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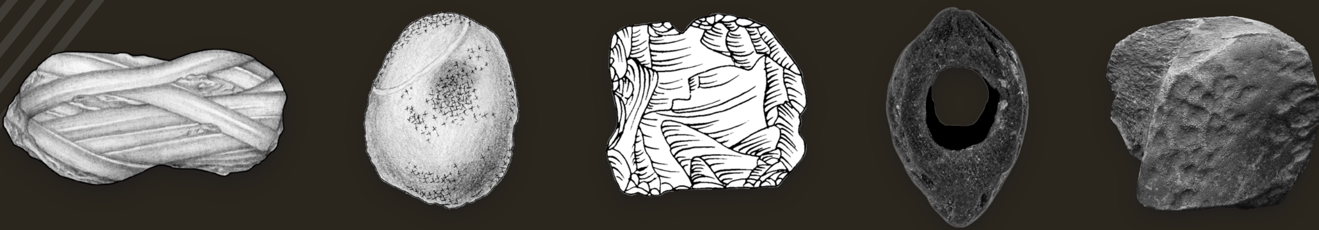
Occupation and exploitation of a Neolithic levee site (c. 4300-4000 cal. BC)



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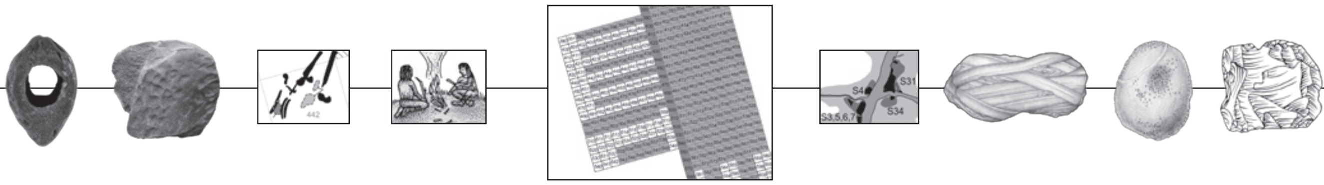

Introduction

D.C.M. Raemaekers[1]

1.1 History of research

The archaeological sites near Swifterbant are located in Oostelijk Flevoland, the Netherlands. Oostelijk Flevoland is a polder, a reclaimed sea floor of the former Zuiderzee (which later, after damming, became a lake, the IJsselmeer), at a depth of c. 4.5 m below mean sea level (NAP; Amsterdam Ordnance Datum). The polder was to become an extensive agricultural area, and to this end, workers of the state service responsible for the polders of the IJsselmeer (at that time the *Rijksdienst voor de IJsselmeerpolders, RIJP*; the IJsselmeerpolders Development Authority), made drawings of the slopes of all freshly cut ditches and carried out numerous corings. In the process, they found evidence not only of the deposits of a prehistoric creek system, but, in 1961, also of archaeological remains on creek banks and dunes (fig. 1.1). These finds marked the start of the archaeological research at Swifterbant. From 1962 onwards, several excavation campaigns by G.D. van der Heide and his RIJP team revealed that the Swifterbant area is a treasure trove of well-preserved Mesolithic and Early Neolithic settlements.

The Biologisch-Archaeologisch Instituut (Biological-Archaeological Institute) of the University of Groningen (now the Groningen Institute of Archaeology) carried out extensive research in the period 1972-1979. The project focused on site S2, located on a bank of a major creek, and on site S3, located on one of the minor creeks. Several dune excavations were carried out at sites S11-S13, S21-S24 and S61 by J.D. Van der Waals, in cooperation with T.D. Price (University of Wisconsin) and R. Whallon (University of Michigan). J.D. van der Waals's team comprised specialists on ceramics, animal bone, human bone, botanical macroremains, geology, flint and wood. The research group produced a large number of publications on various parts of this highly ambitious research project. All relevant publications are listed below.

The research history of Swifterbant site S4 started in 1972, when L. Hacquebord discovered that there are several more sites in the vicinity of site S3, including S4 (Hacquebord, 1976: fig. 3). In 1974, Hacquebord carried out a trial excavation to obtain a sample of archaeological remains for comparison with known sites and to gain more insight into the stratigraphy and age of the deposits. The test trench, which measured 2x8 m, yielded bone, ceramics and flint (Van der Waals, 1976: 23-24). The aspects published so far are the stratigraphy (Van der Waals, 1976: 23-24), the pottery (De Roever, 1979; 2004) and the flint and stone artefacts (Devriendt, 2014).

Exactly 25 years after Van der Waals's last campaign, which was in 1979, the Swifterbant research was resumed by the Groningen Institute of Archaeology as the New Swifterbant Project. In the present project, the University of Groningen is cooperating with museum *Nieuwland Erfgoed* (now Batavialand), Lelystad; local volunteers from *Archeologische Werkgemeenschap Nederland* (Archaeological Working Group the Netherlands), section Flevoland; and the province of Flevoland. All participants are listed in table 1.1. The fieldwork provided opportunities for the *Rijksdienst voor het Cultureel Erfgoe*d (Dutch Cultural Heritage Agency) to study the preservation of the sites S2 (Huisman *et al.,* 2008) and S4 by means of micromorphological analysis (Huisman *et al.,* 2008; 2009; Huisman & Raemaekers, 2014).

In the past decade, Dutch archaeology has seen major changes. As result of new legislation, archaeological research is now a standard part of development plans, and as a consequence, many new sites have been discovered and excavated. Blessed with larger budgets than earlier projects, these projects have made considerable contributions to our knowledge of Dutch prehistory. What can small-scale university field work add? Although lacking some of the possibilities available to large-scale commercial projects, university projects can be fully research

1 d.c.m.raemaekers@rug.nl; University of Groningen / Groningen Institute of Archaeology; Poststraat 6, 9712 ER Groningen, the Netherlands.

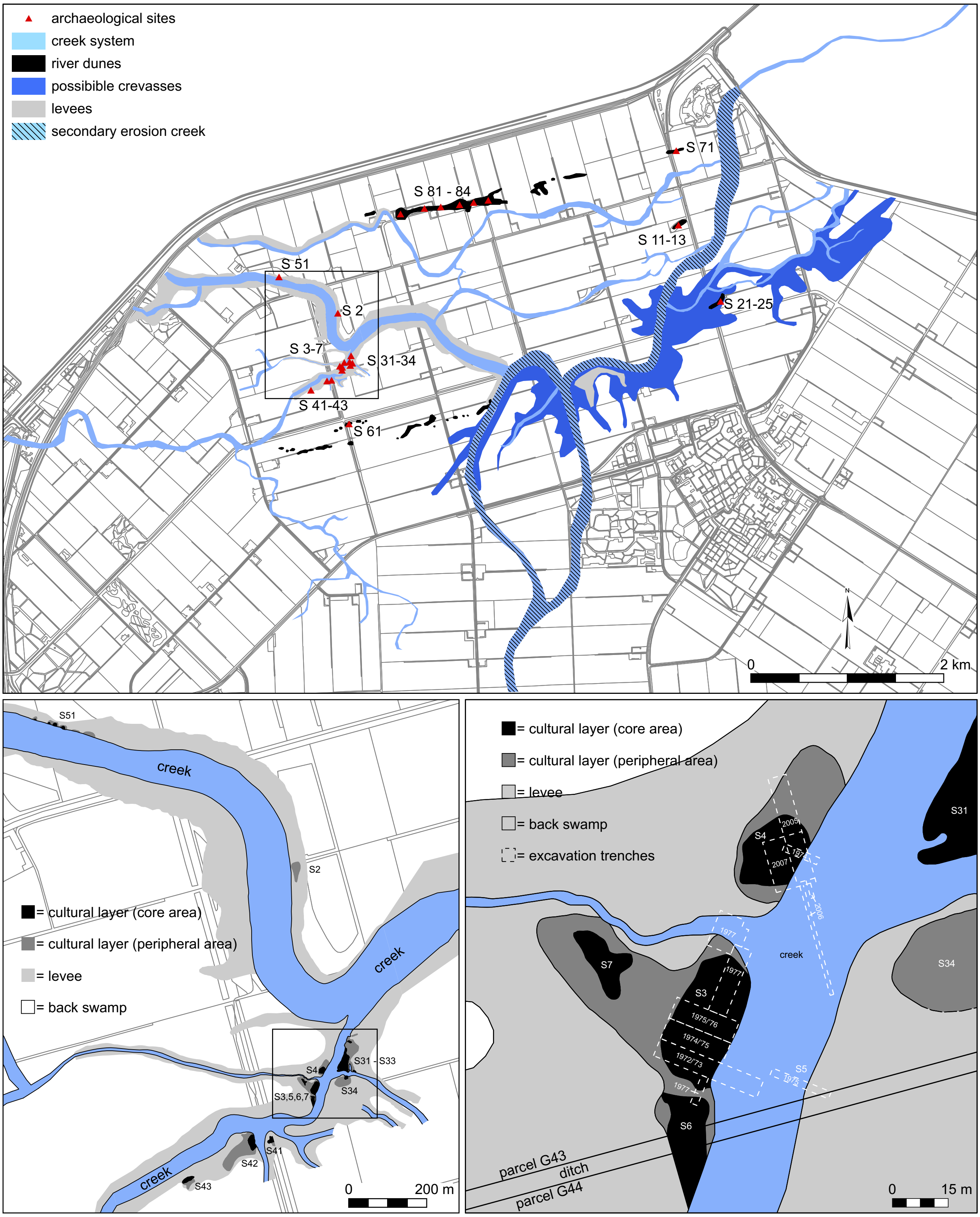

Fig. 1.1 The Swifterbant region (after Devriendt, 2013: figs. 2.2, 2.3 and 2.7).

driven, with research questions leading to research locations, instead of the other way around. In other words, they can focus on important research questions that can be solved with small-scale fieldwork at selected sites. The Swifterbant area is special in this respect: thanks to the previous research efforts in the area (in terms of both fieldwork and publications) its research potential is well understood. The New Swifterbant Project focuses on a number of research questions, the answers to which until now have been left undecided. The research issues involved are as follows (Raemaekers *et al.*, 2005):

1. Local cereal cultivation. For the Swifterbant culture, all evidence of cereal use has been found

Table 1.1 List of participants.

Name	Affiliation	Job capacity
Prof. D.C.M. Raemaekers	University of Groningen	Director 2005-2007
D.E.P. Velthuizen	Nieuwland Erfgoed, Lelystad	Senior field technician 2005-2007
I. Devriendt lic.	University of Groningen	Administration 2005-2007
Drs. I. Woltinge	University of Groningen	Geological research 2007
Drs. W.J. Hogestijn	Municipality of Almere	Archaeology 2007
Drs. A. Nieuwhof	University of Groningen	Archaeology 2007
S. Tiebackx	University of Groningen	Field technician 2007
S.M. Beckerman	University of Groningen	Field assistant 2005
C. Boom	University of Groningen	Field assistant 2006
H. Kranenburg	University of Groningen	Field assistant 2007
A. Pleszynski	University of Groningen	Field assistant 2007
M. van der Wal	University of Groningen	Field assistant 2005
T. Abelen	University of Groningen	Student
K. Blok	University of Groningen	Student
K. Bresser	University of Groningen	Student
M. Brouwer	University of Michigan	Student
S. Cheung	University of Groningen	Student
M. de Boer	AWN Flevoland	Volunteer
P. den Hengst	University of Groningen	Student
T. Dijkstra	University of Groningen	Student
A. Doppert	AWN Flevoland	Volunteer
L. Edens	University of Groningen	Student
J. Eelman	AWN Flevoland	Volunteer
R. Fens	University of Groningen	Student
J. Geuverink	University of Groningen	Student
E. Grefhorst	University of Groningen	Student
S. Griemink	University of Groningen	Student
K. Groothoff	AWN Flevoland	Volunteer
T. Heise	AWN Flevoland	Volunteer
J. Jansen	University of Groningen	Student
A. Kramer	University of Groningen	Student
W. Kreukniet	AWN Flevoland	Volunteer
R. Kruisman	University of Groningen	Student
J. Mendelts	University of Groningen	Student
S. Rathje	University of Kiel	Student
S. Thijsse	AWN Flevoland	Volunteer
H. van Betuw	AWN Flevoland	Volunteer
V. van den Berg	University of Groningen	Student
E. van de Lagemaat	University of Groningen	Student
E. van Galen Last	AWN Flevoland	Volunteer
B. van Rosmalen	AWN Flevoland	Student
R. Verboon	AWN Flevoland	Volunteer
D. Volkerink	University of Groningen	Student
J. Vosselman	University of Groningen	Student
S. Wennink	University of Groningen	Student
J. Wiersma	University of Groningen	Student

on waterlogged sites, in landscapes that seem little suited for cereal cultivation (Cappers & Raemaekers, 2008). The new fieldwork should encompass a sampling strategy equipped for addressing this issue (see chapter 6);

2. Interpretation of intersite variability. The research from the, 1960s and, 1970s made clear that although the creek bank sites are contemporaneous, their archaeological remains differ in such aspects as the presence of human burials and hearths. Archaeobotanical and archaeozoological research was restricted to S3 due to the limited preservation conditions of S2, and so it remained unknown whether site S3 was representative of the Swifterbant creek bank occupation (chapter 7). Zooming out, the dunes sites did provide evidence of occupation in the Mesolithic and Neolithic periods, but the absence of organic remains left uncertainty about how the dune sites functioned in relation to the creek bank sites. The fieldwork should include excavation of a new dune site with well-preserved remains (Raemaekers *et al.*, 2014: S25);
3. Regional occupation history. Although the Swifterbant research was carried out in a clearly defined region, the research was site oriented, and

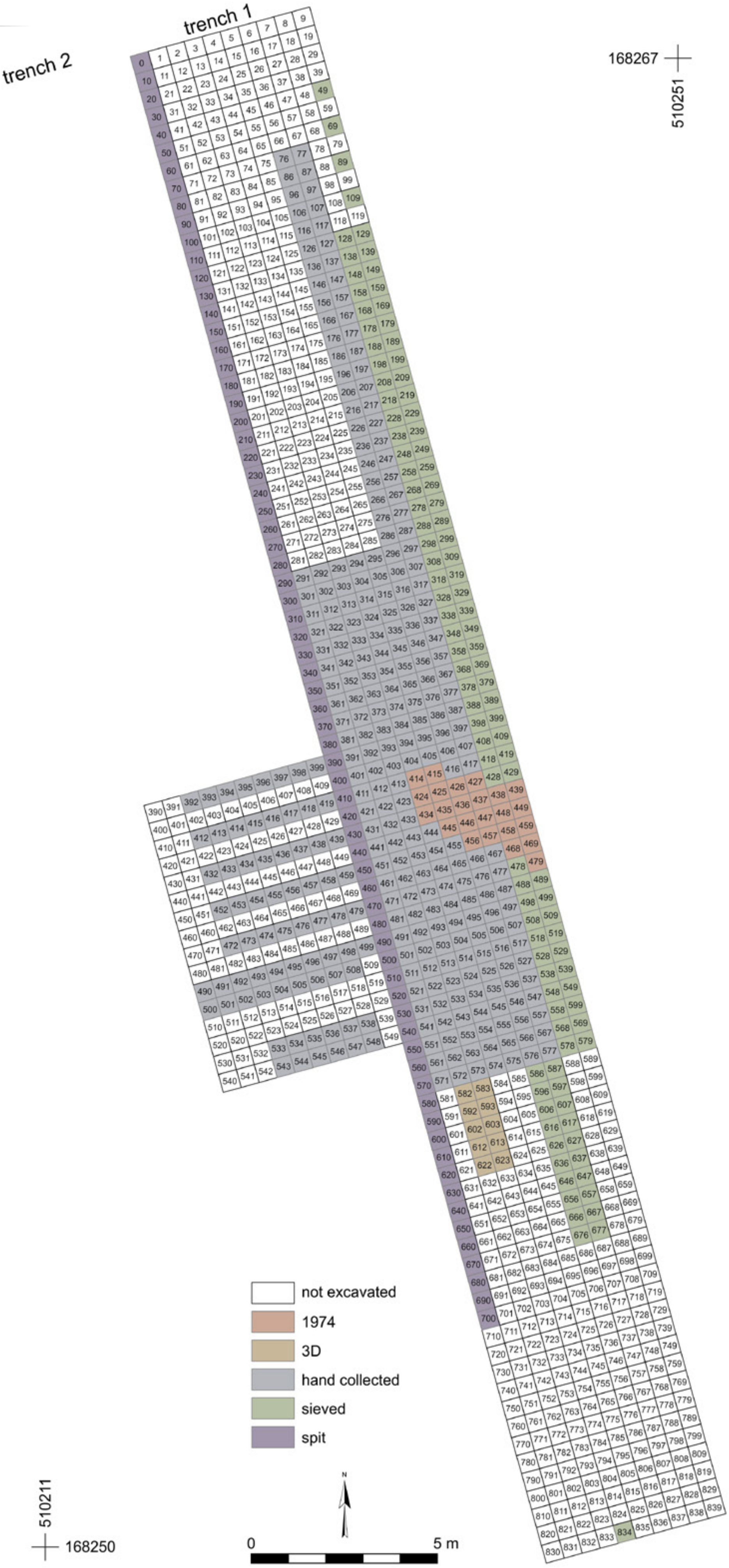

Fig. 1.2 Excavated area of Swifterbant S4 and recovery methods (map E. Bolhuis, UG/GIA).

Table 1.2 Administrative details of the excavation.

Municipality	Dronten
Town	Swifterbant
Location	S4
GIA site code	GIA 92
National research codes (CIS)	12860, 15711, 23748
Coordinates	See figure 1.2
Execution	University of Groningen/Groningen Institute of Archaeology in cooperation with Nieuwland Erfgoed, AWN Flevoland and province of Flevoland
Excavation	Summers of 2005, 2006 and 2007
Duration of the excavation	12 weeks

questions on landscape development, landscape use and infrastructure were left unaddressed. The fieldwork should include excavation of areas outside the settlement sites proper and should include landscape-oriented specialist research;

4. Neolithisation. The available sites do not allow for a study on Neolithisation, as they comprise creek bank sites from the Neolithic and dune sites with occupation histories encompassing the Mesolithic–Neolithic transition but without any organic remains. New fieldwork should provide new sites dating to the centuries before the known creek bank sites, thus allowing for a study on Neolithisation.

The New Swifterbant Project started in 2004, with a small-scale excavation of S2 (Prummel *et al.,* 2009). The major concern was to develop and test fieldwork methods for successful botanical sampling and for wet sieving the clay in which the creek bank sites are embedded. The relatively poor organic preservation of S2 prompted a shift in attention to S4, separated from the well-preserved S3 by a small creek. In 2005, attention focused on the botanical sampling programme and the use of the low-lying area behind the creek bank (fig. 1.2). In 2006, the 2005 trench was expanded into the creek, primarily to establish the relationship between creek bank site and the creek fill, while on the creek bank a small trench was dug for further research on the human burial found in 2005. The 2007 campaign had two goals. First, it aimed to verify the clues, provided by the analysis of thin sections and diatoms, that a cultivated field was located below the settlement. Second, it expanded the excavation area with a series of test trenches to see if more burials were present. The relevant administrative details are given in table 1.2.

From the start, the S4 research was aimed at gaining more information on intersite variability and landscape use (research issues 2 and 3), while the botanical sampling programme was aimed at providing more insight into possible local cereal cultivation (research issue 1). The find of a cultivated field prompted a shift of attention towards both cereal cultivation and the process of Neolithisation. This monograph is the site report proper and focuses on three themes. These are

1. Landscape, exploitation and site function (chapters 2, 6 and 7);
2. Developments in the use history of the site, in terms of material culture and subsistence (chapters 3-7);
3. The use of space (chapter 9).

The second part of this monograph (in prep.) will be dedicated to the full documentation of the cultivated field and will comprise a series of specialist chapters and a synthesis.

1.2 Research methods

In 1974, the excavation plane of S4 was divided into 1x1 m squares, and these were excavated in 10 cm spits. Hand-picked finds were measured in 3D, while the remaining soil was wet sieved with a mesh of 2 mm aperture. Because of the differences in grid orientation, square size and spit depth, the 1974 finds are only incorporated into the analysis here when we describe the find categories in general.

The 2005 trench was positioned to encompass the 1974 trench (fig. 1.3). It allowed a more detailed measuring of the position of the 1974 trench than had previously been available. The 2005 trench was 5 m wide and 29 m long. The plane was subdivided into 50x50 cm squares, numbered 0-9 on the northernmost row to 570-579 on the southernmost row. For spit 2, the square numbers were increased by 1000 (squares 1000-1579), and so on. The westernmost series of squares was shovelled to a depth of, 20 cm to allow superfluous water to flow to the lowest point in the trench. All finds from this trench were collected and attributed to the corresponding square number from spit 1, disregarding the exact depth of the find. On the eastern side of the trench, a 1 m wide strip (square numbers ending with 8 or 9) was selected for wet sieving in the field using a sieve with 2 mm mesh size. This mesh was selected to allow cereal grains to be recovered. Additional soil samples were taken from these squares and kept in reserve for further botanical research (see chapter 6). All remaining squares were excavated using trowels. All finds were bagged together by spit.

The 2006 trench was a southern extension of the 2005 trench into the creek, and it used the same square numbering system. In the 2006 trench, the easternmost squares are designated with 7; these were wet-sieved. The westernmost squares (1-5) were excavated using different documentation systems. At first, the few finds recovered were measured in 3D, but when the find density increased, we shifted to using square numbers and spits. As

Fig. 1.3 The 2005 excavation in progress. Note that the 1974 trench is visible as disturbance (photo D.C.M. Raemaekers, UG/GIA).

Fig. 1.4 Documentation of the cultivated field in 2007 (photo I. Woltinge, UG/GIA).

a result, the finds from this trench are difficult to relate to the other parts of the site.

The 2007 campaign continued excavation in part of the, 2005 trench to spit 9, which was the lowest part of the finds layer. The cultivated field below the finds layer (chapter 9) was documented with field drawings on a scale of 1:1 (see fig. 1.4) and then excavated with shovels. The few finds were simply attributed to the cultivated field. That same year, a second trench was opened to the west of the first trench. Here several test trenches were excavated using trowels.

Specialist research included sampling for soil micromorphology, pollen, diatoms and shells. In the, 2007 campaign, a series of corings at S4 aimed to obtain a more detailed understanding of the site morphology and the extent of the cultivated field (chapter 2).

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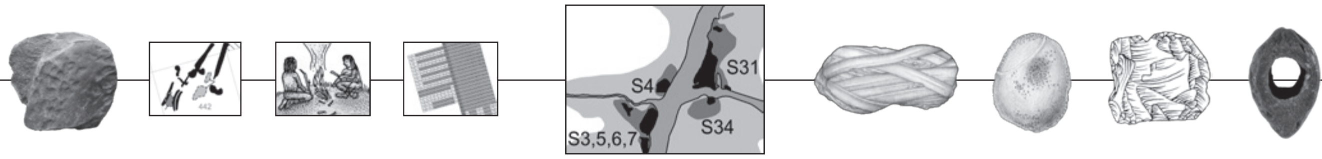

Landscape development and stratigraphy

M. Schepers[1] & I. Woltinge[2]

2.1 Introduction

This chapter deals with the landscape development and stratigraphy in the Swifterbant area in general and at S4 in particular. Although the geology and landscape in the Swifterbant region have been researched and published extensively over the years (Ente, 1976; Hacquebord, 1976), the New Swifterbant Project (Raemaekers *et al.,* 2005) prompted new interest in the geological setting of the archaeological sites, stimulated by the presence of a cultivated field below the S4 cultural layer (chapter 9) and the results of diatom analysis (chapter 6) and thin sections (Huisman *et al.,* 2009; Huisman & Raemaekers, 2014). This chapter gives an update of the developments in sedimentation on a regional scale, followed by a description of the S4 layers and a comparison of the characteristics of this site with those of the neighbouring site of S3.

2.2 Regional landscape development

Swifterbant is located in the Zuiderzee region. This region comprises the IJsselmeer (a lake formed from a sea, the Zuiderzee, by damming in 1932), the polders within the IJsselmeer, and the coastal regions of the former Zuiderzee. Although currently cut off from the sea, the area was, for large parts of its Holocene history, a coastal lagoon. The geological entities described in this paragraph and their relation to the S4 habitation are summarized in table 2.1. The subsoil in this region consists of cover sands deposited during the Weichsel glacial (Boxtel formation), when ice sheets did not reach as far south as the Netherlands and a cold, dry, tundra-like landscape came into existence.

During the Holocene, the post-glacial relative sea level rise, in combination with the relatively flat Pleistocene topography of the Netherlands, resulted in an increased influence of the sea. The sea level rise first led to rising ground water levels and subsequently to peat development on the cover sands in the lower parts of the Swifterbant area. With the continuing sea level rise, ever-increasing parts of the Pleistocene landscape became covered with peat. This peat is known as the basal peat layer (*basisveen*, Formation of Nieuwkoop).

The continuing rise of the sea level in the period between 5100 cal. BC and 3700 cal. BC resulted in the deposition of clay sediments that are part of the Wormer Member, which falls within the Naaldwijk Formation. A freshwater system with minor tidal movement, consisting of small, creek-like river branches, banks and water meadows, developed.[3] There has been some debate with respect to the exact degree of tidal movement in the area, but there is consensus that this was most probably less than 0.5 m (for an overview of the discussion, see De Roever, 2014: 17). Lying at the landward, freshwater end of the coastal lagoon, the Swifterbant system was characterized by slow deposition of very fine sediments. Relative rise of mean sea level continued to be a factor in the region (e.g. Van de Plassche *et al.,* 2005), although it appears to have been slowing down during the period of habitation (Ente, 1976; Huisman *et al.,* 2009).

Based on a Digital Elevation Model, air photography and geological maps, a new map of the Swifterbant creek system was made by Dresscher and Raemaekers (2010; see fig. 1.1). They describe the creek system as anastomosing (2010, 31), meaning a low-energy riverine system in which several connected channels coexist. Although the Swifterbant small river system shows great resemblance to an anastomosing river, the fact that only one main branch is present raises the question whether it can justly be characterized as such. One of the main

1 mans.schepers@rug.nl, University of Groningen / Department of Landscape History, Oude Boteringestraat 34, 9712 GK Groningen, the Netherlands.

2 i.woltinge@baac.be, BAAC Vlaanderen, Zandstraat 5 2223, Heist-op-den-Berg, Belgium.

3 In terms of lithology, height differences and the scale of the system, the Swifterbant creek system is very different to the major river systems in the Netherlands, such as the Rhine and the Meuse. Therefore, the terms creek, bank and water meadows are preferred over their riverine equivalents of river, levee and back-swamp.

Table 2.1 The general lithostratigraphy in the Swifterbant region.

Layers at S4	De Mulder *et al.*, 2003	Hageman, 1963; Pons & Wiggers, 1959	Approximate dates
Lake IJssel deposits	Lake IJssel layer (Walcheren Member, Naaldwijk Formation)	Lake IJssel deposits	1932-1950 AD
Zuiderzee deposits	Zuiderzee layer (Walcheren Member, Naaldwijk Formation)	Zuiderzee deposits	1250-1932 AD
Almere layer	Almere layer (Walcheren Member, Naaldwijk Formation)	Almere deposits	0-1250 AD
Detritus layer	Lake Flevo layer	Lake Flevo deposits	3700-0 cal. BC
Homogeneously grey, heavy, decalcified clay with charcoal and bone fragments (layer 6)	Wormer Member (Naaldwijk Formation)	Calais III / Cardium clay	5100-3700 cal. BC
Anthropogenically influenced creek bank sediments (layers 2-5)		Calais II / Unio clay	
Natural creek bank sediment of light grey, calcareous clay (layer 1)			
Soft, light grey, calcareous clay			
Brown peat layer	Basal peat layer (Nieuwkoop Formation)	Lower Peat	7000-5100 cal. BC
Sand deposits	Wierden Member (Boxtel Formation)	Pleistocene	Before 9000 cal. BC

processes in anastomosing systems is avulsion, meaning the sudden abandonment of a part or the entirety of a channel for some new course at a lower level of the floodplain (Makaske, 1998, 31). The presence of several interconnected secondary branches indicates that, while we are not dealing with a classic example here, the main characteristics of the anastomosing river system do seem to fit to the Swifterbant system.

Banks arose along the streams, and these may be recognised in soil corings based on their compactness and decalcified state. These banks were inhabited and exploited by the people of the Swifterbant culture sometime between 4300 and 4000 cal. BC (table 2.2).[4] The creek bank formation in the Swifterbant region took place in a wetland area on the fresh water side of an interface of freshwater (peat land to the east, south and north) and brackish open water (tidal flood basin to the west). Typical for the Swifterbant creek system is that it is completely built up with clay. The excavations and corings on the riverbank sites have shown that they consist of ripened clay rather than silts or sand. Moreover, sand was not transported along the stream in substantial amounts. Instead, the heavier sediment particles in the region consist of bound together lutum (flocculated clay). During westerly storms, saline, sediment-laden sea water in the creeks will have mixed with the freshwater from the local peat land and the hinterland. During such events, dispersed, negatively charged clay particles bond with divalent magnesium and calcium ions, a process known as flocculation. These flocs can grow to several millimetres in diameter (Eisma & Cadeé, 1991) and are therefore much heavier than loose particles of clay. Along inland creeks, these flocs contribute to the build-up of banks, with sediment imported from areas closer to the sea. At Swifterbant, these lagoon fringe sedimentary processes are likely the main factor in the formation of the banks.

Banks along the sides of waterways typically receive sediment each time the water level in the channel rises to such an extent that the waterway overflows its banks and floods areas outside its normal bed. We propose that, while these short periods of higher water level in the Swifterbant marsh system may have been due to heavy rainfall in the hinterland, they more probably were due to such events as springtides. Judging from the fact that in the present-day Netherlands storms mainly occur in spring and autumn, seasonal variation in water levels likely played a substantial role here. This variation was also of relevance to the exploitation possibilities of the area. Where water with suspended sediment escapes the channel and enters the flood basin, the flow velocity drops and the sediment begins to settle, gradually depositing a layer of sediment. The heavier, flocculated clay particles predominantly settle in the vicinity of the channel. Vegetation growth on the creek bank provides extra flow resistance, helping to trap sediment right next to the channel. A positive

4 The calibrations of the available ^{14}C dates end up on this 300 year plateau, prohibiting more precise dating of the period and duration of occupation.

Table 2.2 Overview of available ^{14}C dates.

Dated material	Laboratory number	Before Present	CalBC (2σ - OxCal 4.3)	Context	Notes
Seed	GrN-30447	5390 ± 70	4352-4046	Layer 5	
Seed	GrA-33953	5010 ± 40	3944-3704	Layer 5	13 cm from top
Seed	GrA-33954	5350 ± 45	4326-4049	Layer 5	69 cm from top
Beaver bone 3387	GrA-35308	5290 ± 40	4238-3994	Layer 5	Collagen
Beaver bone 3387	GrA-34814	5245 ± 40	4229-3971	Layer 5	Carbonate
Reed	GrA-38187	5340 ± 45	4324-4046	Layer 5	*Terminus ante quem* cultivated field
Reed	GrA-38188	5230 ± 40	4228-3963	Layer 2	*Terminus post quem* cultivated field
Reed	GrA-38189	5340 ± 45	4324-4046	Layer 2	*Terminus post quem* cultivated field

feedback loop exists between creek bank vegetation succession and creek bank sedimentation. Pioneer vegetation operates as a trap for sediment, resulting in higher and drier creek banks (Esselink *et al.,* 1998: 577), and these higher creek banks, in turn, stimulate vegetation succession.

Due to the sedimentation of the banks, the relative water level dropped. As a result, the slightly elevated creek banks show initial soil formation processes, such as ripening (via evapotranspiration due to relative elevation and vegetation). The thickness of the ripened packages at the Swifterbant creek banks indicates that the sedimentation kept pace with the relative sea level rise (Ente, 1976: 27). Occasionally, during high floods, parts of the creek banks broke through (creek bank failure) and a channel was formed leading into the water meadows, resulting in large amounts of sediment being transported into the water meadows. This results in a sub-system of small creeks transporting sediments into the basin, known as a crevasse (see fig. 1.1).

The water meadows behind the creek banks filled up with smaller flocs and loose particles. These areas were fed with water from the hinterland and fresh rainwater, causing a rapid desalinisation of the somewhat brackish flood waters. Studies have shown that incidental flooding with saline or brackish water is not likely to have a lasting salinating effect on soils that regularly receive precipitation (De Leeuw *et al.,* 1991). The attribution of creek bank formation to storm surges provides an explanation for the presence of a 'maritime signal' in ecological research in the region (e.g. De Wolf & Cleveringa, 2005 (diatoms); Van Zeist & Palfenier-Vegter, 1981 (plant macro remains); see also chapter 6). A large proportion of lighter, smaller particles is carried farther into the basin. In the water meadows, the soil must have been saturated with water for the greater part of the year, resulting in a swampy area that, over time, became filled in through the deposition of clay.

