3.5. Horse (*Equus caballus*)

Bones of horse are present in consistently small numbers in all three phases of the Middelstum-Bw site, as well as in the unstratified bone material. Almost all of the horse bones were in a fragmentary state.

No horse mandibulae with teeth were available for age determination. A number of loose teeth from subadult or adult animals were present among the horse remains. The epiphysial fusion data for the horse bones are shown in table 14; from this table it can be seen that most of the horse bones came from subadult or adult animals.

From the length measurements of one tibia and one metatarsus it could be ascertained that these bones came from individuals falling into the categories *kleinwüchsig* (small to medium-sized: withers height range 128-136 cm) and *mittelwüchsig* (medium-sized: withers height range 136-144 cm), respectively, according to the classification of Vitt (1952), as recommended by von den Driesch and Boessneck (1974).

A few superficial cut marks were observed on one scapula and two pelvic bones of horse.

3.6. Dog (*Canis familiaris*)

Small numbers of dog bones are present in all three phases, as well as among the unstratified remains. All of the dog bones from phase 2 (32 in number) constitute the incomplete skeleton of one individual. The dog bones from phase 3 include an almost complete calvarium and one mandibula, both from the same animal.

All of the long bones of dog that were found had

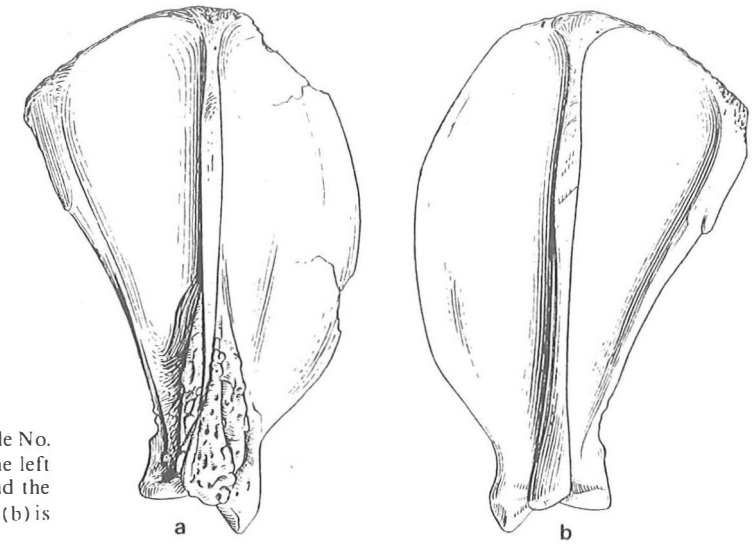

Fig. 4. The two scapulae of the dog skeleton (sample No. 433) from phase 2 of the Middelstum-Bw site. The left scapula (a) shows a pathological deformity around the spina and collum scapulae, while the right scapula (b) is normal.

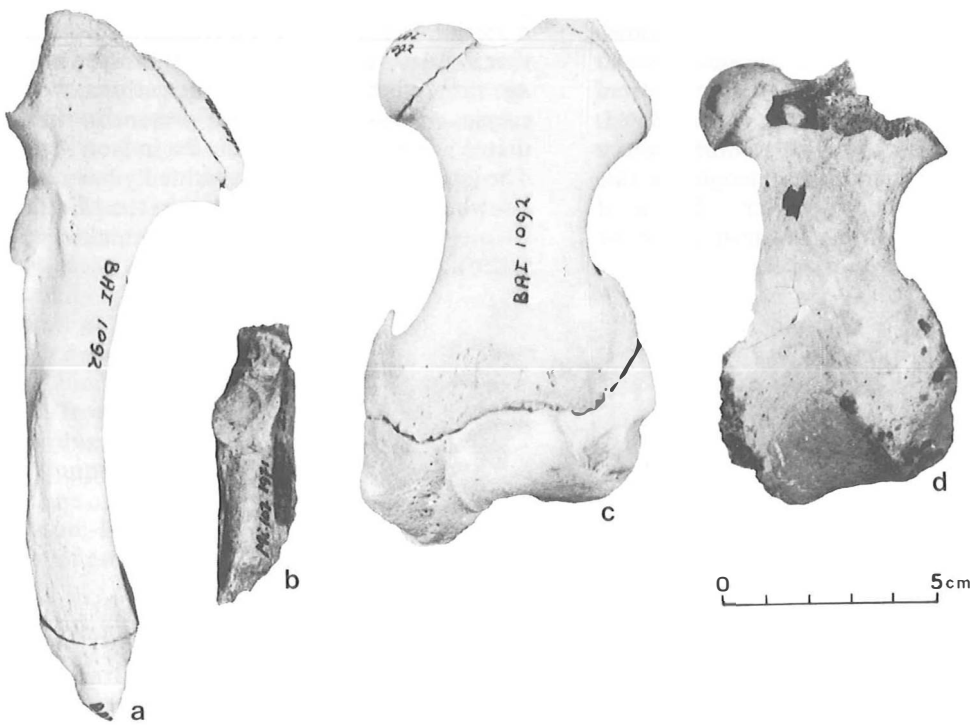

Fig. 5. A fragment of the left ulna of a grey seal (b) and an almost complete left femur of a grey seal (d) from the Middelstum-Bw site, shown next to corresponding bones (a and c) from a recent grey seal (B.A.I. collection).

