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Chapter 13

Dealing with domestic animals in the fifth millennium cal BC Dutch wetlands: new insights from old Swifterbant assemblages

*Canan Çakırlar, Rianne Breider, Francis Koolstra, Kim M. Cohen
and Daan C.M. Raemaekers*

Introduction

One classic case study area regarding the transition to farming is the Swifterbant Culture of the Low Countries bordering the North Sea in north-west Europe, with sites located in the wetlands between Antwerp and Hamburg. The Netherlands' coastal plain constitutes a major part of this zone (Fig. 13.1). Here, the dominant narrative is that of a long substitution phase (*e.g.* Zvelebil, 1984): a several centuries long period in which subsistence is characterised by limited use of domesticates despite frequent interaction with full-scale farming neighbours. In the Netherlands' coastal plain, the beginning of pottery production in Swifterbant style around 5000 cal BC provides the earliest evidence of contacts with farmers (Raemaekers, 1999; 2003; 2014). The small number of bones from domestic cattle (*Bos taurus*), pig (*Sus domesticus*) and sheep/goat (*Ovis aries/Capra hircus*) found in contexts dating to around 4600 cal BC, it has been argued, constitutes the evidence for the beginnings of animal husbandry (Kooijmans, 2007; Out, 2009; Amkreutz, 2013). From around 4300–4000 cal BC these finds increase in relative abundance and occur in combination with evidence of cereal cultivation (Cappers *et al.*, 2008; Huisman and Raemaekers, 2014).

This paper scrutinises pig (*Sus sp.*), cattle (*Bos sp.*) and sheep/goat (*Ovis aries/Capra hircus*) remains in the Swifterbant Culture dating prior to 4000 cal BC. The remains come from sites Brandwijk-Kerkhof (excavated 1991; hereafter Brandwijk) and Hardinxveld-Giessendam De Bruin (excavated 1998; hereafter De Bruin) in the perimarine district of the Rhine-Meuse delta, both in the province of South Holland.

There are three good reasons to revisit these finds. Firstly, zooarchaeological methods and approaches have improved significantly since the late 1990s, when these

3850 BC

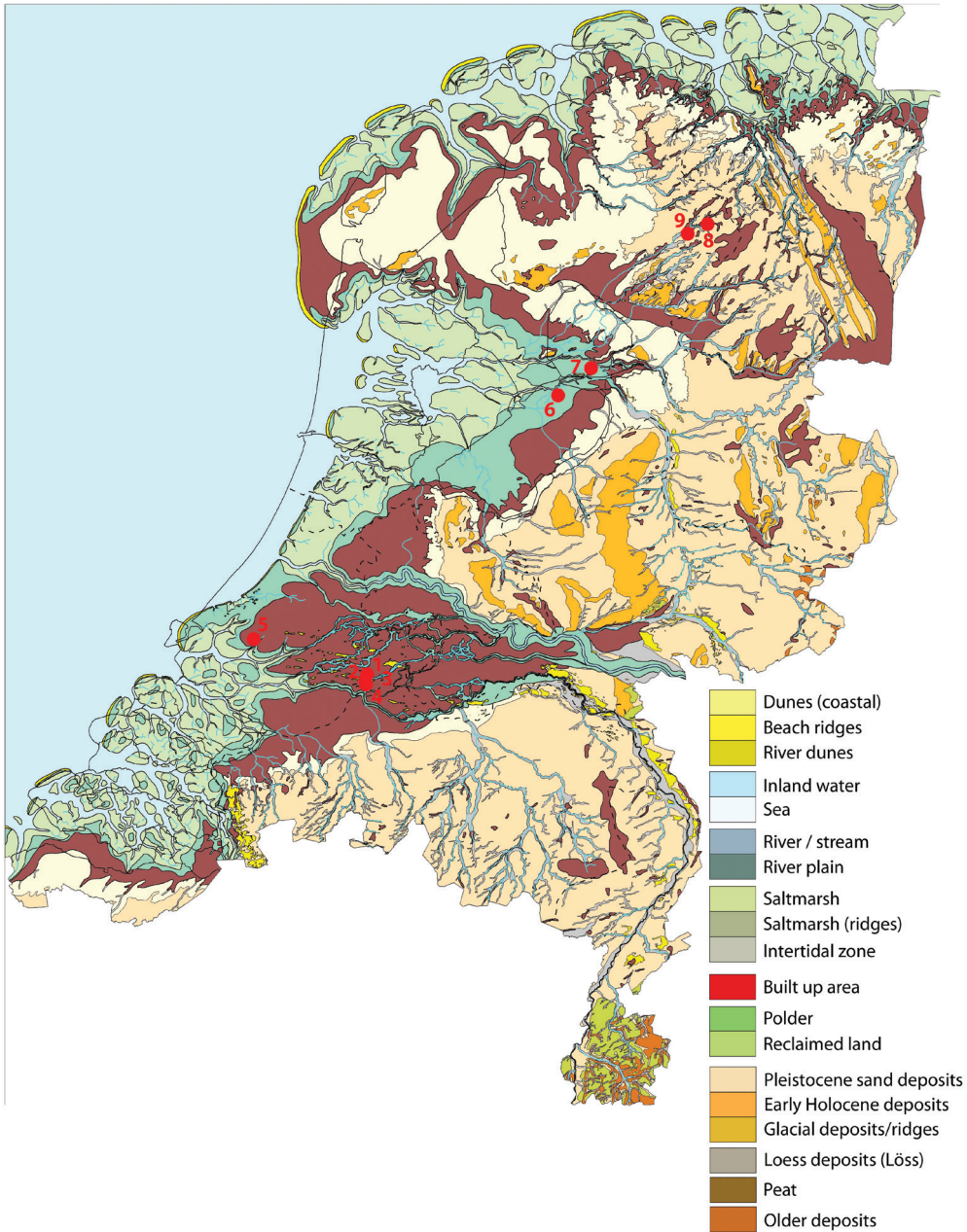


Fig. 13.1. Sites mentioned in the text: 1=Brandwijk-Kerkhof; 2=Hardinxvel-Giessendam De Bruin Polderweg; 3=Hazendonk, 4=Hardinxveld-Giessendam Polderweg; 5=Schipluiden; 6=Swifterbant; 7=P14; 8=Jardinga; 9=Balkweg.

finds were first analysed. Multi-proxy analyses, instead of relying solely on biometry (which provides proxy data for phenotype characterisation), became standard in distinguishing wild and domestic populations, and, more importantly, assessing how humans interacted with them (*e.g.* Rowley-Conwy *et al.*, 2012). Secondly, ancient DNA analysis opened a completely new window into our understanding of the differences between wild and domestic populations, showing that interbreeding between cattle and pigs originating from the Near East and local aurochs and boar played a significant role in the making of European domestic herds (Ottoni *et al.*, 2013; Park *et al.*, 2015). Analysis of mitochondrial DNA from claimed early domestic (small) cattle from Rosenhof in northern Germany, for example, revealed the European maternal ancestry of this individual (Scheu *et al.*, 2008), suggesting a more complex interplay between phenotype and genotype in situations where admixture is plausible. Finally, recent publications have raised doubts about the early dates and the identification of the finds in the lower Rhine-Meuse delta (Krause-Kyora *et al.*, 2013; Rowley-Conwy, 2013; Rowley-Conwy and Legge, 2015), and proposed younger dates more in line with finds from southern Scandinavia and the United Kingdom across the North Sea (*e.g.* around 4000 cal BC).

Triggered by these recent developments in research, we are set to conduct a large-scale, long-term research programme on the Prehistory of Dutch Animal Husbandry from its incipient form to its full-scale establishment, using new methods.

In this paper, we discuss our first findings. We explain that the coherence of all available ^{14}C dates on both a regional level and at the sites concerned makes younger context dates impossible. We embed this argument in the context of the well-studied Holocene geomorphology of the Rhine delta. We assess the nature of interactions between humans and cattle, pigs and sheep/goat based on new and direct ^{14}C dates, osteomorphological re-identifications, recalculated relative taxonomic frequencies, mortality profiles, biometry and body-part representation, as well as evidence from limited $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ analysis. Results have wide implications for the study of early forager-farmer interactions in north-west Europe, and demonstrate that detailed re-analysis of the relevant assemblages is imperative to clarify the nature of these interactions in the Dutch wetlands.