The excavations and corings in the Swifterbant area have shown differences in height between creek banks and water meadows of several tens of centimetres. In seeking an explanation for these height differences, we should keep in mind that land reclamation and associated cultivation activities, such as the digging of ditches, has led to a drastic change in the hydrological situation. The ripened creek bank deposits have suffered less from compaction compared with the unripened clay and peat layers. This differential compaction has distorted our view of their prehistoric elevation in the landscape (Ente, 1976: 20): the height difference between the compacted areas and the creek banks will most likely have been little more than 10-20 cm in prehistoric times.

In conclusion, the Swifterbant area was a freshwater area, at the inland fringe of brackish storm surge influence, bordering a tidal basin in the west. The tidal basin was connected to the North Sea and received suspended sediment. The deposits in the region mainly consisted of clay transported from the sea. Connections with the hinterland through local streams were important for the freshwater situation but were not important as contributors of sediment.

The ^{14}C dates and related archaeological remains date the settlement of the Swifterbant region to the period 4300–4000 cal. BC. It has now become clear that exploitation continued until perhaps 3700 BC, when the area was cut off from marine activity and peat started to develop (Hollandveen Member). Evidence of human activities from the period 4000–3700 cal. BC includes some dumps of ceramics, flints, stones and worked wood at S25 (Raemaekers *et al.,* 2014) and soil working at S2 and S4 (Huisman *et al.,* 2009; Huisman & Raemaekers, 2014). This peat layer that covered the clay landscape is no longer present at S4 due to the fact that, as in most parts of the Swifterbant region, the layer has been eroded and redeposited as detritus. The Late Neolithic finds from the Swifterbant area derive from such reworked peat layers (Raemaekers & Hogestijn, 2008). This layer is known as the 'Lake Flevo layer'. The continuing relative rise of the sea level and the permanent influence of the sea resulted in the deposition of clay and sandy sediments, all part of the 'Walcheren Member'.

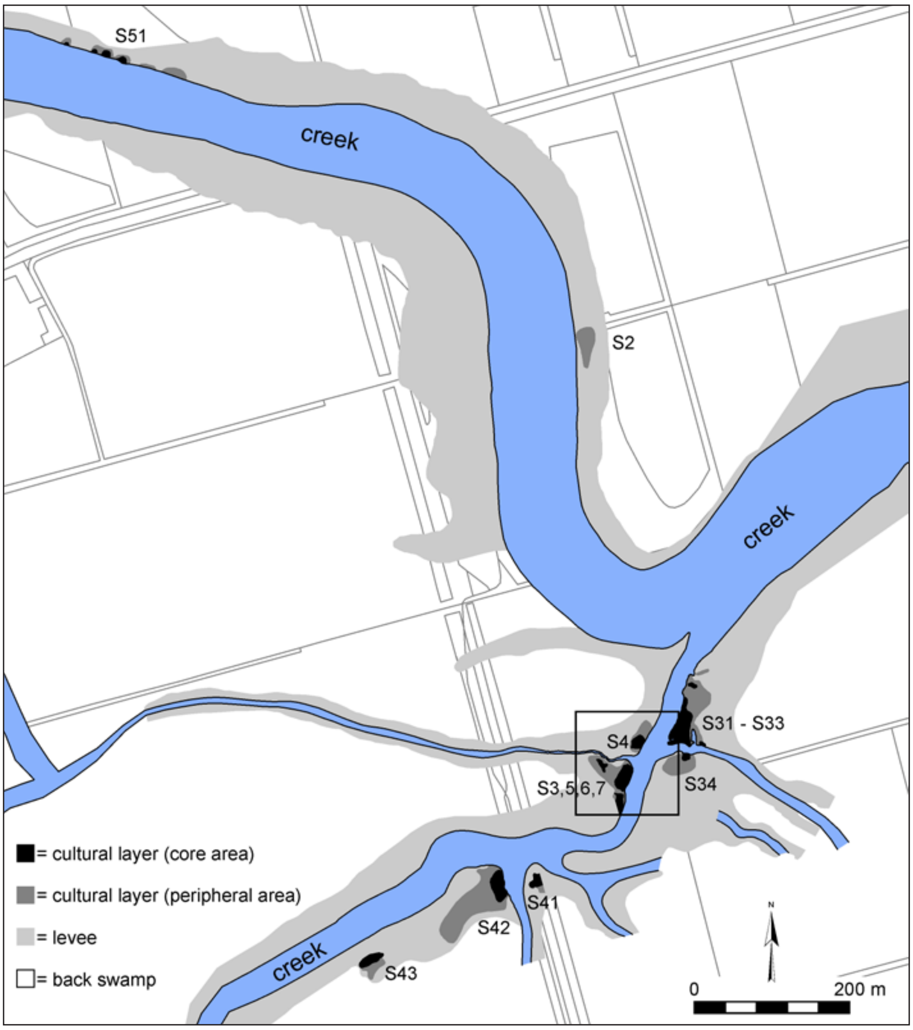

Fig. 2.1 The western part of the Swifterbant creek system (from Devriendt, 2013: fig. 2.3). Box refers to fig. 2.2.

The overlying marine sediments are of later date. From old to young, these are the Almere layer (which consists of strongly laminated sand deposited in brackish lagoonal conditions), the Zuiderzee layer (deposited in saline-brackish conditions) and the Lake IJssel deposits (silty clay, deposited after the construction of the causewayed dam that turned the Zuiderzee into a lake).

2.3 General stratigraphy at S4

S4 is situated at the junction of a number of creeks, just to the south of the main creek in the area and directly adjacent to one of its secondary creeks (figs. 1.1 & 2.1). In order to obtain a reliable view of the exact situation on and around the creek bank site, all sections in the excavation trenches were drawn. Moreover, 53 corings were carried out. The information thus gathered made it possible to define the exact position of the habitation areas, the position of the creek(s) and the local developments over time.

The stratigraphy at S4 will be described as a standard profile (table 2.3). A short remark is required with respect to the usage of the terms calcareous and non-calcareous. A 10% hydrochloric acid solution was used in the field to define the calcareousness of the clay and place it into one of three categories: calcareous, slightly calcareous and non-calcareous. It is assumed that the clay present on the creek banks was calcareous when deposited. Clays which are subjected to the air and leeching of minerals will become firmer and 'ripen', sometimes up to the point of soil formation. Precipitation in combination with 'opening of the soil' by natural and anthropogenic sources subsequently leads to decalcification.

Layer 1 is the oldest layer investigated. It consists of homogeneous, heavy, grey clay that is calcareous and contains very few fragments of pottery or charcoal. On top of this lies a discontinuous, thin layer of dark grey to black humic material, identified as a settlement layer (layer 2). The dark grey, heavy clay overlying this sediment is decalcified and contains large amounts of partially burnt organic material (layer 3). The clay is mixed with plant and archaeological material from layer 2 and shows indications of bioturbation. This clay layer was identified as the remains of a cultivated field during the 2007 field work. One of the crucial characteristics that made the identification of the field possible is the fact that this layer is overlain by an archaeologically virtually 'clean' layer of grey, heavy calcareous clay (layer 4) that separates the field level from the overlying settlement layer (layer 5). This

Table 2.3 The layers of Swifterbant S4 related to the description in Huisman *et al.*, 2009.

Layer	Description	Layer Huisman *et al.*, 2009
6	Homogeneously grey, heavy, non-calcareous clay with charcoal and bone fragments	V
5	Humic, dark grey anthropogenic deposit, c. 50 cm	IV
4	Natural levee sediments consisting of light grey, calcareous clay	III
3	Humic, dark grey, non-calcareous clay with microscopic and macroscopic charcoal and bone fragments, c. 15 cm	
2	Anthopogenic deposit consisting of reed stems and few archaeological finds, c. 5 cm	II
1	Natural levee sediments consisting of light grey, calcareous clay	I

anthropogenic layer contains burnt material, clods of grey clay and coprolite fragments, as well as numerous archaeological finds, and is typically described on all Swifterbant creek bank sites as the 'find layer'. The archaeologically relevant sequence of layers ends with layer 6, a homogeneously grey, decalcified, heavy clay that lies on top of the organic layer and that contains a low number of charcoal and bone fragments (Huisman *et al.*, 2009). Microscopic evidence of cultivation was attested for all these layers, indicating a long, intermittent use of the location as cultivated field, interwoven with phases of occupation (Huisman *et al.,* 2009; Huisman & Raemaekers, 2014).

On a more interpretative level, the chain of events would have been as follows: During a decrease in relative sea level rise, creek banks of ripened clay developed on the shores of the creeks in the Swifterbant area. The inhabitants of the region witnessed this change through absolute changes in the elevation, as well as changes in the vegetation. The formerly inaccessible shores were now visited occasionally to exploit natural resources. From the start, cultivated fields were laid out. Perhaps the fact that the fertile soils were suitable for crop cultivation was the key motivation to use the creek banks. When the silting-up of the creek bank deposits continued, people settled there and laid out bundles of reed on the creek banks. This practice was repeated over and over again, resulting in the thick settlement layers[5] characteristic for most Swifterbant creek bank sites.[6] The fact that the creek banks were only slightly higher than the water meadows made them vulnerable to channel breakthroughs. When this happened, the failure resulted in crevasses. During periods of high water (the winter half of the year), the creek banks may very well have been deserted. The incidental flooding of the creek banks is visible in the sections as layer 4 and the intermittent presence of clay layers within layer 5. Although the flooding was problematic, it also provided the fields and the other parts of the creek banks with new minerals, stimulating plant growth, including crops. Trees, such as alder and hazel, will have been able to survive incidental flooding, provided these were of fresh to brackish conditions. When the sea level rise accelerated again, the sedimentation rate of the creek banks was no longer able to keep up with it and the creek banks once more became covered with marine clay.

2.4 Delimiting the cultivated field

The presence or absence of decalcified clay at S4 was taken as a starting point for a methodological study using indicators that are less traditional in coring research. The micromorphological research (Huisman *et al.,* 2009) showed that decalcification is one of the characteristics of the layer now interpreted as the field; testing for calcification was therefore used to see if the extent of the layer could be found by coring rather than excavating the entire area. The spatial extent of corings with decalcified sediment could then be used as an indication for the extent of the potentially arable land.

While S4 was being excavated, 53 corings were executed around the trench. This way, the coring results could be checked against the sections in the trench, which is a luxury hardly ever available in prospection research. The entire trajectory cored was checked for visual characteristics and the amount of calcium present in the clay. There are a number of decalcified layers present in the area, but the one associated with the stratigraphic position of the field layer (layer 3) could be traced rather easily for a couple of metres in all directions from the trench (fig. 2.2). The area in which the field could be traced based on the colour differences measures some 200 m2, and the extent to which the decalcified layer could be traced is approximately 1600

5 Investigation of the well-preserved, lower part of layer 5 indicates that the individual reed bundles are some 1.5 cm thick. This suggests that layer 5, with a thickness of some 50 cm, was built up during c. 35 events. It is not possible to determine the time depth of this build-up, but is attractive to suppose annual renewal of the settlement site, which would translate to a time depth of 35 years (compare Raemaekers, 2015).

6 Excluding Swifterbant S2, which is built up from natural clay mixed with archaeological debris.

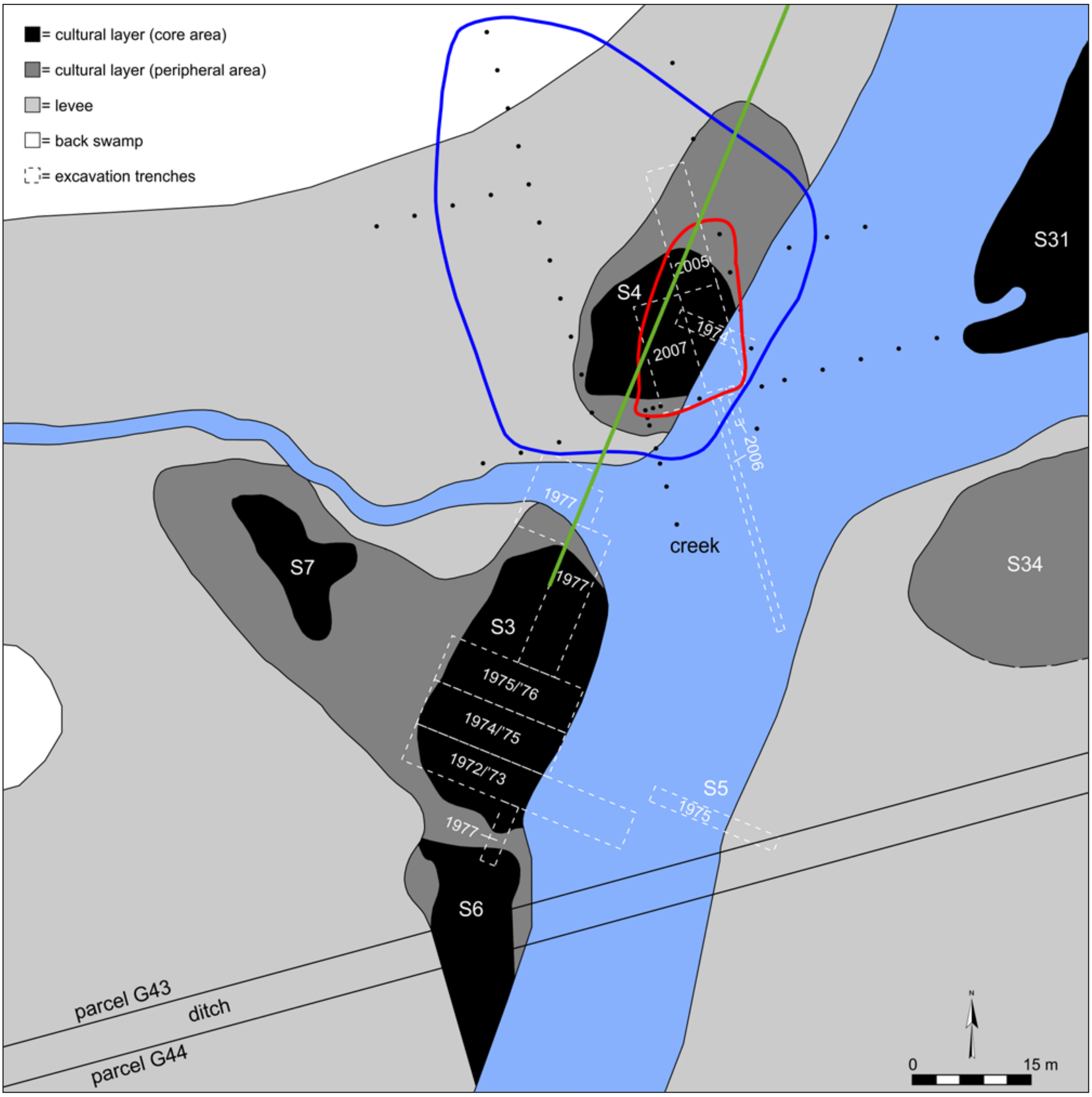

Fig. 2.2 The corings (•) on and near S4 in relation to the excavation trenches (based on Devriendt, 2013: fig. 2.3). The area in which the field could be traced is delimited with a red line; the extent to which the decalcified layer could be traced is delimited in blue. The green line represents the transect of corings placed over the creek between S3 and S4 referred to in the text (map E. Bolhuis, UG/GIA).

m2. The latter is the area thought to be available to the Swifterbant people tilling the field, though no discolouration could be noted here.

2.5 The relationship between S4 and S3

How we interpret the role S4 within the group of sites in the Swifterbant area is directly related to the range of activities executed at the site. This viewpoint has resulted in sections on comparisons with S2 and S3 in most other chapters in this volume. A similar section might seem less evident here, but when we analysed the S4 stratigraphy, striking similarities to that of S3 came to light, prompting a discussion on the stratigraphic relationship and the contemporaneity of these two sites.

During the 1977 excavations of S3, a lacquer peel was made of a part of a southeast-northwest section. This section shows a remarkable similarity to the more recently revealed stratigraphy of S4. With the newly acquired knowledge about the appearance of a field in a section, a field was also recognised, in hindsight, at S3.[7] A new section drawing was made of the lacquer peel, in which the

7 At the time, a layer of grey clay with darker stains was documented. These stains were thought to be the result of cow footprints. The relatively high levels of cereal grains found in the lowermost layers at S3 also suggests that activities related to cereals were important at the start of this site's biography (field documentation and pers. comm. J.P. de Roever, 2011).

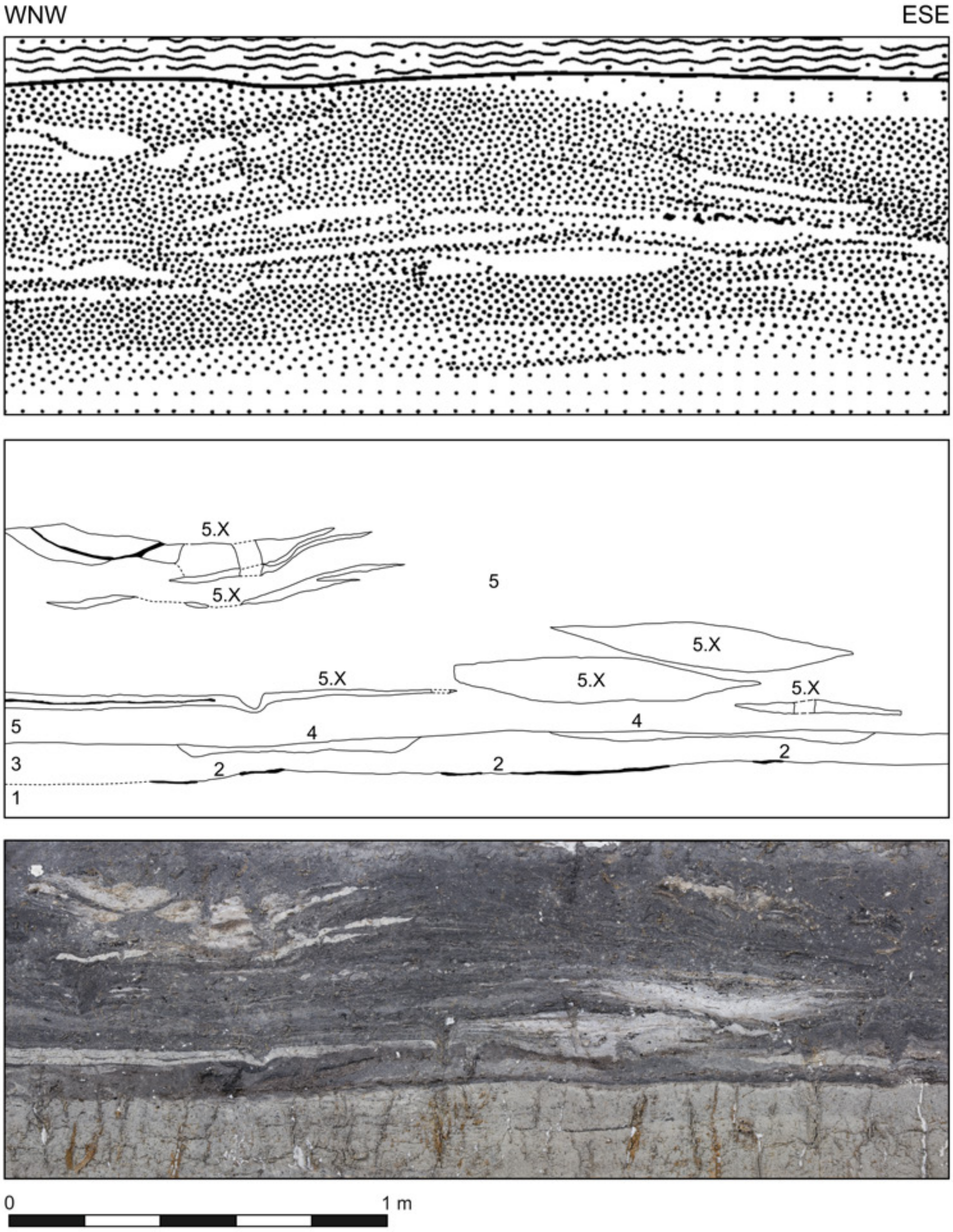

Fig. 2.3 Top: The relevant part of the 1970s S3 cross-section (after Van der Waals, 1977: fig. 11). Middle: The interpretation of the S3 cross-section on the basis of the S4 lithostratigraphy (see table 2.3). Layer 5.x refers to clay layers and anthropogenic features (e.g. hearths) embedded in the anthropogenic deposit layer 5 (drawing M. Schepers, UG/LH & I. Woltinge, UG/GIA). Bottom: Photo of the S3 lacquer peel (photo T. Penders, RCE).

refinement of the section was noted. The new drawing was compared with the 1970s one in order to determine the absolute height (in m below mean sea level; NAP) for the field at S3 (fig. 2.3). The similarities in stratigraphy suggest a similar occupation history at both S3 and S4 (compare figs 2.3 and 2.4).

There are several possible reasons for this difference in height. First of all, there may be a difference in date, in which case the greater depth at S3 would suggest that cultivation started earlier at that site. Another explanation is that there may have been a difference in sedimentation due to the fact that S4 is situated on the convex side of a bend in the stream, while S3 is on the concave side (see fig. 2.1). Differential compaction may also have played a role: If there was a difference in the depth of the soft clay underlying both sites, this could have led to more compaction at S4 than at S3, thus resulting in the same layer lying lower at S4 than it does at S3. The stratigraphic relationship between S3 and S4 was further studied by placing a transect of corings, running more or less north to south, from S4 to S3. The idea was to test the hypothesis that S3 and S4 were part of one site that had later been split in two by an erosion gully. If the gully was part of the main creek system while S3 and S4 were in use, the two sites have to be interpreted as two different activity areas and it would be hard to establish contemporaneity. If, however, the gully between the two was a later breakthrough from the gully running to the south of the sites, this would be a first indication that S3 and S4 could well have been one large site. This would mean that the total arable land available may have been almost 1.5 times as big as the estimate of 1600 m^2 based on the coring research at S4.

Six corings were executed, to a depth of up to 10 m below the present surface. The bank on either side of the gully was traceable in the northernmost and three southernmost corings, making the width of the gully at this location a little under 10 m. Both banks consist of greenish grey ripened clay that is mostly decalcified. On the S4 side, ostracodes were

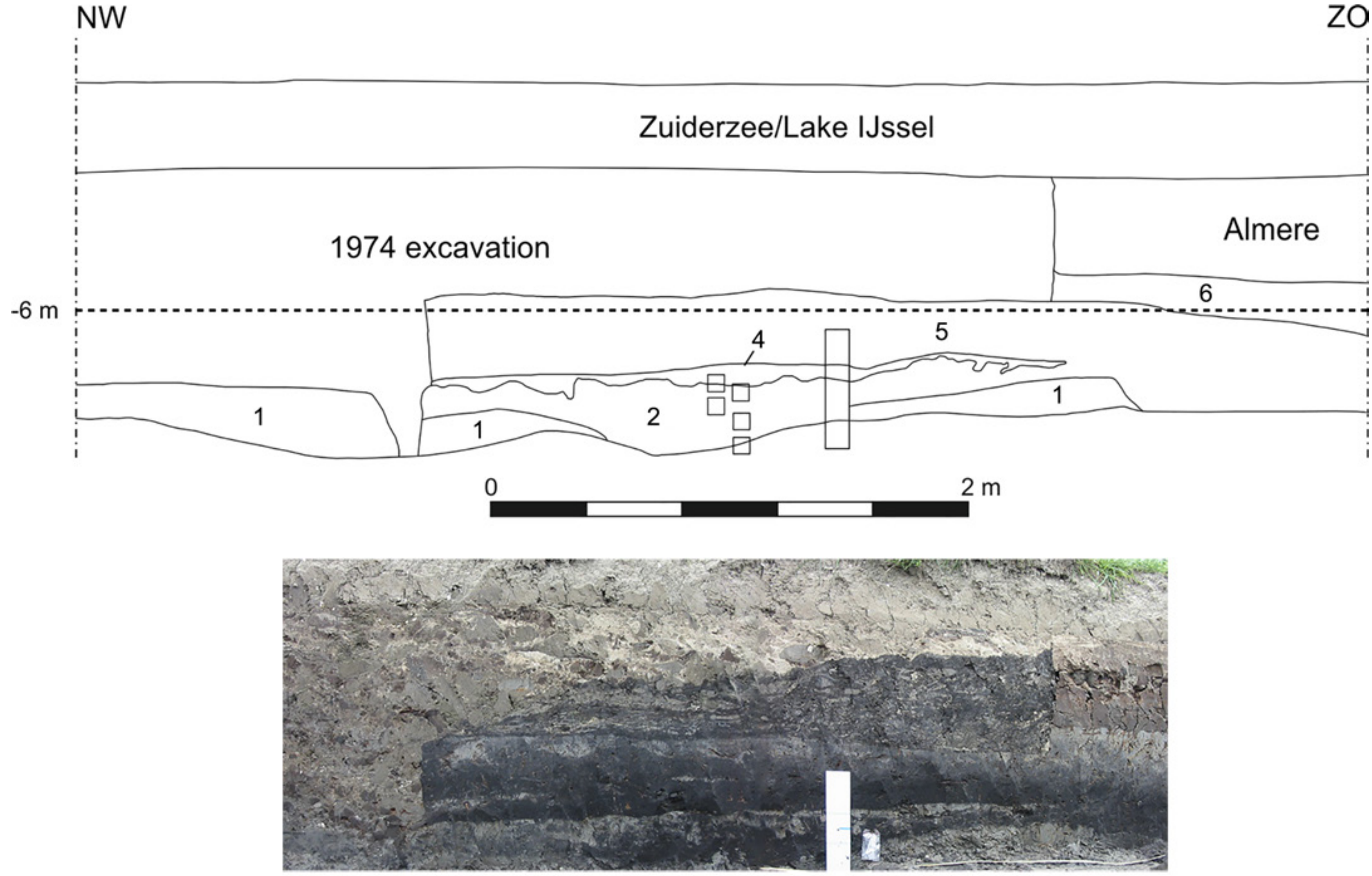

Fig. 2.4 Eastern section of trench 1 (2005) showing an identical build-up to that seen at S3. Layer numbers refer to table 2.3 (drawing E. Bolhuis, UG/GIA, photo D.C.M. Raemaekers, UG/GIA).

present in the ripened clay. These were not found on the S3 side. Here, some iron concretions were found in the bank layers. The top of the bank on both sides is 5.9 m below NAP, gently sloping to 6.2 m below NAP on the S3 side. The ripened clay layer has a thickness of 40 cm closest to the gully and up to 100 cm at the farthest corings, more to the centre of the two sites. The banks do not seem to be sloping much over the length of the transect: On the S4 side, the boundary between the top of the bank and the gully lies within 2 m. On the S3 side, the bank slopes 30 cm over an 8 m distance. The gully infill is made up of soft clays interspersed with layers of sand, suggesting a dynamic character for the infill.

These dynamics characterized the system throughout the total timespan of habitation (De Roever, 2004: 10; Ente, 1976: 32; Haquebord, 1977;) and are also confirmed by the vegetation reconstruction (Schepers, 2014: 97-98). The homogeneous nature of the build-up on both sides of the gully might suggest that the banks were part of one larger area of ripened clay. However, the presence of ceramics from the same pot at various depths in the infill near S3 (De Roever, 2004: 20 & 37) suggests that the breakthrough of the small gulley between S3 and S4 happened when the sites were already there and that the infill had already started during habitation. We propose that, at the start of the occupation, S3 and S4 were one site, and that they became disconnected during the occupation period due to the formation of a small creek.

2.6 Conclusions

Swifterbant S4 is located on the freshwater side of an estuary linking the prehistoric Hunnepe river (the predecessor of the river Overijsselse Vecht) and the North Sea. The landscape is built up with clay that originated in a marine environment but was deposited in a freshwater environment. The archaeological layers of S4 indicate an intricate development of occupation. Occupation starts with de deposition of a thin layer of reed on the somewhat ripened bank of the creek. After the natural deposition of clay, the new surface was repeatedly worked as cultivated field. Next, the site was reused as settlement, and a reed layer some 50 cm thick developed. Later, this layer became covered with clay deposits.

The geological fieldwork focused on delimiting the maximum extent of the cultivated field using corings. From the spatial extent of the decalcified clay layer that is the basis of the lowermost settlement layer, it is clear that some 1600 m2 was available for cultivation. The strong similarities in lithostratigraphy between S4 and neighbouring S3 suggests that both sites may have been part of one site. Sometime later during the period of habitation, these sites became severed from each other as the result of the birth of a small erosion creek running between them.

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3

The ceramics

Raemaekers, D.C.M.[1], J.W. Bembom[2], S. Dresscher[3], A. Koops-Besijn[4] & E. van de Lagemaat[5]

3.1 Introduction

This chapter discusses the ceramics of Swifterbant S4. The analysis encompasses the ceramics found in 1974 and in the period 2005-2007. A total of 1626 sherds (c. 21.5 kg) were described using the descriptive system of Raemaekers (1999: appendix 1). Table 3.1 presents the different components of the assemblage.

In the first phase of the analysis, all sherds with a minimum weight of 5.0 g were described. The analysis of the pottery production was carried out by describing the wall thickness, temper, type of the joins and surface finish of the pottery and the technique, pattern and location of the decorations. The use was examined by describing the occurrence of food crusts and repair holes. Next, the vertical distribution of the sherds was examined to search for the presence of temporally distinguishable occupation phases. This section is of crucial importance, as ceramics provide the only key to unlocking possible relevant temporal units of analysis to use with respect to the other find categories. Another aim is to obtain a discernment of the functional differences among the Swifterbant sites. To this end, we compare the Swifterbant pottery of S2, S3 and S4.

3.2 General characteristics

Tempering agents

The pottery is tempered with different types of material (quartz, granite, other stones, plant, grog and bone) and in different combinations, resulting in 16 different tempering groups (table 3.2). Most of the sherds are tempered with two or more tempering agents (70.9%). Only 28.5% are tempered with a single material. Ten sherds have no visible temper. The most prevalent temper is a mix of some kind of stone grit and plant material (1105 sherds; 68.0%). In some instances, the type of stone was identified. The combination of granite and plant is found in 290 sherds; that of quartz and plant is present in 283 sherds. The other sherds with grit and plant are tempered with unidentified stone material. The second largest group of sherds has only grit temper (365 sherds; 22.4%). Of these, 114 sherds are tempered with quartz and 72 with granite. The third largest tempering group has only plant tempering (96 sherds; 5.9%). There are 16 plant-tempered sherds with an admixture of grog.[6]

For all grit-tempered sherds, both the density and average particle size of the grit were estimated. Table 3.3 presents the correspondence between these variables. A general conclusion is that most grit-tempered sherds were tempered in low to average densities, with 1-2 mm temper particles. A subdivision within the quartz and granite tempered sherds indicates some subtle differences. The highest percentages for quartz-tempered sherds are found for low density and 1 mm particle size, while for granite tempered sherds the highest values are found for average density and 2 mm.

Coiling

The pottery was built up from coils that were connected by two types of joins (fig. 3.1), namely, U-joins (perpendicular in cross-section; Dutch: *H-rollen*) and Hb-joins (slanting in cross-section; Dutch: *N-rollen, Z-rollen*). The type of join was determined for 26.6% of the sherds. The most common type of join are the Hb-joins (67.2%), while U-joins make up the remainder (32.8%). There is no correlation between the type of join used and the thickness of the sherds.

1 d.c.m.raemaekers@rug.nl; University of Groningen / Groningen Institute of Archaeology; Poststraat 6, 9712 ER Groningen, the Netherlands.

2 bemboom@wxs.nl; drs. J.W. (Willem) Bembom; Stationsweg 33, 7731 AX Ommen, the Netherlands.

3 s.dresscher@rug.nl; University of Groningen, Arctic Centre / Groningen Institute of Archaeology; Aweg 30, 9718 CW Groningen, the Netherlands.

4 A.M. Koops-Besijn; Kiel-Windeweer, the Netherlands.

5 esterhofman84@gmail.com; Universitetet i Stavanger / Arkeologisk Museum; Peder Klows gate 30A, Stavanger, Norway.

6 Mica was identified in several sherds. Mica is not considered a tempering agent here, because it occurs naturally in the Swifterbant clay.

Table 3.1 Provenance of the S4 ceramics.

Excavation	Context	N described sherds
1974	No spatial information	124
2005-2007	Spits	1417
2005-2007	3D-measured	43
2005-2007	Features	12
2005-2007	Field	8
2005-2007	No context	22
Total		**1626**

Table 3.2 Temper groups.

Temper	N	%
Quartz	114	7.0
Quartz & grog	5	0.3
Quartz & plant	283	17.4
Quartz. grog & plant	2	0.1
Stone grit	179	11.0
Stone grit & grog	10	0.6
Stone grit & plant	532	32.7
Stone grit. grog & plant	7	0.4
Granite	72	4.4
Granite & grog	3	0.2
Granite & plant	290	17.8
Granite & bone	2	0.1
Granite. grog & plant	3	0.2
Grog	2	0.1
Grog & plant	16	1.0
Plant	96	5.9
No temper	10	0.6
Total	**1626**	**100.0**

Vessel wall thickness

The wall thickness of the ceramics varies between 5 and 25 mm; the average thickness is 10.8 mm. The thickness displays a unimodal distribution: there is no evidence of fine ware and coarse ware. There appears to be variation in wall thickness in relation to tempering. Sherds with only quartz temper have an average thickness of 10.1 mm, sherds tempered with only granite have a thickness of 10.6 mm, and sherds tempered with only plant have a thickness of 11.1 mm. This variation is a first clue that the ceramic assemblage may comprise sub-assemblages that can be distinguished based on interrelated variables.