closed epiphyses. All of the dog mandibulae with teeth present were from subadult or adult animals.

It was possible to estimate withers heights on the basis of length measurements of one femur and one tibia from phase 3: values of 54.4 cm and 52.3 cm were obtained, respectively, using the factors given by Harcourt (1974). Both of these values fall within the range for Iron Age dogs in Britain given by Harcourt, and also within the range established for dogs in the pre-Roman Iron Age period in the Netherlands (see section 4). The basal length of the dog skull from phase 3 also falls within the ranges

established for British and Dutch Iron Age dogs (see Harcourt, 1974, and Section 4). All of these bones, as well as those of the individual represented in phase 2, come from moderately large dogs.

The incomplete skeleton from phase 2 included several long bones that had evidently been broken through the middle intentionally. Of the two scapulae of this dog, the left one shows a pathological deformity around the spina and the collum scapulae, where a distinct thickening and malformation of bone tissue is visible (fig. 4). The development of this condition was probably preceded by the growth of a tumour in the adjacent soft tissues (pers. comm., Mr. J. Straatman, veterinary surgeon in Groningen).

3.7. Grey seal (*Halichoerus grypus*)

Two bones of grey seal were identified: a fragment of a left ulna from phase 1, and an almost complete left femur from an unstratified context (fig. 5). These bones have been previously described elsewhere by Clason (1988). The femur has both the proximal and distal epiphysis fused and thus comes from an adult animal; in view of its small size in comparison with the ulna of a recent male grey seal with incompletely fused epiphyses in the B.A.I. comparative collection, it probably comes from a female animal. The original total length of this femur will have been about 9.5 cm. Traces of burning are visible on this bone, suggesting that the flesh of the animal had been roasted.

Remains of grey seal have been found elsewhere in the sea clay region of the northern Netherlands, including Pingjum (Clason, 1988) and Marssum (van Giffen, 1913). The area of distribution of grey seal in northwestern Europe is concentrated in the coastal waters around Great Britain, Ireland, Iceland and Scandinavia; its usual habitat is a rocky coast, but it is known to frequent sandy estuaries and sandbanks as well. The grey seal does not breed in the Netherlands, but it is occasionally observed on sandbanks in the Wadden Sea region (Clason, 1988). Finds of grey seal bones have been made in several prehistoric sites in this region of the Netherlands, indicating that this species frequented the shores of the Wadden Sea also in former times. Seal meat has been eaten in many parts of Europe until comparatively recent times; especially the flippers are esteemed a delicacy (Clark, 1952 (1974)).

3.8. Red deer (*Cervus elaphus*)

Red deer is represented by a few finds of antler from phases 2 and 3, and from the unstratified bone material. In the case of two fragments it can be seen that these were antlers that had been shed naturally. As the red deer is predominantly a woodland species, it was probably not present in the immediate vicinity of Middelstum-Bw in Iron Age times. The (shed) antlers had undoubtedly been collected elsewhere and had been taken to the Middelstum-Bw site for use as a raw material for making tools or other artefacts.