The regional sedimentary stratigraphic framework

After the lower Rhine-Meuse valley drowned in response to sea-level rise, Brandwijk and Hardinxveld-Giessendam became positioned in a swampy deltaic wetland, upstream of the contemporary river mouths. Deltaic aggradation was controlled by the steady rise of water table (Fig. 13.2): that of sea level at the river mouth and equally that of swamp freshwater and tidally affected open river channel water levels over distances 50 km inshore (Cohen, 2005; Hijma and Cohen, 2011; Koster *et al.*, 2017). In the vast plain, deltaic river branches formed that avulsively succeeded each other (Bosch and Kok, 1994; Berendsen and Stouthamer, 2001). The deltaic channel belts of these

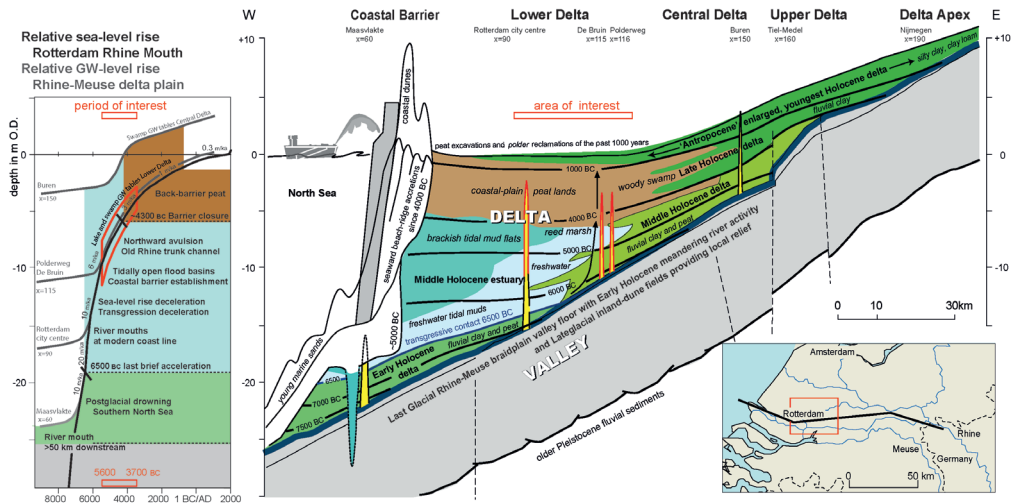


Fig. 13.2. Longitudinal section of the Rhine-Meuse delta in relation to Holocene sea-level rise (after Hijma and Cohen, 2011; Moree and Sier, 2015). Deltaic depositional anatomy shown in color (grey: palaeovalley; yellow: inland dunes; green: fluvial deltaic fines; cyan: tidal-fluvial and tidal muds; brown: peats; white: coastal-barrier sands), state-of-art sea-level rise (Hijma and Cohen, 2010; van de Plassche et al., 2010; Hijma and Cohen, 2019) and inland groundwater-table rise (GW-level rise; Cohen, 2005; Koster et al., 2017) indicated in black lines. Red colour boxes and buried inland-dune surface indicate period and area of interest to Middle Holocene Neolithisation (this paper).

ivers are of limited width and the majority of the deltaic aggradation was trapped in-between the channels, in so-called flood basins.

Importantly, sites such as Brandwijk and Hardinxveld-Giessendam lay preserved within such flood basins, with find levels slowly buried below flood-basin deposits. In international perspective, the geological research on the Holocene flood-basin sequence has been intensive and has brought very strong chronostratigraphic control on the intercalated peat and clay beds from the time-depth interval of interest, from repeated ^{14}C dating and 3D architectural mapping (van de Plassche, 1995; van de Plassche et al., 2010; van Asselen et al., 2017). At the base of the flood-basin sequence one typically finds a peat bed, grading into subaqueous mud deposition. That succession marks a time when rising water levels outpaced sedimentation and forced the river mouth to retreat inland. The depth (Z) of encounter and the dating (Age) of such successions have been determined at >300 locations (XY). Plotting Age vs. depth for series of sites from the study area from the sixth and fifth millennium BC reproduces the rapid rates of 10 m/kyr that match global and North Sea-specific insights in sea-level rise for that period (Hijma and Cohen, 2010; van de Plassche et al., 2010), with flood-basin lakes (clayey gyttja deposits) and phragmites fens (peaty beds) dominating around the sites. Then, from the fifth and into the fourth millennium BC, rates of rise drop to c. 3 m/kyr (Fig. 13.2), and distal flood-basin sedimentation (clay beds) and

autochthonous production of organic sediment (peat beds) catch up with water-level rise establishing the swampy surroundings of the sites. At this stage, the height of the water table in the flood basins surrounding Brandwijk and Hardinxveld-Giessendam varied between 0.3 and 0.7 m above contemporary sea level (van de Plassche, 1995; Cohen, 2005; Berendsen *et al.*, 2007; Koster *et al.*, 2017; van Asselen *et al.*, 2017).

The archaeological sites developed on top of isolated inland-dune topography in these flood basins. Elongated eolian dune complexes with individual dunes of variable height had developed millennia before, downwind and alongside channels that were active over the Pleistocene-Holocene transition (Verbruggen, 1992; de Jong, 1995; Moree and Sier, 2015). The archaeological sites showing Neolithisation sit on the tops and flanks of the dunes. During the Mesolithic, with ongoing transformation of the wider landscape from valley to delta, isolated dunes became landmarks for human dwelling in the area. Their highest tops rose over 10 m above the surrounding flood-plains (Fig. 13.2 simplifies morphology, but vertical expression is to scale), making them well visible from the river, also at some distance from the main channel across fen and lake landscapes. As deltaic aggradation proceeded, the dunes were gradually buried, while regular occupation continued and concentrated on shrinking areas of high ground. Peats, organic muds and clays began to onlap the toes and flanks of the dune forms from 8500 years ago onward and, as time proceeded, did so at increasingly higher levels. The non-buried upper parts of the dunes became islands in the marsh. Medium-high dune tops eventually were fully buried, but the tops of the highest dunes still outcrop in the delta plain today.

The archaeological layers with Neolithisation evidence are from the period of encroaching swampy onlap against the dune flanks, explaining the taphonomy of the sites (*e.g.* Verbruggen, 1992; Amkreutz, 2013). Dunes occupied during the aggradation develop a stacked archaeological stratigraphy along the toes and flanks of the dune topography, besides a palimpsest occupation layer on the highest part of the dunes. It is from the stacked stratigraphy along the dune flanks that the Neolithisation records with the best time control are developed.

The regional deltaic-hydrological control is an especially powerful constraint for age attribution to layers within the sixth and fifth millennium BC, when sea-level and flood-basin water tables rose some 10 m. At rates of rise that dropped from *c.* 0.5 m/cy (mid-sixth millennium) to 0.2 m/cy (end fifth millennium; Cohen, 2005), the marsh around the archaeological sites encroached the dune flanks steadily. It has been practice to create local groundwater rise data sets for each dune site in the delta (van Dijk *et al.*, 1991; Cohen, 2005). Having that multi-site, multi-curve data-set meant that dating of a swamp peat at a certain depth on a dune flank on site A could be cross-verified vs. dates of similar peats at similar absolute depth on dune flanks on site B. In the same manner, the time-depth position of hearths and charcoal concentrations could also be cross-verified. The vertical accuracy to which this can be done is a few dm (Cohen, 2005; Koster *et al.*, 2017), and given the rates of sea-level and water-table rise in the study area this translates to a few centuries. In the drowning setting of the Rhine-Meuse

delta from the sixth to the third millennium BC, a robust common trend in age-depth data plots exists (10 m/kyr to 3 m/kyr deceleration; Fig. 13.2), on top of which only modest secondary fluctuations occur (Berendsen *et al.*, 2007; van Asselen *et al.*, 2017).