Surface finish

The surface finish of the pottery is very uniform (table 3.4). Most sherds have a smooth surface. Only a small percentage have an uneven, rough, or polished surface or are finished with *Besenstrich* (whereby the still-wet surface was brushed with some grass).

Table 3.3 Correspondence between stone grit density and particle size.

	Stone grit density			
Temper size	**Low**	**Average**	**High**	**Total**
1 mm	40.9	6.6	0.8	**48.3**
2 mm	19.7	20.1	1.6	**41.4**
3 mm	2.8	4.6	1.3	**8.7**
> 3 mm	0.3	0.9	0.3	**1.6**
Total	**63.7**	**32.2**	**4.1**	**100.0**

	Quartz density			
Temper size	**Low**	**Average**	**High**	**Total**
1 mm	32.4	9.7	0.7	**42.8**
2 mm	27.5	15.8	2.5	**45.8**
3 mm	4.0	4.5	2.2	**10.6**
> 3 mm	0.0	0.7	0.0	**0.7**
Total	**63.9**	**30.7**	**5.4**	**100.0**

	Granite density			
Temper size	**Low**	**Average**	**High**	**Total**
1 mm	18.9	7.3	1.1	**27.3**
2 mm	23.5	34.3	1.1	**58.9**
3 mm	3.0	7.0	1.4	**11.4**
> 3 mm	0.5	1.6	0.3	**2.4**
Total	**45.9**	**50.3**	**3.8**	**100.0**

Table 3.4 Ceramic surface finishing techniques.

Surface	N	%
Smoothed	1325	84.0
Roughened	195	12.4
Uneven	41	2.6
Polished	10	0.6
Besenstrich	7	0.4
Total	**1578**	**100.0**

Decoration

There are 44 decorated body sherds (2.9%). Of these, 20 have spatula impressions in three variations: nine have single impressions, eight have double impressions and three have multiple impressions (fig. 3.1). Three sherds have hollow spatula impressions, and two sherds have paired fingertip impressions. Grooves were observed on ten sherds; in eight cases it was not possible to say what instrument was used. The decoration was carried out in rows on either shoulder (14 instances) or the body (18 instances). For 11 cases it was not possible to locate the position of the sherd within the pot.

There are 115 rim sherds, of which 47 are decorated (41%). Of these decorated sherds, 22 are decorated on the top, 20 on the inside and 2 on the outside. Two sherds are decorated on both the inside and the top, and one sherd is decorated on the inside, top and outside. Rim decoration was mostly created

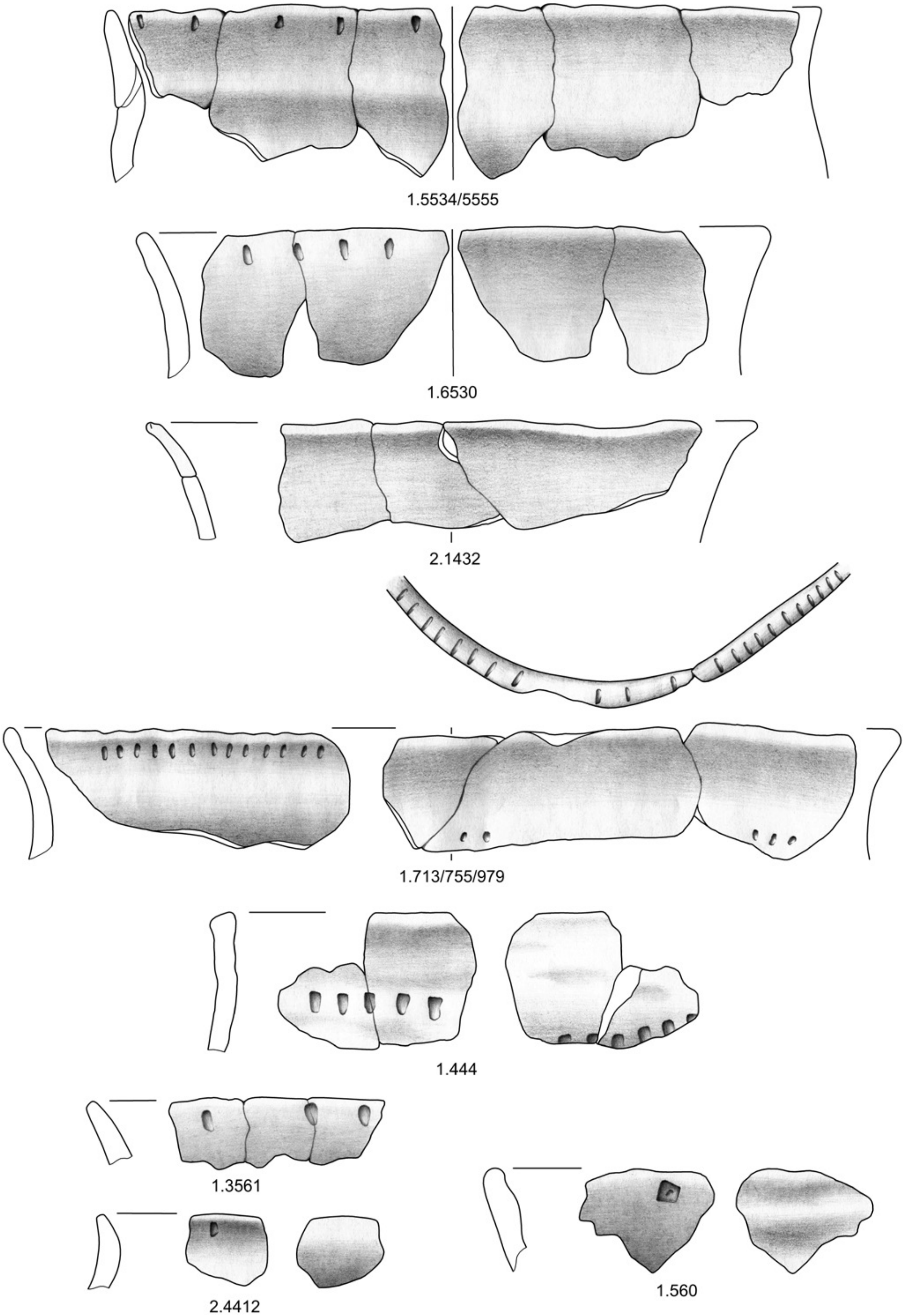

Fig. 3.1a Examples of ceramics from S4. Scale 1:2 (drawings M.A. Los-Weijns, UG/GIA).

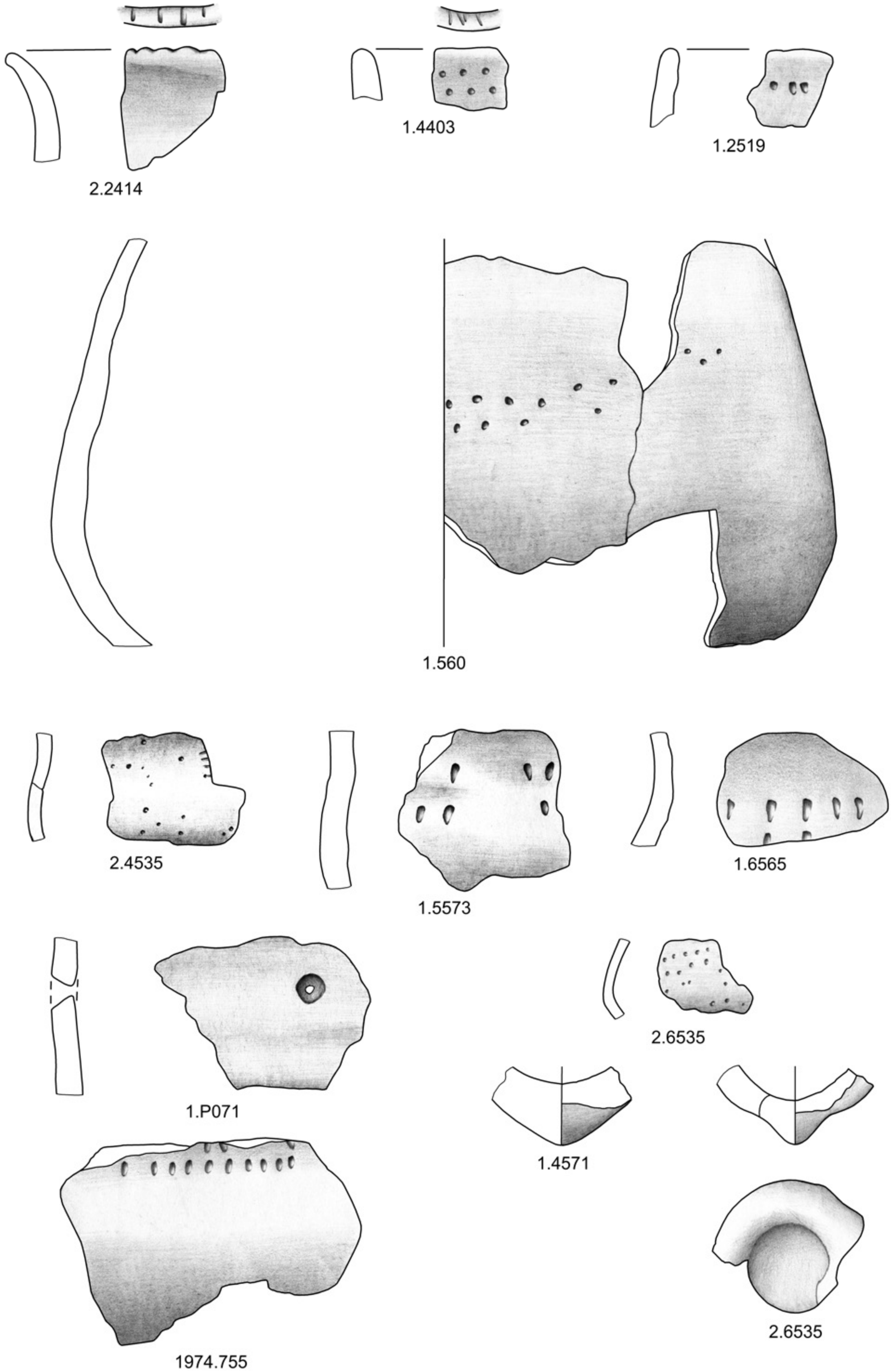

Fig. 3.1b Examples of ceramics from S4. Scale 1:2 (drawings M.A. Los-Weijns, UG/GIA).

Table 3.5 Correlations between ceramic decoration frequency and tempering agents.

Temper	All body sherds	Decorated body sherds	
	N	N	%
Quartz	113	0	0.0
Granite	70	0	0.0
Stone grit	159	9	5.7
Plant	87	5	5.7
All sherds	**1510**	**44**	**2.9**

Temper	All rim sherds	Decorated rim sherds	
	N	N	%
Quartz	8	4	50
Granite	4	3	75
Stone grit	21	11	52
Plant	9	3	33
All sherds	**117**	**47**	**40**

with spatula impressions (29 instances). There are two sherds with *Randkerbung* (a series of small impressions on the top surface of the rim created by means of a fingernail or small instrument), and six have wavy rims. Five rim sherds were decorated using fingernail or fingertip impressions, while two rim sherds show a combination of techniques.

There is a correlation between tempering agents and the frequency of decoration (table 3.5). While 2.9% of the body sherds overall are decorated, sherds tempered with only quartz or granite show no decoration at all. In contrast, 5.7% of the sherds only tempered with undetermined stone grit and of sherds only tempered with plant were decorated. The rim sherds, which are fewer in number, lead to a more general conclusion: sherds tempered with plant only are less often decorated than sherds tempered with any kind of stone temper. These patterns are a second indication that there are subgroups in the assemblage.

Firing conditions

The colour of the cross-section of the sherds may be indicative of the presence of oxygen during the firing of the pots. The cross-sections vary in colour. With a total of 1609 determinations, 34.6% have a light-dark-light cross-section, indicative of a first firing phase with low oxygen levels and a final firing phase rich in oxygen. A dark-dark-light cross-section (with light being the outside of the pot) was found on 28.1% of the sherds, while completely dark (18.9%) and completely light (10.4%) cross-sections occur in significant frequencies as well. The remainder of the sherds (7.9%) have different cross-sections.[7] The wide variation in colour makes clear that the potter did not control the influx of oxygen.

Table 3.6 Correlation between vessel wall thickness and presence of charred food remains.

Ware	N	N with food residue	% with food residue
Fine ware (5-9 mm)	415	94	22.65
Medium ware (10-12 mm)	881	198	22.47
Coarse ware (13-25 mm)	272	44	16.18

Morphological evidence

It is typical for settlement sites , at Swifterbant but also in general, that it is difficult to refit the pottery sherds into larger pottery fragments. Part of the problem lies in the generally more homogeneous character of the sherds. But the more distinctive sherds make clear that major parts of the pots are lacking from the assemblage. This observation suggests that the use history of pottery is more complicated than the present dichotomy between intact (in use) and broken (discarded). Missing parts may have ended up on other sites or as tempering agent in new pots. The pottery may be characterized as S-shaped, with rim diameters of 23-32 cm. Base forms are varied and include round bases (4 instances) and pointed bases (2 instances) (fig. 3.1: 6535 and 4571).

Repair holes

There are seven sherds with repair holes. These hourglass-shaped holes were created after firing, probably to facilitate the repair of fractures.

Charred food remains

Charred food remains are found on 462 sherds (28.5%), mostly only on the inner face (278 instances), but also only on the outer face (106 instances) or on both faces (78 instances). These food residues make clear that most if not all of the Swifterbant S4 pottery was used for cooking. In order to investigate the hypothesis that thin-walled ceramics were table ware and not used for cooking, the correlation between wall thickness and the occurrence of charred food remains is tabled in table 3.6. It is concluded that the hypothesis cannot be substantiated because the percentage of thin-walled sherds with charred food remains is similar to that of sherds

7 These sherds are light-light-dark (0.7%), dark-light-light (2.2%), dark-light-dark (0.4%) and light-dark-dark (4.5%) in cross-section.

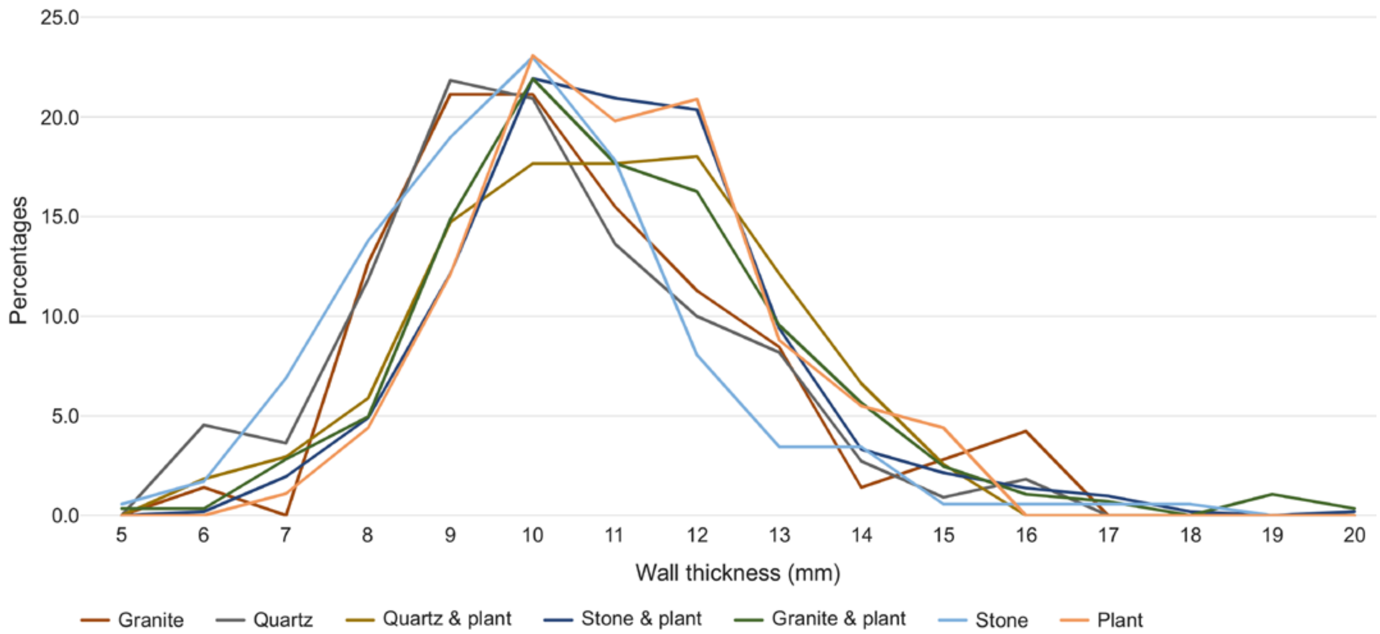

Fig. 3.2 Correlation between wall thickness and temper (diagram D.C.M. Raemaekers, UG/GIA).

with medium wall thickness. Noteworthy is that thick-walled sherds less frequently have adhering charred food remains. More often than the thinner sherds, these sherds may be the remnants of the lower part of a pot. One might suppose that in the cooking process, fluid remained in the lower part of the pot, prohibiting the charring process here.

Ceramic subgroups?

The analysis of the correlations between the variables suggests that there is variation in this assemblage based on temper, wall thickness and proportion of sherds that have decoration. Fig. 3.2 presents this correlation in a graphic way. In general, the wall thickness curves of the seven largest temper groups are very similar. However, when viewed in close detail, it becomes clear that sherds tempered with stone (granite, quartz or undetermined stone grit) are relatively more abundant among sherds with a wall thickness of 8-9 mm, compared with the four other curves, which all have plant temper, in three instances combined with a type of stone temper. For sherds with a wall thickness of 11-13 mm, this trend is reversed. This pattern is not repeated in the percentage of body decoration. The sherds tempered with only granite or quartz are all undecorated, while 5.7% of the sherds tempered with an undetermined type of stone and 5.7% of the sherds tempered with only plant are decorated. The other temper groups have percentages that are intermediate between these values. The significance of these observations is discussed in section 4, where the S4 assemblage is compared with the assemblages from the other Swifterbant levee sites.

3.3 Trends

This section studies the possibility of subdividing the assemblage into units of analysis corresponding to phases of occupation. There are two ways to define such units. The first is to use refits between sherds in different contexts to indicate which parts of the assemblage may be contemporaneous. Despite intensive refitting efforts, no refits were found other than in neighbouring squares from the same spit. The second approach is to study developments in ceramic variables from the lowest spit, spit 9) and the sherds from the underlying agricultural field, all the way up to the sherds from spit 1. We realize that this approach is of little absolute value, given that De Roever has already pointed out for neighbouring site S3 that sherds from a single pot may be found across an area of several square meters and, more importantly, across several spits (De Roever, 2008: especially figs. 3-5). The aim of the analysis proposed here is not to define absolute occupation phases, but, rather, to propose spatially defined units of analysis which allow for the study of trends in material culture and ecological remains. Three units have been defined.

- Unit 1: the youngest part of the stratigraphy: spits 1-3;
- Unit 2: the middle part of the stratigraphy: spits 4-6;
- Unit 3: the oldest part of the stratigraphy: spits 7-9 and the underlying cultivated field.

The proportional importance of the different tempering agents is more or less the same throughout the finds layer (table 3.7), but this statement can be nuanced with some additional remarks.

Table 3.7 Break-down of the ceramic assemblage for the three units: Unit 1 (top), Unit 2 (middle) and Unit 3 (bottom).

		Total	Unit 1	Unit 2	Unit 3
Total sherds (N)		**1418**	**433**	**845**	**140**
Total squares (N)		**2547**	**1236**	**908**	**403**
Sherds per square (N)		**0.56**	**0.35**	**0.93**	**0.35**
Temper	Stone grit & plant (%)	32.7	27.0	32.4	30.8
	Granite & plant (%)	17.8	16.8	17.5	24.1
	Quartz & plant (%)	17.4	24.9	16.4	12.8
	Stone grit (%)	11.0	11.1	11.2	9.8
	Quartz (%)	7.0	6.6	8.5	1.5
	Plant (%)	5.9	8.4	4.9	6.8
	Granite (%)	4.4	3.4	5.7	3.8
	Other (%)	3.7	1.8	3.4	10.5
Coiling	Coiling visible (%)	24.4	23.8	22.7	36.4
	U-joins (%)	34.4	42.7	35.4	13.7
	Hb-joins (%)	65.6	57.3	64.6	86
Body	Body sherds (N)	1241	336	674	114
	Decorated body sherds (N)	44	7	24	6
	Body decoration (%)	3.5	2.1	3.6	5.3
	Of which on shoulder (%)	45	57	25	33
Rim	Rim sherds (N)	114	34	56	10
	Decorated rim sherds (N)	45	12	23	4
	Rim decoration (%)	40	35	41	40
	Of which on inner face (%)	42	8	61	25
	Of which on upper face (%)	49	67	30	75
	Of which on outer face (%)	4	8	0	0
	Of which on more than one face (%)	7	17	9	0

The combination of granite and plant as temper is relatively abundant in Unit 3, and it increases throughout the occupation. Sherds tempered with only quartz are relatively rare in Unit 3.The pottery was built up from coils using U-joins and Hb-joins. In Unit 3, coil-building was recognised more frequently, which might indicate that the coiling technique was carried out less precisely in the earlier stages of occupation. This corresponds to a predominance of the Hb-coiling technique in this unit. Body decoration, while rare, does show some trends. First, body decoration becomes steadily less frequent during the occupation. Second, the relative popularity of shoulder decoration increases by Unit 1. It is frequent in spits 1-3, less frequent in spits 4-5 and more again frequent in spits 6-7. Patterns in rim decoration cannot be ascertained due to the limited number of sherds with rim decoration. The presence of some trends in sherd characteristics suggests that the assemblage of the finds layer as a whole is not a complete mixture and that the three units within it can be used to study developments in other categories of material culture and subsistence.

The density of sherds, expressed as the number of described sherds per excavated square, varies considerably, with Unit 2 having triple the find density of Units 1 and 3. Potentially, there are two explanation for this. It may result from a more intensive use of the site during the formation of Unit 2. Or it may relate to a decrease in the rate of accumulation of the reed layer. This issue will be discussed in later chapters and in the conclusion.

3.4 Comparison

The S4 assemblage presented here is not the first assemblage of Swifterbant pottery from the area that has been analysed. The neighbouring levee sites S2 and S3 yielded substantial assemblages, studied and published by De Roever (1979; 2004), while a sample of S2 and S3 was studied and published by Raemaekers (1999). We compare the S4 assemblage with the two samples studied by Raemaekers (table 3.8) because these were described using the same descriptive system. A quantitative comparison with De Roever's publications is more difficult.

During his analysis of the S2 and S3 samples, Raemaekers did not look into the type of stone used as tempering material. To allow for a comparison of tempering materials between the two studies, the three types of stone temper identified at S4 were combined into one temper group. The proportion of sherds tempered with only plant is the most striking difference, being dominant at S3 and very restricted

Table 3.8 Comparison of the ceramics from the Swifterbant levee sites S2, S3 and S4.

		S4	S2	S3
Total sherds (N)		1418	380	400
Temper	Stone grit & plant (%)	67.9	36	28
	Stone grit (%)	22.4	20	5
	Plant (%)	5.9	43	67
	Rest (%)	3.7	0	0
Coiling	Coiling visible %	24.4	25	17
	U-joins (%)	34.4	84	82
	Hb-joins (%)	65.6	16	18
Body	Body sherds (N)	1241	380	400
	Decorated body sherds (N)	44	8	41
	Body decoration %	3.5	2	10
	Of which on shoulder (%)	45	100	65
Rim	Rim sherds (N)	114	7	74
	Decorated rim sherds (N)	45	3	43
	Rim decoration %	40	43	58
	Of which on inner face (%)	42	100	60
	Of which on upper face (%)	49	0	7
	Of which on outer face (%)	4	0	28
	Of which on more than one face (%)	7	0	5

Table 3.9 Correlation among temper, wall thickness and decoration frequency for the ceramics from the Swifterbant levee sites S2, S3 and S4.

	S2 (N = 380)		
	Plant	Plant & stone	Stone
Number	179	129	72
Average wall thickness (mm)	9.2	9.2	9.0
Body decoration (%)	6	6	1
Rim sherds (N)	17	20	7
Rim decoration (%)	35	30	43

	S3 (N = 400)		
	Plant	Plant & stone	Grit
Number	259	110	19
Average wall thickness (mm)	10.5	9.9	9.7
Body decoration (%)	10	3	5
Rim sherds (N)	52	19	2
Rim decoration (%) (n/total)	48	79	100

	S4 (N = 1626)		
	Plant	Plant & stone	Grit
Number	112	1200	385
Average wall thickness (mm)	11.1	11	10.1
Body decoration (%)	5	3	2
Rim sherds (N)	9	77	33
Rim decoration (%) (n/total)	33	35	54

in importance at S4. S2 and S3 are rather similar in the proportional occurrence of the combination of stone grit and plant, while S2 and S4 are more similar in terms of tempering with only stone grit. Coiling is visible a on very similar percentage of sherds, suggesting that the potters had similar notions about how firmly a new coil should be pressed onto the preceding coil. S4 does stand out in terms of its high proportion of Hb-joins. The popularity of body decoration differs among the sites as well, with S3 scoring much higher than S2 and S4. S2 stands out in terms of the importance of decoration on the shoulder, but this may be a result of the small number of decorated body sherds. The figures relating to rim decoration should be approached with great caution due to the small numbers involved. They testify to large intersite variation. This may be interpreted in two ways. The first is that the potters involved had very different ideas about tempering, albeit within a shared framework defined by the use of plant and stone grit. The second option is that this variation is related to function.

Ceramic subgroups?

One of the intriguing results of our analysis is the suggestion that there are two subgroups of ceramics in the S4 assemblage based on correlations among temper, wall thickness and decoration. Table 3.9 presents the results of similar queries conducted on the S2 and S3 databases. It is striking that, although the numbers differ, all three assemblages show the same correlations. This suggests that the potters at Swifterbant had two slightly different templates to work from. It might be envisaged that these two

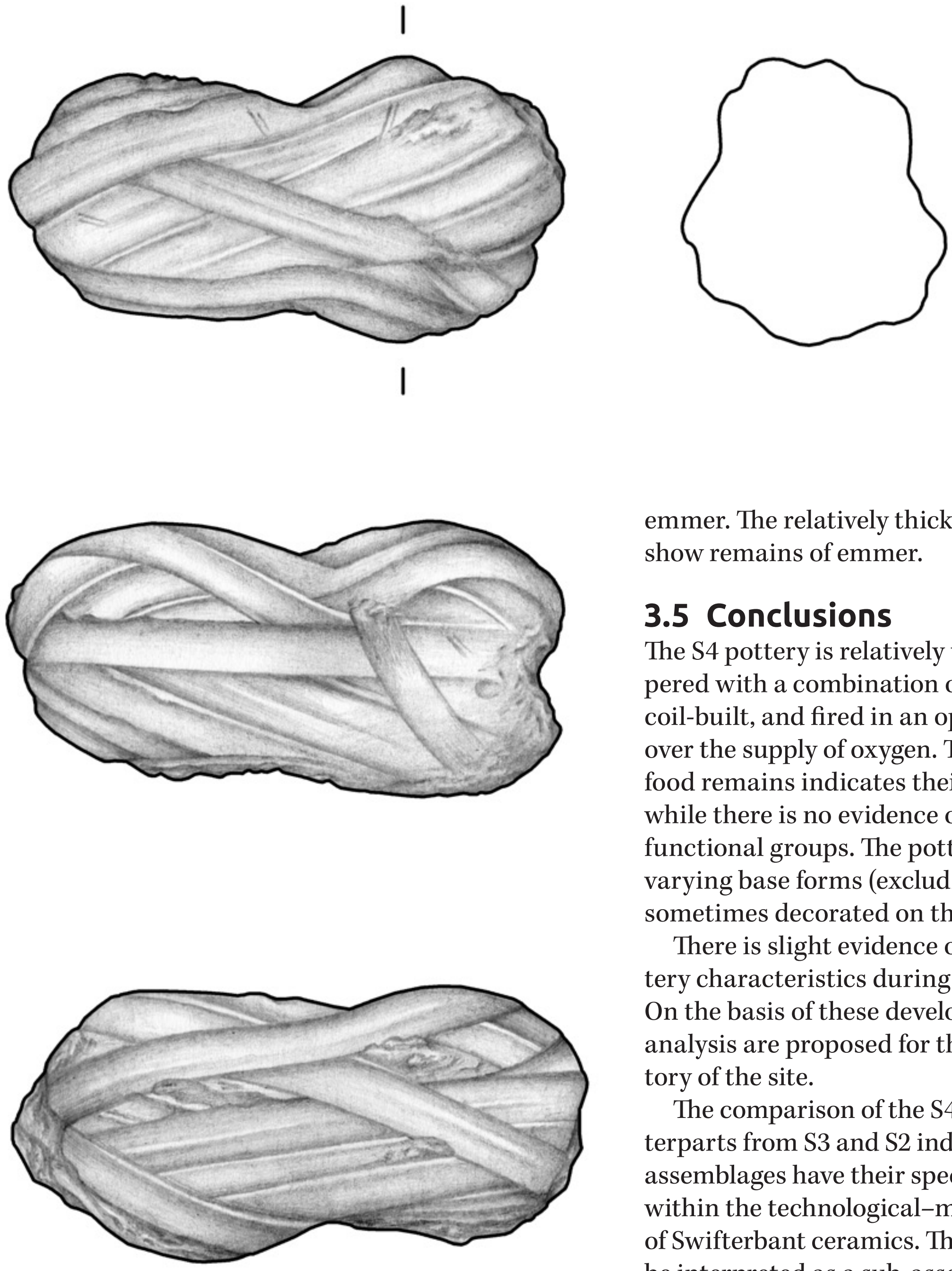

Fig. 3.3 Ceramic object. Scale 1:1 (drawing M.A. Los-Weijns, UG/GIA).

templates correspond to two micro-traditions, that is, two groups of potters at work in the area. The produce of their work then found its way to all known sites in the Swifterbant region.[8] Another option is that these patterns relate to functional differences. On the basis of these patterns, a functional analysis was carried out on a selection of ceramics from S3 using lipid and scanning electron microscopy (SEM) analyses, which suggested (Raemaekers *et al.,* 2013) that the relatively thin-walled pots, tempered with stone grit, were used for meals with emmer. The relatively thick-walled pots did not show remains of emmer.

3.5 Conclusions

The S4 pottery is relatively thick-walled, mostly tempered with a combination of grit and plant material, coil-built, and fired in an open fire with little control over the supply of oxygen. The presence of charred food remains indicates their use as cooking vessels, while there is no evidence of table ware or other functional groups. The pottery is S-shaped, has varying base forms (excluding flat bases), and was sometimes decorated on the rim or the shoulder.

There is slight evidence of developments in pottery characteristics during the site's occupation. On the basis of these developments, three units of analysis are proposed for the study of the use history of the site.

The comparison of the S4 pottery with its counterparts from S3 and S2 indicates that all three assemblages have their specific characteristics within the technological–morphological framework of Swifterbant ceramics. The S4 assemblage cannot be interpreted as a sub-assemblage of the S3 assemblage, despite the close proximity of the sites. The analysis suggests, based on the correlation between temper, wall thickness and decoration frequency, that the assemblage comprises two subgroups. These two subgroups were found at the neighbouring sites S2 and S3 as well and probably relate to different meals having been produced in different pots.

3.6 A ceramic object

The excavation yielded one singular ceramic object, found in square 5531, without any other special artefacts nearby. It concerns a peanut-shaped object with a length of c. 8.1 cm and a maximum diameter of c. 4.1 cm (fig. 3.3). The clay is untempered, and when wet, it had been covered with strings of plant material. At a later point in time, the object was fired, preserving the imprint of the plant material. This object will be published in detail elsewhere (Raemaekers *et al.,* in prep.).