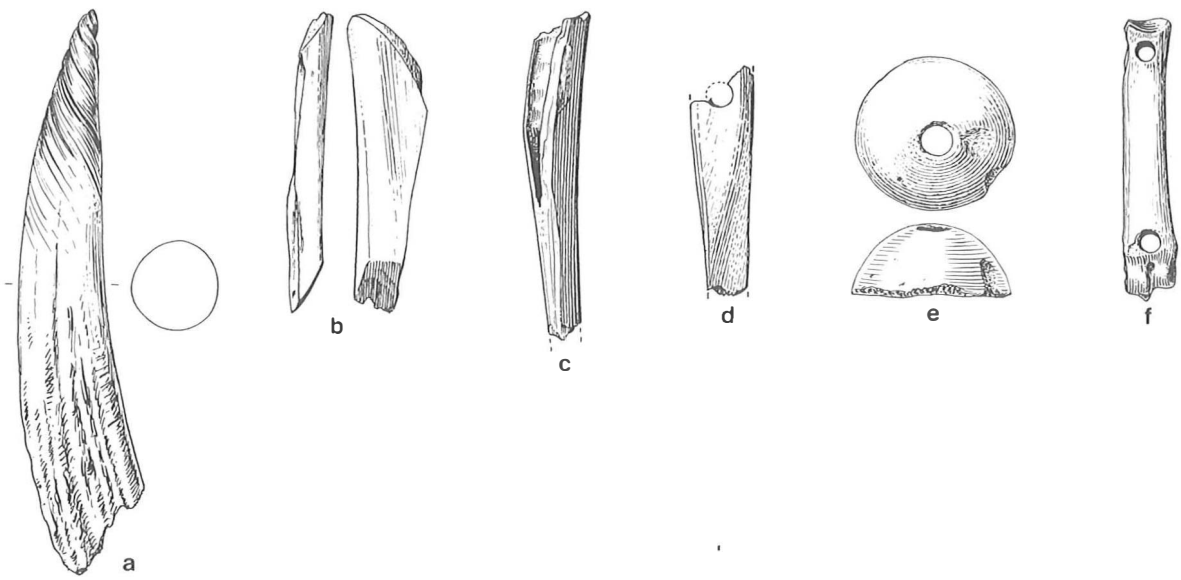

Fig. 6. Worked bone from the Middelstum-Bw site. a. antler tine of red deer with a spiral pattern of grooves near the tip; b, c, d. fragments of worked bone with a highly polished surface (fragment b is a bone chisel, fragment c a kind of gouge, while fragment d was an artefact of some kind broken through a perforation as shown); e. the perforated caput of a bovine femur, shown from above and in side view; f. the third metatarsus of a pig with a perforation at each end (a comes from phase 2; b-f are unstratified finds).

An antler tine from phase 2 (a fragment measuring about 15 cm in length; see fig. 6) shows a distinct pattern of spiral grooves near the tip, indicating that it had been used for some special purpose. Also distinct cut marks can be seen on an antler fragment from phase 2, showing that this fragment had been cut off using a sharp instrument.

3.9. Birds

Only a few bird bones were found at the Middelstum-Bw site. Birds may be underrepresented at this site because during the excavation bones were collected only by hand, with no sieving being carried out.

Two species of bird were identified: wild duck (*Anas platyrhynchos*) and sea eagle (*Haliaetus albicilla*) (also known as the white-tailed eagle).

Wild duck is represented by the find of one humerus from phase 1 and one humerus fragment from an unstratified context. This species is present in large numbers throughout the year in the Netherlands, and it was certainly consumed on a wide scale in prehistoric and historical times.

The sea eagle bone identified from Middelstum-Bw was the proximal fragment of an ulna. At the present time the sea eagle is a resident species over a wide area in eastern Europe and around the coasts of Scandinavia; it is an occasional winter visitor to the Netherlands. It normally frequents rocky coasts, large lakes and rivers in forested and other wild country (Heinzel et al., 1972 (1984)). Nowadays it is occasionally observed in the province of Groningen (Boekema et al., 1983). In former times it was probably a more common species in northwestern Europe. Finds of sea eagle bones have also been reported from other Iron Age *terp* sites such as Oosterwijtwerd (van Giffen, 1913) and Tritsum (Clason, unpublished).

Only one other bird bone was present among the Middelstum-Bw material, namely the shaft of the humerus of an unidentified species, from phase 3.

3.10. The rest of the bone material

As for the unstratified and roughly stratified bone material (i.e. not attributable specifically to phase 1, 2 or 3), a similar pattern of species distribution was found to occur as with the clearly stratified material, with the same species being represented (apart from the sea eagle, which was absent). Among these remains cattle was by far the most frequently occurring species, with bones of sheep/goat, pig, horse and dog occurring in small numbers, while grey seal and wild duck were each represented by one bone only (see above). Most of the unstratified and roughly stratified material was fragmented to a very considerable degree, with a high proportion of unidentifiable fragments. In view of their size and shape most of these fragments almost certainly come from cattle.

3.11. Worked bone

An antler tine with a spiral pattern of grooves near the tip has been mentioned above (section 3.8). In addition to this, among the unstratified bone remains from Middelstum-Bw, a total number of five worked bones or bone fragments were found (fig. 6). These consist of three fragments of bones with a highly polished surface and traces of working, including one with a perforation, through which the bone has broken, as well as the epiphysis of the caput of a femur (probably bovine) with a hole drilled through the middle, and a third metatarsus of a pig with two holes drilled through it, one at each end. The perforated caput of a femur may have been used as a spindle whorl, for example. Two similar bones have been found in the Iron Age *terp* site of Paddepoel (Knol, 1983). Knol mentions that these may be spindle whorls, for spinning wool or flax, or alternatively parts of a harness. Roes (1963) mentions that a number of such heads of bovine femurs have been found in *terpen* in Friesland, some of them decorated. She considers them to be spindle whorls. It is not clear what the perforated pig metatarsus could have been used for; pig metatarsal bones with a single perforation in the middle, known from Iron Age sites in Great Britain, have been interpreted as toggles (for fastening clothing) or toys (MacGregor, 1985).