The sites

Hardinxveld-Giessendam De Bruin

De Bruin is located a few hundred metres away from the key Pottery Mesolithic (5500–5000 BC) site of Polderweg. Excavations at the site investigated an 18×24 m area, and revealed three distinct phases, Phase 1 to 3, from bottom to top (Louwe Kooijmans, 2001a; 2003). Sterile Holocene sedimentation interrupts the build-up of cultural layers. The time-depth and phasing of the occupation is based on a series of ¹⁴C dates (Table 13.1), which lead to three phases between 5500–4450 cal BC. Pottery was found in Phases 1 and 2. Almost 11,000 mammal remains were recovered through hand-collection and sieving, but less than 3000 fragments could be determined to lower taxa (Oversteegen *et al.*, 2001). A small number (proportionally and in absolute terms) of domestic pigs, cattle and sheep/goat were present in Phases 2 and 3. The landscape setting is very similar to that of Brandwijk, and there is no evidence for local crop cultivation (Out, 2009).

Brandwijk-het Kerkhof

The site is located on the border zone between the relatively high sand dune (4 m high) and the surrounding wetlands in the perimarine district, very close to Hardinxveld-Giessendam De Bruin and Polderweg. Excavations in 1991 investigated a 3×10 m area crosscutting several find layers in Holocene sediments (Verbruggen, 1992). Find locations were recorded using x, y, z coordinates, and administered within their contexts (Raemaekers, 1999). Similar to De Bruin, sterile deposits separate the prehistoric find layers, from bottom to top, L30, L50, L60 and L70, covering a millennium between 4600 to 3600 cal BC (Verbruggen, 1992). The proposed ages for the different find layers (Table 13.2) are based on a visual correlation between the available dates from Brandwijk and those from the area at large (Verbruggen, 1992), making use of the interconnection of the ¹⁴C dates in this perimarine sedimentation area (see above). The surrounding vegetation is dominated by a mixed deciduous forest of lime, oak, elm and ash, the wetlands are characterised

Table 13.1. Proposed ages for the different phases of De Bruin (from Mol and Louwe Kooijmans, 2001).

Layer	Proposed age (cal BC)
Phase 3	4685-4459
Phase 2	5100-4800
Phase 1	5475-5100

Table 13.2. Proposed ages for the different find layers of Brandwijk (from Verbruggen, 1993).

Layer	Proposed age (cal BC)
L70	3700-3630
L60	3940-3820
L50	4220-4100
L30	4610-4550

by an alder carr, and crop plants are present from c. 4200 BC, though not on a large scale (Out, 2008b). Pottery was present from the first phases of occupation onwards (c. 4610–4550 BC) (Raemaekers, 1999). Flint finds indicate contacts with southern regions and the incorporation of material culture from the Michelsberg culture between c. 4220 and 3940 cal BC (Raemaekers, 1999). Robeerst, who was a bachelor's student at the time, studied the faunal remains and claimed the presence of a small number of domestic pig, cattle and sheep in Brandwijk as early as 4600 cal BC (L30) among the 843 vertebrate remains recovered (787 of them through hand-collecting) (Robeerst, 1995). This interpretation was incorporated into the narrative of Dutch Neolithisation by subsequent researchers (Raemaekers, 1999; 2003; Out, 2008b).

Material and methods

Although we had access to the primary zooarchaeological data-sets (digital files in varied forms) of Robeerst (1995), Louwe Kooijmans (2001) and Oversteegen *et al.* (2001), due to typical problems involving legacy data re-use in zooarchaeology (*cf.* Atici *et al.*, 2013), we additionally re-analysed the data-set physically. We re-identified the ungulate specimens from Brandwijk and De Bruin using the rich skeletal reference collection of the Groningen Institute of Archaeology (Çakırlar *et al.*, 2016).

We use biometric methods and reconstruct mortality profiles to assess the domestic status of populations rather than individuals, following the methods suggested by Wright and Viner-Daniels (2015) for *Bos* and by Albarella and Payne (2005) for *Sus*. Admittedly, sample sizes are not ideal (*e.g.* for the cattle from Brandwijk) to make definitive conclusions about population-wide trends. Nevertheless, comparing standardised measurements (von den Driesch, 1976; Payne and Bull, 1988) from the assemblages in question with those from nearby Mesolithic and Neolithic populations (Albarella and Payne, 2005; Manning, 2016) helps situate the phenotypic characteristics represented by our samples in the larger context of European Neolithic. Reconstructed mortality profiles help interpret the scale and intensity of interactions between ungulates and humans, exploitation pressure and targeted products. We also assess patterns in body part representations, although with caution, considering the limitations of assemblage sizes.

Notwithstanding the high quality of context dates in our cases study area, direct ¹⁴C dates on claimed early occurrences of domesticates outside their homeland are crucial to check their secure position in stratigraphy (*e.g.* Perry-Gal *et al.*, 2015). We directly AMS-dated two sheep/goat specimens from Brandwijk and two from De Bruin at the Centre for Isotope Research (CIO) of the University of Groningen (RUG). Both of the Brandwijk samples received extra pre-treatment using the so-called Soxhlet procedure to remove contaminants. Collagen was extracted and purified using a modified Longin (1971) method.

We also examined the stable isotope compositions of bone collagen from selected specimens. Compositions of $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ of bone collagen show variation depending

on individuals' dietary strategies (C3 vs. C4 plants, marine vs. freshwater proteins *etc.*), ambient environments (*e.g.* forested, coastal *etc.*), and how these are controlled by humans (Ambrose and Norr, 1993; Drucker *et al.*, 2008). They can also reveal a correlation between cereal cultivation and animal husbandry, bearing implications about the interplay between foddering strategies and manuring in mixed farming systems (Bogaard *et al.*, 2007). The analysis of $\delta^{34}\text{S}$ of bone collagen can provide insights into proximity to the marine coast (Nehlich, 2015). AMS dating provided $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values of bone (and dentine in Specimen 22.23 L60) collagen for sheep/goat.

In addition, we attempted to obtain $\delta^{15}\text{N}$, $\delta^{13}\text{C}$, $\delta^{34}\text{S}$ values from six *Bos* sp. specimens (three from De Bruin and three from Brandwijk), and three specimens of red deer (*Cervus elaphus*) from Brandwijk for comparative purposes (Table 13.3). Collagen extraction took place in the Department of Archaeology, Durham University. Sulphur isotopic compositions were measured on the devoted sulphur IRMS in the Stable Isotope Biogeochemistry Laboratory (SIBL) at Durham University. All specimens from Brandwijk and two specimens from De Bruin were consolidated with a preservative of unknown composition. The preservative was removed through physical means, and sampling avoided areas that had been consolidated (*e.g.* the interior of the bone). The collagen was extracted, as it was at the CIO, following a modified Longin (1971) protocol. The collagen yields were low and the atomic C:N, C:S and N:S were predominantly outside the acceptable ranges. In interesting contrast to the sheep/goat specimens analysed for AMS dating in CIO, only one specimen provided reliable $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values, and only one specimen provided an acceptable $\delta^{34}\text{S}$ measurement. We examine the admittedly small new $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ data-set alongside previously published $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values from *Sus* and red deer from Polderweg, an early Mesolithic site adjacent to De Bruin, and De Bruin itself (Smits and van der Plicht, 2009). As we could not match the metadata of these stable isotopic data with published zooarchaeological descriptions and stratigraphy, we cannot tell whether the specimens were adult and we do not know where in the stratigraphic sequence they belong (see Louwe Kooijmans *et al.*, 2001). This situation reduces the potential of our re-examination.

Results

Taxonomic abundance

One of the most striking outcomes of our osteomorphological re-identifications is that the majority of the 19 sheep/goat remains from Brandwijk (Roberst, 1995) actually represent *Sus* sp. (Fig. 13.3 depicts one such specimen). The post-cranial specimens appear to be burnt (or otherwise calcined and assumed a white-light grey colour) and they are deformed, which make them less easy to identify. Nevertheless, osteomorphological identification is possible with a good collection and experience. Most of the *Sus* sp. specimens are teeth, phalanges and distal epiphyses of metapodia. Some of the 10 sheep/goat teeth were found very close to each other, and looking at their wear and size it is probable that they belong to the same individual. Eight cattle specimens were

Table 13.3. $\delta^{15}\text{N}$, $\delta^{13}\text{C}$ and $\delta^{34}\text{S}$ values of *Bos* sp. and *C. elaphus* specimens from De Bruin and Brandwijk (analysis took place at the Department of Archaeology and the Department of Earth Sciences at Durham University). Struck-through samples fall outside acceptable elemental atomic ratios.