8 Similar micro-traditions are proposed for the somewhat younger Hazendonk group (Raemaekers, 2008).

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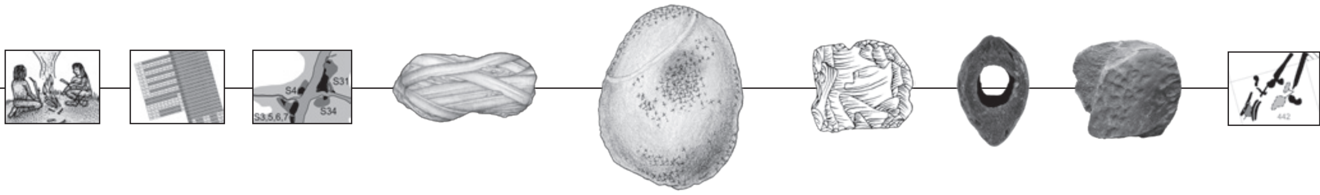

The stone industry

I. Devriendt[1]

4.1 Introduction

During the 1974 and 2005-2007 excavation campaigns, roughly 32 kg of stone artefacts were obtained, comprising 18,403 individual artefacts. Of these, 557 have a minimum weight of 3.0 g and 17,846 weigh less than that. The heavier artefacts (≥ 3 g) were described in terms of artefact type, degree of fragmentation, raw material type, degree of heat exposure, metric attributes and weight.[2] Some tools were also examined for traces of use-wear and of residue, all adding to the functional interpretation of the site. The vertical distribution of the artefacts was analysed as well to provide answers concerning the formation and use history of the site. Finally, the differences and similarities among S4 and the other Swifterbant sites, S2 and S3, are discussed with the aim of discerning the functional relations among these sites.

4.2 General characteristics

One of the most striking aspects is the large proportion of artefacts < 3 g (97%; table 4.1), here termed grit. This grit was retrieved from all areas of the site, but mainly from sieved excavation units. Because not all excavated soil was sieved, the true proportion is even higher. The remaining 557 artefacts, weighing ≥ 3 g, are divided into pieces of waste (60.7%), debitage (30.0%), tools (9.1%) and pendants (n = 1; 0.2%). Only a limited proportion of the stone artefacts have been exposed to heat (4%).

A clear preference for raw material use was observed: granite, quartzitic sandstone, and gneiss are found in high proportions (20-30%). Of the 17 remaining rock types, porphyry was the most frequent (8%). Among the tools, the same three rock types are the most common, especially quartzitic sandstone (table 4.1).

All the stone material had to be brought to the site, because no stone material naturally occurs in the area around Swifterbant. It is clear that the people at Swifterbant preferred certain types of stone for certain types of tools or activities and that these raw materials must have been obtained by selective gathering. The raw material mainly consists of cobbles and pebbles gathered from boulder clay and boulder sand deposits, for example the outcrops of Urk and Schokland (at c. 10 km and 14 km distance). The Rhine and Meuse deposits in the middle of the Netherlands (c. 50-60 km away) must be seen as minor, yet desirable sources of other types of raw material, such as flat pebbles of sandstone or quartzitic sandstone.

Debitage material

The debitage material comprises 55 flakes, 85 chips, 1 blade and 26 cores. Most of the flakes and chips are undamaged. The chips measure up to 34x31x10 mm, the flakes measure up to 47x50x15 mm, and the blade measures 56x26x9 mm. The positioning of the impact blow behind the central ridge must have resulted in the long length of the blade. The cores are mainly defined as tested fragments, yet four are of a more structured type, with one to three (opposing) striking platforms. The tested fragments have one to three flake removals and have average measurements of 28x25x16 mm. The four "structured" cores have varying dimensions, between 24x32x14 mm and 152x112x103 mm, with three to eight removals and are defined as flake cores. It was observed that one of the chips was produced out of exactly the same raw material as one of the cores. Even though the two pieces could not be refitted, they indicate actual stone knapping at the site.

Tools

For the production of tools, cobbles of a specific shape, weight, and rock type were chosen, most likely with a specific function already in mind (Devriendt, 2014: 123, 289). It is clear that a different combination of characteristics was preferred for specific tools, i.e. the blanks chosen for

1 izabel@unitedtelecom.be; Archeo Lithics; Louis Varlezstraat 9, 9030 Mariakerke-Gent, Belgium.

2 For a detailed description of the method of analysis, see Devriendt, 2014.

Table 4.1 Total number of stone artefacts per typological category, number of burnt stone artefacts and use of stone raw materials.

	Total		Burnt		Raw material				
	N	%	N	%	Granite	Quartzitic sandstone	Gneiss	Porphyry	Other
Debitage material	**167**	**30.0**	**1**	**1**					
Flakes	44				9	9	12	5	9
Flake fragments	11				6		2	2	1
Blades	1					1			
Chips	85				19	23	23	5	15
Cores	26		1	4	8	10	6	1	1
Tools	**51**	**9.1**	**3**	**6**					
Hammerstones	4				1	2		1	
Anvils	8				1	4	2		1
Grinding stones	10					4	1		5
Ground stone fragments	12		1	8	5	1	3	2	1
Combination tools	12		2	17		4	3		5
Polished axe fragments	5								5
Ornaments	**1**	**0.2**							**1**
Waste	**338**	**60.7**	**16**	**5**					
Indeterminate fragments	219		9	4	88	36	44	15	36
Pebbles / cobbles	49		2	4	5	19		8	17
Frost flakes / potlids	1				1				
Possible debitage / tools	69		5	7	22	15	14	5	13
Subtotal ≥ 3 g	**557**	**100.0**	**20**	**4**	**165**	**128**	**110**	**44**	**110**
Raw material (%)					29	23	20	8	20
< 3 g	**17846**								
Total	**18403**								

Table 4.2 Total number of stone artefacts per Unit.

	Unit 1	Unit 2	Unit 3
Debitage material (%)	**28**	**20**	**35**
Flakes	16	14	1
Blades	1		
Chips	28	19	6
Cores	15	6	
Tools (%)	**10**	**9**	**5**
Hammerstones		1	1
Anvils	2	4	
Grinding stones	3	6	
Ground stone fragments	8	2	
Combination tools	5	3	
Polished axe fragments	3	1	
Waste (%)	**62**	**71**	**60**
Indeterminate fragments	98	80	7
Pebbles / cobbles	19	19	3
Frost flakes / potlids		1	
Possible debitage / tools	15	36	2
Subtotal ≥ 3 g	**213**	**192**	**20**
< 3 g	**9829**	**6364**	**1233**
Total	**10042**	**6556**	**1253**

hammerstones are different from those chosen for grinding stones. Typical of the cobbles and pebbles from the boulder clay is their round shape, with naturally rolled edges and surfaces. Instead of modifying these blanks into tools, by careful selection of the correct, hand-sized rocks, the knappers avoided needless time investment, as these blanks were ready for use. Pebbles as well as some smaller cobbles have rounded or oval shapes, whereas larger cobbles are often cubic or beam shaped, with two opposing flat surfaces and mostly four sides. Some of the larger cobbles have the shape of an upside-down pyramid and a flat working surface positioned opposite a point, which may or may not have been pushed into the ground while being used.

The set of tools consists of four hammerstones, eight anvils, ten grinding stones, twelve ground stone fragments, twelve combination tools, and five polished axe fragments. Some of these tools' blanks were re-used cores or even re-used tool fragments. The hammerstones all have different shapes and show a variety of marks, as impact traces around the edges differ in intensity and in some cases resulted in the removal of several small flakes (fig. 4.1). One of them is a re-used hammerstone/anvil fragment with a small but deep pit.

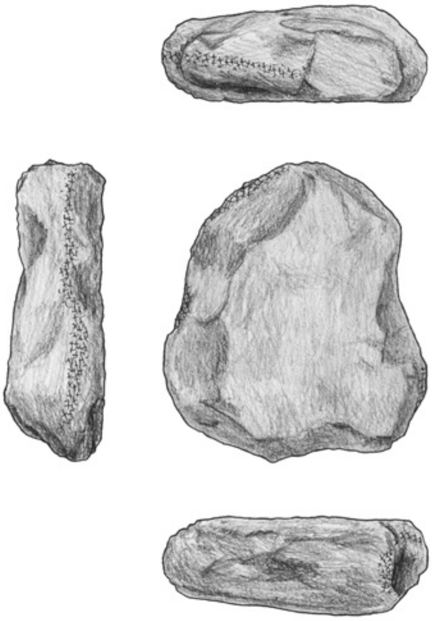

Fig. 4.1 Hammerstone 124. Scale 1:2 (after Devriendt, 2014: plate 24).

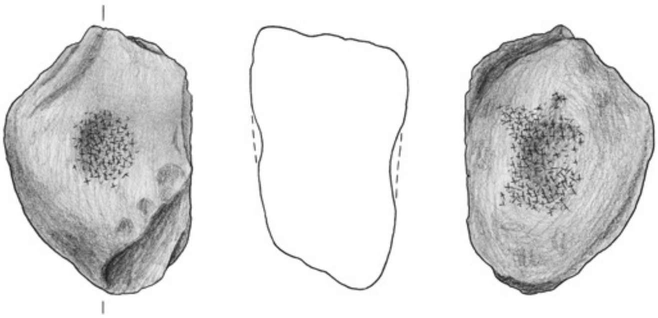

Fig. 4.2 Anvil 126. Scale 1:2 (after Devriendt, 2014: plate 24).

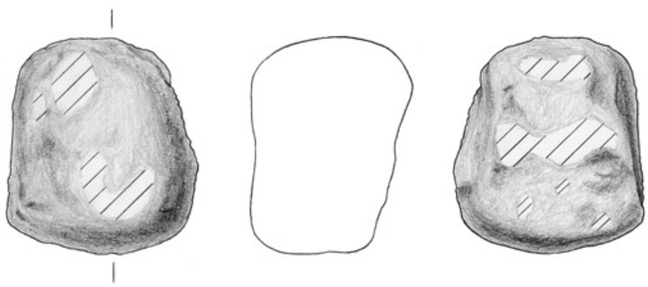

Fig. 4.3 Grinding stone 128. Scale 1:2 (after Devriendt, 2014: plate 25).

The anvils are tools with two opposing flat surfaces and tools with a triangular cross-section. The working surfaces – one, two and in rare cases three – all have grouped impact traces in the middle. One working surface is more crushed than hammered on, whereas anvil pits occur only once (fig. 4.2). Two triangular tools have a somewhat protruding working surface instead of the more common flat surface. The location and intensity of the impact traces is, however, the same as on all the other tools. Impact traces on the edges of some tools may point to isolated knapping attempts.

The grinding stones are defined as one polisher, six handstones (fig. 4.3), and three netherstones, most of which have two opposing flat surfaces. The handstones have one or two working surfaces showing smoothing or even patches of gloss. In addition, some isolated impact traces were observed on the surface or near the edges. The three netherstones are all larger fragments used in different intensities. One even has patches of a clear, mirror-like gloss, showing striations running in various directions. This distinctive gloss is the result of heavy wear, which may have been caused by different contact materials. Flake scars on the sides of these grinding tools point to knapping or even deliberate fragmentation. This is, however, not an isolated event, as the fracture rate of grinding stones can be as much as five times that of other tool types at the Swifterbant sites (Devriendt, 2014: 115, 122). The twelve ground stone fragments found at the site support this theory of stone knapping and deliberate fragmentation. These fragments are all smaller flakes or indeterminate fragments with a smoothed to polished surface, some of which have impact traces, fresh planes of fracture and/or flake scars.

The combination tools (fig. 4.4) have been identified as follows: seven hammerstone/anvils, three anvil/grinding stones, one hammerstone/grinding stone, and one hammerstone/anvil/grinding stone. Again, these are dominated by artefacts with two opposing flat surfaces. Their use-wear traces are a combination of the characteristics visible on the single-activity tools. Two of these combination tools were found some 15 cm apart, next to a large fragment of a pot. The proximity of these two artefacts, and their general shape, suggest that the upper and lower parts were used together as one grinding tool (fig. 4.5). The handstone has a convex working surface with a deep pit in the middle. One could interpret this pit as an anvil pit, but it may also have been used to 'capture' food, grain or other plant material during grinding. In combination with the shattered pot found close by, this is such a rare find that it could be interpreted as a special deposit. The three artefacts together do provoke the image of some sort of agricultural ritual or deposit, but there is no evidence that these three artefacts even belong together or that they were deposited in some special way.

The axe fragments are four pieces of the same axe and one flake of a second axe. Of the four fragments, two fit together, forming part of the cutting edge (fig. 4.6). One of these fragments was found during the 1974 campaign, while the other was found in the 2005-2007 trench, some 6 m to the south. And even though the other two fragments – found within a 2x6 m area – do not join together with this refit, they most likely belong to the same axe, as these are the only artefacts made out of diabase at S4.

Ornaments

The only ornament on the site is the tear-shaped amber pendant found in the child's grave (fig. 4.7). The single trace of alteration to this naturally formed lump measuring 14x10x7 mm is an hourglass-shaped perforation. Unlike the amber ornaments found in other graves at Swifterbant (Devriendt, 2014: 64), the perforation in this pendant shows only minor traces of wear. Based on the observation that there is only minor wear on the child's pendant and heavy wear on the adult man's pendants from S2, the ornaments in the graves at Swifterbant are regarded as part of the personal belongings of the deceased that were used by the deceased over their lifetime, to be buried with them when they died.

It can also be argued that the use of amber as raw material was a social or even an ethnic marker. Amber was used for nearly all of the stone ornaments at Swifterbant, while jet and shale were used only once and twice, respectively (for a combined total of 3%). The proportion of jet at sites in the middle part of the Netherlands is much higher – for example at Schipluiden (Van Gijn, 2006), where it is 69% – while that of amber is far lower. This is above all related to the location of the procurement areas of these raw materials. For amber, this is mainly the north coast of the Netherlands, while for jet it is the middle portion of the west coast. Yet, even if the preference for amber or jet is related to local availability, this does not exclude its use as a social or ethnic marker – just the opposite. Therefore, the people buried at Swifterbant with amber can be considered as being of local (northern) origin. The suggestion that the only person (a woman) at Swifterbant buried with a jet pendant was an 'immigrant' of southern origin was confirmed through stable isotope analysis (Smits & Van der Plicht, 2009).

The remaining stone material

The final group of artefacts ≥ 3 g is a collection of 219 indeterminate fragments, 49 cobbles and pebbles, 1 frost flake and 69 possible pieces of debitage or tool fragments. The indeterminate fragments show the widest variety of rock types at the site, and at least seven fragments may have come from a single piece of gneiss. The cobbles and pebbles form a more selective assemblage of raw materials, with several having been defined as flat pebbles from the Meuse deposits. One of the latter may even be an unfinished pendant. Finally, the artefacts defined as possible pieces of debitage material or tool fragments show insufficient diagnostic characteristics, which hinders definitive categorisation.

Fig. 4.4 Hammerstone/anvil combination tools 135 and 138. Scale 1:2 (after Devriendt, 2014: plates 27 and 29).

The grit

The 17,846 artefacts < 3 g make up 97% of the stone artefacts. Most of this material was weighed in bulk, so individual weights are not available. Yet the impression gained is that these pieces mostly weigh between 0.1 g and 1.0 g. One might suppose that this fine material was intended for tempering clay, but the quartz and red granite (feldspar) that is typically found in the ceramics (chapter 3) is hardly present among the grit. It remains unclear what led to the high proportion of grit at S4.

Use-wear analysis and residue analysis

As part of a larger study on grinding stones at Swifterbant (Van Gijn *et al.,* 2007; Devriendt, 2014: 94-99), the S4 use-wear analysis comprised the complete grinding tool (handstone plus netherstone found together) and a large netherstone. The handstone of the grinding tool has strongly developed traces of processing of cereal grains or grasses, oriented in multiple directions. On the upper

Fig. 4.5 Grinding tool comprising hand stone 141 and nether stone 136 (after Devriendt, 2014: cover photo).

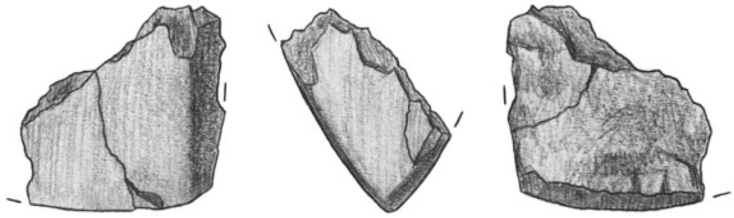

Fig. 4.6 Two refitted axe fragments 139. Scale 1:1 (after Devriendt, 2014: plate 29).

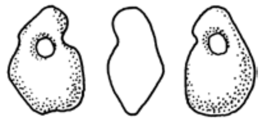

Fig. 4.7 Amber pendant 140, from grave. Scale 1:1 (after Devriendt, 2014: plate 29).

surface of the accompanying netherstone, a clear and strongly developed gloss of contact with cereal grains or grasses and/or other siliceous plants is visible. The traces on the lower surface are defined as friction gloss, produced as the grinding stone was positioned on a hide or something similar to collect the ground material. The other lower stone was used more intensively, showing completely smoothed to polished areas. Processing traces of grains or siliceous plants are clearly visible, and the orientation of use is variable, from longitudinal to transverse. The lower surface shows only minor smoothing.

Residue analysis focused on organic remains, such as phytoliths or starch grains, still present in and on the surfaces of tools and artefacts. In order to compare the taxonomic identifications of the phytoliths generated by the grinding stones with those present in the matrix, several soil samples were analysed as well. The handstone of the grinding tool yielded almost no residue, with mainly non-diagnostic fragments. However, after resampling, a wider variety of phytolith fragments was captured. The netherstone produced a remarkably high amount of phytoliths, both on the upper and on the lower surface. This sample showed all types of phytoliths, indicative of all parts of a plant, such as leaves, stems and what are thought to be roots. The large amount of phytoliths found on the third tool comprised many different types of fragments. A considerable amount of charcoal fragments was also detected.

The residue analysis conducted on grinding stones from sites S3 and S4 showed a correlation between handstones and a low number of phytoliths, on the one hand, and netherstones and a higher number of phytoliths, on the other hand. It also showed that the number of phytoliths seems to rise with the use intensity of the tool. It was, furthermore, observed that even though the number of phytoliths in the soil samples is much larger than that on the grinding stones and that they are larger and less fragmented, they are basically the same taxonomic groups.

Site function

One of the clearest indications of which specific activities were carried out at a site is the presence of certain tool types. The recovered stone tools are mainly grinding stones, anvils and hammerstones or a combination thereof, representing many different functions. For the grinding tools, it was established that they were used to process plant material or cultivars. Presumably this involved plant processing for food as well as plant processing for crafts or maintenance purposes. Grinding tools may also have been used for polishing axes or other types of artefacts, such as bone awls, while the smaller polishers may have been used for smoothing pottery or processing hides. Hammerstones were probably used, often in combination with anvils, for flint knapping, the roughening of grinding stones, and the production of temper. But they may also have been used for processing food or even colourants or other mineral substances. Another tool type, represented by a few pieces, is the axe. Axes, whether perforated or not, were often used for different kinds of woodworking and for felling trees. While the small fragments of axe found at the site are no longer suitable for these purposes, use-wear analysis of axes from S3 revealed that axes were indeed used for these purposes at Swifterbant. Evidence from the Hazendonk site of Schipluiden revealed traces of woodworking on several unaltered stone flakes (Van Gijn & Houkes, 2006). It seems likely that unmodified flakes were used to sharpen the ends of the numerous pointed wooden posts retrieved from S4. On the basis of the spectrum of activities evidenced by the stone tools, S4 is here interpreted as a settlement site.

4.3 Trends

The ceramic analysis indicates that some trends exist, which in turn suggests that, during the build-up of the finds layer, mixing of the material was not complete. This analysis provides three units of

Table 4.3 Number of stone artefacts at the different levee sites at Swifterbant (after Devriendt, 2014: table 4.9).

	S2		S3		S4		S51	
	N	% ≥ 3 g	N	% ≥ 3 g	N	% ≥ 3 g	N	% ≥ 3 g
Debitage material	**192**	**36.2**	**951**	**42.2**	**167**	**30.0**	**24**	**47.1**
Flakes	58		321		55		7	
Blades	1		12		1			
Chips	99		473		85		11	
Cores	34		145		26		6	
Tools	**37**	**7.0**	**244**	**10.8**	**51**	**9.2**	**10**	**19.6**
Hammerstones	2		12		4			
Anvils	3		21		8		1	
Grinding stones	6		34		10		2	
Ground stone fragments	19		71		12		3	
Combination tools	**5**		**92**		**12**		**3**	
Hammer / anvil	2		58		7		2	
Hammer / grinding stone	2		11		1		1	
Anvil / grinding stone	1		9		3			
Hammer / anvil / grinding stone			14		1			
Polished axes (incl. fragments)	**2**		**10**		**5**		**1**	
Retouched pieces			**4**					
Other	**1**	**0.2**	**4**	**0.2**				
Ornaments	**26**	**4.9**	**51**	**2.3**	**1**	**0.2**		
Waste	**274**	**51.7**	**1005**	**44.6**	**338**	**60.7**	**17**	**33.3**
Indet. fragments	146		660		219		6	
Pebbles / cobbles	96		232		49		3	
Frost flakes / potlids	2		8		1			
Possible debitage / tools	30		105		69		8	
Subtotal ≥ 3 g	**530**	**100.0**	**2255**	**100.0**	**557**	**100.0**	**51**	**100.0**
< 3 g	**2625**		**8563**		**17846**		**241**	
Total	**3155**		**10818**		**18403**		**292**	

analysis that can be used for the study of trends in other find categories (labelled, from top to bottom, Units 1-3). The analysis of the stone artefacts did not reveal any clear trends. Only minor differences are discernible in the assemblage or toolkit composition (table 4.2). The only aspect that may point to a difference in site function is the tools. Among the used surfaces of the tools, anvil and grinding functions outnumber hammer functions in Unit 2 (39%, 44% and 17%, respectively), whereas the three functions are represented roughly equally in Unit 1. Whether these small differences are evidence of a change in site function or simply point to the excavation of different special activity areas is difficult to determine. The only clear trend that could be discerned is that the density of stone artefacts increases from the lower to the upper layers. An average of 3.1 artefacts per square were found in Unit 3, while an average of 7.2 and 8.1 artefacts per square were found in Units 2 and 1, respectively. When only the larger artefacts are taken into account, the average densities increase from 0.05 to 0.21 and 0.17, respectively, but they still indicate the proliferation of artefacts in Unit 3 in comparison with the upper layers. Unit 2 yielded slightly more artefacts ≥ 3 g than Unit 1. To what extent the process of trampling and associated fragmentation has influenced these figures is difficult to determine.

Another way of establishing time depth or contemporaneity is by refitting artefacts and tool fragments. Even though such an analysis was not performed systematically, one remarkable fit was found. It involves several fragments of a diabase axe found in Unit 1. Of the four axe fragments discovered at S4, two fit together. It is argued that the other two fragments belong to the same axe, as these are the only artefacts made out of diabase at S4. Considering the rarity of this raw material at Swifterbant, it is proposed that the diabase axe fragment from S3 belongs to this same shattered axe, suggesting contemporaneous use of S3 and S4.

4.4 Comparison

The S4 stone industry is remarkably similar to that from the three other documented levee sites in the Swifterbant levee system (tables 4.3 and 4.4). S2 and S51 are located along the main creek, c. 0.7 and 1.1 km from S4, respectively. The neighbouring site of

Table 4.4 Overview of the stone tool functions at the different levee sites at Swifterbant. The presence of combination tools results in numbers that are higher than those in table 4.1 (after Devriendt, 2014: table 4.11).

	S2		S3		S4		S51	
	N	%	N	%	N	%	N	%
Hammerstones	6	29	95	36	13	28	3	33
Anvils	6	29	102	38	19	40	3	33
Grinding stones	9	43	68	26	15	32	3	33
Total	**21**	**100**	**265**	**100**	**47**	**100**	**9**	**100**

S3 yielded the largest assemblage of stone artefacts and, likely as a function of sample size, presents the widest spectrum of artefact types. The stone industry from all of the Swifterbant sites is similar and indicates predominantly activities expected to have taken place in a settlement. One artefact category should be interpreted differently from site to site, namely, the ornaments. At S2 and S4, these derive from the burials, whereas at S3, they were found in the settlement layer, and their presence there is interpreted as the result of loss or discard.

The functional analysis of S2, S3 and S4 provides a second perspective on the degree of similarity of these sites. The use-wear traces on the grinding stones are the same on the different levee sites, indicating the same kinds of activity. It was concluded that almost all grinding tools were used for the processing of plant material. Whether this was a grain, a grass or some other type of siliceous plant cannot easily be attested to with this type of analysis (Devriendt, 2014: 97). Furthermore, it appears that all the phytoliths from the different sites are alike, indicating the processing of similar plants, i.e. different types of grasses (*Poaceae*). A comparison of the sampled phytoliths with modern phytoliths of emmer wheat and naked barley revealed morphological similarities as well as differences. Because the phytoliths at Swifterbant are significantly smaller, there is no conclusive evidence for the processing of cultivated grains. But because it has been established that cultivated fields are present at Swifterbant, these different kinds of grasses may very well be early cultivars.

4.5 Conclusions

The high proportion of artefacts < 3 g (97%) is one of the most prominent characteristics of S4. This proportion is especially remarkable because most of the soil of the 2005-2006 excavations was not sieved. It is therefore unlikely that the high proportion of grit results from the excavation technique. Instead, it is likely to result from a pre-existing condition at S4, perhaps a different use of the site or some sort of taphonomic phenomenon we currently have no handle on.

The remainder of the assemblage consists of many pieces of waste and debitage material, several tools and an amber ornament. The tools include single-purpose tools, such as grinding stones, anvils and hammerstones, as well as combination tools, such as hammerstone/anvils or anvil/grinding stones. When the tools are divided by function, the anvils outnumber the grinding stones and hammerstones.[3] Fragments of two polished stone axes have been found as well, one of which, made on diabase, was scattered among several excavation contexts. An axe fragment found at the neighbouring S3 most likely belongs to this scattered diabase axe, suggesting contemporaneous use of these two sites. The amber ornament was retrieved from the only grave at S4; it had been placed with the deceased child as part of the child's personal belongings when he or she was buried.

No trends in tool typology or technology were observed throughout the use history of the site; in other words, there is no evidence of change in the site function. There is only evidence of an increase in the number and density of stone artefacts from the older to the younger layers, possibly indicating an intensification of activities. However, the possibility that slackening sedimentation led to the accumulation of artefacts cannot be ruled out.

A comparison of the stone assemblages from the levee sites S2, S3 and S4 shows that there are no differences in the typo-technological framework of their stone industries. Additionally, it shows the same preference for certain types of raw material in combination with specific shapes of cobbles. It is only the small variations in assemblage and toolkit composition that point to minor differences in site function or the sometimes specific use of certain sites, especially in combination with other features, for example the burials.

3 This calculation excludes the ground stone fragments because it is unclear how many individual grinding stones they represent.

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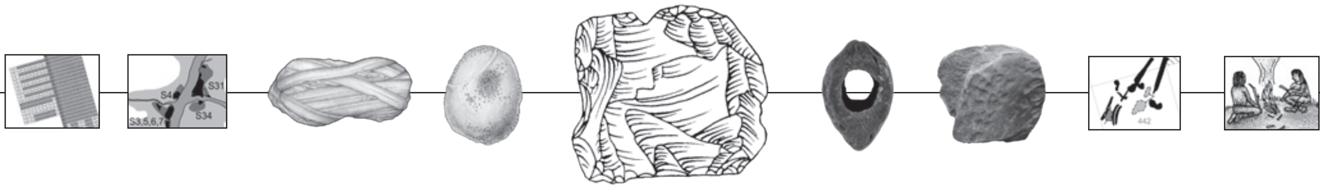

The flint industry

I. Devriendt[1]

5.1 Introduction

The flint material was collected during two excavation campaigns, the first in 1974 and the second in 2005-2007. Roughly 2.8 kg of flint artefacts were obtained, comprising 3702 individual flint artefacts. The division between large and small artefacts was arbitrarily set at 1 cm; 1484 flint artefacts have this minimum length of 1 cm, and 2218 artefacts are smaller than that. For the analysis of the general characteristics, the larger artefacts (≥ 1 cm) were described by artefact type, degree of fragmentation, raw material type, degree of heat exposure, metric attributes, and weight.[2] Some tools were also examined for use-wear traces, adding to the functional interpretation of the site. The vertical distribution of the artefacts was analysed as well, to provide answers concerning the use history of the site. The temporal information obtained by means of the pottery analysis is used here, as pottery is of crucial importance to provide possible relevant units of analysis within the cultural layer. Finally, the differences and similarities between S4 and the other Swifterbant levee sites are discussed with the aim of discerning the functional relationships among these sites.

5.2 General characteristics

Exactly 40% of the flint artefacts are ≥ 1 cm (table 5.1). These artefacts are defined as debitage material (61.9%), different kinds of tools (11.0%), bipolar pieces (3.5%), artefacts with visible use-wear traces (5.2%), polished axe fragments (0.1%), an unfinished pendant (0.1%), and waste (18.2%).

A rather high proportion of the flint artefacts was exposed to heat (34%), mostly moderate heat. This high proportion is mainly related to the proportion of artefacts ≥ 1 cm that were burnt (41%). For the artefacts < 1 cm, the proportion of heat alteration is a more typical 29%. Because heat damage leads to fragmentation, it is no wonder that fragments from tools, flakes and blades are burnt more often than their undamaged counterparts.

Raw material usage

For the production of the flint artefacts, preference was given to fine-grained flint without bryozoans (58%). Fine-grained flint with bryozoans was used far less frequently (14%). Both medium- and coarse-grained flint varieties were rarely used (2%).[3] Heavy heat exposure prohibited the identification of the material used for 26% of the artefacts overall, and this proportion varies only slightly among the individual artefact categories.

The flint shows a wide variety of colours, ranging from pale beige and darker brown to different tones of grey and almost black. The brownish colours are mostly translucent, whereas the greyish colours can be translucent or opaque, and sometimes even mottled or cloudy. The density of bryozoans is variable. Quite a few artefacts are partially or fully covered with an old, natural surface, i.e. different types and combinations of cortex and/or patina. The cortex is mostly weathered or rolled, while the patina has different colours and intensities of gloss.

The appearance of the generally small cores and nodules, and the texture of the cortex and patina, suggest secondary deposition of the raw material, in this case the boulder clay and boulder sand deposits. The most likely sources of such types of flint are the outcrops at Urk and Schokland, as these are the closest to Swifterbant, being located some 10 km and 14 km to the north and northeast, respectively.

Two operational chains

The technological attribute analysis clearly indicates the presence of two different production sequences, or operational chains. Small nodules and cores were used to produce flakes and small (irregular) blades. These cores were knapped in

1 izabel@unitedtelecom.be; Archeo Lithics; Louis Varlezstraat 9, 9030 Mariakerke-Gent, Belgium.

2 For a detailed description of the method of analysis, see Devriendt, 2014: appendix 1.

3 Fine-grained quartzite, for example Wommersom quartzite, was not used.

Table 5.1 Total number of flint artefacts per typological category and number of burnt flint artefacts.

	Total		Burnt	
	N	%	N	%
Debitage material	**918**	**61.9**	**307**	**33**
Flakes	295		77	26
Flake fragments	363		151	42
Blades	88		14	16
Blade fragments	132		57	43
Rejuvenation pieces	20		5	25
Cores	20		3	15
Tools	**163**	**11.0**	**48**	**29**
Scrapers	49		15	31
Borers	3		2	67
Rounded pieces	10			
Trapezoid pieces	6			
Tools on flake	14		2	14
Tools on blade	24		6	25
Tools on other blanks	5		2	40
Indeterminate tools / fragments	52		21	40
Bipolar pieces	**52**	**3.5**	**18**	**35**
Items with visible use-wear	**78**	**5.2**	**21**	**27**
Polished axe fragments	**2**	**0.1**		
Pendant	**1**	**0.1**	**1**	**100**
Waste	**270**	**18.2**	**212**	**79**
Indeterminate fragments	101		70	69
Frost flakes	30		8	27
Potlids	133		133	100
Nodules	6		1	17
Subtotal ≥ 1 cm	**1484**	**100,0**	**607**	**41**
< 1 cm	**2218**		**641**	**29**
Total	**3702**		**1248**	**34**

an opportunistic way by using natural surfaces as platforms. It is proposed that most occupants could produce their own everyday tools for their daily needs and activities.

A second operational chain concerns the use of big cores, knapped by using a specialised technique, most likely performed by specialised persons. These nodules were larger than the nodules used for everyday debitage and presumably had been specially selected. This second method was not used at the settlement site itself, but somewhere else, i.e. at an 'off-site' location, possibly even the procurement site for the nodules used with this technique. This second method was used with the specific aim to produce large, regular blades which could be transported to the site, possibly to be used for specific activities.

Debitage material

This category of artefacts comprises 658 flakes, 220 blades, 20 rejuvenation pieces and 20 cores. This sets the flake-to-blade ratio at roughly 3:1, or 75% versus 25%, indicating the importance of flake production in this assemblage.

Both flakes and blades were predominantly detached using unidirectional debitage; signs of the bipolar technique could be observed in only a few cases. The intact flakes have dimensions between 10x6x1 mm and 48x38x16 mm (and an average of 17x15x4 mm), while the intact blades have minimum and maximum measurements of 10x2x1 mm and 60x28x25 mm (average 27x10x4 mm). The blades can be divided into two dimensional clusters, with the largest blades measuring between 47x13 mm and 60x28 mm. One refit is of relevance here. It involves the sequential refit of two blades in a set of seven (fig. 5.1). With lengths reaching up to 60 mm, these blades are among the largest at the site. The production process of these blades is very similar, yet not identical to the more regular blades at the site, as these smaller blades often have sub-parallel edges and converging ridges. Their somewhat different technological signature reinforces the idea that the seven blades belong together. In total, 58% of the flakes show remnants of a natural surface, such as patina or cortex. The flakes with 75% or more of the natural surface present are defined as decortication flakes (16%). Cortex and patina are present on 43% of the blades, but only a small portion of them can be described as decortication blades (3%). This suggests that the production of blades occurred more often in the later stages of the production sequence, possibly once certain criteria had been met.