In addition, a number of cattle metapodial bones were observed to have very shiny surfaces; these may have been used for some special purpose (see also Knol, 1983).

4. DISCUSSION

The animal bones from the Middelstum-Bw site indicate that the people who lived here in the pre-Roman Iron Age exploited the rich natural pastures of the salt marshes by keeping herds of cattle and sheep. The high proportion of cattle bones reflects the importance of cattle in the economy. Sheep were kept in smaller numbers, while pigs represented a small proportion of the livestock. Cattle will have provided meat, milk and traction power, as well as other products like hides and horn. Sheep will have been kept for their meat, milk and wool. The small numbers of pigs kept were probably fed on household scraps; these pigs will have been raised as a source of meat. Horses were probably kept primarily for riding or as beasts of burden. Their flesh was probably eaten, although it is unlikely that horses were deliberately slaughtered, unless old or infirm,

in view of their high prestige value. Dogs will have been useful in guarding the homesteads and for herding livestock. The very low proportion of bones of wild mammals and birds and the absence of fish at this site suggests that these animals played a relatively unimportant role in the economy.

The frequency of occurrence of the different animal species represented by the bone remains shows a consistent pattern throughout the three phases of occupation that have been discerned. The age spectra of cattle, sheep and pig indicate that these animals were mostly slaughtered after they had reached maturity. Slaughtering of these meat-providing species was probably carried out at the settlement, in view of the presence of most parts of the skeleton at the site. It is presumed that the meat was thus consumed locally.

The withers heights estimated for cattle, sheep, horse and dog at Middelstum-Bw are of a similar order of magnitude as those estimated for other pre-Roman Iron Age sites in the Netherlands, including Spanjaardsberg (Clason, 1967), Culemborg and Tritsum (Clason, unpublished). The values for withers heights of these animals at Middelstum-Bw are comparable to the corresponding values estimated for Paddepoel, also a *terp* site in the province of Groningen, dating from c. 200 BC-AD 250. The animal bones from Paddepoel have been studied by Knol (1983); the reader is referrred to his article for details of values for withers heights of these animal species at Paddepoel as compared to other sites in the coastal region of the northern Netherlands and the adjacent part of northwestern Germany.

The *terp* sites of the coastal region of the northern Netherlands were first studied in detail by van Giffen, who collected animal bones from a number of *terpen* in the provinces of Groningen and Friesland in the early part of this century. His study of the bones of wild animals found in these *terpen* formed the subject of his doctoral thesis, which was published in 1913. An appraisal of the work of van Giffen as archaeozoologist has been presented by Clason (1983). In 1932 Reitsma published an article on sheep of the *terpen*. In 1963 a study appeared by Roes on bone and antler objects from *terpen* in Friesland. In 1970 a small book about the *terpen* appeared, with contributions by members of the B.A.I., including a chapter by Clason on the animals kept and hunted in former times by the *terp* dwellers. During the last few years a great deal of attention has been devoted to the archaeological study of settlements in the *terpen* region, as is evident from the recently published book *Terpen en wierden in het Fries-Groningse kustgebied* (edited by Bierma et al., 1988). In addition to the archaeozoological articles in this book (by Brinkhuizen, Clason, Prummel, Schelvis, and Zeiler), in recent years articles have been published on animal remains from the *terpen* region by Knol (1983) and by Milojković and Brinkhuizen (1984). Unpublished work on the fauna of the *terpen* include the notebooks of van Giffen, consisting mainly of records of numbers of bones of domesticated animals from various *terpen* of Groningen and Friesland, and a study made by Clason of animal bones from the *terp* site of Tritsum (referred to in Clason, 1975).

The results of the study of the animal bone remains from Middelstum-Bw fit in well with our knowledge of the animal life of the *terpen* in prehistoric and early historical times as based on the studies mentioned above. The species distribution at Middelstum-Bw is typical of the *terpen* region as whole, not only in the Iron Age but in later periods also. The great importance of cattle in the economy is clearly evident. Flocks of sheep were kept throughout the region, in addition to small numbers of pigs. The opportunities for grazing cattle and sheep provided by the extensive salt marshes must have been recognized at an early date after this region became accessible around 600 BC.