Site	Taxon	Element	SIBL ID	%N	$\delta^{15}\text{N}$	%C	$\delta^{13}\text{C}$	C/Natomic	%S	$\delta^{34}\text{S}$	C/Satomic	N/Satomic	Sample mass (mg)	Collagen weight (mg)	% yield	Side	Context	Notes	Original find no. (Vondstnr)
De Bruin	<i>Bos taurus</i>	Phalanx 1	DB1	15.19	6.7	43.94	-22.6	3.4	0.31	2.43	377	112	507.46	106.1	20.90%	L/pair	23/4/15/21		15410/1
De Bruin	<i>cf. Bos taurus</i>	Femur	DB2	12.78	7.1	39.06	-23.4	3.6	no data	no data	no data	no data	246.65	5.06	2.10%	L	21/2/15/19	unfused distal femur	11680/2
De Bruin	<i>Bos</i> sp.	Metapodial	DB3	1.95	5.2	24.23	-27.8	14.5	no data	no data	no data	no data	578.47	1.15	0.20%	?	18/2/15/15	unfused distal metapodial	13388
Brandwijk	<i>Bos taurus</i>	Phalanx 2	BW1	no data	no data	no data	no data	no data	no data	no data	no data	no data	352.61	7.02	2.00%	L/pair	L50	preservative on surface	2751
Brandwijk	<i>Cervus elaphus</i>	Humerus	BW2	10.21	3.6	34.32	-23.3	3.9	0.51	4.86	179	46	364.55	25.13	6.90%	L	L60	preservative on surface	21,019
Brandwijk	<i>Bos primigenius?</i>	Axis	BW3	3.88	7.6	13.47	-22.4	4	0.36	2.3	99	24	641.98	65.23	10.20%	axial	L60	SBV=60,5 mm BFcr=104.3 mm (est. at 106 mm, broken), preservative on surface	34,039
Brandwijk	<i>Cervus elaphus</i>	Phalanx 1	BW4	8.02	6.8	26.05	-23.3	3.8	0.41	6.64	168	44	492.63	20.26	4.10%	R/pair	L50	preservative on surface	12,082



Fig. 13.3. Specimen 11,238 from Layer 60, identified previously as *Ovis/Capra*, compared to (right) distal epiphysis of metacarpus III right side of Specimen BAI-54, a 20th-century wild boar (*Sus scrofa*) from the Veluwe Nature Reserve in southern Netherlands.

reported from Brandwijk (Robeerst, 1995). We identified one vertebral fragment previously identified to 'Bos' to elk (*Alces alces*), but another sheep/goat horn core with skull to *Bos* sp., and two maxillary teeth previously assigned to 'Cervidae' (=deer family) also to *Bos* sp. There are therefore now nine cattle specimens in the Brandwijk assemblage. However, according to the revised stratigraphic data-set, cattle and sheep remains originate from Layers 60 and 50, not the oldest Layer 30 as was previously mentioned (e.g. Raemaekers, 2003).

The quality of identifications is different for the De Bruin assemblage, which contained 13 sheep/goat remains (Oversteegen *et al.*,

2001, table 8.13). The analyst identified all of them correctly as caprines. However, we think that some of the sheep/goat remains, being elements of the hind lower leg, and especially autopodial, actually articulate anatomically – *i.e.* they belong to the same individual, decreasing the NISP for sheep/goat. Most of them were found in Phase 2 of the site.

Body-part representation

Reconstructing body-part representations from small samples is problematic. Potentially interesting trends emerge, however, and these are worth mentioning. At Brandwijk, *Sus* is represented peculiarly by cranial (tooth, jaw and skull) and autopodial (fore and hind feet) elements only. It is important to note that 14 of the 40 *Bos* specimens from De Bruin are proper worked bone tools made out of the thick and robust elements of the skeleton, mostly metapodia, but also radii and tibiae (Oversteegen *et al.*, 2001). Of the remaining 26 specimens, only six represent meaty parts of the postcranial skeleton (*i.e.* non-autopodial elements, such as scapulae, femora *etc.*). *Bos* autopodial elements are clearly over-represented in De Bruin, whereas in Brandwijk, despite small sample size, *Bos* is represented by a variety of elements from head to toe.

Size

Once we confirmed or rejected the osteomorphological identifications of the *Sus* and *Bos* specimens, we also double-checked the measurements, re-measured or measured, in some instances, all *Sus* and *Bos* specimens for the first time.

Based on the size of two *Sus* sp. canines and the length and width of multiple maxillary and mandibular molars, Robeerst identified eight specimens as wild boar and five specimens as domestic pig (Robeerst, 1995, 10–11, table 3). Biometric analysis of *Sus* remains from De Bruin and Brandwijk in comparison with relevant (chronologically and geographically) assemblages situates the population more clearly. In Brandwijk Layer 60 (so, post-4000 cal BC), *Sus* were, in terms of size, mostly comparable with the fully domestic herds (represented by the now standard population of Durrington Walls, the third millennium site on the Stonehenge landscape in the UK (Albarella and Payne, 2005). However, they are smaller than the large individuals from De Bruin (Figs 13.4 and 13.5), which cluster well with fifth millennium BC sites in the perimarine environments of the Netherlands. This is in interesting contrast with Swifterbant –S3 (dating to the 4300–4000 cal BC; Amkreutz, 2013, appendix 1, fig. 73). At both Brandwijk and at Swifterbant –S3, presumable male and female individuals separate out nicely in terms of their size, and there is little overlap between the two populations. Few measurements could be taken on fused and/or non-porous postcranial specimens of *Sus* in the Brandwijk sample, and most of them are on early-fusing portions such as the acetabulum and proximal radius. The comparison of one astragalus Greatest Lateral Length (=GLL) with relevant assemblages is not very informative, although it does show that this one specimen compares well with the mean size of astragalus from late fifth millennium BC Swifterbant –S3, and is larger than post-4000 BC *Sus*.

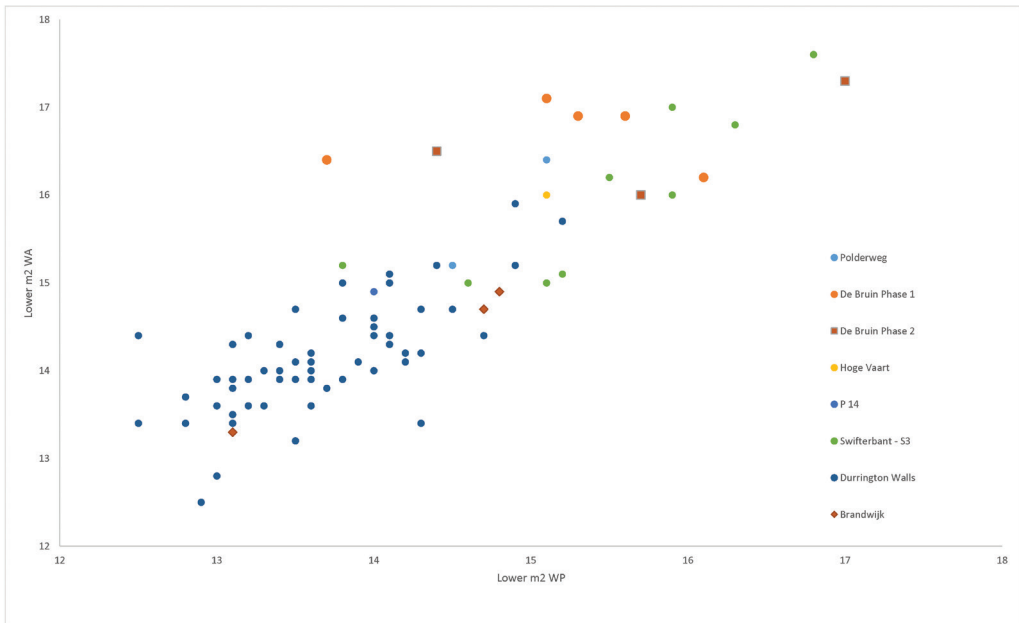


Fig. 13.4. Width (WA and WP, measurements following (Payne and Bull, 1988)) of lower second molar (=m2) from Brandwijk Layer L60, De Bruin and Late Neolithic domestic pigs from Durrington Walls in the UK (Albarella and Payne, 2005; Albarella and Lauwerier, unpubl., this study).