The cores show a wide variety of types and general morphology. They can have one, two (opposing or crossed), or multiple striking platforms, as well as centripetal flake scars and testing. All cores are characterised by flake scars, only rarely in combination with irregular blade scars.

Tools

The toolkit shows a wide variety of tool types, with a predominance of scrapers and retouched pieces (see table 5.1). All other tool types are represented by a dozen pieces or fewer. The high number of tool fragments can be partly explained by extensive heat exposure, but even taking that into account, their number is rather high. Whether this is an indication of a more intensive use and repair of the tools is uncertain. For the production of the tools, an equal number of flakes and blades were used, even though flakes largely outnumber blades in the debitage material. For certain tool types, such as the artefacts with visible use-wear traces, the preference for blades is even clearer.

The scrapers are mostly end scrapers (95%), with or without retouched edges, and are more often of the single type than the double type (fig. 5.2). Side scrapers occur in only small numbers. The scrapers are predominantly produced out of flakes, which has resulted in a large morphological variation.

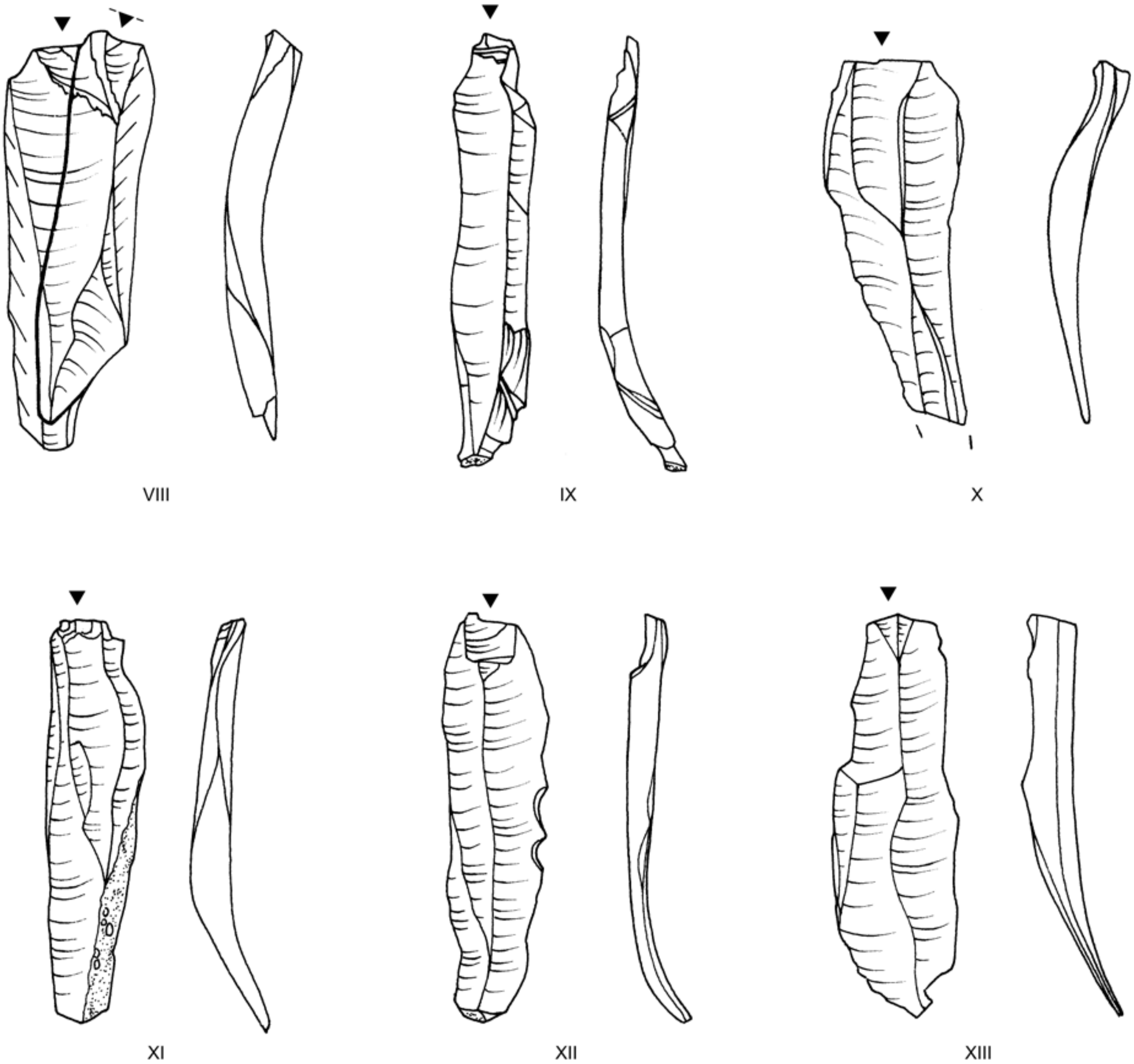

Fig. 5.1 The seven blades found together, including the refit. Scale 1:1 (after Devriendt, 2014: plate 67).

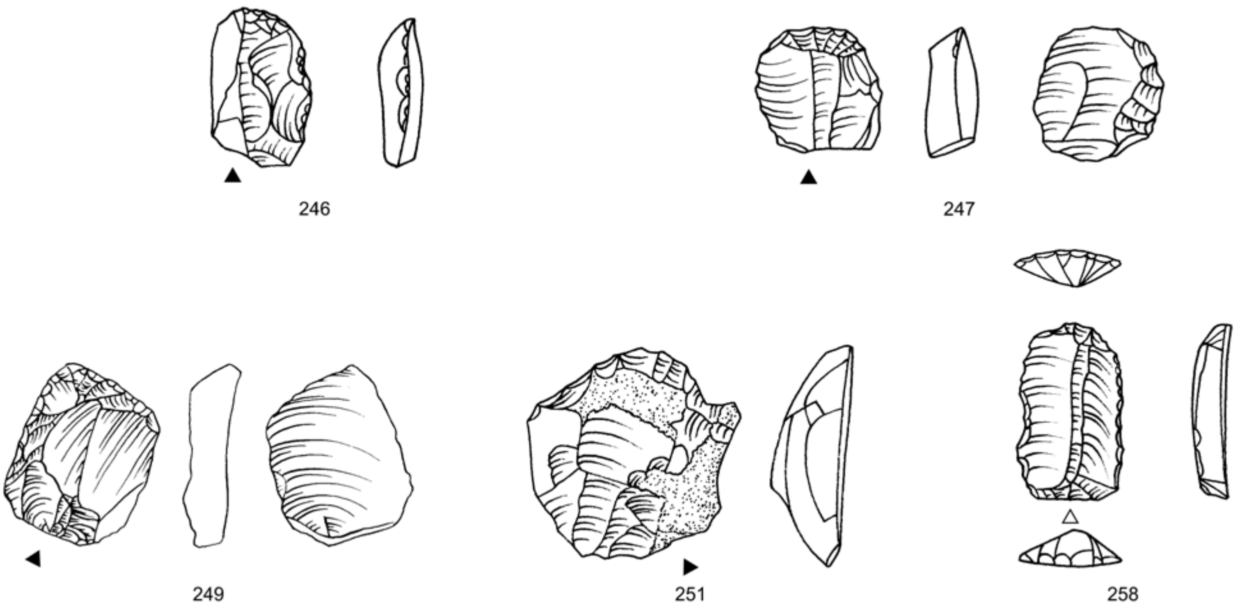

Fig. 5.2 Scrapers 246, 247, 249, 251 and 258. Scale 1:1 (after Devriendt, 2014: plate 61).

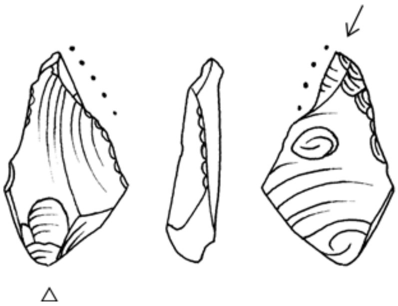

Fig. 5.3 Borer 264. Scale 1:1 (after Devriendt, 2014: plate 62).

Fig. 5.4 Rounded piece 265. Scale 1:1 (after Devriendt, 2014: plate 62).

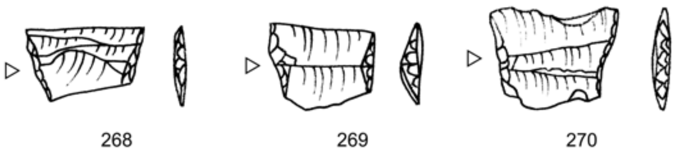

Fig. 5.5 Trapezes 268, 269 and 270. Scale 1:1 (after Devriendt, 2014: 62).

Only the few scrapers on blades have a more regular appearance. Despite the large morphological variation, their technological signature is very similar. Most of them can be defined as distal end scrapers produced on the dorsal side. In general, they are rather small, varying between 11x9x2 mm and 30x29x12 mm, with average measurements of 19x16x6 mm.

The few borers are all rather indistinct, with small retouches on the edges and poorly pronounced borer tips. Although the three borers are morphologically a bit different, their dimensions are similar, with an average of 29x13x7 mm. One of the tools has a tip that is distinctly rounded (fig. 5.3).

Other artefacts can have tips or ends that are rounded off as well. These are defined as rounded pieces (fig. 5.4). The mechanisms and uses that led to rounding off are varied (Devriendt, 2008; Van Gijn, 2008; Woltinge *et al.,* 2008). The rounded pieces are a combination of blades and broken-off tips. Most tools show only one rounded end; two rounded ends occur only rarely. The blanks generally have a flat shape; none of them has a pronounced triangular cross-section with a tapering tip, suggesting their use in a scraping manner instead of a boring manner.

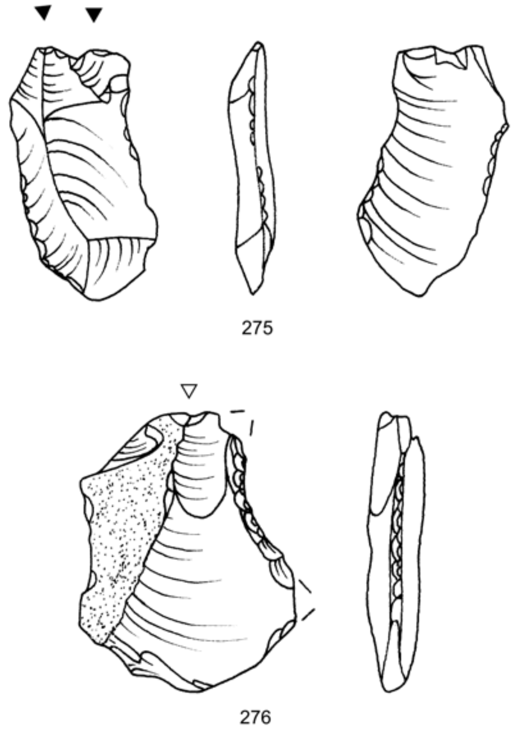

Fig. 5.6 Retouched flakes 275 and 276. Scale 1:1 (after Devriendt, 2014: 62).

The only arrowheads are asymmetrical trapezes, mostly made from blades, with direct, abrupt, short retouched edges (fig. 5.5). The only exception is a trapeze produced out of a flake, which has indirect retouches and a somewhat different shape. The minimum and maximum dimensions of the intact trapezes vary between 14x9x2 mm and 16x14x3 mm, with an average of 16x12x3 mm. This results in a length-to-width ratio ranging from 1.1 to 1.8 (average 1.4).

The retouched pieces mainly consist of retouched blades and retouched flakes; other types of retouched blanks occur only rarely. The retouched flakes mostly have direct, short, abrupt or semi-abrupt retouches that follow the natural curvature of the blank (fig. 5.6). Only a handful have a slightly more irregular delineation, such as a denticulated edge, a truncated edge, or a faintly notched edge. The dominant part of the retouched flakes is intact, measuring between 13x11x2 mm and 39x30x11 mm (average 25x20x6 mm).

The retouched blades are nearly all backed blades, forming a homogeneous group (fig. 5.7). They are very alike in appearance because they are generally made from large, regular blades. Noteworthy is that the larger blades also show gloss on the unretouched edges, indicating a prior, secondary, or alternate usage. Only a few tools were produced on more irregular blades. Almost all of the blades are characterised by direct, abrupt and/or indirect (semi-)abrupt retouches along the edges. The minimum and maximum measurements of the

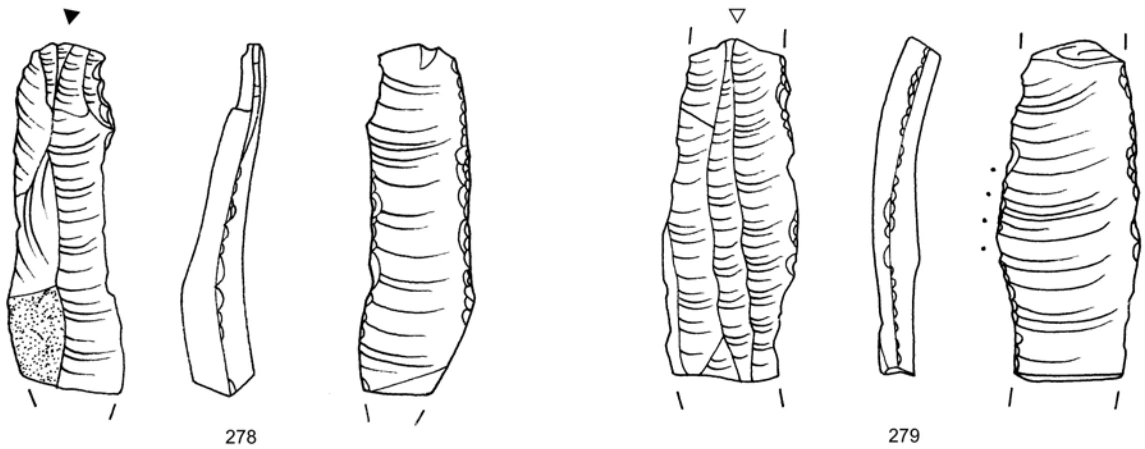

Fig. 5.7 Retouched blades 278 and 279. Scale 1:1 (after Devriendt, 2014: plate 63).

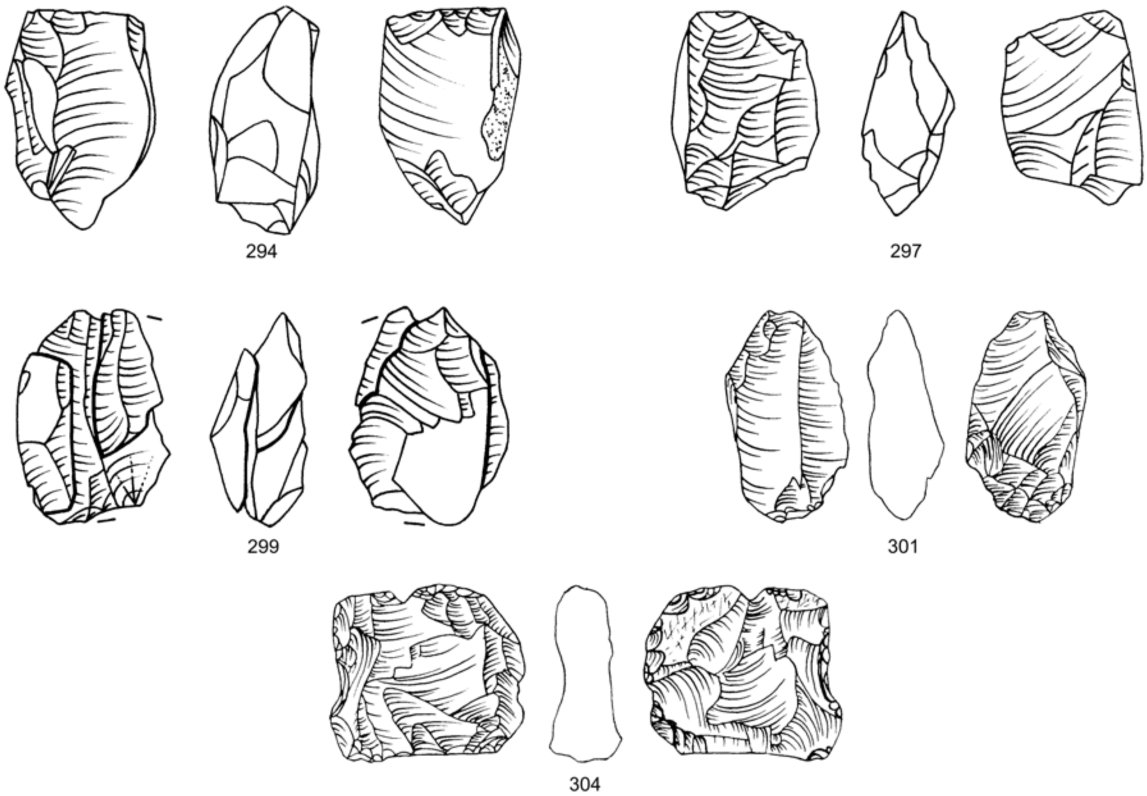

Fig. 5.8 Regular, irregular and square-shaped pieces 294, 297, 299, 301 and 304. Scale 1:1 (after Devriendt, 2014: plate 65).

intact tools vary from 18x8x2 mm to 49x21x8 mm (average 31x14x4 mm).

Finally, there is a set of tools that are fragmented or of an indeterminate type. They are smaller or larger tool fragments or retouched blanks showing some resemblance to known tool types. These tools are unfinished or produced very poorly, which hinders a proper classification.

Bipolar pieces

Based on morphological and technological characteristics, the bipolar pieces can be divided into three subtypes: regular, irregular and square-shaped pieces (fig. 5.8). The use or function of these pieces is diverse, yet it is argued that at Swifterbant their usage as cores is plausible. Their use as burins or other types of tool is proven in one or two cases (Devriendt, 2011; 2014). The bipolar pieces are a combination of mainly irregular pieces and, to a much lesser extent, regular and square-shaped pieces. Most of the artefacts are still partially covered with cortex and/or patina, indicating that their current size is rather similar to their original size. The intact pieces form a wide dimensional cluster, with minimum and maximum measurements of 13x8x4 mm and 38x30x20 mm (average 25x16x8 mm). The reorientation of the artefact with a quarter turn is observed in a few cases. As the original striking ridges often show stacked steps and hinges, this reorientation must have been an

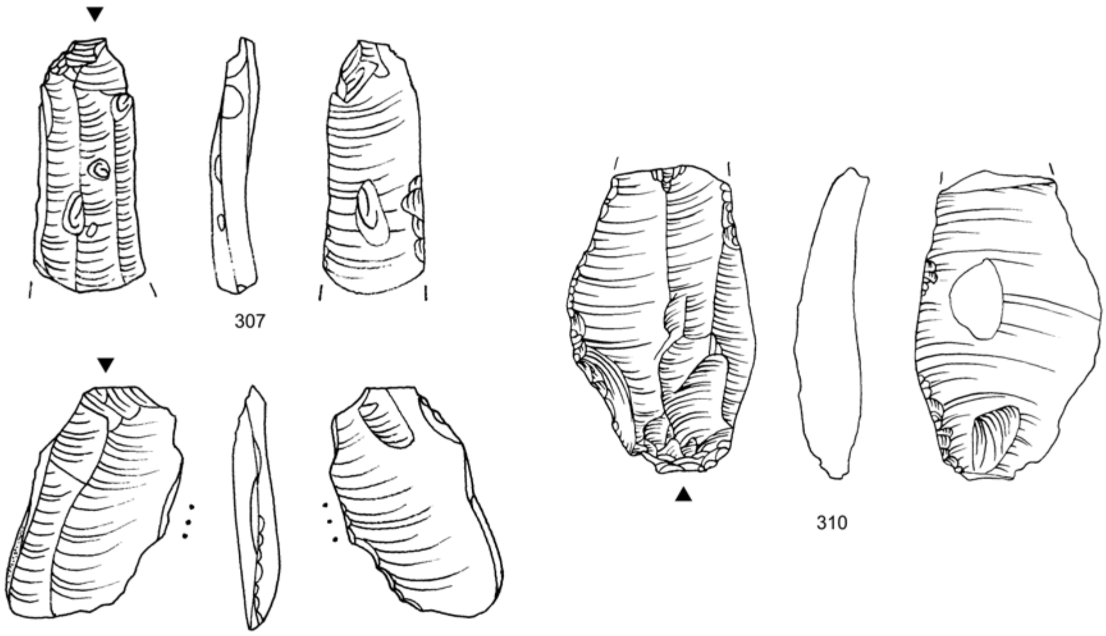

Fig. 5.9 Artefacts with visible use-wear traces 307 and 310. Scale 1:1 (after Devriendt, 2014: plate 66).

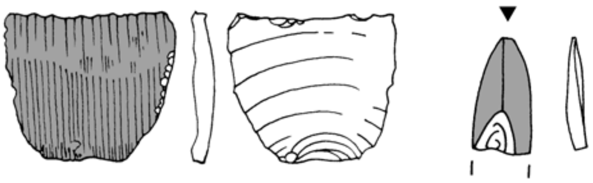

Fig. 5.10 Polished flint axe fragments 312 and 313. Scale 1:1 (after Devriendt, 2014: plate 66).

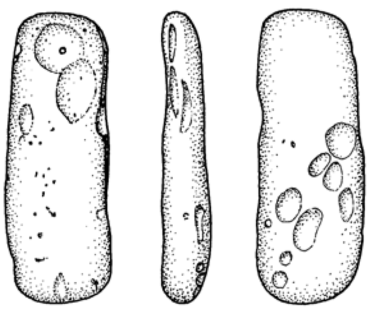

Fig. 5.11 Unfinished pendant. Scale 1:1 (after Devriendt, 2014: plate 66).

attempt to employ a new striking ridge in the hope of detaching more flakes.

Artefacts with visible use-wear traces

These artefacts are not defined as tools, strictly speaking, as they were not modified or retouched before usage, yet they clearly show traces of usage on the edges, such as gloss and/or use-retouch (fig. 5.9). They are mostly regular blades with one or two parallel ridges. The fragmentation rate of these blades is high (82%), especially compared with that of the unretouched blades (60%) and the retouched blades (64%). The proximal–medial parts dominate, while for the (un)retouched blades, the medial parts dominate.

The intact blades measure between 26x7x2 mm and 49x23x7 mm (average 35x14x4 mm), while some fragments have lengths up to 52 mm, making them slightly larger than the ones to be transformed into retouched blades. The largest blades are, however, blanks, with lengths between 50 and 60 mm. A noteworthy feature is the rounding off of two specimens. The rounding is located on the lateral edge, contrary to the more common location, which would be the tip or end, as seen with rounded pieces and some borers. This may indicate a different, and possibly specific, use of these artefacts (see below).

Fragments of polished flint axes

These fragments are a flake and a blade of two different flint axes (fig. 5.10). The flake fragment is rather wide, measuring 18x21x2 mm, and has a light grey colour. The blade fragment measures 15x7x2 mm and may have been detached from the side of the cutting edge. This flint type is also fine-grained, without bryozoans, and has a dark mouse grey colour.

Unfinished pendant

The dimensions of this unfinished flint pendant (39x14x6 mm) correspond well with the measurements of the flat, stone pebbles used for pendants at S2 and S3. Because of the suitable dimensions, it is possible that this flint pebble was chosen as a blank. However, the raw material makes it unfit for this

Table 5.2 Total number of flint artefacts per Unit.

	Unit 1	Unit 2	Unit 3
Debitage material (%)	**60.9**	**61.1**	**72.7**
Flakes (N)	147	77	23
Flake fragments (N)	207	88	18
Blades (N)	47	27	4
Blade fragments (N)	57	34	15
Rejuvenation pieces (N)	9	5	2
Cores (N)	11	8	1
Tools (%)	**10.4**	**13.0**	**9.1**
Scrapers (N)	27	10	2
Borers (N)	2	1	
Rounded pieces (N)	3	3	1
Trapezoid pieces (N)	4	2	
Tools on flake (N)	8	5	
Tools on blade (N)	15	7	1
Tools on other blanks (N)	2	2	
Indeterminate tools / fragments (N)	21	21	4
Bipolar pieces (%)	**3.7**	**3.3**	**2.6**
Items with visible use-wear (%)	**4.1**	**6.7**	**1.3**
Polished axe fragments (%)	**0.1**		
Pendant (%)		**0.3**	
Waste (%)	**20.8**	**15.6**	**14.3**
Indeterminate fragments (N)	69	18	5
Frost flakes (N)	17	10	1
Potlids (N)	76	28	6
Nodules (N)	1	5	
Subtotal ≥ 1 cm (N)	**785**	**391**	**86**
< 1 cm (N)	**1444**	**604**	**111**
Total	**2229**	**995**	**197**

purpose, which presumably led to the rather quick abandonment of the perforation attempt (fig. 5.11).

Waste material
This final group of artefacts is a combination of potlids, indeterminate fragments, frost flakes, and nodules. The latter have measurements that range from 27x18x13 mm to 42x32x24 mm (average 33x25x20 mm), which is in accordance with the size of the cores at the site.

Use-wear analysis
During the analysis of the 1974 finds, all blades, blade fragments and retouched tools were selected for use-wear analysis, and half showed traces of use (Bienenfeld, 1985). Evidence for soft plant and hide processing was found on 30% of the items analysed. Evidence for bone and antler processing was less frequent, and there was just one example of wood working. The soft plant polish, often thought to be the result of contact with wheat or reeds, mainly occurs on the blades and is well developed. It indicates cutting and other plant processing activities, possibly including basketry and the production of matting and winnowing receptacles.

The research on the 2005-2007 finds focussed on blades, including blades with visible use-wear traces, and one rounded piece. The analysed blades (with or without visible use-wear traces) were nearly all used to process siliceous plant material. In most cases, the plant material could not be identified to species. For two artefacts, it may have been reed. The blades were mostly used in a scraping manner; evidence for the cutting of siliceous plants was not often observed. On a few blades, both motions could be detected, mostly on separate edges. Even though these traces do not resemble the typical polish seen on artefacts used in experimental harvesting studies of domesticated grains, it is possible that the polish may be the result of the tool having been used in a transverse manner to pluck or scrape the ears from the stems. An ongoing experiment is also investigating to what extent these transversal traces are related to the processing of plant material for the production of baskets or fibres, or to food processing and food supply (Van Gijn *et al.*, 2007). The final blade was probably used to cut soft wood. Only in a few cases were traces of hafting observed. The rounded piece also showed traces of plant processing. Research at the other levee sites revealed that rounding off of edges and tips can be caused by many different activities and phenomena (Devriendt, 2014: 173-174).

Because the new use-wear research mainly focussed on blades (with or without visible use-wear traces), there is an overrepresentation of the importance of plant processing. In the previous research a wide range of tool types was analysed; this shows a wider variety of performed activities. The tools, dominated by scrapers and retouched blades, suggest mainly the processing of hides and plant material. Yet it seems reasonable to assume that activities such as flint knapping, food production, animal butchering, and bone, antler, and wood working must have occurred at the site as well.

5.3 Trends
As with the other find categories, an attempt was made to subdivide the assemblage into different occupation phases based on the division proposed by the ceramic analysis. It is concluded that differences in assemblage or toolkit composition are negligible (table 5.2). In contrast, the density of flint artefacts shows a clear increase throughout the different layers, from an average of 0.5 artefacts in Unit 3 to an average of 1.1 in Unit 2 and 1.8 in Unit 1. This increase in the density of artefacts may be explained either as an intensification of the occupation of the site, or at least of activities related to flint knapping, or as the result of a slower build-up rate of the finds

Table 5.3 Numbers of flint artefacts ≥ 1 cm at the different levee sites at Swifterbant (after Devriendt, 2014: table 5.35).

	S2		S3		S4		S51	
	Number	%	Number	%	Number	%	Number	%
Debitage material	**505**	**49.2**	**11147**	**68.9**	**918**	**61.9**	**83**	**54.6**
Flakes	107		3824		295		22	
Flake fragments	194		4362		363		35	
Blades	17		1061		88		5	
Blade fragments	164		1522		132		18	
Rejuvenation pieces	10		211		20			
Cores	13		167		20		3	
Tools	**198**	**19.3**	**1420**	**8.8**	**163**	**11.0**	**27**	**17.8**
Scrapers	28		435		49		13	
Borers	12		27		3			
Rounded pieces	9		41		10			
Trapezoid pieces	7		40		6		2	
Transverse arrowheads	1		6					
Tools on flake	23		205		14		2	
Tools on blade	59		209		24		5	
Tools on other blanks	7		53		5			
Indet. tools	4		14		5		1	
Indet. tool fragments	38		247		44		2	
Retouched chips	10		143		3		2	
Bipolar pieces	**26**	**2.5**	**721**	**4.5**	**52**	**3.5**	**3**	**2.0**
Items with visible use-wear	**65**	**6.3**	**468**	**2.9**	**78**	**5.3**	**12**	**7.9**
Polished axe fragments			**38**	**0.2**	**2**	**0.1**		
Other tools			**2**	**0.0**	**1**	**0.1**		
Waste	**233**	**22.7**	**2375**	**14.7**	**270**	**18.2**	**27**	**17.8**
Indet. fragments	78		713		101		10	
Frost flakes	28		392		30		2	
Potlids	110		1162		133		14	
Nodule	17		108		6		1	
Subtotal ≥ 1 cm	**1027**	**100.0**	**16171**	**100.0**	**1484**	**100.0**	**152**	**100.0**
< 1 cm	**359**		**9194**		**2218**		**65**	
Total	**1386**		**25365**		**3702**		**217**	

layer in the upper layers during the occupation. The refitting of artefacts and tool fragments is another way of visualising time depth or contemporaneity. Such research was not performed systematically. Refitting was confined to the same or neighbouring 0.25 m^2 squares, and involved several pieces.

5.4 Comparison

Swifterbant S4 is one of four levee sites excavated. S4 lies directly next to S3 and is located c. 0.7 km from S2 and 1.1 km from S51. The four levee sites show use of the same types of flint, which were knapped using the same two debitage techniques. Only the composition of the assemblage is different. The debitage material always forms the largest group of the artefacts ≥ 1 cm, the waste always forms the second largest group, and the tools always form the third largest group. Yet, differences in the proportions of these artefact groups and the composition of the tools give them an individual character and suggest different uses of these sites (table 5.3). For example, site S3 shows a dominance of debitage material and a low tool count, while site S2 shows the opposite. Depending on the aspect studied, sites will correspond with other sites in different combinations, yet most often site S51 corresponds most closely to site S2, while site S4 relates most closely to S3. Most striking is that the proportion of tools is twice as high for S2 and S51 compared with S3 and S4, suggesting that flint knapping was more common at S3 and S4, while tools were more often used and/or discarded at S2 and S51.

In terms of tool composition, the four levee sites show hardly any differences at the presence–absence level, with the exception of polished flint axe fragments. Yet the percentages of these different tool types suggest a focus on different activities at the different sites. S2 shows a dominance of retouched blades and a high percentage of blades with visible use-wear traces. Therefore, it would appear that plant-gathering and -processing activities were possibly more important at S2 than hide working, which is one of the activities most commonly associated with scrapers. S51 is remarkable in that it has the highest percentage of scrapers as well as the highest percentage of blades with visible use-wear traces. This site appears to have been specialised in two specific activities to be performed with scrapers and blades, namely, hide working and plant processing and/or gathering. Another aspect that sets S51 aside from the other levee sites is the absence of the bipolar technique. One aspect that sets S4 aside is the high number of chips, a characteristic also observed for the stone industry. The large proportion of stone grit and flint chips remains unexplained.

5.5 Conclusions

The large proportion of flint artefacts < 1 cm (60%) is one of the most intriguing aspects of site S4, especially because a high percentage of small material was also observed in the stone assemblage (chapter 4). This proportion is unlikely to be the result of the excavation techniques. It is hard to determine whether it is the result of a different use of the site or of some sort of taphonomic phenomenon we currently have no handle on.

The remainder of the assemblage primarily consists of debitage material and, to a lesser extent, of pieces of waste and different types of tools. The tools show a wide variety of types, with a clear dominance of scrapers. The importance of blades, whether used as tools or otherwise, is also evident. One of the more remarkable examples is the group of seven blades recovered in a single square (50x50x5 cm). Their similar lengths and technological features make them stand out from the other debitage material and reinforce the idea of their close relationship, as suggested by their proximity.

No chronological evolution in tool typology or technology was observed throughout the different layers of the occupation area. There is only evidence of an increase in the density of flint artefacts from the older to the younger layers.