The first settlers of the salt marshes of Friesland and Groningen who arrived around 600 BC are presumed to have come from the higher sandy region of Drenthe, situated further south. Van Gijn and Waterbolk (1984) put forward the view that the coastal salt marsh region became colonized by the inhabitants of the Drenthe plateau at a time when the economic potential of their own territory was diminishing as a result of sand-drifting, peat formation and soil exhaustion, possibly coinciding with a population explosion. Roeleveld (1974) is of the opinion that overpopulation alone is a sufficient explanation for the migration to the coastal area as soon as new lands emerged there. Van Gijn and Waterbolk suggest that there may have been a transhumant prelude to this colonization process, during which the salt marshes were used as grazing grounds during the summer only, when these clay regions were more easily accessible. With this idea in mind, they tentatively interpret the first phase of the site of Middelstum-Bw as a summer encampment for herdsmen. In their view, cattle that had been grazed on the marshlands in the summer would have been slaughtered upon the return of the herdsmen, together with their herds, to the upland plateau in the autumn. Yet we have seen from the study of the animal bones at Middelstum-Bw that remains of cattle, presumably of slaughtered animals, are abundantly present in phase 1 already, suggesting that the animals were slaughtered and consumed on the spot. This is suggestive of a kind of settlement of a more permanent nature than a summer encampment. Van der Waals (1987) has pointed out that the presence of what appear to be granaries in the phase 1 of the Middelstum-Bw site

argues against the view that this first phase of the settlement represents a summer encampment for herdsmen. Van der Waals (1987) has taken an ethno-archaeological approach to make a critical assessment of the views proposed by van Gijn and Waterbolk (1984), which will be discussed further below.

The information provided by the animal bones of Middelstum-Bw does not show evidence of any great differences between the three phases of occupation. This suggests that animal husbandry was practised in essentially the same way throughout the entire period of occupation.

In view of the evidence provided by the animal bones of Middelstum-Bw a prelude of summer pasturing prior to the colonization of the marshlands, if it did occur at all, must have been of relatively short duration. Only then would such a phenomenon be undetectable in the animal bone spectrum of phase 1.

Phase 2 of the occupation of the Middelstum-Bw site is represented by a low *terp*. The *terp* area, that was enclosed within a circular ditch, contained many small 'granaries' around the perimeter and a few small houses around a well in the centre. Boersma (1983) and Waterbolk (1988) emphasize the rather unusual nature of these houses compared to other house ground-plans of this period in the northern Netherlands, inasmuch as the houses of phase 2 of Middelstum-Bw do not appear to have a byre area for stalling cattle. Waterbolk suggests that this site at Middelstum-Bw may have functioned as a special place for penning cattle, serving as a depot or regional centre for the safekeeping of livestock, in which respect it may be comparable to prehistoric sites elsewhere that clearly had a central function of regional importance, like British Iron Age hillforts. Waterbolk (1988) also suggests that the site may have had a special kind of religious function in this period, in view of the remarkable find at Middelstum-Bw of a fragment of an earthenware mask, representing a human face (illustrated by Boersma, 1983: fig. 3). The possibility of the use of the site for religious practices such as sacrificing animals cannot be excluded, but there is no positive evidence of this from the faunal remains.

During phase 2 at least, the inhabitants of the Middelstum-Bw site may have practised agriculture in addition to stock-breeding, in view of the finds of grains of barley and emmer wheat studied by van Zeist (1989). In his article van Zeist discusses the possibility of growing food crops in an unprotected salt-marsh environment. He regards the presence at Middelstum-Bw of grains of emmer wheat in particular as being possibly indicative of a supply of agricultural produce coming from the sandy soils of Drenthe, further south, seeing that emmer wheat does not thrive in a brackish environment. The many 'granaries' of phase 2 could have been used for storing such agricultural produce.

Although no traces of any buildings have remained from phase 3 of the occupation, in view of the similarity between the animal bone material from this phase and that from the two preceding phases it is assumed that the inhabitants of this site continued to lead the same way of life as their predecessors, until occupation finally became impossible due to the onslaught of the sea.