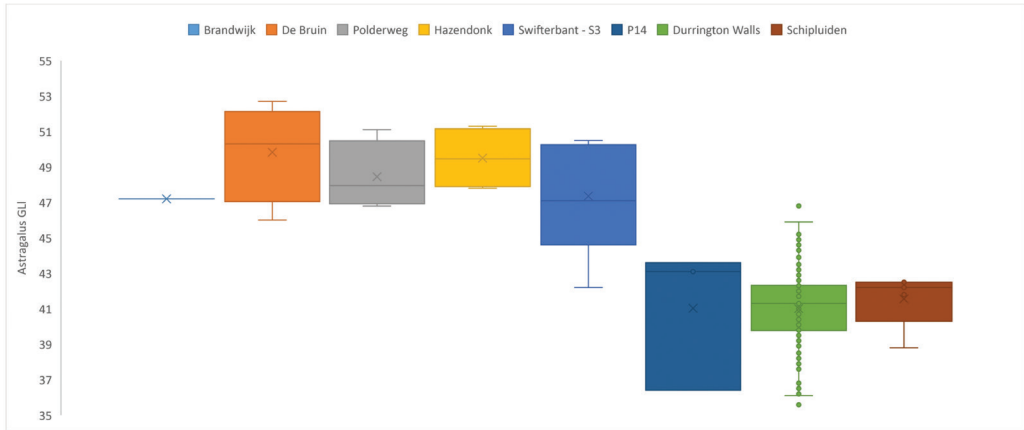


Fig. 13.5. *Sus astragalus* Greatest Lateral Length (=GLI) measurements (in mm) from Brandwijk, De Bruin, Polderweg (5500–5100 cal BC), Hazendonk (4340–3375 cal BC), Swifterbant –S3 (4335–3965 cal BC), Schipluiden (3600–3400 cal BC) in the Netherlands, and Late Neolithic Durrington Walls in the UK (from the Durrington Walls assemblage, no burnt or porous specimens were included in the analysis).

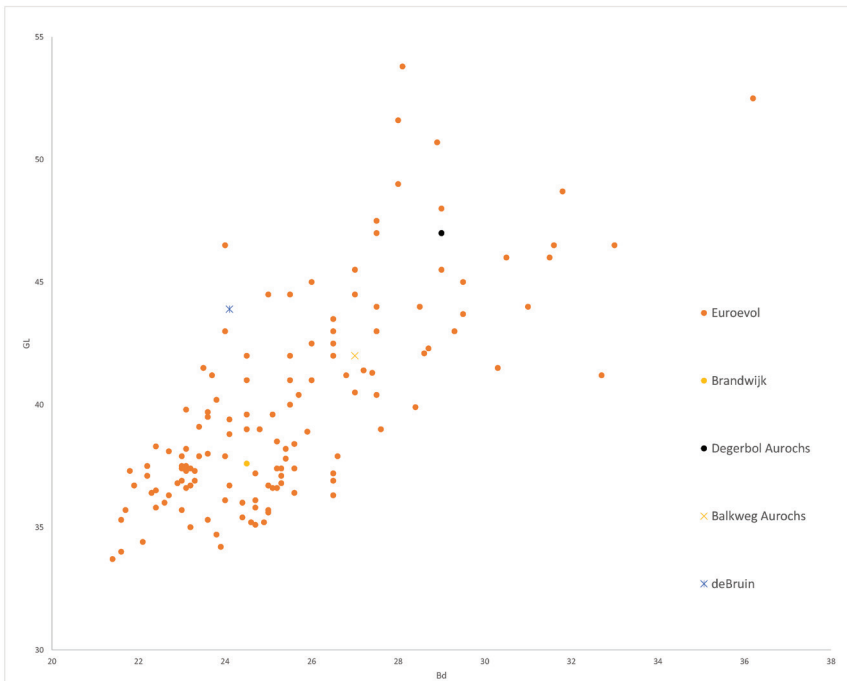


Fig. 13.6. Second phalanx GL and Bd measurements from *Bos* in De Bruin and Brandwijk assemblages compared to Late Mesolithic Balkweg (5680–5520 cal BC) in the northern Netherlands (Prummel and Niekus, 2011), Schipluiden in the Netherlands (Zeiler, 2006), a mean second phalanx of the ‘standard’ female aurochs from Mesolithic Denmark (Degerbøl and Fredskild, 1970) and all Neolithic specimens collected by Manning (2016) for Neolithic Europe.

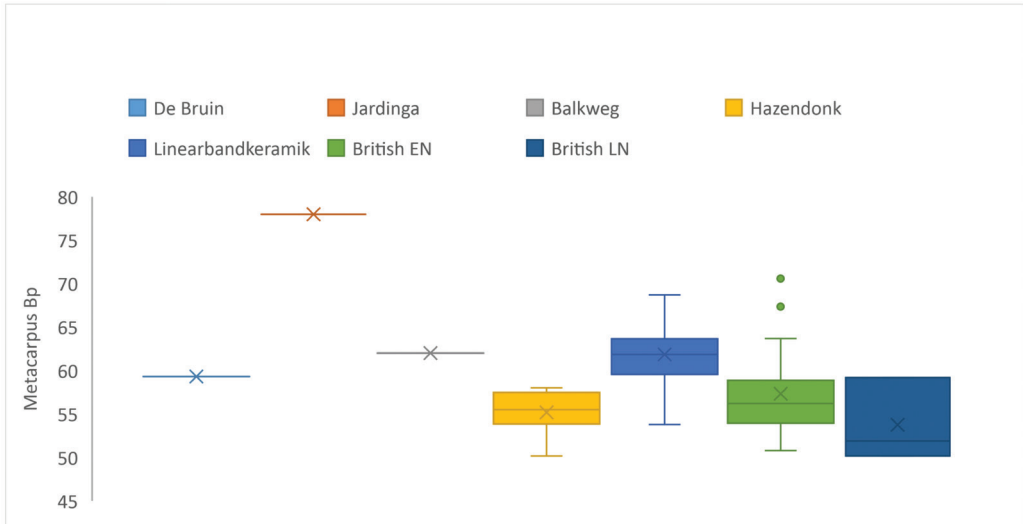


Fig. 13.7. De Bruin cattle metacarpal (an artefact) Bp compared to data from cattle in the EuroEvol data-set (Manning, 2016) and various Mesolithic and Neolithic data-sets from the Netherlands (see also Fig. 13.6).

The only measurable *Bos* extremity bone from Brandwijk is a second phalanx (Fig. 13.6). This specimen is slightly larger than the measured cattle second phalanges from the early fourth millennium BC site of Schipluiden (Zeiler, 2006), well in the range of ‘Middle Neolithic’ cattle in Europe, and smaller than the Mesolithic aurochs from north-west Europe. A second phalanx from Brandwijk, on the other hand, clusters well with the Schipluiden specimens as well as the smaller, more numerous specimens from Neolithic Europe. A metacarpal from De Bruin, an artefact, in terms of size, could come from a small female aurochs or a domestic bull (Fig. 13.7). There is also an almost complete fused axis, which measures at least 106 mm at the breadth of the cranial face (Bfcr; von den Driesch, 1976). This measurement places this specimen in the uppermost range of Middle and Late Neolithic specimens in Europe, which range between 81.4 and 108.5 mm at the Bfcr (Manning, 2016).