The comparison of the flint material from the Swifterbant levee sites S2, S3, S4 and S51 shows that there are no differences in the typo-technological framework of the assemblages. However, small variations can be seen in the assemblage and toolkit composition of S3 and S4, on the one hand, and S2 and S51, on the other hand. The flint artefacts point to a more residential character of the occupation and the performed activities at S3 and S4 and to the more specific use of S2 and S51. The fact is that S4 largely resembles S3; indeed, it shows so many similarities that it may be interpreted as an annex to site S3. S2 and S51 are interpreted as special-activity sites at which people performed certain tasks with blades (S2) and scrapers and blades (S51). As these two sites also show the highest percentage of imported regular blades, it may be presumed that these blades were specially produced to perform these specific tasks.

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6

The vegetation and exploitation of plant resources

M. Schepers[1] & N. Bottema-Mac Gillavry[2]

6.1 Introduction

This chapter deals with the results of the archaeobotanical analyses carried out on samples from Swifterbant S4 collected during the 2005–2007 excavations. Archaeobotanical research is typically carried out in order to (1) reconstruct the natural or synanthropic vegetation in the vicinity of a site, (2) gain insight into the (possibilities for) exploitation of plant resources within that vegetation, and (3) identify possible imported plant resources.

As is often the case in archaeology, both fieldwork and specialist analyses will bring new insights and findings not specified or thought of upfront. The specified research questions for the S4 excavations in which archaeobotany might play a role are (Raemaekers *et al.*, 2005; see chapter 1):

1. What activities were carried out in the natural landscape outside the settlement proper? Were the water meadows behind the slightly elevated shores exploited by people for instance for the grazing of livestock?
2. Were cereals cultivated locally at Swifterbant?
3. What extra information can be gained by taking samples from the stream channel, rather than the settlement layers?

The natural environment of the Swifterbant small-river system was reconstructed in detail in 2014, and this included the analysis of samples from S4, and an exploration of the implications of this reconstruction for the exploitation possibilities of the area (Schepers, 2014a). To allow the reader to understand this chapter without having to first read the 2014 paper, the findings from that paper will be incorporated here in summarized form. The emphasis in this chapter lies on the various palaeobotany-related topics not or only barely covered in that paper.

Samples from a variety of features and layers have been studied by a number of specialists. Pollen analysis was performed by J. van der Veen under the supervision of H. Woldring (report 2008). Wooden objects were identified and described by N. Bottema-Mac Gillavry in that same year (results included in this chapter). Macro remains were examined by J.A.G. van Rooij (report 2006), M. Schepers (report 2007, and additional sieve residues studied in 2015 included in this chapter) and a number of students who studied the material under Schepers' supervision as a lab work practical. A pilot study with respect to the reconstruction of the natural vegetation based on plant macro remains was carried out by N. Scheepens (2007) of the Community and Conservation Ecology Group of the University of Groningen. Taxon names for wild plants follow Van der Meijden (2005), whereas syntaxon codes and names follow Schaminée *et al.* (1995-1999) and Stortelder *et al.* (1999a). Taxon names for crop plants follow The Plant List (2013). Vernacular names are adapted from the e-flora of the British Isles (Stace *et al.*, 2004).

6.2 Sampling strategy and sample processing

Plant macro remains

As described in Chapter 1, a 1 m strip (square numbers ending in 8 or 9 for the 2005 field season and in 6 or 7 for the 2006 field season) was selected for wet sieving in the field using a sieve with 2 mm mesh size. After drying of the residues, plant macro remains were picked out manually. A 2 mm mesh size allows cereal grains to be recovered. These samples are here referred to as 'sieve residues', following Van Zeist and Palfenier-Vegter (1981). In addition to the sieve residues, a half-litre soil sample was taken every fourth square in all spits (one soil sample per m^2). These samples are here referred to as 'wet samples'. The overall methodology is similar to that of Van Zeist and Palfenier-Vegter (1981).

Rita Palfenier-Vegter carried out a first check on the sieve residues of the 2005 field season, counting

1 mans.schepers@rug.nl; University of Groningen / Department of Landscape History; Oude Boteringestraat 34, 9712 GK, Groningen, the Netherlands.
2 University of Groningen / Groningen Institute of Archaeology; Poststraat 6, 9712 ER Groningen, the Netherlands.

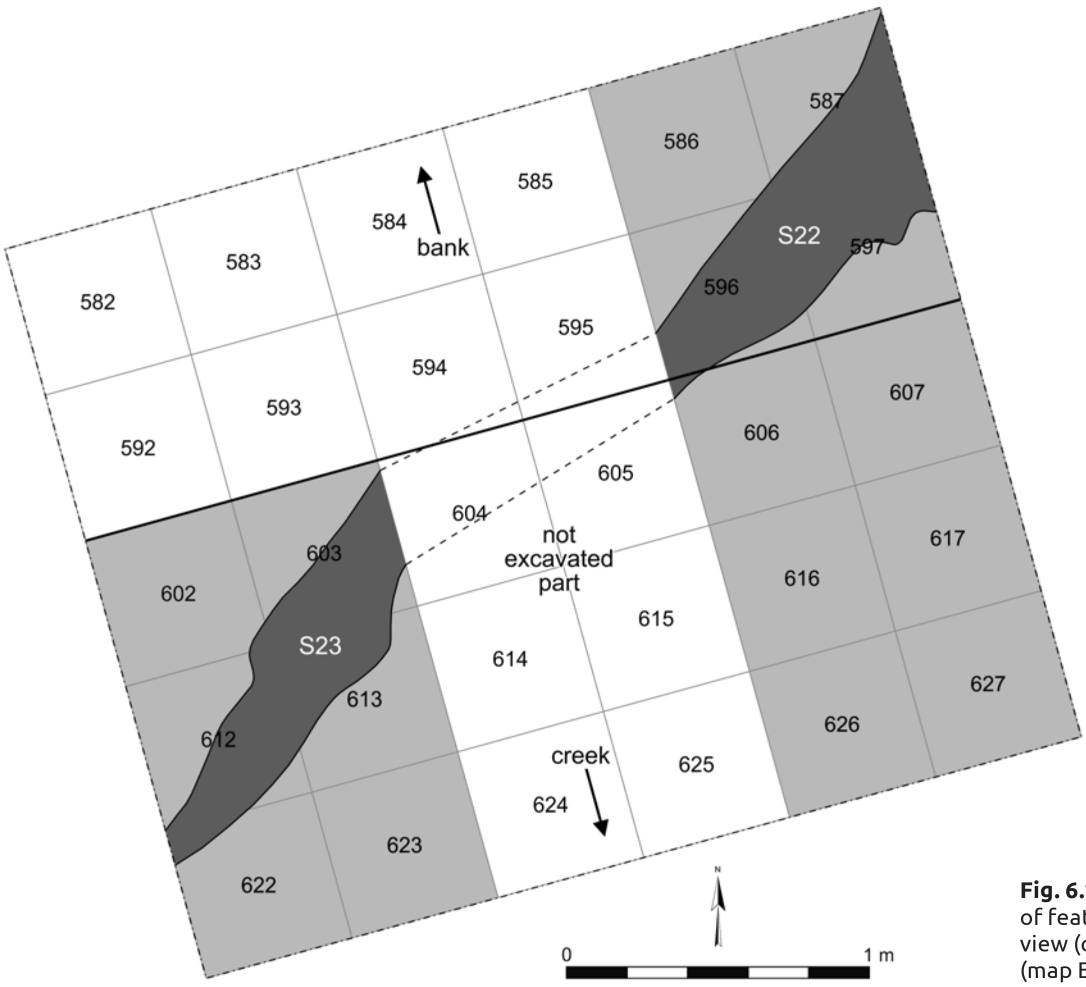

Fig. 6.1 Spatial correlation of features 23 and 22 in plan view (compare 22 in fig. 6.2) (map E. Bolhuis, UG/GIA).

the number of cereal grains present irrespective of species. Based on this assessment, Jeroen van Rooij carried out a more detailed analysis of the sieve residues, aiming for six squares from all seven excavated spits, which, in theory, should have resulted in 42 samples. For reasons detailed below, the total number of samples examined was 34, which were included in a student report (Van Rooij, 2006).

Although sieve residues were available from both the 2005 and the 2006 field season, these have not all been picked through and divided into the different find categories, including botanical. Some botanical sieve residue samples yielded no identifiable plant macro remains. For the squares with zero palaeobotanical identifications, unfortunately, it cannot be reconstructed whether this points to actual absence of botanical material, or that the sieve residue of this square was simply not picked out and separated into different find categories. As a consequence, empty squares in the botanical sieve residue distribution maps represent both truly empty squares and samples not analysed. Therefore, the empty squares cannot not be interpreted in a meaningful way.

The non-empty sieve residues samples available primarily derive from the 2005 field season. This means that they are restricted to the upper seven spits in the wet sieving strip, with square numbers ending in 8 or 9. The detection of possible changes through time is therefore focussed on these samples, totalling 284 (see fig. 6.6). A further 11 sieve residue samples come from lower spits within the sieve strip. The data from these spits, as well as the data from the sieve samples analysed from the upper seven spits outside the sieve strip (79 in total), will be published here as well, but will not be dealt with in the text. The decision not to include the data from these 79 samples in the spatial interpretation was based in part on the fact that at least some of their locations are clearly wrong in the distribution overview, due to reading or typing errors. A clear indication of such an error is present in spit 4, where the sample from square 3358 is missing from the sieve strip, but square 3385 is available where it should not be.

All wet samples were sieved through nested mesh sizes (4.0, 2.0, 1.0, 0.5 and 0.2 mm), and different volumes of each of the different residues were checked for plant macro remains under a stereomicroscope. Whereas the 4.0, 2.0 and 1.0 mm fractions were studied in their entirety, the 0.5 and 0.2 mm fractions were analysed only to the point where no new taxa were found within reasonable amount of time. Identification was carried out based on the reference collection of the Groningen Institute of Archaeology and the Digital Seed Atlas of The Netherlands (Cappers *et al.*, 2006). Van Rooij (2006) analysed 14 wet samples from the settlement layers excavated in 2005. These turned out to contain relatively few taxa when compared with the samples studied by Van Zeist and Palfenier-Vegter (1981). This cannot, however, be interpreted as a general indication for better preservation conditions at S3, since the latter selected their samples based on high seed density in a preliminary screening (Van Zeist & Palfenier-Vegter, 1981: 110).

During the 2006 field season, the research focus shifted to the infill of the stream channel. The find of an accumulation of (presumed) organic material on the slope of the bank provided an excellent opportunity to gain better insight into the landscape outside the settlement proper. This accumulation was excavated as three different features (21, 22 and 23). Features 22 and 23 are located at the same depth on the slope (c. 6 m below mean sea level (NAP)). They are separated by an unexcavated section, but they can safely be interpreted as being part of the same phenomenon (figs. 6.1 and 6.2). Feature 21 is a more stretched out feature located several metres closer to the stream channel, and, since it follows the slope, somewhat deeper as well (c. 6.8 m below mean sea level). In a first study of 2 litres of sediment from this drift litter, the density of plant macro remains turned out to be much higher than in the square samples (Schepers, 2007). More material (>10 litres) from the same samples was studied by students as part of their training to allow for the identification of additional taxa. In this part of the analysis, taxa were no longer quantified but simply entered as presence/absence data, in order to allow a new, complex form of analysis (pilot study in Scheepens, 2007, published in an improved version as Schepers *et al.*, 2013). Wet samples from both S3 and S25 were later analysed in the same manner, resulting in the aforementioned reconstruction of the environment (Schepers, 2014a).

Deforce *et al.* (2014: 10) correctly point out that the formation processes of these drift litter sediments do not allow for a direct connection of the plant taxa encountered therein to the settlement levels higher up the bank. However, the newly devised methodology *does* allow for the identification of 'drier' vegetation types from the drift litter, since this type of context holds a mixture of plant remains derived from various vegetation types present in the area. For a discussion of the value of samples from stream channels and ditches, see Schepers (2014b: 109-121).

Fig. 6.2 Drift litter feature 22 viewed from the south (compare with fig. 6.1) (photo D.C.M. Raemaekers, UG/GIA) .

Palynology

Pollen has only been studied from the cultivated field (Van der Veen, 2008) and will therefore not be dealt with at length here. Palynology has provided a botanical signal on a more regional scale, as well as providing information concerning the field itself. Moreover, pollen analysis allows for the identification of a number of taxa hardly ever recognized as seeds, and 10 pollen spectra within a 50 cm vertical section enabled a detailed overview of regional developments before, during and after the use of the field (Van der Veen, 2008).

Wood

Wood remains were collected manually in all three years of excavation, but the vast majority in the 2007 season. This is a direct result of the fact that most posts and postholes were encountered in the lower layers on the south side of the 1974 trench (see Chapter 9). Most of the collected wood remains represent posts; no other wooden artefacts were found. In all, 52 wood samples were examined from a total of 42 features. The difference in counts is caused by the fact that some samples contained multiple wood fragments and that three wood samples from the field layers were not assigned a feature number. All wood remains were studied by the second author.

Most wood remains collected exhibited obvious anthropogenic traces in the form of cut marks and/ or an obvious point. Points on wooden posts can be generated by natural phenomena as well, most notably by beaver activity (see, for example, Casparie *et al.*, 1977: 43-44). The limited number of natural, unworked wood fragments hampers interpretations with respect to wood collection strategies by people in the past and their possible preferences for particular species therein (Out, 2009a). However,

Table 6.1 Plant communities (syntaxa) identified from the three drift litter samples (after Schepers *et al.*, 2013: table 6.). The numbers indicate how often the syntaxa have been suggested (see original publication for details). The colour scheme follows the field guide of Dutch plant communities (Schaminée *et al.*, 2010). Blue: open water and marsh. Light green: grassland and heathland. Orange: coastal and inland pioneer communities. Dark green: thicket and woodland. Compare with fig. 6.3.

Syntaxon code	21	22	23	Total	Syntaxon
06Ac4			1	1	Samolo-Littorelletum
08Aa2	3		2	5	Polygono-Veronicetum anagallidis-aquaticae
08Bb2		1		1	Scirpetum tabernaemontani
08Bc2b	1	1		2	Caricetum gracilis comaretosum
08Bd1		2		2	Cladietum marisci
16Ab4a	1			1	Ranunculo-Senecionetum juncetosum articulati
29Aa2b	6	2	5	13	Rumicetum maritimi chenopodietosum
29Aa3a	1	2		3	Chenopodietum rubri spergularietosum
29Aa3b	3	2		5	Chenopodietum rubri inops
29Aa4	3		1	4	Eleocharito acicularis-Limoselletum
30Ab3		1		1	Chenopodio-Oxalidetum fontanae
30Bb1b		1		1	Spergulo-arvensis-Chrysanthemetum euphorbietosum
31Aa2b		1		1	Erigeronto-Lactucetum erysimetosum
31Ab2c		2		2	Hordeetum murini arctietosum
31Ab3a		2	2	4	Balloto-Arctietum typicum
31Ab3c	1	6		7	Balloto-Arctietum verbascetosum
31Ca1b		3		3	Echio-Melilotetum
34Aa1b			1	1	Senecioni-Epilobietum ceratocapnetosum
34Aa1c			1	1	Senecioni-Epilobietum inops
37Ab1a		2	1	3	Pruno-Crataegetum typicum
43Aa1a		2		2	Violo odoratae-Ulmetum allietosum
43Aa4			1	1	Carici remotae-Fraxinetum
43Aa5	2		1	3	Pruno-Fraxinetum

the wood taxa encountered can be interpreted in combination with the macro remains and pollen in order to identify possible transportation of wood to S4 from other landscape elements, including the nearby river dunes. A recent study on the wood remains from Swifterbant site S25, directly adjacent to one of these sandy outcrops, provides an important reference for comparison (Raemaekers *et al.*, 2014).

6.3 Results

Landscape and landscape development

This section is built around a summary of the description of the environment of the Swifterbant river system as described in Schepers (2014a). The three drift litter samples are the only ones in that paper that derive from Swifterbant S4 (see appendix 6.1). These samples were used as a test set for a newly devised method for detailed vegetation reconstruction based on present-day plant communities (published in Schepers *et al.*, 2013, where they are labelled A, B, and C for 21, 22, and 23, respectively). The results from that analysis are summarized in table 6.1.

It must be mentioned here that the complete list of identified plant communities for the Swifterbant environment, which includes the results of the analyses of samples from Swifterbant sites S3 and S25, is longer, thus allowing for a more detailed reconstruction.

The last column in table 6.1 shows the scientific name for plant communities, so-called syntaxa. Plant communities are groups of plant known to frequently occur together in more or less comparable ratios to each other. In many landscapes, including that of prehistoric Swifterbant, most of these plant communities do not end abruptly, but gradually merge into others, thus sharing species where they overlap. This area of merging is referred to as the *limes divergens*. A simple example is the bank of a stream channel, where a transition zone occurs containing species more typically associated with vegetation types higher up, as well as species more typically associated with the water's edge.

In modern cultural landscapes, sharp vegetation boundaries (*limes convergens*) exist between, for example, forests, meadows and crop fields. These boundaries will not have been as sharp and permanently defined in prehistoric landscapes, given that these landscapes saw agricultural activity on a more modest scale. Van Leeuwen (1965) refers to this notable but non-permanent signal as more-or-less-now-and-then-boundaries in vegetation.

The plant communities identified enable the reconstruction of the landscape on a local level. Based upon individual species indicator values for various abiotic characteristics of plants occurring in a plant community, boxplots can be produced

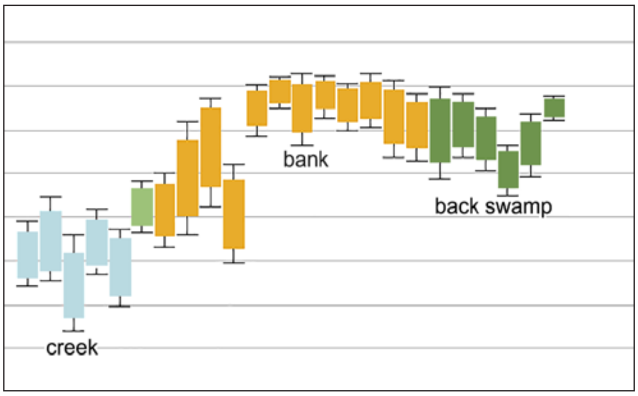

Fig. 6.3 A vertical flip of a series of boxplots displaying the range in moisture values for taxa commonly present in modern syntaxa as identified from the drift litter samples, resulting in a visual match closely approaching the known geomorphology of the banks (see chapter 2). The colour scheme follows the field guide of Dutch plant communities (Schaminée *et al.*, 2010). Blue: open water and marsh. Light green: grassland and heathland. Orange: coastal and inland pioneer communities. Dark green: thicket and woodland. Figure produced via SynBioSys (Hennekens *et al.*, 2010) based on indicator values presented in Ellenberg *et al.*, (1991).

for every plant community, as described for the Netherlands through SynBioSys (Hennekens *et al.*, 2010). When the boxplots showing the moisture values for all plant communities listed in table 6.1 are vertically flipped, the image that emerges closely resembles the known geomorphology of the landscape. Simply put, aquatic communities have high moisture values, thus end up low down compared with other plant communities when the values are flipped vertically (fig. 6.3).

Open water was abundantly present in the river system, both in the stream channels and in the ponds in the floodplain behind the channel banks. For methodological reasons, true open water vegetation will be underrepresented in the vegetation analysis (Schepers, 2014a: 89-90). The water in both the stream channels and the ponds was fresh. A minor brackish influence may have occurred incidentally during severe storms, but if it did occur, it had no permanent impact upon the salinity of the area. Various species-poor water's edge vegetation types grew alongside the stream channels, dominated by relatively tall-standing plants, such as reed (*Phragmites australis*) and various club-rush species.

The vegetation on the river banks themselves was probably highly variable, depending on minor elevation differences and on human influence. Willow carr vegetation occurred on the more dynamic, frequently flooded parts of the banks, whereas alder carr vegetation was present in more permanently wet areas at the floodplain-side of the river system. In addition to the willow carr and alder carr vegetation, relatively drier woodland vegetation must have been present as well. These deciduous forests would have been dominated by woodland communities

Table 6.2 Identified wood taxa for posts and pegs. Numbers indicate diameters or length–width measurements (cm) for S4. Where this could not be determined, an 'x' is given. Numbers in the final two rows indicate percentages for S3 and S4. For S3, these do not add up to 100% because some additional taxa were found at that site (see Casparie *et al.*, 1977: 35, table 2).

Feature	Alnus	Corylus	Fraxinus	Quercus	Betula	Trench
30	5–6					2
31	6.5					1
32	5					2
37	2.5–4.5					1
38	4–4.5					1
43	5					2
63	4.5					1
64	7–8					1
67	5.5					2
68	x					1
78	x					1
91	3–3.5					1
15		x				1
57		4.5				1
63		5				1
66		6				2
82		3.5				1
86		3.3				1
92		2.5				1
95		2–2.8				1
104		4				1
99a		4.5				1
42			4.2–4.5			2
52			5–6			1
74			5			1
83			5–6.5			1
94			4.5			1
100			7			1
73				5.5		2
80				7		1
99				5–6.5		1
18					x	1
% S4	38	31	19	9	3	
% S3	44	25	10	6	4	

within the Alno-Padion that still require incidental flooding (see also van Zeist & Palfenier-Vegter, 1981: 135-136; for a detailed description, see Stortelder *et al.*, 1999b, 301-318). The analysis of wood from S4 fits within the reconstruction of such woodlands, in that it shows a clear predominance of the relatively wet tree species alder and hazel (table 6.2).

Based upon the relatively small diameters of the posts and pegs, there is doubt about whether a more fully developed forest occurred in the area, and more specifically on the permanently dry nearby dunes

Table 6.3 Plant macro remains retrieved from 14 squares (analysis by Jeroen van Rooij). Boldface indicates charred plant parts (in this case 1 cf. *Persicaria lapathifolia*); underlining indicates crop plants and wild plants likely to have been collected intentionally.

Taxon	Part	359	1359	2359	3359	4359	5359	6359	499	1499	2499	3499	4499	5499	6499
Alnus glutinosa	catkins	+									+	+			
Alnus glutinosa	fruit	1									1	10			
Amaranthaceae	fruit		2		3	+			2	1	1	2			
Atriplex patula/prostrata	fruit	5	3	25		2	44	40			6			65	30
Carduus crispus	fruit														9
cf. Hippuris vulgaris	fruit						1								
cf. Persicaria lapathifolia	fruit		1											**1**	1
Chenopodium album	fruit		1	1		2							18	92	
Cladium mariscus	fruit														1
Conium maculatum	fruit														4
Corylus avellana	fruit				0,1										
Ficaria verna	tuber											+			
Hordeum vulgare	rachis		2												
Hordeum vulgare	fruit								1		2				
Juncus bufonius	seed			60	16										
Juncus gerardii	seed				2										
Oenanthe aquatica	fruit											1			
Poaceae tribe triticeae	fruit								+						
Poaceae tribe triticeae	fruit					14	4								
Polygonaceae	fruit														3
Polygonum aviculare	fruit		3												
Ranunculus sceleratus	fruit			4	12										
Schoenoplectus tabernaemontani	fruit					14	1			1					
Solanum nigrum	seed		1	4	4			2	3						2
Sonchus arvensis	fruit	2													
Sonchus asper	fruit	2													
Sonchus oleraceus	fruit			1											
Stellaria media	seed	4		22	14									2	9
Urtica dioica	fruit	294	2	32	40	10			30	10	22			8	260
Veronica anagallis-aquatica	fruit			14											

Fig. 6.4 Charred seed (cotyledon) of oak (*Quercus*) from square 3547 (outside the sieve strip) (photo M. Schepers, UG/LH).

(Van Zeist & Palfenier-Vegter, 1981: 135; see also Out, 2009a: 178). The rarity of more fully developed forests is also confirmed by the rarity of oak in the wood remains (table 6.2 & appendix 6.2) and the virtual absence of acorns in the seed record (fig. 6.4). The fact that acorn remains are so rare in the settlement samples and absent from the drift litter confirms that oaks must have been bound to the dunes. Alder must have been the most common tree in the vicinity of the settlements, as illustrated by the high frequency of alder poles and occasional high numbers of its catkins in the sieve residues (up to a maximum of 175 in square 1499; see appendices 6.3 & 6.4).

Near the settlements, the landscape was probably more open, resulting in both moist-to-wet meadow vegetation and, where human impact was more severe, ruderal vegetation. The latter includes the arable weed communities. Confirmation for this reconstruction is found in the wet samples from the spits (table 6.3). These are dominated by common generalist ruderals, such as stinging nettle (*Urtica dioica*), orache (*Atriplex patula/prostrata*), common chickweed (*Stellaria media*) and black nightshade (*Solanum nigrum*). The first two in particular are present not only in high frequency (in 9 and 10 samples, respectively) but also in substantial numbers. Although 294 fruits (square 359) of stinging nettle sounds less impressive considering that a single shoot of this species can develop up to 30,000 fruits (Taylor, 2009: 1449), such a concentration within a single sample justifies the interpretation that nettle was present locally. Obviously, these generalist species, and nettle in particular, are so widespread and are represented in such a variety of vegetation types that ecological interpretations based upon these species' individual characteristics can only be made in broad terms. However, the specific combination of species in the samples can be meaningful depending on the number of species present.

In addition to these generalist species, a number of plants have been identified in the wet samples that definitely did not grow on top of the bank. These species require permanently wet or even aquatic conditions as evident from both the vernacular and the scientific names for water-speedwell (*Veronica anagallis-aquatica*) and fine-leaved water dropwort (*Oenanthe aquatica*). Where it is tempting to relate their presence to deliberate human actions, they do, in fact, testify of occasional flooding of the banks (see also chapter 2).

Most of the species encountered in the settlement samples have been identified from Swifterbant S3 as well (Van Zeist & Palfenier-Vegter, 1981). Moreover, the most frequently and abundantly encountered taxa in terms of seeds are the same at both sites. It is therefore valid to state that, from a botanical point of view, S3 and S4 were very similar indeed.

The analyses confirm that grazing took place on wet meadows. The low proportion of finds of plant communities within this group does not necessarily equate to low coverage of grassland in the area; the vegetation analysis itself does not allow for any conclusions with regard to relative coverage of the various communities identified. Grassland communities are relatively hard to identify (see Schepers, 2014a: 92), but the grassland as reconstructed for Swifterbant would only have persisted under a grazing regime.

Noteworthy is the difficulty of identifying patterns in the changes in the vegetation over time. The vegetation analysis of the seed samples from S3 did show a faint signal of alternating wetter and drier phases (Schepers, 2014a: 97), but this probably reflects samples deriving from relatively clean clay layers deposited during storms. As such, they represent events, rather than a drastic change towards longer and more prominent wet phases, let alone drowning, of the system in the higher (younger) spits. The same problem occurs in the pollen samples, where spectra from the 'clean clay sediments' are wetter than spectra from either the cultural layer or the field layer.

Exploitation of resources

The results of the analysis of the 284 sieve samples used to detect possible developments in time, in particular with respect to crop species, are presented in appendix 6.3. This appendix includes sieve residues from lower spits within the range of the sieve strip as well, but those are represented in numbers that are too small to allow for a meaningful interpretation (11 squares over 6 spits). The results of the remaining samples are presented in appendix 6.4.

Fig. 6.5 Charred grain of barley (*Hordeum vulgare*) encapsulated in a burnt clay fragment, from square 2478 (photo M. Schepers, UG/LH).

Van Zeist and Palfenier-Vegter (1981: 141-143) identified three different cereal species for S3. Six-row naked barley (*Hordeum vulgare*, fig. 6.5) is by far the dominant cereal at S3, in terms of both sample frequency and seed counts. Van Zeist and Palfenier-Vegter (1981) present an overall ratio between barley and emmer wheat (*Triticum dicoccon*), primarily to point out the dominance of barley. When the ratio between absolute numbers of these two species shows a clear dominance of barley, this can probably be interpreted as a sign of local cultivation (see also Out, 2008: 135; 2009a: 421-422; Schepers, 2014b: 201). Van Zeist and Palfenier-Vegter (1981) do not further explore possible trends in time (vertical space) between the two cereals.

The absolute numbers of cereal grains recovered from the S4 sieve samples also convincingly point to a dominance of barley over wheat (2863 vs 74 in spits 1–7). Although the ratio between the two is less dramatic in terms of sample frequency (220 vs 48), this also confirms this pattern. However, sample frequency is probably better suited to assess the general availability of a particular species than are absolute seed numbers, since the latter can easily be distorted by a low number of samples with large concentrations of cereal grains. At S4, the ten samples with the highest number of barley grains together already account for 1787 grains (62% of 2863).

Bread wheat (*Triticum aestivum*) is represented by a single cereal grain only in the analysis by Van Zeist and Palfenier-Vegter (1981). It is very likely that this individual grain is an underdeveloped specimen of the more commonly found wheat species,

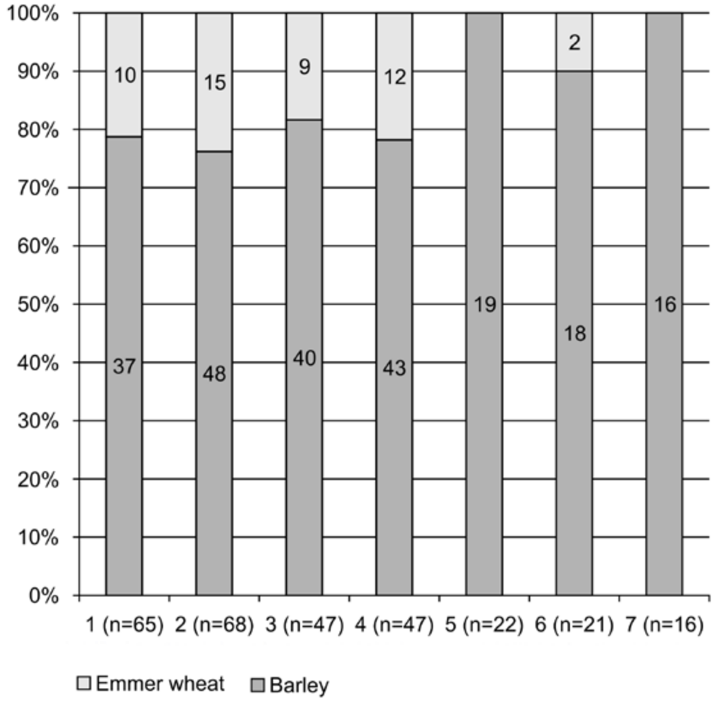

Fig. 6.6 Ratio between the sample frequency of barley and emmer wheat for spits 1–7 (absolute numbers given within the bars). The total number of samples examined per spit is given in parentheses. For some spits, the numbers within the bars add up to a higher total than the total number of samples per spit, which follows from the fact that samples often contain both species (diagram M. Schepers, UG/LH).

emmer wheat, a possibility already mentioned by Van Zeist and Palfenier-Vegter (1981: 143) and later adapted by Out (2009a: 172-173).

Fig. 6.6 gives the sample frequency between barley and emmer wheat per spit. The total number of samples available per spit is indicated below the bars, highlighting a substantial decrease in research intensity, from more than 60 samples in the highest two spits, to just 16 samples in spit 7. A clear pattern emerges. Barley was identified from many or, in the case of spit 7, all of the samples from the lowest spits presented in this graph, as well as from the upper spits. But the vertical distribution for emmer wheat is very different. Only two samples containing emmer wheat occur in the lower spits, in spit 6. A clear increase in emmer wheat sample frequency is visible in spit 4, and this increased frequency persists in the spits above it, resulting in two main groups of spits (1-4 and 5-7). Whilst still present in a lower number of samples than barley, emmer wheat seems to have become a more permanent factor from spit 4 upwards.