The relevance of the site of Middelstum-Bw to our understanding of the colonization of the coastal marsh region of the northern Netherlands in the pre-Roman Iron Age has been discussed by van der Waals (1987). Although van der Waals accepts the possibility of a transhumant prelude in the Early Iron Age as proposed by van Gijn and Waterbolk (1984), he rejects the idea that the early settlers of the coastal marshes carried out trade based on a surplus production of animal products (i.e. hides, meat and dairy products) that he considers to be implicitly suggested by van Gijn and Waterbolk in their article. Van der Waals regards the inhabitants of the *terpen* region in the pre-Roman Iron Age as representative of a tribal level of social organization, at which level organized trade in surplus products does not occur. In his opinion the first settlers from the plateau of Drenthe probably practised the mixed farming economy with which they were familiar in their original home territory, while later on environmental factors (the succeeding transgressive phase) may have enforced a shift to a pastoral economy. Van der Waals expresses this viewpoint within the context of what he calls an ethno-archaeological approach. Waterbolk (1987a), however, finds the use of the term 'ethno-archaeological' by van der Waals inappropriate in this case. The idea of a tribal, unstratified level of social organization in the northern Netherlands in the pre-Roman Iron Age is rejected by Waterbolk, in view of the archaeological evidence for stratified societies (e.g. hillforts, oppida, rich metal industries, supraregional cultic centres) in surrounding regions of northern Europe, with which the northern Netherlands certainly had close contacts. Waterbolk (1987b), in his reinterpretation of the settlement site of Elp (in Drenthe) suggests that during the Bronze Age already a distinct pattern of territorial organization existed in Drenthe, which would signify a certain degree of complexity of social organization. Consequently the first settlers of the coastal marshes of the northern Netherlands, who presumably migrated there from the agrarian settlements of Drenthe, probably brought with them their tradition of some degree of social stratification.

It is clear that the interpretation of the site of Middelstum-Boerdamsterweg has prompted ques-

tions that have yet to be answered satisfactorily. In the meantime it is hoped that further studies of faunal remains from other sites in the coastal marsh region of the northern Netherlands will help us to gain more insight into the way in which the first settlers of this region in the pre-Roman Iron Age exploited the economic potential of their environment.

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APPENDIX: Measurements of the animal bones

Measurements were taken according to von den Driesch (1976). All measurements are expressed in mm. All measurements given are for phases 1, 2 and 3 combined, unless otherwise stated. All bones measured come from subadult or adult animals. Approximate measurements are given between brackets. M = mean; N = number of specimens measured; L = left; R = right.

	M	Min.	Max.	N
Cattle (*Bos taurus*)				
Horncores				
Max. diameter of base	53.0	38.0	73.0	47
Min. diameter of base	39.6	29.6	60.0	44
Circumference	149.5	110.0	210.0	42
Length of outer curve	164.8	120.0	207.5	18
Cranium				
Length of cheektooth row	124.5	-	-	1
Length of molar row	77.7	75.5	80.5	3
Length of premolar row	51.5	-	-	1
Mandibula				
Length of cheektooth row	132.9	128.0	137.8	3
Length of molar row	85.9	81.0	91.0	4
Length of premolar row	50.2	48.2	53.0	7
Length of diastema	78.9	74.7	83.8	4
Length from ramus to foramen mentale	294.0	290.0	298.0	2
Scapula				
Min. length of neck	45.7	34.0	57.0	45
Max. length of proc. articularis	62.5	53.0	76.5	47
Length of articular surface	50.2	41.0	60.0	47
Width of articular surface	43.5	32.5	55.7	45
Humerus				
Max. dist. width	74.9	65.8	92.5	36
Width of trochlea	67.2	58.0	86.5	49
Min. width of diaphysis	29.7	25.0	36.2	13
Max. prox. width	91.2	85.1	97.2	2
Max. length from caput	228.8	223.0	239.5	3
Radius				
Max. prox. width	73.5	64.8	88.0	29
Min. width of diaphysis	35.4	33.2	37.5	4
Max. dist. width	64.4	56.2	76.8	8
Max. length	248.5	-	-	1
Width of prox. articular surface	68.5	64.0	79.5	27
Ulna				
Width across coronoid process	44.4	40.6	49.8	9
Depth across coronoid process	58.5	52.5	68.5	3
Min. depth of olecranon	47.5	-	-	1
Metacarpus				
Max. prox. width	51.4	45.6	61.9	41
Min. width of diaphysis	27.2	22.1	35.2	47
Max. dist. width	48.4	43.5	59.5	34
Max. dist. thickness	29.3	26.8	33.5	24
Max. length	181.5	171.0	193.2	18
Pelvis				
Length of acetabulum	63.8	53.0	69.5	6
Femur				
Max. prox. width	101.2	-	-	1
Depth of caput	42.3	39.8	45.0	9
Min. width of diaphysis	29.3	29.0	29.5	2
Max. dist. width	80.3	71.0	92.5	8
Patella				
Max. length	55.1	55.0	55.2	2
Max. width	42.3	39.6	44.5	3
Tibia				
Max. prox. width	81.3	72.5	88.0	10
Min. width of diaphysis	31.6	28.8	34.5	6
Max. dist. width	55.5	49.7	65.0	27
Max. length	294.3	291.5	297.0	2
Astragalus				
Lateral length	59.6	54.0	64.3	32
Medial length	55.5	49.4	64.2	34
Lateral thickness	33.6	30.8	37.3	33
Medial thickness	33.6	30.0	38.3	31
Max. dist. width	38.1	31.5	43.2	32
Calcaneus				
Max. length	122.3	118.0	130.9	5
Metatarsus				
Max. prox. width	43.4	39.2	49.5	31
Min. width of diaphysis	23.2	18.8	32.5	34
Max. dist. width	48.5	44.2	54.7	25
Max. dist. thickness	29.6	27.0	32.7	19
Max. length	210.0	203.2	217.5	10
Phalanx I (fore-/hind-limb)				
Max. prox. width	27.2	23.5	31.7	22
Min. width of diaphysis	22.0	20.0	24.2	6
Max. dist. width	25.7	21.3	31.3	22
Length of peripheral half	54.8	47.5	59.9	22
Phalanx II (fore-/hind-limb)				
Max. prox. width	27.3	23.7	33.8	3
Min. width of diaphysis	18.1	-	-	1
Max. dist. width	21.9	20.3	24.0	3
Length of peripheral half	36.5	33.8	40.7	3