Age at death

The *Sus* specimens from both De Bruin and Brandwijk represent individuals who died relatively young (Table 13.4). At Brandwijk Layers 60 and 56, the age-at-death is particularly low, with all four individuals slaughtered before one year of age. In the slightly larger sample from De Bruin Phases 1 and 2, most specimens represent older individuals.

The tooth samples from Brandwijk are not very helpful in building a mortality profile (two specimens of upper molar 1 or 2, one moderately worn, the other not worn). The postcranial material contains both old specimens (the fused axis, for example) and possible subadult/young adults (unfused but grown femur, for example), but

Table 13.4. Mandibular teeth eruption and wear patterns of *Sus* from De Bruin and Brandwijk, following Grant 1982, and estimated ages (following Lemoine et al., 2014). De Bruin recorded by U. Albarella and C. Küchelmann. Brandwijk recorded by R. Breider.

No. Albarella	Context no.	Element	Phase	Sex	m1	m2	m3	Estimated age in months
80083	11086	Teeth in mandible	1		e	b	V	8-12
80084	11267	Teeth in mandible	1	f	e	b	V	8-12
80069	9556	Teeth in mandible	1		h	g	d	72-96
80054	10491	Teeth in mandible	2		f	e	b	52-72
80058	11432	Teeth in mandible	1	m	e	c	V	8-12
80051	19285	Teeth in mandible	2		g	d	a	30-52
-	6884	Teeth in mandible	1		k	h	g	>96
-	18090	Teeth in mandible	2			f	d	72-96
-	18943	Teeth in mandible	2		V			Perinatal

De Bruin (recorded by U. Albarella and C. Küchelmann).

No. Gia	Layer	Element	d4	p4	m1	m2	m3	Estimated age in months
5	L60	Mandible				b	V	8-12
6	60	Lower molar 2				c		3-8
8	L60	Lower deciduous molar 4	d					3-8
11	L56	Lower molar 1+2			d	b		8-12

Brandwijk data (recorded by R. Breider).

no infants. In De Bruin, some of the *Bos* postcranial specimens have open epiphyses, others are closed, and several carpal and tarsal bones are porous, indicating that they belong to infants, but there is no clear trend apart from the fact that they are not all fully adult specimens.

Diet and foraging environment

$\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values are available from 20 specimens in total (Fig. 13.8). These have implications in terms of diachronic trends in feeding strategies and the general environmental characteristics of feeding grounds. The $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values for *Sus*, none of which seem to be infants or juveniles according to the different data-sets, are very different from those from humans, who have an enriched $\delta^{15}\text{N}$ in both Polderweg and De Bruin, indicating a diet heavy on protein originating from freshwater ecosystems (Smits and van der Plicht, 2009). The $\delta^{15}\text{N}$ values of *Sus* are more or less in the same range as the forest-dwelling, herbivorous red deer (Fig. 13.8). In $\delta^{13}\text{C}$, there is a +1 per mil shift from Polderweg, whose ^{14}C dates range between 5500 and 5000 cal BC (Amkreutz, 2013), to De Bruin. A shift in the opposite direction can be observed for red deer, suggestive of a change in tree cover, the foraging grounds of these forest-dwellers or a shift between seasonal exploitation to year-around exploitation. It may also be due to a combination of these factors.

One of the sheep/goats (the root of the third molar) gives a 'carnivorous' signal in terms of its $\delta^{15}\text{N}$ value. Foraging in coastal environments and grazing on seaweed

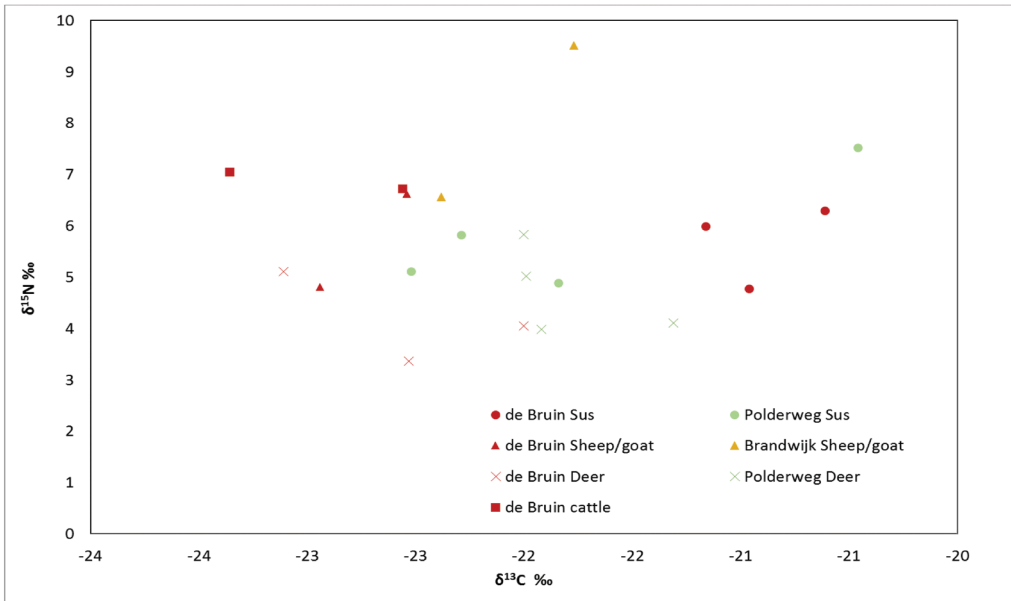


Fig. 13.8. $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values of ungulates from De Bruin and Brandwijk (this study) and Polderweg (data from Smits and van der Plicht, 2009; sheep/goat, cattle: this study, results from RUG CIO).

and coastal grasses could explain its high $\delta^{15}\text{N}$ value. However, it is more likely that, deriving from the dentin collagen, this value reflects the $\delta^{15}\text{N}$ composition of a suckling animal, a signal not seen in the remodelled $\delta^{15}\text{N}$ of bone collagen.

The one valid $\delta^{34}\text{S}$ value from an osteomorphologically domestic cattle specimen from De Bruin falls into the range expected from freshwater environments, but the range of expected $\delta^{34}\text{S}$ values from freshwater environments is rather broad (Nehlich, 2015).

Direct AMS-dates

Direct AMS-dates on four sheep/goat specimens provide a 500-year range, all pre-dating 4000 cal BC (Table 13.5, Figs 13.9 and 13.10). The two sheep/goat specimens from De Bruin Phases 2 and 3 provide non-overlapping dates between c. 4400 and 4200 cal BC. The date of the metatarsus fits better to post-Phase 3, and the date of the radius/ulna fits better to Phase 3, because Phase 2 is dated to c. 5000–4800 cal BC. The dates for the two sheep/goat specimens from Brandwijk are remarkably similar to each other, despite the fact that it is highly unlikely that they represent the same specimen. The third molar is unworn, and probably belongs to an individual considerably younger than the one represented by a fused proximal femur. Although they were found in Layer 60, direct ^{14}C dates accord better with the dates from Layer 50. The ^{14}C dates from wood and charcoal from Layer 60 suggest a life span around or after 4000 cal BC for this layer. Three of the four direct ^{14}C dates

Table 13.5. Radiocarbon dates, $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values, %C, %N and C/N on sheep/goat from De Bruin and Brandwijk. Calibrated using Oxcal at 2σ (analysis took place at the Centre for Isotope Research at the University of Groningen).