In theory, a single deposition of emmer wheat in an archaeologically 'invisible', shallow pit during the period when the settlement had grown to the height of spit 1 or 2 could be responsible for this pattern. In order to explore this possibility, the distribution of emmer wheat in the top four spits of the sieve strip is presented in fig. 6.7. The distribution shows

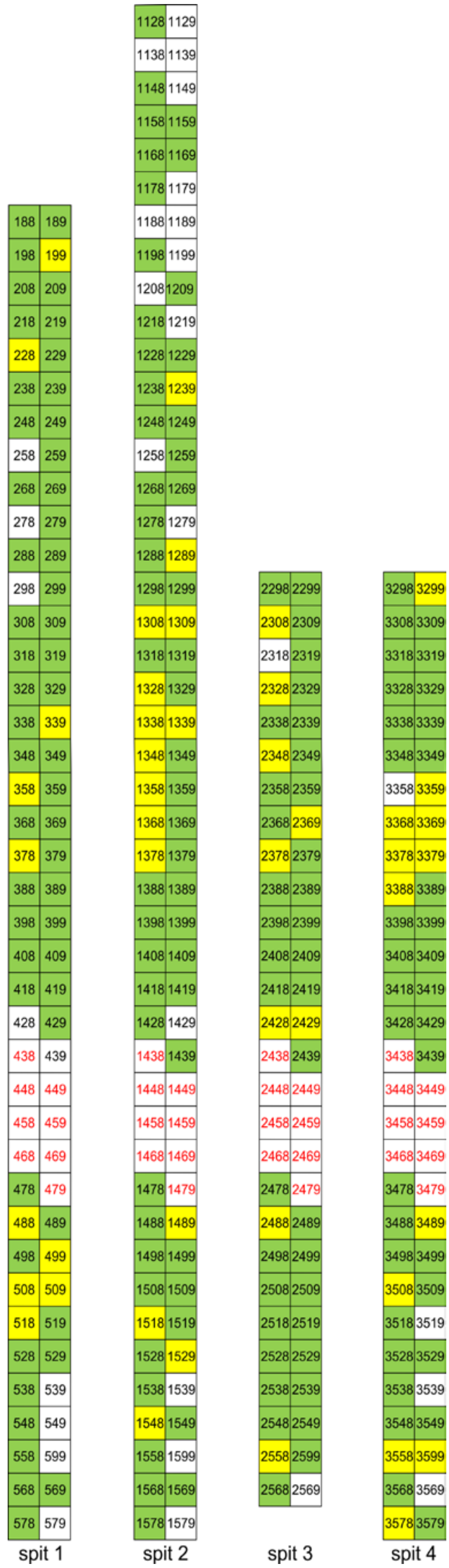

Fig. 6.7 Distribution of sieve residues in, from left to right, spits 1–4 in the sieve strip. Yellow fill indicates squares with sieve residues that were studied and that contain emmer wheat. Green fill indicates squares with sieve residues that were studied but that do not contain emmer wheat. White fill indicates squares with sieve residues that were not included in the analysis. Red text indicates squares located within (or bordering) the 1974 excavation trench (map M. Schepers, UG/LH).

Table 6.4 Sample frequency of the most frequently occurring species in the sieve samples expressed as a percentage of the total number of samples per spit (e.g. hazel in spit 1=52/65*100). Compare with fig. 6.6.

Spit	Barley	Emmer	Hazel	Hawthorn	Celandine	Cleavers	Alder
1	57	15	80	3	26	34	14
2	71	22	69	15	35	31	16
3	85	20	65	20	30	20	26
4	93	26	43	15	33	28	11
5	86	0	18	0	14	5	18
6	86	10	19	0	5	24	14
7	100	0	13	0	19	6	0

Fig. 6.8 Charred fruit (endocarp) of hawthorn (*Crataegus monogyna*) from square 3369 (photo M. Schepers, UG/LH).

that clusters of emmer wheat finds do exist (e.g. spit 4, squares 3359–3388), but that incidental finds of emmer occur throughout the whole sieve strip.

The other frequently occurring species in the sieve samples follow the pattern observed for emmer wheat, rather than barley, in the sense that they show a clear increase in sample frequency between spit 5 and spit 4 (fig. 6.6 and table 6.4). Intentional gathering probably explains most of the finds of these wild plant species. The edible fruits of hazel (*Corylus avellana*) and hawthorn (*Crataegus monogyna*) (fig. 6.8) are commonly accepted as food plants in prehistory (Out, 2009a: 350-351). Klooss *et al.* (2015) have made a case for lesser celandine (*Ficaria verna*) in this respect as well. Cleavers (*Galium aparine*) has tentatively been linked to deliberate human actions as well, for example to temper bleeding or a source of dye (for a discussion, see Out, 2009a: 344-345; Schepers, 2014a: 90). Alder is the only species in this selection where this effect of a steep rise in sample frequency between spit 5 and spit 4 cannot be observed at all.

Fig. 6.9 Charred bulbous root fragment of sea club-rush (*Bolboschoenus maritimus*) from square 3528 (photo M. Schepers, UG/LH).

The analysis of the ceramics allows for a distinction into three different units for the S4 spits, being spits 1–3 (Unit 1), spits 4–6 (Unit 2) and spits 7–9 (Unit 3). As stated earlier, the botanical sample numbers from spits 8 and 9 are too low to assign them interpretational value, so in order to compare like with like, palaeobotanical comparisons among the units have to be restricted to the upper two units. Had the palaeobotanical results been leading in the construction of units, spit 4 would have been included in unit 1, and not unit 2. The differences between the S4 spits should not, and cannot, be interpreted based upon botanical remains only, but there seems to be an obvious possible explanation for the patterns observed: S4 was used for crop cultivation at an early stage, as evident from the hoe marks encountered. The barley grains encountered in spits 5–7 may actually represent a signal of this practice, possibly in combination with crop processing. Emmer wheat, and other food plants, only occur in substantial frequencies from spit 4 upwards. The strong dominance of a crop plant in layers otherwise virtually devoid of obvious gathered food plants can in itself serve as an additional argument for the, at Swifterbant widely debated, local cultivation (Cappers & Raemaekers, 2008; Out, 2008; 2009a; 2009b). The botanical remains therefore suggest that spits 4 and younger (higher) represent an actual settlement signal, whereas the lower spits only testify to barley cultivation.

In addition to the plants mentioned above, which occur in greater frequencies, there are plants that occur in lower frequencies. This includes acorns (*Quercus*, fig. 6.4), which may have been used as fodder for pigs, but which could also have been used for human consumption (Out, 2009a: 347-350;

Fig. 6.10 Charred seed of crab apple (*Malus sylvestris*) from square 3429 (photo M. Schepers, UG/LH).

Deforce *et al.*, 2009). In some years, acorns may have been available in abundance, despite the relatively low presence of oaks in the region. In addition to the roots of lesser celandine, mentioned above, a bulbous charred root fragment of sea club-rush (*Bolboschoenus maritimus*, fig. 6.9) could be identified from square 3528. Root fragments from this and closely related species have been attested for in archaeological context before, and its use as a food source is commonly accepted, although other uses may have occurred as well (Kubiak-Martens, 2006: 344-349; 2014: 136-138). A more obvious food plant, crab apple, is represented in the form of seeds (fig. 6.10) and almost complete charred fruits (see Schepers, 2016: fig. 3.6).

The wood remains do not include apple, which may partly be due to a focus on posts or pegs in the wood sample collection, but *Malus*-type wood has been identified in the wood remains from S3 (Casparie *et al.*, 1977: 35). The detailed description of the S4 wood remains is given in appendix 6.2. No artefacts other than posts or pegs were found in any of the wood samples examined. As was the case in earlier research at Swifterbant, all of these have relatively small diameters. The general preservation of the post remains was highly variable, which hampered identification and interpretation. On most posts, cut marks could be identified, primarily for creating a clearly visible point. Not all samples designated as posts, however, were pointed. The interpretation as post is, then, based on the overall shape, the presence of cut marks, and/or the find conditions in the field.

The dominance of posts and pegs, and the wood taxa used for these, fit in quite well with the findings of previous research at Swifterbant S2 and S3 (Casparie *et al.*, 1977; Prummel *et al.*, 2009). Minor differences only can be observed between S3 and S4, especially in the stronger dominance of alder at S3. At S25, however, at the edge of one of the river dunes, no wooden posts or pegs could be identified with certainty. Taking all worked wood as a reference point for species comparison, there is an even stronger dominance of alder (*Alnus*) at S25, making up almost 80% of the finds (see Raemaekers *et al.* 2014: table 9.2). A striking difference between S25 and S4 is the absence of ash (*Fraxinus*) and hazel (*Corylus*) at S25, whereas these make up 31% and 19%, respectively, of the posts at S4 (table 6.4). These percentages directly explain the lower percentage for alder at S4 (38%). Various authors have suggested that the dominance of alder, whether or not in combination with the limited diameters, points to a 'least effort' approach on the part of the people making the posts, using nearby available wood that does not require the felling of large trees (Casparie *et al.*, 1977: 39; Out, 2009a: 178; Prummel *et al.*, 2009: 35; Raemaekers *et al.*, 2014: 49).

Only two pieces of wood charcoal were identified (one each of alder and oak), and such a small sample size precludes conclusions with respect to a possible preference for fuel at S4. Previous research at S3 did not show clear preferences in this respect (Casparie *et al.*, 1977: 38-39).

A remarkable find

Arguably the most unexpected and spectacular find is a single carbonized stone of sloe (*Prunus spinosa*) (spit 3, square 2299). Sloe is a wild plum species whose fruits, according to Out (2009a: 352), 'were probably an important food source in the coastal region'. However, it has not been identified from Swifterbant previously, which, considering the size and recognisability of the stones and the high number of samples involved in the analysis, has to be interpreted as a true signal of rarity and justifies the conclusion that sloe did not occur locally.

Although the taxon of this find is already quite interesting, the true surprise of this find lies in the fact that it concerns not a 'normal' plum stone, but a bead made out of one (fig. 6.11). A plum stone is actually the inner part of a fruit (endocarp). The bead at first seemed hollow, but a close examination revealed that remnants of the seed are still preserved inside the endocarp. The openings in the middle of the fruit were made not by drilling, but by grinding the stone until an opening appeared, once from each side.

Within Europe, various examples of botanical beads in a Neolithic context exist, such as the beads made out of cherry stones (*Prunus avium*) in Catalonia (Antolin & Buxo, 2011: 164-165). Perfect matches occur on various sites on the Bodensee,

Fig. 6.11 Pierced stone of sloe (*Prunus spinosa*) from square 2299 (photo M. Schepers, UG/LH).

both on the Swiss side and on the German side (Hosch & Jacomet, 2004; Kolb, 1997; Schlichtherle, 1988). These beads were not only made out of the same species, but they were also prepared in exactly the same manner. Half-finished examples and stones lacking any sign of anthropogenic treatment testify to both local production and and local availability at these sites (Hosch & Jacomet, 2004). The finds along the Bodensee indicate that these sloe stone beads occur from around 3900 BC until 3300 BC, thus covering a time span of 600 years.

According to Schlichtherle (1988: 202), the various finds indicate that decorative beads made out of seeds and fruits were a widespread phenomenon, at least in the Neolithic of middle and eastern Europe.[3] Korb (1998: 135) wonders if, despite the long time-period in which they occur, there might be some form of regional tradition present here. The bead find of Swifterbant are slightly earlier in date than the fourth millennium BC finds from the Bodensee area, and extends their dispersal to northwestern Europe.

There is no way of saying where exactly the Swifterbant bead came from. After all, sloe trees were definitely present considerably closer than Switzerland. However, it seems justified to conclude that the similarity between the Swifterbant bead and those found around the Bodensee testifies to the exchange of ideas and traditions in supra-regional networks, beyond the strictly functional.

6.4 Conclusions and reflections

The overall image of the Swifterbant environment is quite clear from a botanical perspective. Despite an occasional storm event bringing in more saline water (and associated palaeoenvironmental remains) from the west, the area as a whole was a freshwater wetland. Within this wetland, permanently and seasonally drier patches were available on the higher sand dunes rising above the maximum water level, and elevated banks that grew along the various branches of the small river system. On these higher grounds, various types of woodland and thickets provided fruits and nuts, wood for building material and other artefacts, as well as habitat for a range of animals. Grasslands covered the deforested parts of the channel banks, thus providing grazing grounds for livestock. Wetter woodland types probably covered greater surface areas within the landscape behind these banks, dominated by various types of alder carr.

Evidently, the people of the Swifterbant Culture were well equipped for making good use of this landscape, which resulted in an extraordinary way of life. Settlements were located along the banks of the stream channels, allowing for easy access to all sorts of natural food sources, yet at the same time resulting in relatively small areas with a more cultural landscape appearance, including the settlements proper, grazing grounds, and areas used for small-scale arable farming. Repeatedly, the Swifterbant Culture has been referred to as a hunter-gatherer-farmer community, arguably even more so than considerably older non-wetland Neolithic communities, such as the Linear Pottery groups. Within the wetland environment, a subsistence model developed in which natural and domesticated food sources both play a major role and did so for centuries, aptly described by Louwe Kooijmans as an extended broad-spectrum economy (1993). While this may be seen as a transition phase from hunter-gatherer to farmer from a present-day perspective, it will not have been perceived as such in the past. Journalist Hendrik Spiering (2015) argues that the introduction of arable farming estranged people from nature. His words can be translated as follows: "Amidst the wilderness, the farmer slogged." Within the Swifterbant environment, the opposite was true: Amidst the wilderness, the farmer thrived. Temporary, mainly seasonal, differences will, however, have posed serious challenges for the people dwelling along the streams. These challenges include incidental flooding, but also quite simply the profound seasonal differences in available wild food sources. It is tempting to describe vegetation in its most-developed, growth or fruiting season form. Arguably, we have succumbed to that temptation in this contribution as well. But the late autumn or winter landscape may not have been all that appealing or easy to exploit (Filatova, 2014).

Arable farming was evidently not as important to the provision of food as it would become in later history. However, the fact that, in terms of sample

3 "...Schmuckperlen aus Samen und Früchte zumindest in Neolithikum Mittel- und Osteuropas ein weitverbreites Phänomen waren".

frequency, cereal (predominantly barley) remains are second to those of alder throughout all of the S4 spits (that is, spits 1-7), shows that they must be considered a constant and substantial component of the Swifterbant diet. Louwe Kooijmans (2017: 481) argues that the S4 tillage levels do indeed represent some type of small field or garden, but that it is still unclear whether or not cereals were actually grown locally. An important finding from the S4 sieve samples is a clear and sharp shift in the ratio between barley and wheat between spits 5 and 4. Botanically, plants probably used by humans are less abundant in the lower spits in general, which leads to the tentative conclusion that these lower parts actually represent field levels rather than settlement levels. Moreover, since emmer wheat was a well established cereal crop at the time, it is very unlikely that such clear local shifts in the ratio between barley and wheat would have occurred had all cereal been imported from elsewhere. Shifts in the ratio between barley and wheat are also known from recent studies in the terps area, where emmer wheat virtually disappears when the environment becomes wetter (Schepers, 2018). At Swifterbant, the environmental situation may have been the other way around.

There is only one convincingly non-local botanical item. Botanically, the sloe bead retrieved from the sieve samples is as spectacular as it gets. Many questions arise with respect to its origin and significance, but it is safe to assume that it must have been a cherished item.

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Appendix 6.1 The results of the macrobotanical analyses from the drift litter features (S21-S23). All numbers are actual seed counts. x=present, bold remains are charred.

Scientific name	21	22	23
Atriplex patula	33	48	16
Bolboschoenus maritimus	3	5	4
Chenopodium album	134	90	139
Cladium mariscus	3	1	2
Conium maculatum	4	3	2
Corylus avellana	x	1	1
Eleocharis palustris	x	6	x
Eriophorum angustifolium	1	1	1
Galium	x	x	1
Humulus lupulus	x	5	1
Malus sylvestris	x	x	x
Mentha aquatica	1	x	x
Persicaria lapathifolia	10	20	5
Phragmites australis	x	1	x
Polygonum aviculare	8	6	5
Rumex obtusifolius	x	1	x
Schoenoplectus tabernaemontani	9	5	12
Solanum dulcamara	3	2	1
Solanum nigrum	19	123	16
Sonchus asper	x	x	x
Stellaria media	18	7	6
Urtica dioica	12	14	16
Alnus glutinosa	3	2	
Anthriscus sylvestris	1	3	
Arctium	x	2	
Aster tripolium	x	x	
Atriplex littoralis	2	x	
Carduus crispus	3	1	
Hordeum vulgare			**1**
Hordeum vulgare	**x**	**1**	
Juncus	1		1
Persicaria hydropiper	1		1
Ranunculus sceleratus	x		1
Rubus fruticosus	1		x
Typha latifolia	1		x
Galeopsis tetrahit		1	x
Juncus gerardi		x	x
Persicaria maculosa		x	x
Alisma plantago-aquatica	1		
Bidens cernua	1		
Bidens tripartita	1		
Carex	1		
Carex nigra	1		
Galium aparine	1		
Lycopus europaeus	1		
Plantago major	1		
Rumex	1		
Rumex crispus	1		
Scirpus	1		
Sonchus arvensis	1		
Sonchus oleraceus	1		
Alisma		1	
Carex paniculata		1	
Carex pseudocyperus		1	
Galeopsis		1	
Lolium		1	
Triticum turgidum ssp. dicoccon		1	
Crataegus monogyna			1
Erica tetralix			1
Ruppia maritima			1
Veronica anagallis-aquatica			1

Appendix 6.2 The results of the wood analysis.

Feature	Trench	Description	Length (cm)	Width (cm)	Thickness (cm)	Diameter (cm)	Growth rings (n)	Details	Taxon
15	1	Part of post, point missing	22			4.5 x 4		part of cut mark: 7.0 cm l x 4.0 cm w	*Corylus.*
18	1	Point of post	17			5.2 x 4	c. 10	Three cut marks: 11.5 cm l x5.0 cm w ; 3.5 cm l x 1.8 cm w ; 3.5 cm l x 1.5 cm w	*Betula*
19	1	Probably branch or root fragments	11	2					*Alnus*
20	1	Indet	13.5	max 2.5	2				*Betula*
30	2	Post with bark (sharp edges)	24			5 x 6			*Alnus*
31	1	Post, point broken off	26.5			6.5		cut mark 8.0 cm l x 3.5 cm w	*Alnus*
32	2	Part of post, possibly start of point at one side	18.5			5	4		*Alnus*
33	2	Upper part of post. Top splitting in two branches	15			5 x 8			*Alnus*
33	2	Tangential segment	15			4 x 5			*Alnus*
34a	1	Two fragments with bark	8.5			3 x 3.5			*Alnus*
34b	1	Indet	9			2.4 x 3			*Alnus*
37	1	Part of post	10.5	4.5	2.5				*Alnus*
38	1	Part of post	15.5			4 x 4.5			*Alnus*
40	2	Small dehydrated fragments							
41	2	Long, intact post	102			6.5	14 - 17	Five cut marks: 80.0 cm l x 6 cm w; 77.0 cm l x 4 cm w; 64.0 cm l x 3.5 cm w; 78.0 cm l x 4 cm w;72.0 cm l x 1.5 cm w. Probably younger than Swifterbant.	*Alnus*
42	2	Post fragments	12.5			4.2 x 4.5	c. 17	One side with cut marks	*Fraxinus excelsior*
43	2	Post with cut marks.	17			5		Three cut marks	*Alnus*
52	1	Bend post, point missing	27			5 x 7		Two cut marks: 7.0 cm l x 3 cm w; 8.0 cm l x ?w	*Fraxinus*
55	1	Three fragments	11.5 combined	3.5	5				*Alnus*
57	1	Pointed post, three axe strokes; top degraded	38			4.5		Three cut marks: 3,5 l x 3,8 w ; 4.5 cm l x 3.5 cm w; 4.0 l x2.8 w	*Corylus avellana*
63	1	Pointed base of post		3		4.5		Two cut marks: 3 cm l ; 4.5 cml	*Alnus*
63	2	Pointed base of post	15.5	5	4.5-2.5				*Corylus avellana*
64	1	Point of thick post	32.5	9	7-7.5			17 cm long section with cut traces from multiple directions.	*Alnus*
66	2	Pointed base of post	14			6		Four cut marks	*Corylus avellana*
67	2	Pointed base of post	23			5.5		Three cut marks: 8.0 cm l x 3.0 cm w; 6.0 cm l x 3.0 cm w; 13.5 cm l x 3.0 cm w	*Alnus*
68a	1	Indet	7	4.5-3.6	1.8		10-12		*Alnus*

Appendix 6.2 continued.

Feature	Trench	Description	Length (cm)	Width (cm)	Thickness (cm)	Diameter (cm)	Growth rings (n)	Details	Taxon
68b	1	Indet	7	4.5-3	1.8				*Alnus*
68c	1	Indet	5	2	1. 2				*Alnus*
68d	1	Point of thick post	28.5	max 7.5	max 4.5			Two cut marks: 26.0 cm l x 6.0 cm w; 18.5 cm l x4 cm w	*Alnus*
70	1	Bark fragments							
73	2	Pointed base of post	10	5.5	4.5				*Quercus robur*
74	1	Pointed base of post	19			5	c. 13	Three cut mark: 13.5 cm l x 5 cm w; c. 4 cm l x ?w; 2.5 cm l x ?w. Severely degraded.	*Fraxinus excelsior*
78	1	Post fragment							*Alnus*
80	1	Point of thick post	20.5			7		Four cut marks	*Quercus robur*
82	1	Pointed base of post	25			3.5		Three hardly visible cut marks	*Corylus avellana*
83	1	Post fragment. Top and bottom missing	31			5 x 6.5		Four cut marks: 10.0 l x 3.0 cm w; 7 cm l x 5 cm w; 4.5 cm l x 2 cm w; 6.5 cm l x 4.5 cm w	*Fraxinus excelsior*
86	1	Post	8	3.3	2.5	2.5 x 3.3		Two cut marks: 3.0 cm l x 2.3 cm w; 3.3 cm l x 2.0 cm w	*Corylus avellana*
87	1	Small fragments							*Corylus avellana*
91	1	Many small wood fragments	33	3.5	3			Possible point fragments	*Alnus*
92	1	Three fragments of post				2.5			*Corylus avellana*
93	1	Three fragments from one specimen	12.5 combined	max 4.5	max 2			Split lengthwise	*Alnus*
94	1	Three fragments of post. Point is missing	43			4.5		Cut marks from two sides: 17 cm l x 3,7 cm w; 19 cm l x 3 cm w	*Fraxinus excelsior*
95	1	Post segment	12	2.8	2	2.8		Branch split in half	*Corylus avellana*
97	1	Small fragments							*Corylus avellana*
99a	1	Post, one side missing	35.5			4.5		Three short cut marks	*Corylus avellana*
99b	1	Post	23.5	max 6.5	max 5			One side pointed with 4-5 axe strokes, one of them 5.0 cm l x 2.5 cm w	*Quercus or Fraxinus*
100	1	Post segment	26			7			*Fraxinus excelsior*
104	1	Pointed base of post: severely degraded	2-3.5	max 4	max 4			Cut marks all around	*Corylus avellana*
Field	1	Indet							*indet*
Field	1	Indet. Below field layer	3			1.2 x 1.5	4 - 5		*indet*
Field	1	Indet. Below field layer	2.5	1-1.5	1-1.5				*indet*
square 8533	2	Two charcoal fragments 1) pointed fragment 2) small fragment	1) 3 2) 2.0	1) 3 2) 0.8	1) 2 2) 0.8				*1) Quercus robur* *2) Alnus*

Appendix 6.3 The results of the macrobotanical sieve samples within the sieve strip.

square	Ficaria verna	Corylus avellana	CORAVE frgmnt	Alnus glutinosa (cone)	Hordeum vulgare (fruit)	Galium aparine	Triticum dicoccum	Crataegus monogyna	Poaceae tribe triticeae	Hordeum vulgare (rachis)	malus sylvestris	Ceratophyllum	Polygonum aviculare	Bolboschoenus maritimus	indet	cf. Quercus	cf. Malus	Iris pseudacorus	cr. Raphanis raphanistrum	Quercus	Brassicaceae	fossil endocarp, carbon age	Prunus spinosa
128									1														
158		0,1	3																				
188	1	1	6		3																		
189		0,5	2																				
198		0,1	2		2	2																	
199	1	0,1	1			1	1																
208		0,5	3																				
209						1																	
218	1				1																		
219					1									1									
228	1	0,1	2		1	1	1																
229						1																	
238		0,1	1			2																	
239		0,5	2		5	3																	
248	1	0,25	3		3																		
249		0,1	1			1																	
259		0,5	5			1																	
268		0,1	2		3																		
269		0,1	2																				
279		0,1	1		3																		
288					2																		
289		0,5	5		2																		
299		0,1	2		2	3																	
308		1	5		1																		
309		0,5	4		1	1		1															
318		1	15		1																		
319	2	0,5	7			2																	
328		0,5	2																				
329		0,25	2																				
338		0,5	4		3																		
339						1	1																
348		0,1	1		1																		
349	1				1	1																	
358		0,53					1																
359		0,5	5		1	1																	
368		0,5	6																				
369	1	2	22		1	1																	
378	1	3	25		6	1	1																
379		1	10	2																			
388		0,5	2																				
389	2	1,5	9	2	1																		
398		3	21	2																			
399		0,5	3	2																			
408	1	0,3																					
409		0,1	2	5	4																		
418		1	7		1																		
419		0,1	1		2																		
429		0,1	1		3	1																	
478					22	1																	

Appendix 6.3 continued.

square	Ficaria verna	Corylus avellana	CORAVE frgmnt	Alnus glutinosa (cone)	Hordeum vulgare (fruit)	Galium aparine	Triticum dicoccum	Crataegus monogyna	Poaceae tribe triticeae	Hordeum vulgare (rachis)	malus sylvestris	Ceratophyllum	Polygonum aviculare	Bolboschoenus maritimus	indet	cf. Quercus	cf. Malus	Iris pseudacorus	cr. Raphanis raphanistrum	Quercus	Brassicaceae	fossil endocarp, carbon age	Prunus spinosa
488	7	0,2		x	129		1		±60						x								
489	1				13																		
498	1	0,5	5	1	22																		
499	2	0,25	3	150	11	1	1																
508					1		2																
509		0,1	2		6		2																
518		0,5	4		3		2	0,5															
519		0,13											1										
528	1	0,2			3				3														
529		0,13			4																		
538	2	0,1	1	1	3																		
548						1																	
558		0,25	2																				
568		0,2																					
569						2																	
578		0,1	2																				
1128		0,25	3						1														
1148		0,25	2		1																		
1158		0,5	5																				
1159					1																		
1168		0,5	4			1																	
1169	1								1														
1178						1																	
1198						1																	
1209					1																		
1218		0,1	1																				
1228		0,1	1		4																		
1229					2																		
1238		0,1	1		2																		
1239							2																
1248		0,1	1		1				3														
1249					4																		
1259					1																		
1268		0,5	3		1																		
1269		0,5	3		2																		
1278								1															
1288		0,1	1																				
1289	1	0,25	3		1		1																
1298		0,25	2		1	1		1															
1299	1	1	14		3	1																	
1308		1	7				1	1	1														
1309	3	0,25	2		1		1																
1318	2	0,25	3		5	1		1,5															
1319	1	0,25	3		7			1															

Appendix 6.3 continued.

square	Ficaria verna	Corylus avellana	CORAVE frgmnt	Alnus glutinosa (cone)	Hordeum vulgare (fruit)	Galium aparine	Triticum dicoccum	Crataegus monogyna	Poaceae tribe triticeae	Hordeum vulgare (rachis)	malus sylvestris	Ceratophyllum	Polygonum aviculare	Bolboschoenus maritimus	indet	cf. Quercus	cf. Malus	Iris pseudacorus	cr. Raphanis raphanistrum	Quercus	Brassicaceae	fossil endocarp, carbon age	Prunus spinosa
1328	1	1	9		2		3	2			1							1	1				
1329		0,25	2		4																		
1338		1	8		4	1	2																
1339					1		1																
1348	2	0,25	5	0,5	5		1		2														
1349		0,5	4		1	1																	
1358		1,5	16	0,5		1	2																
1359		1	12					2															
1368		0,3			5		1		1														
1369	1	2	35	0,5	5	1		1															
1378		2	33		7	5	1	0,75															
1379		1,5	20																				
1388	1	2	25		6	1																	
1389				167																			
1398	3	3	39		7	1			2														
1399	1	3	33	125	7																		
1408		1			9				±10														
1409	3	1	15	1	10	1																	
1418	1	1	13		5	3		1									1						
1419					2																		
1428	1																						
1439	1																						
1478	1			11	112																		
1488		0,1		x	817	1			±120						x								
1489	4	0,5	4	45	93	3	2																
1498	2	0,1	1	26		1																	
1499		0,1	1	175	16																		
1508					7																		
1509	2	0,1	1		2																		
1518	7				14		2																
1519	2	0,25	1																				
1528	1	0,1	1		1	1			3														
1529					4		1																
1538		0,25	3		1				1						1								
1548	1	2			144		1																
1549		0,25	1		1				1														
1558		0,1	1		5	1																	
1568					1	1			1														
1569					1																		
1578		0,1	3																				
2298		0,75	7		1																		
2299		0,25	4		5																		1
2308	1				2	2	1	1					1		1								
2309	1	0,25	2		4																		

Appendix 6.3 continued.

square	Ficaria verna	Corylus avellana	CORAVE frgmnt	Alnus glutinosa (cone)	Hordeum vulgare (fruit)	Galium aparine	Triticum dicoccum	Crataegus monogyna	Poaceae tribe triticeae	Hordeum vulgare (rachis)	malus sylvestris	Ceratophyllum	Polygonum aviculare	Bolboschoenus maritimus	indet	cf. Quercus	cf. Malus	Iris pseudacorus	cr. Raphanis raphanistrum	Quercus	Brassicaceae	fossil endocarp, carbon age	Prunus spinosa
2319		0,25	1		2																		
2328					8		2	2			1												
2329					2																		
2338	1	0,25	1							1													
2339		0,1	1																				
2348		0,75	11	2	4		2	1,5															
2349		1	8		2																		
2358		0,25	2					3															
2359		0,1	2					1															
2368															x								
2369		1	13		4	1	2	1									1						
2378		0,25	5	1	4		2																
2379	1	0,25	9		5				2														
2388		0,5	6		2										2								
2389		1	6	55																			
2398		4	39		6	1		1	2														
2399		1	10	15	1											0,5							
2408	4	1			6				1														
2409		0,5	4		3																		
2418	1	1,5	16		4	1		1	1														
2419		0,25	3		1																		
2428		0,25	3		7	4	1								3								
2429	1				1		1																
2439					3																		
2478				x	108	2						1											
2488	12			x	182		1		±15	1													
2489	5	0,1	1	8	19																		
2498	2			65	99			1															
2499				115	7																		
2508	1				19	1																	
2509					7																		
2518	3	0,2	1		13	1																	
2519		0,5	3		9																		
2528					7										x								
2529					3																		
2538		0,1	1		1																		
2539				1	2	1																	
2548	1	0,25	1		6																		
2549		0,1	1	1	2																		
2558	1				5		1																
2559		0,25	5	1																			
2568		0,3			5																		
3298					13	1																	
3299	1			1	4		1																

Appendix 6.3 continued.

square	Ficaria verna	Corylus avellana	CORAVE frgmnt	Alnus glutinosa (cone)	Hordeum vulgare (fruit)	Galium aparine	Triticum dicoccum	Crataegus monogyna	Poaceae tribe triticeae	Hordeum vulgare (rachis)	malus sylvestris	Ceratophyllum	Polygonum aviculare	Bolboschoenus maritimus	indet	cf. Quercus	cf. Malus	Iris pseudacorus	cr. Raphanis raphanistrum	Quercus	Brassicaceae	fossil endocarp, carbon age	Prunus spinosa
3308					12																		
3309					3																		
3318					9																		
3319					5																		
3328	3					1																	
3329					7																		
3338					1																		
3339	1	0,25	2		4			1															
3348					2																		
3349	1				2																		
3359		0,1	1		5		1		5														
3368		0,2			6		2	3	3														
3369	1	0,5	7		5		2	6															
3378		0,25	2		17	1	3								1								
3379	1	0,1	2		5		3	1															
3388	2	1,5	13		8	1	4		5														
3389		1	7	5	5			1															
3398	2				3																		
3399	1				4	1																	
3408		0,2			8	1			±3														
3409					5																		
3418		0,25	1		4	1																	
3419		0,1	2		3																		
3428		0,1	1		3	1																	
3429					1			1			1												
3439									2														
3488		0,1		x	38				8														
3489	1				13		1		3														
3498		1	20	22	54	5																	
3499	2			45	3	1																	
3508	2				29	4	1																
3509					12	1																	
3518					17	1														1			
3528		0,25	3		7				3					1	x								
3529					1																		
3538		0,25	1		1																		
3548	1				4																		
3549		0,25	2		1																		
3558					9		1																
3559	1	0,25	3		3		2	1															
3568					4																		
3578	1				4		2																
3579		0,1	1																				
3669		0,25	1		3																		

Appendix 6.3 continued.

square	Ficaria verna	Corylus avellana	CORAVE frgmnt	Alnus glutinosa (cone)	Hordeum vulgare (fruit)	Galium aparine	Triticum dicoccum	Crataegus monogyna	Poaceae tribe triticeae	Hordeum vulgare (rachis)	malus sylvestris	Ceratophyllum	Polygonum aviculare	Bolboschoenus maritimus	indet	cf. Quercus	cf. Malus	Iris pseudacorus	cr. Raphanis raphanistrum	Quercus	Brassicaceae	fossil endocarp, carbon age	Prunus spinosa
4298					3																		
4299					1																		
4308					3																		
4329					9				7														
4349	2				3																		
4359	1	0,25	3		2				1							1							
4389		0,25	4	1																			
4399					2																		
4408		1			5						1												
4409					3																		
4419					5																		
4488				x	8				4														
4489				1		1																	
4499					1																		
4509				1	2				3														
4519					2															1			
4528					3																		
4529									1														
4539					2																		
4548					5																		
4549	1				1																		
4568		0,3			9																		
5349					1																		
5368									2														
5379					1																		
5389		0,5	2		2																1		
5399					2	1			1														
5408		0,3			4	1																	
5409					1																		
5419				1	2																		
5429					3																		
5439					1										1								
5488									2														
5489		0,25	2	1	2				2														
5519					1																		
5528				x	13																		
5529					1																		
5539						2				1													
5548					3																		
5549	2	0,25	1		15					2													
5559					4		2																
5568					18	1																	
5569					11	1	1																
6368					8				1														

Appendix 6.3 continued.

square	Ficaria verna	Corylus avellana	CORAVE frgmnt	Alnus glutinosa (cone)	Hordeum vulgare (fruit)	Galium aparine	Triticum dicoccum	Crataegus monogyna	Poaceae tribe triticeae	Hordeum vulgare (rachis)	malus sylvestris	Ceratophyllum	Polygonum aviculare	Bolboschoenus maritimus	indet	cf. Quercus	cf. Malus	Iris pseudacorus	cr. Raphanis raphanistrum	Quercus	Brassicaceae	fossil endocarp, carbon age	Prunus spinosa
6379					12																		
6389					10																		
6399					49																		
6408					14				±4														
6409					26																		
6419					3																		
6429					5																		
6509					2																		
6528		0,2			5				2														
6539	1				9																		
6549					4				7														
6559	2				18	1																	
6568	1				10																		
6569		0,5	1		2																		
6579					5																		
7588					1																		
7589	4	0,25	1		4				3														
8588		0,25	1																				
9588	1	0,1	1		2																		
9589				3																			
11588		0,1	2		3																		
11589					2		1	2														1	
12588	1				5		2																
12589		0,25	1		3																		
13588	1	0,25	1		2		1																
13589	1					1																	

Appendix 6.4 The results of the macrobotanical sieve samples outside the sieve strip.

square	Hordeum vulgare (fruit)	Corylus avellana	CORAVE frgmnt	Ficaria verna	Poaceae tribe triticeae	Galium aparine	Triticum dicoccum	Crataegus monogyna	Alnus glutinosa (cone)	malus sylvestris	indet	Hordeum vulgare (rachis)	cf. Malus	Quercus	Conium maculatum	Rubus fruticosus	Chenopodium album	Asteracaeae	cf. Fabaceae	Rumex obtusifolius
345		0,5	2																	
453	1																			
1133		1	9	1				2												
1479		0,25	2																	
2414	3	2	22							3										
2415	11																			
2458		0,5	1																	
2462	1																			
2473	4								9											
2479		0,5	2																	
2537	1	0,1	2																	
3385		0,1	1																	
3481		0,1	2																	
3527				1																
3547														1						
4450															1	1	1			
4602	9																			
4603	7																			
4612				1																
4613	5																			
4622	2	0,25	3	1																
5452	2					1														
5453	2				1	1														
5455	13			1		2	1	1												
5459										1										
5462	3					1	1		0,25		1									
5464	3			2	6		1		3											
5470	1																			
5471	5	0,25	1																	
5472	1				1															
5473	1																			
5474	2	0,5	2	1	1						1									
5475/76	7	0,5	3	4					1			1								
5602	8				4	2														
5612					2		1													
5613	2	0,1	1			1	2													
5622	2						1													
6453	1																			
6454	8	0,25	1	2																
6455	97	0,25	2	1																
6464	4																			
6465	1																			
6470	3	0,25	3																1	
6472	1							1												
6473	2				2															
6474	5				1															
6475	3	0,25	10	1				1												
6535							1													1
6602	4			2									1							
6603	8	0,5	5	1		2														

Appendix 6.4 continued.

square	Hordeum vulgare (fruit)	Corylus avellana	CORAVE frgmnt	Ficaria verna	Poaceae tribe triticeae	Galium aparine	Triticum dicoccum	Crataegus monogyna	Alnus glutinosa (cone)	malus sylvestris	indet	Hordeum vulgare (rachis)	cf. Malus	Quercus	Conium maculatum	Rubus fruticosus	Chenopodium album	Asteracaeae	cf. Fabaceae	Rumex obtusifolius
6612	8																			
6613	8	0,1	1		3															
6622	3																			
6623	1			1		1														
7452	1			1																
7454	11	0,25	2																	
7455	92	0,25	3	3		2			1											
7462	2																	1		
7463	1	0,1	1		1															
7464	1																			
7472		0,25	1		1															
7473	7																			
7474	3																			
7602	3																			
7603	1	0,25	1	1																
7612	4																			
7613	1	0,5	3			1														
8602								1												
8603	4	0,5	5	1																
8612	8	0,25	2	1																
8613	6				1															
8622	2	0,25	1																	
8623	1	0,25	1																	
9602	1																			
9603	1	0,25	1																	
9612	3							1												
9613	1			1				1												
30834									1											

7

The use of domestic and wild animals

H. Kranenburg[1] & W. Prummel[2]

7.1 Introduction

This chapter discusses the use of animals on S4. It is based on the hand collected bone material and part of the sieved material of the 2005-2007 excavations. All hand collected mammal, bird, amphibian and fish remains were studied. Of the sieved material, only the fish bones from a selection of the sieved samples were studied. Soil samples were sieved over a 2 mm mesh.