Phalanx III (fore-/hind-limb)				
Max. diagonal length of sole	58.5	53.7	62.1	4
Length of dorsal surface	47.0	43.7	50.0	4
Atlas				
Max. width	127.4	125.2	129.5	2
Max. length	90.1	85.5	100.0	4
Max. width cranial articular surface	87.7	85.5	91.0	4
Max. width caudal articular surface	87.1	80.0	98.0	5
Epistropheus				
Max. width cranial articular surface	82.2	78.0	88.0	4
Height	79.2	-	-	1

Sheep (*Ovis aries*)

A. One individual sheep (sample No. 518) from phase 2

Horncore				
Max. diameter of base (L+R)	-	(29.5)	(31.0)	2
Min. diameter of base (L+R)	-	(22.0)	(22.3)	2
Circumference of base (L+R)	-	(90.0)	(90.0)	2
Length of outer curve (L+R)	-	(110.0)	(110.0)	2
Humerus				
Max. dist. width	29.8	-	-	1
Width of trochlea	27.0	-	-	1
Metacarpus				
Max. dist. width (L+R)	-	24.5	25.0	2
Astragalus				
Lateral length	26.0	-	-	1
Medial length	24.7	-	-	1
Lateral thickness	14.5	-	-	1
Medial thickness	15.4	-	-	1
Max. dist. width	16.5	-	-	1
Metatarsus				
Max. dist. width	24.3	-	-	1

B. Other sheep bones (from phases 1-3 combined)

Horncore				
Max. diameter of base	34.2	-	-	1
Min. diameter of base	22.0	-	-	1
Circumference of base	100.0	-	-	1
Scapula				
Min. length of neck	20.4	20.3	20.5	2
Max. length proc. articularis	32.0	30.6	33.3	5
Length of articular surface	25.2	24.3	26.2	5
Width of articular surface	19.8	17.8	20.8	5
Height along the spine	146.0	-	-	1
Max. height	149.2	-	-	1
Max. dorsal length	101.9	-	-	1
Humerus				
Max. dist. width	30.7	24.8	34.5	6
Width of trochlea	26.9	25.0	31.5	5
Min. width of diaphysis	13.6	-	-	1
Max. prox. width	38.5	-	-	1
Max. length from caput	125.5	-	-	1
Max. length	143.0	-	-	1
Radius				
Max. prox. width	28.5	28.0	28.8	3
Min. width of diaphysis	14.9	14.8	15.0	2
Max. dist. width	26.2	-	-	1
Max. length	165.5	-	-	-
Width of prox. articular surface	25.3	25.0	25.8	3
Width of dist. articular surface	21.2	-	-	1
Metacarpus				
Max. prox. width	21.5	-	-	1
Min. width of diaphysis	13.5	-	-	1
Max. dist. width	24.9	-	-	1
Max. length	128.4	-	-	1
Femur				
Max. prox. width	43.5	42.0	44.3	5
Depth of caput	19.0	18.3	19.3	5
Min. width of diaphysis	14.6	14.2	14.8	3
Max. dist. width	34.8	34.8	34.8	2
Max. length from caput	175.4	175.0	175.8	2
Max. length	177.6	176.9	178.3	2
Calcaneus				
Max. length	60.2	-	-	1
Max. width	20.7	-	-	1

Pig (*Sus domesticus*)

Mandibula				
Height behind M3	36.8	-	-	1
Humerus				
Max. dist. width	35.1	33.7	36.4	2
Min. width of diaphysis	12.2	-	-	1
Metacarpus III				
Max. dist. width	16.3	-	-	1
Max. length	74.0	-	-	1
Metacarpus IV				
Max. dist. width	16.2	-	-	1
Max. length	74.0	-	-	1
Femur				
Max. dist. width	41.0	-	-	1
Calcaneus				
Max. length	66.5	-	-	1