GrA #	Sample name	Specimen	Stratigraphy	Age BP	Cal BC (at 2 sigma)	$\delta^{13}\text{C}$	$\delta^{15}\text{N}$	%C	%N	C/N
64342	De Bruin 98BRUV16824	Sheep metatarsus, distal fused	Phase 3 Layer 15	5380±40	4335-4221, 4210-4153, 4133-4060	-22.5	6.6	43.8	14.5	3.5
62951	De Bruin 98BRUV06258	Sheep/goat radius proximal half	Phase 2 Layer 2	5610 ±40	4520-4356	-22.9	4.8	27.7	9.9	3.3
62952	Brandwijk -22.23	Sheep/goat slightly worn upper 3rd molar	Layer 60	5240 ±40	4229-4199, 4171-4090, 4083-3968	-21.8	9.5	41.3	15.5	3.1
62955	Brandwijk -12.6	Sheep/goat femur, proximal fused	Layer 60	5265 ±40	4231-4192, 4179-3982	-22.4	6.6	45.1	15.8	3.3

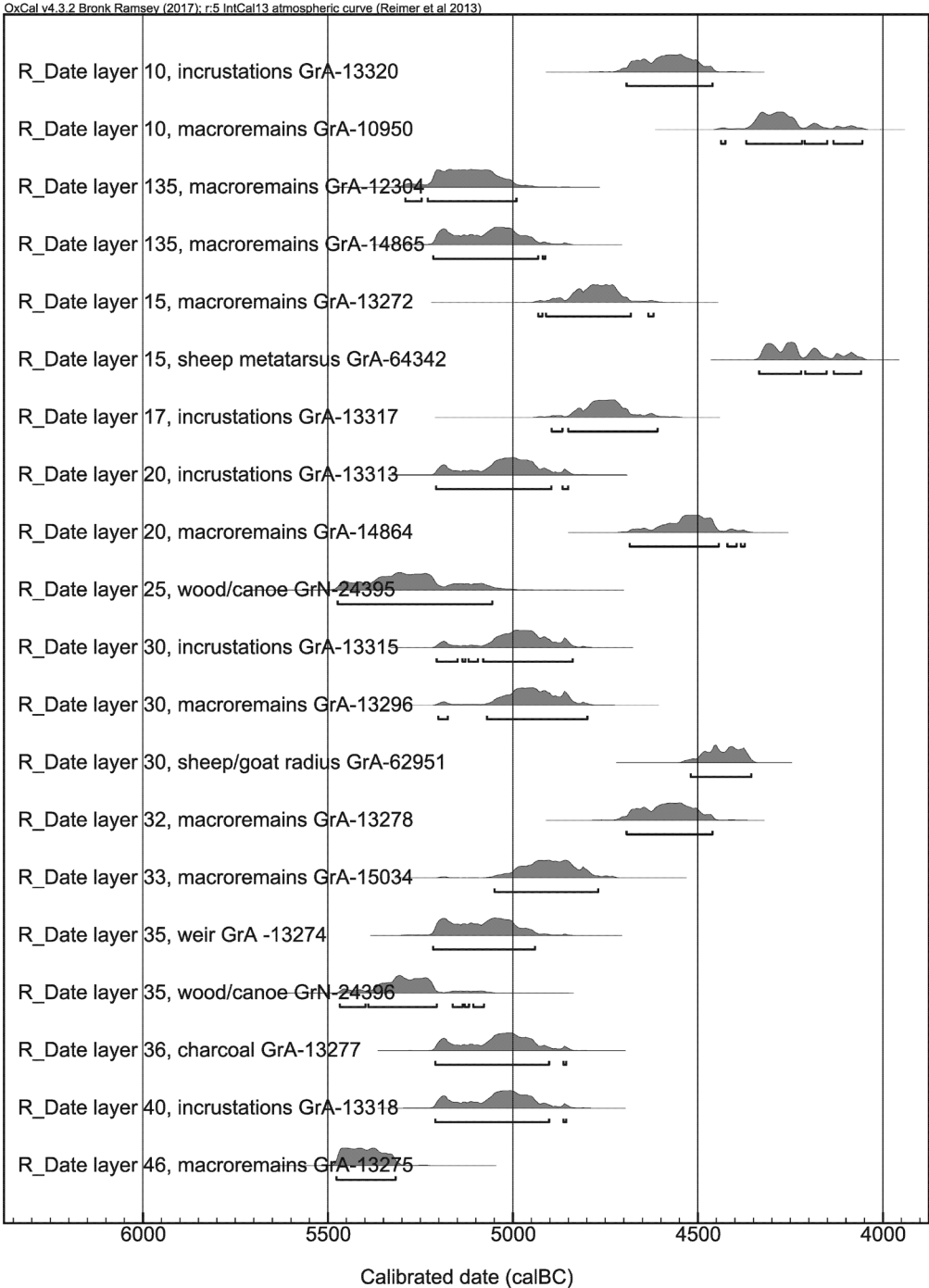


Fig. 13.9. Radiocarbon dates from De Bruin ordered by layer (from Amkreutz, 2013, appendix 1, fig. 23; animal remains: this study).

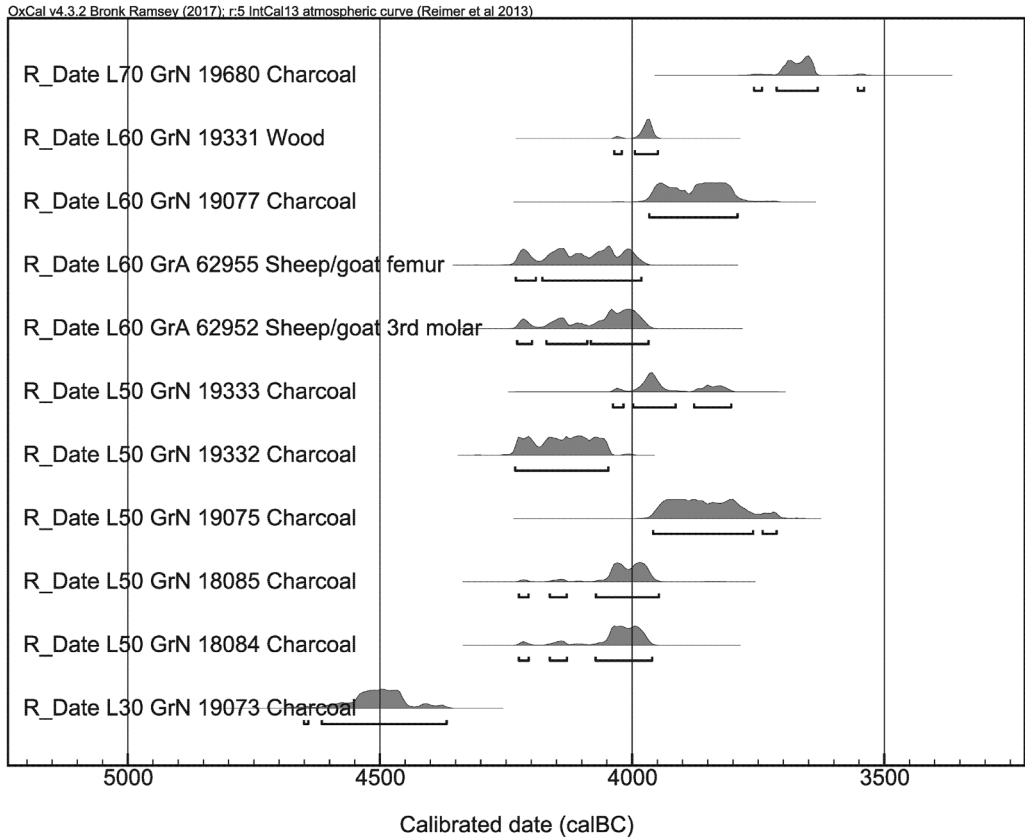


Fig. 13.10. Radiocarbon dates from Brandwijk ordered by layer (from Raemaekers, 1999: 301–302; animal remains: this study).

fall on a plateau in the calibration curve (c. 4300–4000 cal BC), but it is clear that these dates do pre-date the transition to farming in the UK and northern Europe. The fourth ^{14}C date (De Bruin 98BRUV06258) pre-dates the plateau and testifies to the presence of sheep/goat around 4520–4356 cal BC in the Swifterbant culture.

Discussion

It is crucial to embed the zooarchaeological results in their geoarchaeological background. The understanding of sites such as De Bruin and Brandwijk is closely tied to their well-dated geomorphological and archaeological-stratigraphic context, leaving little reason to doubt their chronological integrity. That said, problems with the preservation of fifth millennium contexts, especially of organic remains, are intrinsic to the geology of the larger region. Acidic sandy soils, which do not allow any preservation of organic remains, prevail in the regions between the Dutch wetlands and the central European loess belt. Moreover, coastal regions have been eroded through

sea-level rise. The sites that do represent the Mesolithic-Neolithic transition in the Netherlands are then chance finds representing a zone of preservation rather than a chronologically and geographically well-distributed set of evidence.