Horse *(Equus caballus)*

Scapula				
Min. length of neck	58.2	-	-	1
Humerus				
Max. dist. width	69.3	68.5	70.0	2
Width of trochlea	67.5	-	-	1
Max. prox. width	86.0	-	-	1
Radius				
Max. prox. width	77.1	76.5	77.7	2
Min. width of diaphysis	35.5	34.5	36.4	2
Max. dist. width	70.0	-	-	1
Width of prox. articular surface	69.0	68.0	70.0	2
Width of dist. articular surface	59.5	-	-	1
Pelvis				
Length of acetabulum	63.9	62.5	65.3	2
Femur				
Max. prox. width	108.0	-	-	1
Depth of caput	53.3	53.0	53.5	2
Max. dist. width	87.6	-	-	1
Tibia				
Max. prox. width	87.7	85.0	90.3	2
Min. width of diaphysis	37.5	-	-	1
Max. dist. width	68.5	66.7	72.0	4
Max. dist. depth	44.6	42.6	46.9	4
Max. length	330.5	-	-	1
Metatarsus				
Max. prox. width	48.1	45.0	50.0	3
Min. width of diaphysis	31.8	-	-	1
Max. dist. width	48.4	47.0	49.7	2
Max. dist. depth	37.7	36.8	38.5	2
Max. length	266.0	-	-	1
Min. circumference of diaphysis	100.0	-	-	1
Phalanx II (fore-/hind-limb)				
Max. prox. width	50.9	50.4	51.4	2
Min. width of diaphysis	31.1	31.0	31.2	2
Max. dist. width	44.6	-	-	1

Dog (*Canis familiaris*)

A. One individual dog (sample No. 321) from phase 3

Cranium				
Min. interorbital width	37.0	-	-	-
Length of cheektooth row (L+R)	-	62.2	63.6	-
Length of molar row (L+R)	-	21.0	21.5	-
Length of premolar row (L+R)	-	48.8	48.8	-
Max. palatal breadth	65.8	-	-	-
Condyle-basal length	176.2	-	-	-
Total length	188.3	-	-	-
Mandibula				
Length of cheektooth row	72.3	-	-	1
Length of molar row	37.0	-	-	1
Length of premolar row	37.5	-	-	1
Length M3-C	77.0	-	-	1
Length from angular proc. to C alveolus	121.5	-	-	1
Total length from condyle to infradentale	136.0	-	-	1
Length from condyle to C alveolus	118.2	-	-	1

B. One individual dog (sample No. 433) from phase 2

Scapula				
Min. length of neck	29.7	-	-	1
Max. length of proc. articularis	36.5	-	-	1
Length of articular surface	29.5	-	-	1
Width of articular surface	25.0	-	-	1
Height along the spine	152.2	-	-	1
Humerus				
Max. dist. width	37.8	-	-	1
Max. prox. depth	47.0	-	-	1
Radius				
Max. prox. width	20.4	-	-	1
Ulna				
Width across coronoid process	19.6	-	-	1
Min. depth across proc. anconaeus	29.0	-	-	1
Femur				
Max. prox. width (L+R)	42.2	42.0	42.3	2
Depth of caput (L+R)	21.6	21.5	21.6	2
Tibia				
Max. prox. width	39.5	-	-	1

C. Other dog bones (from phases 1-3 combined)

Mandibula				
Length of cheektooth row	73.0	70.0	76.0	2
Length of molar row	35.0	33.2	36.8	2
Length of premolar row	40.3	38.0	42.5	2
Length M3-C	78.0	75.0	81.0	2
Ulna				
Width across coronoid proc.	15.8	-	-	1
Pelvis				
Length of acetabulum	22.0	-	-	1
Max. length of one half	135.2	-	-	1
Femur				
Max. prox. width	37.0	-	-	1
Depth of caput	17.5	-	-	1
Min. width of diaphysis	13.0	-	-	1

Max. dist. width	31.8	-	-	1
Max. length from caput	177.5	-	-	1
Tibia				
Max. prox. width	33.5	-	-	1
Max. dist. width	21.3	-	-	1
Max. length	176.0	-	-	1
Calcaneus				
Max. length	48.3	-	-	1
Max. width	21.1	-	-	1

Wild duck (*Anas platyrhynchos*)

Humerus				
Max. prox. width	20.9	20.4	21.4	2
Min. width of corpus	7.5	7.4	7.6	2
Max. dist. width	14.8	14.5	15.1	2
Max. length	94.5	92.8	96.2	2

Sea eagle (*Haliaetus albicilla*)

Ulna				
Max. diagonal of dist. end	18.5	-	-	1