Results from the zooarchaeological re-analysis of old Swifterbant assemblages in comparison with older and younger assemblages from the Netherlands, Britain and Europe provide a firmer basis for inference about the status and meaning of the (claimed) domestic animals in fifth millennium Dutch wetlands.

Aurochs (*Bos primigenius*) is not very common in the Early Holocene Netherlands. Late Mesolithic Polderweg, near Brandwijk and De Bruin, for example, produced no aurochs bones (the total number of excavated vertebrate fragments was 1812; Louwe Kooijmans, 2001). We cannot, however, rule out that aurochs were present, even common, in this area in the fifth millennium BC; acidic conditions may have left behind no organic evidence. *Bos* sp. do not become significantly more common in the fifth millennium BC assemblages. The apparent size range of *Bos* from Brandwijk L60 corroborates reconstructions of mortality patterns, body part distribution and relative abundance, in that they cluster better with the expected and known results from living domestic populations rather than living wild populations. However, it must be underlined that the evidence for *Bos* is much thinner than the evidence for *Sus*, for which we can assess population-wide trends with more confidence.

Sus, typical wetland fauna, are abundant in sixth millennium BC contexts (such as Polderweg), and they remain abundant at De Bruin and Brandwijk. The representation of exclusively cranial bones, teeth and extremities of *Sus* in Brandwijk is also intriguing, because it suggests that the site may have been a processing site. However, the sample size is too small to speak about this possibility with certainty. The *Sus* in De Bruin range well with the other fifth millennium cal BC sites in the region in terms of size, and some individuals were captured in old age, as expected from a wild population. The Brandwijk *Sus*, however, display a larger size range, indicating the presence of two, possibly interbreeding, populations. Interbreeding may have taken place among different domestic populations, between domestic and wild populations, and/or it may have involved feral individuals who had escaped from farmers inland. So, although two populations seem to be present, the small-bodied population culled before their first year in life and large individuals, these are probably best considered as parts of a continuum. In any case, it is not possible to speak of such a situation at earlier sites such as Swifterbant -S3. In Brandwijk Layer 60, the claim for an (inter)breeding population representing a new phenotype of morphologically domestic *Sus* is reasonable. Domestic pigs living close to the settlements may not have replaced the open forest-feeding *Sus* of De Bruin (based on $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ values) at all, but may have interbred with them regularly. The size reduction observed in *Sus* in post-4000 cal BC contexts probably indicates a more tightly controlled type of pig husbandry. This may have resulted from an increase in communities practising intensive agriculture and its accompanying deforestation. Two *Sus* specimens from the Brandwijk-contemporary Swifterbant S4 (c. 4300–4000 cal BC) yielded mtDNA results indicating European

haplotypes (Krause-Kyora, 2011, 107). It will be interesting to probe the Brandwijk *Sus* for palaeogenomic analyses, and evaluate this information in combination with more detailed zooarchaeological work from the entire spectrum of Swifterbant sites.

According to our new identifications, there are considerably fewer sheep/goat specimens than previously reported. The sheep/goat remains from De Bruin and Brandwijk, at least four of which date before 4000 cal BC, represent in a way an island of small domesticated ruminants in time and space. Despite a visible change in relative taxonomic abundances later in early fourth millennium sites (Bakels *et al.*, 2005; Zeiler, 2006; Brinkkemper *et al.*, 2011), sheep and goats remain virtually absent in the Netherlands until the Late Neolithic period. It has been argued that sheep and goat appeared in the Dutch region much later than other farm animals because they were not resilient to the river flukes that occur in wetlands (Brinkkemper *et al.*, 2011). It is also possible that sheep and goat did not thrive in the region until the mid-third millennium BC because they require winter foddering in cold and wet climates. Without substantial cultivation to produce a surplus sufficient to provide winter fodder, sheep and goat herding would not have been a viable option. Even if there were sheep and goats roaming in the perimarine area, they were probably not herded. Even if they were herded for a short time, attempts to establish caprine herding were not successful at least for another millennium.

No major reconfiguration of taxonomic compositions took place through the fifth millennium BC or even after, during the transition to the fourth millennium BC. *Bos* and *Ovis/Capra* remains are not abundant in the De Bruin and Brandwijk assemblages. These assemblages are clearly dominated by species adapted to life in wetlands (fish, *Sus*, beavers, otters and waterfowl). However, there is good reason to suggest that in Brandwijk Late Phases (Layers 50 and 60; 4200–3900 cal BC), husbandry of cattle and at least management of pigs have become part of the subsistence strategies. This would be in line with the presence of cereals (Out, 2008b) and tillage marks in the Swifterbant region dating to the late fifth millennium cal BC (Huisman and Raemaekers, 2014). The introduction of animal husbandry in the Dutch wetlands in this period may have involved different mechanisms for different species. One possibility includes the substantial intermixing with local *Sus* populations through an ‘organic’ entry of domestic pigs into the Dutch wetlands. The introduction of small herds of domestic cattle was possible in the perimarine landscape that contained either a very small aurochs population or none at all. We surmise that, at this stage in the late fifth millennium cal BC, Swifterbant groups would have perceived and managed these small numbers of pigs and cattle differently than their wild counterparts. Forthcoming data from recent rescue excavations in Utrecht (Nieuwegein) and Gelderland (Tiel-Medel) should reveal more about human-animal interactions at this time.

Conclusions

Our research does not support the previous assertions regarding the presence of domestic animals or domestic animal husbandry in the early and mid-fifth millennium

BC Netherlands (Raemaekers, 2003; Cappere *et al.*, 2008; Out, 2008a). However, based on multi-proxy zooarchaeological data and direct ^{14}C dates, we think it is reasonable to suggest that animal husbandry began in the Dutch delta at the end of the fifth millennium BC.

The small assemblage from Brandwijk, as well as results from studies on Mesolithic and Neolithic *Sus* in Europe and beyond confirm that substantial introgression, especially in the case of *Sus*, played a crucial role in the establishment of pig husbandry in the Swifterbant region (Krause-Kyora *et al.*, 2013; Ottoni *et al.*, 2013; Price and Evin, 2017; Frantz *et al.*, 2019). Although the same is true for cattle (Park *et al.*, 2015), the presence of widespread aurochs herds prior to the beginning of farming in the Dutch wetlands is questionable. Radiocarbon dates and zooarchaeological identifications leave no doubt as to the presence of sheep/goat in the area at the end of the fifth millennium BC, probably as animals on the hoof.

These animals may have belonged to herds, they could have been exchanged as gifts or they may have represented escaped and hunted animals. Regardless of how they ended up in the Late Swifterbant sites in the Dutch delta, it is clear that their presence did not lead to continued sheep and goat herding in the region. Changes in *Bos* and *Sus* management practised at a small scale and in their phenotypic and genotypic composition at the end of the fifth millennium BC did not lead to a large societal change, at least not an archaeologically visible one (Raemaekers, 2019).

These results are compelling in terms of the dominant model of the beginnings of farming in the Dutch wetlands. The present narrative of first animal husbandry in the early fifth millennium BC and then small-scale cultivation needs to be reconsidered. Although foraging remained an important activity at least until 3700 cal BC (as evident at Schipluiden), it is clear that the changing relationships between humans and animals at the end of the fifth millennium are in one way or another related to encounters with domesticates. This period needs to be explored in detail with new methods and multi-disciplinary perspectives utilising larger assemblages.

Finally, yet importantly, our study highlights the importance of proper long-term data and storage management and accessibility of archaeological data, which the Dutch Heritage Agency regulates by codes of conduct and legislation (<https://www.sikb.nl/>). Without these open archives, it would be impossible to re-examine the zooarchaeological assemblages to test widely held beliefs that have enormous influence on our archaeological narratives.

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stable isotope analyses of selected specimens from Brandwijk and De Bruin were conducted at the Department of Archaeology and the Department of Earth Sciences at Durham University. We would like to thank Kurt Gron for his kind collaboration in this experiment.

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