Almost all hand collected bone material (98%) comes from the anthropogenic deposit layer 5 (see chapter 2). Huisman *et al.* (2009: table 1, fig. 5A (there layer IV)) described this layer on the basis of micromorphological research as a heavy, blackish grey, tiered layer that was deposited by man on the bank of the creek. The remaining 2% of the hand collected animal remains are 3D mapped finds from larger units, post holes and sections within layer 5 or come from the cultivated field below layer 5 (table 7.1).

Students of the University of Groningen examined the animal remains from the different spits.[3] For this chapter, the data were combined into one database. We will answer the following questions: which animals played a role in the life of the people who created layer 5 of S4; in which seasons were people active on account of the animal remains, how was the environment used for animal husbandry, hunting and fishing; are diachronic developments traceable in the use of animals; how different is S4 from the nearby sites S2 and S3 in terms of the composition of the animal remains, and was layer 5 of S4 a dwelling site or not?

The following characteristics were noted for each bone fragment, if possible: the animal species, the skeletal element, the sex of the animal, the weight of the bone fragment, the age of the animal, special characteristics of the bone as such as traces of burning, cut marks, traces of bone working, dog gnawing and the degree of weathering. If possible, bone measurements were taken according to the measuring systems of Von den Driesch (1976), Habermehl (1985) and Brinkhuizen (1989).

In total 1051 bone fragments in the hand collected material, with a weight of 2425.5 g, could be identified to species, genus, family or class. Among them are remains of mammals, birds, fishes and an amphibian. Mammal bones form the vast majority of the material. However, most mammal bones could not be identified to species. Birds and fishes are represented by much smaller numbers of remains, amphibia only by a single bone (table 7.2).[4]

Table 7.1 Provenance of the S4 hand collected bone assemblage.

	Number	Weight (g)
The nine spits	5768	4230.1
Features, 3D measured finds	89	232.4
Cultivated field	18	34.3
Total	**5875**	**4496.8**

7.2 Fragmentation

The S4 faunal material is strongly fractured. The average weight per fragment is 0.76 g. Because of the strong fracturing it was only possible to identify to species or group about one sixth of the hand collected bone material (table 7.2). The strong fracturing has several causes. The first is the butchering of the animals. The carcasses were fragmented to get manageable chunks of meat. However, subsequent bone fracturing made it impossible to say anything about the ways of killing, skinning and butchering of the animals. Cut marks of the removal of the

1 heleenkranenburg@hotmail.com; Havenstraat 1, 9973 PL Houwerzijl, the Netherlands.

2 w.prummel@rug.nl; University of Groningen / Groningen Institute of Archaeology; Poststraat 6, 9712 ER Groningen, the Netherlands.

3 The students were J. Vosselman (Vosselman, 2007), A. Kramer (Kramer, 2007), K. Bresser (Bresser, 2007), K. Wheeler and A.G.J. Hullegie (Hullegie, 2009).

4 The shells of the marine mollusc species *Scrobicularia plana*, *Mya arenaria* and *Cerastoderma* sp. are later intrusions. They are not further discussed. Neither are the human remains and the only amphibian bone.

Table 7.2 Hand-collected animal remains from S4.

Species	Number	%	Weight (g)	%
Mammals				
Canis familiaris, dog	22	3.3	48.3	2.1
Sus domesticus, pig	99	14.6	197.5	8.6
Bos taurus, cattle	163	24.1	912.0	39.9
Ovis aries, sheep	2	0.3	4.9	0.2
Ovis aries/Capra hircus, sheep/goat	27	4.0	29.8	1.3
Sus domesticus/scrofa, pig/wild boar	92	13.6	207.2	9.1
Bos taurus/primigenius, cattle/aurochs	17	2.5	107.2	4.7
Castor fiber, beaver	85	12.6	109.5	4.8
Lutra lutra, otter	25	3.7	29.0	1.3
Meles meles, badger	1	0.1	5.9	0.3
cf. *Lepus europaeus*, hare	1	0.1	0.4	0.0
Unknown mouse	1	0.1	0.0	0.0
Talpa europaea, mole	1	0.1	0.5	0.0
Vulpes vulpes, fox	1	0.1	0.6	0
Ursus arctos, brown bear	1	0.1	1.9	0.1
Sus scrofa, wild boar	41	6.1	159.0	7.0
Cervus elaphus, red deer	96	14.2	456.4	20.0
Bos primigenius, aurochs	1	0.1	14.8	0.6
Total identified mammals	**676**	**100.0**	**2284.9**	**100.0**
Size cattle/horse/red deer	283		417.7	
Size sheep/goat/pig	230		166.1	
Small mammal	14		3.4	
Mammal, size unknown	4282		1445.5	
Birds				
Podiceps cristatus, great crested grebe	1		1.4	
Anas platyrhynchos, mallard	1		2.3	
Anas sp., anas-duck	23		1.1	
Unknown duck	1		0.4	
Unknown bird	30		3.9	
Fish				
Acipenser sp., sturgeon	21	11.2	10.5	8.5
Salmo salar/trutta, salmon/sea trout	1	0.5	0.1	0.1
Esox lucius, pike	65	34.6	16.3	13.2
Cyprinidae, cyprinids	11	5.9	1.2	1.0
Abramis brama, bream	1	0.5	0.0	0.0
Tinca tinca, tench	1	0.5	0.4	0.3
Silurus glanis, catfish	83	44.1	94.5	76.6
Anguilla anguilla, eel	1	0.5	0.1	0.1
Perca fluviatilis, perch	3	1.6	0.0	0.0
Liza ramada, thin-lipped grey mullet	1	0.5	0.2	0.2
Total fish	**188**	**100.0**	**123.3**	**100.0**
Unknown fish	130		8.2	
Amfibians				
Unknown amfibian	1		0.0	
Shell				
Scrobicularia plana, peppery furrow shell	2		0.4	
Mya arenaria, sand gaper	7		1.6	
Cerastoderma sp., unknown cockle	3		0.0	
Unknown mollusk	1		0.6	

meat from the bones were found on 40, possibly 43, mammal bone fragments (table 7.3).

The second cause of the strong fracturing is that most bones made contact with fire. 73% of the S4 bone remains is burnt; the large majority of these (85%) is calcined and have been exposed to temperatures higher than 550 °C. Bones shatter easily in fires of these temperatures (Lyman, 1994: 386). The remaining 15% is black stained by contact with fires between 400 and 550 °C (table 7.3). The high proportion of calcined bone fragments in the hand collected material may partly be the result of the high visibility of the white calcined bone in the blackish grey layer 5 which may have led to a higher recovery rate than for the non-calcined bones.

The third reason for the strong fracturing of the bones may have been trampling by humans and animals. Bones break when being trodden, which causes an increase of their numbers. This was established for S2 by Huisman *et al.*, 2008; see also Prummel *et al.*, 2009: 25.

The fourth and last cause of bone fracturing may have been weathering of unburnt bone lying on the surface exposed to wind, rain and biological agents. Unburnt bone will completely disappear by long-term exposure to the air. Calcined bone is virtually untouchable for weathering and biological degradation. Only 4.3% of the unburnt bones are weathered (table 7.3). This indicates that the S4 bones were soon covered with earth after being deposited.

7.3.1 Domesticated and wild mammals

Cattle and aurochs

The largest contribution to diet was provided by domestic cattle (*Bos taurus*). It concerns 163 bones – 24.1% of all identified mammal bones (table 7.2). For only two cattle bones (a milk premolar and a mandible) the age of the animals could be established: younger than 3 months and 19-24 months respectively (appendix 7.1). Butchering marks on

Table 7.3 The special characteristics (burning, cut marks, gnawing, processing, weathering) of the hand-collected animal remains.

Species	Total Sum of n	Black (by fire?)	Burnt	Burnt + cutmark	Calcined	Calcined + cutmark	Cutmark	Cutmark?	Gnawed (by dog)	Gnawed?	Gnawed + burnt	Worked/used	Worked?	Worked + burnt	Weathered
Dog	9		1		5		2	1							
Domestic pig	46		14		28		1		1					1	1
Cattle	99		20		42		6			1		1	1		28
Sheep	2		1		1										
Sheep/goat	20		3		16				1						
Domestic pig/wild boar	61		10		35				2						14
Cattle/aurochs	11		9									1			1
Beaver	56		9		42										5
Otter	5		2	1	2										
Cf. hare	1				1										
Fox	1				1										
Wild boar	25	1	15		2				1			3			3
Red deer	64		15	2	31	1	2	1	2			2		1	7
Aurochs	1						1								
Size cattle/horse/red deer	229	1	81		93	2	3		2	2		4	2		39
Size sheep/goat/pig	188	1	23		152	1	1	1	1						8
Mammal, size unknown	3640	13	375	3	3080	7	5		2	1	1	5	2		146
Small mammal	12		1		9	1									1
Unknown duck	1					1									
Unknown bird	9		2		7										
Sturgeon	1				1										
Salmon/sea trout	1		1												
Pike	30	1	6		23										
Cyprinid	5		2		3										
European catfish	10		3		6										1
Eel	1				1										
Perch	1				1										
Unknown fish	45	1	5		39										
total	**4574**	**18**	**598**	**6**	**3621**	**13**	**21**	**3**	**12**	**4**	**1**	**16**	**5**	**2**	**254**

six cattle bones indicate that beef was eaten (table 7.3). A total of 17 bone fragments of the genus *Bos* were too incomplete to decide whether they came from domestic cattle or aurochs. The contribution of domestic cattle to diet might have been larger than after the 163 domestic cattle bones alone. Aurochs (*Bos primigenius*) is represented by one atlas fragment with cut marks (fig. 7.1). This singular find implies that aurochs did not play a significant role in the food supply. The river banks and the back swamps will have supplied pastures for cattle, but also for aurochs (Van Vuure, 2003: 196-204; Van Vuure, 2005). Schepers (2014) identified grassland plant communities on the river banks that were the result of grazing. The original vegetation of the river banks had been a dense riparian forest.

Domestic pig and wild boar

The distinction between domestic pig (*Sus domesticus*) and wild boar (*Sus scrofa*) bones was based on size differences of the two forms, wild boar bones and teeth being larger than those of domestic pig.[5] Published domestic pig and wild boar bone measurements from other Neolithic sites, such as Hekelingen III (Prummel, 1987) and Swifterbant S2 (Prummel *et al.*, 2009) and early medieval sites, such as Starigard/Oldenburg (Prummel, 1993) were used to separate the domestic pig bones from those of wild boar. The risk of a circular argument by the use

5 The list of Neolithic sites that were used as basis for the domestic pig – wild boar distinction is found in Prummel, 1987: 193-194. The list of early medieval sites that were used as basis for the domestic pig – wild boar distinction is found in Prummel, 1993: 93.

Fig. 7.1 Fragment of the atlas of an aurochs (*Bos primigenius*) with cut marks (1.4632). Scale 1:1 (photo H.Kranenburg).

of the S2 domestic pig/wild boar size data is limited by the large body of measurements from the other sites. Bones that could not be identified as either domestic pig (small) or wild boar (large) because they were too incomplete to decide on the size of the animal or were intermediate in size, were put in the group domestic pig/wild boar (appendix 7.2).

Ancient mtDNA studies by Larson *et al*. (2007), Krause-Kyora *et al*. (2010), Krause-Kyora (2011) and Ottoni *et al*. (2013) made clear that the first domesticated pigs in Europe had Southwest-Asian ancestors. They were introduced in Europe approximately 6500 cal. BC. These pigs had Southwest-Asian D-loop mtDNA haplotypes (ANC-Y1-6A and ANC-Y2-5A). In the millennia after the introduction of Southwest-Asian domestic pigs, these haplotypes were replaced by European wild boar mtDNA haplotypes (ANC-A and ANC-C). It is not certain whether this happened by incorporating female European wild boars in the herds of domestic pigs, by domestication of European wild boars or both. At any case, all European domestic pigs since at least 3900 cal. BC have European D-loop mtDNA haplotypes, originating from female European wild boars (Larson *et al*., 2007: 15277; Ottoni *et al*., 2013). Krause-Kyora (2011) incorporated six unburnt teeth from S4 in his mtDNA study of domestic pig and wild boar in Europe (table 7.4). Larson *et al*. (2007: Supporting Information, table 5) found haplotype ANC-A in an upper incisor from S3. This tooth was not further identified than as domestic pig or wild boar. It is concluded that the replacement of West-Asian mtDNA haplotypes by European haplotypes was going on or had already finished in Swifterbant at 4300-4000 cal. BC, making it impossible to use haplogroup analysis to distinguish between wild and domestic pig at Swifterbant S4.

Domestic pig (*Sus domesticus*) was the second most important animal after bone number as well as bone weight (table 7.2). Thirteen bones and bone fragments identified as domestic pig yield age data (appendix 7.1). Seven pig bones come from animals slaughtered before they were two years old. Six other bones come from pigs that were slaughtered at ages over two years (appendix 7.1). This means there was no preferential age to slaughter pigs. The domestic

Table 7.4 The result of aDNA analyses at six Swifterbant S4 pig bones. After Krause-Kyora, 2011: 235 (517 and 6507) and personal communication Ben Krause-Kyora (rest).

Findnumber	Spit	Skeletal element	Metrical identification	Haplotype
517	1	Lower first molar	Domestic pig	ANC-A
6507	7	Lower third incisor	Domestic pig or wild boar	ANC-A
6474	7	Lower deciduous fourth premolar	Domestic pig or wild boar	ANC-C
3406	4	Upper third molar	Wild boar	ANC-C
P025	-	Upper third molar	Domestic pig	Not identified
5507	6	Lower permanent incisor	Domestic pig	Not identified

pigs will have been kept in the riparian forests on the river banks and in the reed/sedge swamps and the wet woodlands in the area (Schepers, 2014).

The proportions between the numbers and the weight of the *Sus* bones identified as either domestic pig or wild boar suggest that more domestic pig than wild boar bones are represented in the domestic pig/wild boar group and that domestic pig was more important than wild boar at S4.

Wild boar (*Sus scrofa*) played a moderate role in the food supply. Nearly 6% of the identified mammal bones are from wild boar. The bone fragments are evenly divided over the skeleton. Some wild boars were killed at young ages, others at advanced ages (appendix 7.1). Tools were made out of some of the teeth (table 7.3).

Since bone shrinks by burning, some burnt wild boar bones were perhaps falsely identified as domestic pig, thus pushing down the number of burnt and calcined wild boar bones (Prummel *et al*., 2009: 16). Only two of the 41 wild boar bones are calcined, and fifteen are burnt black (in total 41%; table 7.3) – this percentage is similar to that for domestic pig (42%) suggesting that this potential problem is probably limited. The wild boar will have found good opportunities to live in the same types of vegetation as the domestic pigs: riparian forests, reed/sedge swamps and wet woodlands (Schepers, 2014).

Sheep

Sheep (*Ovis aries*) played a subordinate role in the diet with only 29 bone fragments of sheep and sheep/goat (4.2% of the identified mammal remains).[6] The fresh water river banks and back swamps were unsuitable for sheep, also because of

6 Since no goat, *Capra hircus*, bones have been identified, also the bones of sheep or goat (sheep/goat) are considered to be sheep bones, *Ovis aries*.

Fig. 7.2 Base of a shed red deer (*Cervus elaphus*) antler 1.3545, debris of antler working; top: lateral view, bottom: medial view with notches on the fracture of the brow tine (left) and on the base of the beam (right).Scale 1:2 (photo H.Kranenburg).

the occurrence of the liver fluke, *Fasciola hepatica*. Sheep are very susceptible to infections of this flatworm. Liver fluke eggs have been found at the nearby site S3 in dog coprolites (De Roever-Bonnet *et al*., 1979; Zeiler, 1997: 33).

Dog

A total of 22 dog bones (*Canis familiaris*) were found. Cut marks were observed on two or three dog bones and suggest that dogs were slaughtered and that their meat was consumed, or at least that dogs were skinned. Traces of dog gnawing were found on various bones of other species (table 7.3). This means that dogs walked around at the site.

Red deer

Red deer (*Cervus elaphus*) delivered most wild mammal meat. It also supplied antler, which was a raw material for tools (see 7.3.6). A total of 59 of the 96 red deer bone fragments (456.4 g) are antler fragments (61%). The remaining 39% of the red deer remains are front and hind leg bones, a few rib fragments, a vertebra and a few molars. In particular many metapodial fragments were found, from the front as well as the hind limb. Among them are tools and waste of tool making. The large size of a number of the postcranial bones shows that at least some stags were hunted (appendix 7.2).

Most antler fragments are burnt or calcined. A large shed antler base comes from a 12-13 years old stag (appendices 7.1-7.2, fig. 7.2; age after Habermehl, 1985: 34-35). Chop marks show that the beam had been removed; it was likely used to make implements. Only one other antler fragment with traces of antler working was found. No implements made from antler were found. Red deer will have found ample vegetal food on the river banks and in the back swamps of the Swifterbant area.

Beaver

The beaver (*Castor fiber*), represented by 85 remains, probably gave various products to the S4 inhabitants. Although no cut marks were found on beaver bones, it may be assumed that its meat was eaten, as was the case at neighbouring site S3 (Zeiler, 1997: 80-81). The beaver was also hunted for its fur, while the fat from its tail was perhaps eaten as well and the castor oil (castoreum) was perhaps used as medicine or as bait (Coles, 2006: 48-57; Coles, 2010: fig. 29).

A large number of beaver incisors were found. They might have been used as implements, such as chisels, but no evidence for this was found. This was neither the case on S3 (Bulten & Clason, 2001) and S2 (Prummel *et al*., 2009). Beaver incisors were presumably not used to make tools on these sites. Beavers of various ages were hunted (appendix 7.1). The fresh water stream channels with riparian forest on the river banks in the Swifterbant area (Schepers, 2014) will have offered optimum conditions for beaver (Coles, 2006; Coles, 2010; Prummel, 2017).

Otter

A total of 25 otter bones (*Lutra lutra*) were found. The otter was most probably hunted for its fur and meat, although no cut marks were found. The two otter bones that supplied age data belonged to adult otters (appendix 7.1; Zeiler, 1988a; 1997: 23, 133-134). The fresh water stream channels near the site with their good fish stock (see 7.3.4) will have been a suitable habitat for otters.

Other wild mammals

The badger (*Meles meles*) is represented by one bone. This species played no role in the food supply. It will have been captured for its fur, although no cut marks were found. The environment in the vicinity of S4 was not very suitable for badgers, because of the density and the wetness of the riparian forest near the site (Zeiler, 1997: 33). The badger was perhaps captured on the river dunes at some distance of S4.

A calcined bone fragment presumably comes from a hare (*Lepus europaeus*). The meat as well as the fur of the animal will have been used, although no cut marks were found. The wet surroundings of S4 will not have been very suitable for hares.

The mole (*Talpa europaea*), represented by one bone, weighing 0.5 g, did not play a role in the food supply, but may have been caught for its fur. Mole bones were also found on the site S3 (Zeiler, 1997: 31).

The red fox (*Vulpes vulpes*) is also represented by a single bone. The bone fragment is calcined. The fox was probably caught for its fur (Zeiler, 1997: 30).

Table 7.5 The identified fish remains subdivided according to collection method and interpretation (cleaning offal. meal refuse and group unknown). In the grey colums a proportion is modelled on the basis of an equally intensive analyse of hand collected and sieved squares. The scutes from the skin of the sturgeon and perch scales belong to meal refuse.

	Hand collected					Sieved						Total						
Species	**Cleaning offal**	**Meal refuse**	**Unknown**	**Total**	**Total**	**Cleaning offal**	**Meal refuse**	**Unknown**	**Total**	**Total**	**Corrected**	**Cleaning offal**	**Meal refuse**	**Unknown**	**Total**	**Total**	**Corrected**	**Corrected**
	Number	**Number**	**Number**	**Number**	**%**	**Number**	**Number**	**Number**	**Number**	**%**	**Number**	**Number**	**Number**	**Number**	**Number**	**%**	**Number**	**%**
Acipenser sp., sturgeon	1	16	4	21	15.2							1	16	4	21	3.5	21	0.2
Salmo salar/trutta, salmon/sea trout		1		1	0.7		12		12	2.9	392		13		13	2.2	393	2.9
Esox lucius, pike	62	1	2	65	47.1	7	23		30	7.4	981	69	24	2	95	16.0	1046	7.7
Cyprinidae, cyprinids	2	9		11	8.0		226		226	55.5	7390	2	235		237	39.9	7401	54.8
Abramis brama, bream	1			1	0.7					0.0		1			1	0.2	1	0.0
Tinca tinca, tench		1		1	0.7	5			5	1.2	164	5	1		6	1.0	165	1.2
Silurus glanis, European catfish	39	33	11	83	60.1	1	47		48	11.8	1570	40	80	11	131	22.1	1653	12.2
Anguilla anguilla, eel		1		1	0.7	1	80		81	19.9	2649	1	81		82	13.8	2650	19.6
Perca fluviatilis, perch		3		3	2.2					0.0			3		3	0.5	3	0.0
Gymnocephalus cernua, ruffe							1		1	0.2	33		1		1	0.2	33	0.2
Liza ramada, thin-lipped grey mullet		1		1	0.7		4		4	1.0	131		5		5	0.8	132	1.0
Identified total	**105**	**66**	**17**	**188**	**136.2**	**14**	**393**		**407**	**100.0**	**13309**	**118**	**459**	**17**	**594**	**100.0**	**13497**	**100.0**
% of identified total												**19.9**	**77.3**	**2.9**				

A molar of a brown bear (*Ursus arctos*) is the only brown bear find on S4. The molar has no cut marks. An incisor of an unknown mouse species was found in the hand collected material. The mouse may have died a natural death.

7.3.3 Birds

Of the 56 bird bone fragments from S4, only two could be identified to species. One comes from a great crested grebe (*Podiceps cristatus*), the other from a mallard (*Anas platyrhynchos*). The 23 very small bone fragments identified as *Anas* sp. presumably belonged to one bone. Another bone was identified as belonging to an unknown duck species. Not even the bird family could be identified for the remaining bird bone fragments.

The great crested grebe was presumably not eaten because it mainly eats fish. The bird is hardly found in other Neolithic sites in the Netherlands, not even on sites where fowling was important (Lauwerier *et al*., 2005; Zeiler, 1997; 2006). The species will have lived in the stream channels and ponds near S4. The great crested grebe presumably died a natural death near the site, or drowned in a fish trap.

The mallard is a common bird in open fresh water and in fresh water marsh, biotopes that were numerous around S4 (Schepers, 2014). Some more duck remains are perhaps among the 30 unidentified bird bones. Ducks have a very good yield in terms of food due to their favourable fat/protein ratio (Serjeantson, 2009: 233-234).

The number of bird remains is low for a Neolithic site, e.g. compared with the sites Kolhorn and Schipluiden (Zeiler, 1997: 37-38; 2006). Birds were perhaps not of great importance in the S4 diet, but it needs reminding that bird bones are fragile and are easily squashed when trodden on, gnawed by dogs or exposed to fire.

7.3.4 Fish

The 318 fish bones in the hand collected material are from at least nine species (table 7.2). In addition, 532 fish bones from the sieved samples were studied (Hullegie, 2009). Seven fish species were found among the fish bones in the sieved samples (table 7.5).

Bones of European catfish (*Silurus glanis*), pike (*Esox lucius*) and sturgeon (*Acipenser* sp.) predominate in the hand collected material.[7] The first

7 The sturgeon remains were identified as *Acipenser* sp., since recent research made clear that two sturgeon species occurred in Western Europe, *Acipenser sturio*, the European sturgeon, and *Acipenser oxyrinchus*, the Atlantic sturgeon (Desse-Berset, 2009; Thieren *et al*., 2016; Van Neer *et al*., 2012).

precaudal vertebrae and fragments of the spina pinnae pectoralis are the most numerous among the European catfish bones. The pike bones mainly consist of fragments from the head skeleton, particularly the dentale. One pike had a total length of 15.5 cm (appendix 7.2). Scute fragments predominate among the sturgeon remains. Perch (*Perca fluviatilis*), salmon/sea trout (*Salmo salar/trutta*), cyprinids such as bream (*Abramis brama*) and tench (*Tinca tinca*), eel (*Anguilla anguilla*) and thin-lipped grey mullet (*Liza ramada*) had low priority in fishery on basis of the numbers found in the hand collected material.

The study of the sieved material was restricted to the fish remains of 29 sieved squares of spit 3 and one sieved square of spit 9. Cyprinid bones, at any case of tench, predominate and are followed by those of eel, European catfish and pike. Salmon and/or sea trout played a modest role on the basis of the sieved samples, whereas thin-lipped grey mullet and ruffe seem to have been unimportant.

The numbers of the identified fish bones from the sieved squares were corrected to compensate for the much lower number of squares the sieved material comes from (30) in comparison with the hand collected material (981) to allow a quantitative comparison of hand collected and sieved material.[8] The related numbers are found in the grey cells in table 7.5. The result is that the cyprinids, among them at least bream and tench, were by far the most often captured fishes. Eel, European catfish and pike were rather often captured, whereas salmon and/or sea trout, sturgeon, thin-lipped grey mullet, ruffe and perch played minor roles in fishery. European catfish and sturgeon may have been more important in terms of meat than the numbers of their remains suggest because of their large size and weight (table 7.2). Salmon/see trout may be underrepresented, because bones of these species easily dissolve due to their high oil content (Brinkhuizen, 1976: 250).

All demonstrated fish species are fresh water fishes or migratory fish species that stay part of their life in fresh water (see 7.3.5). They will have been caught in the fresh water stream channels and ponds in the Swifterbant area, which will have supplied good conditions for these species. They are all reckoned to the bream zone fish fauna, the lowest of European river zonation with slow-running and stagnant water (Brinkhuizen, 1976; 2006; Van Neer *et al.*, 2013: 96).

The bones of the fish skeleton may be divided into two groups: those of the head, shoulder and pelvic girdle (group 1), and those of the trunk and tail (group 2) (Brinkhuizen, 1989: 42-43). Skeletal elements of group 1 are parts of the fish skeleton without much meat. They are removed during the cleaning of the fish before cooking, i.e. belong to the fish cleaning offal. Skeletal elements of group 2 belong to the parts of the fish rich in meat. They are waste of meals (Brinkhuizen, 1989: 269-274). If the waste of the cleaning and the meals are deposited on different locations, you may find places with fish cleaning remains and places with fish consumption remains. If the fish cleaning and consumption were done at the same place or near to each other, or if the waste of cleaning and consumption was deposited together, you will find waste of fish preparation and consumption on the same place.

Fish bones as fish cleaning offal are the spinae pinnae pectoralis of European catfish in the hand collected material, the many pike skull bones in the hand collected material and the perch scales in the hand collected and the sieved materials.[9] Skull bones of small cyprinids are rare. They were perhaps overlooked in the hand collected material and not recognized in the sieved material because of their small size. Most cyprinid vertebrae come from small individuals, of less than about 15 cm total length. Eel bones of the head, shoulder and pelvic girdle do not very well preserve (Lepiksaar & Heinrich, 1977); they may be underrepresented.

Fish bones belonging to meal refuse are the many cyprinid vertebrae, mainly in the sieved material, the European catfish vertebrae in the hand collected and sieved materials, the pike vertebrae in the sieved material, the many eel vertebrae in the sieved material, the salmon/sea trout vertebrae in the sieved material and the sturgeon scutes in the hand collected material. From the presence of both groups it may be concluded that the S4 fish bones are a mixture of waste of the cleaning of the fish and of fish meals. Therefore they may be waste of a settlement site.

7.3.5 Seasonality

There are various ways to determine the season of occupation on the basis of zoological remains. Migratory birds and fishes are only present in a given area in a restricted period within a year, for instance in summer or winter, or only during a few months. Some species that are present throughout the year, may be captured more easily in specific seasons. Some animal products, such as shed antlers or beaver furs, can only or best be collected in a short period of the year. The slaughtering age of animals may give information on the season the animal was

8 The numbers of remains of the fish remains of the sieved samples were multiplied with 32.7 (which is 981/30) to represent the same amount of squares and soil as the hand collected material.

9 Perch scales were found in other sieved squares than in those of spits 3 and 9, personal observation H. Kranenburg).

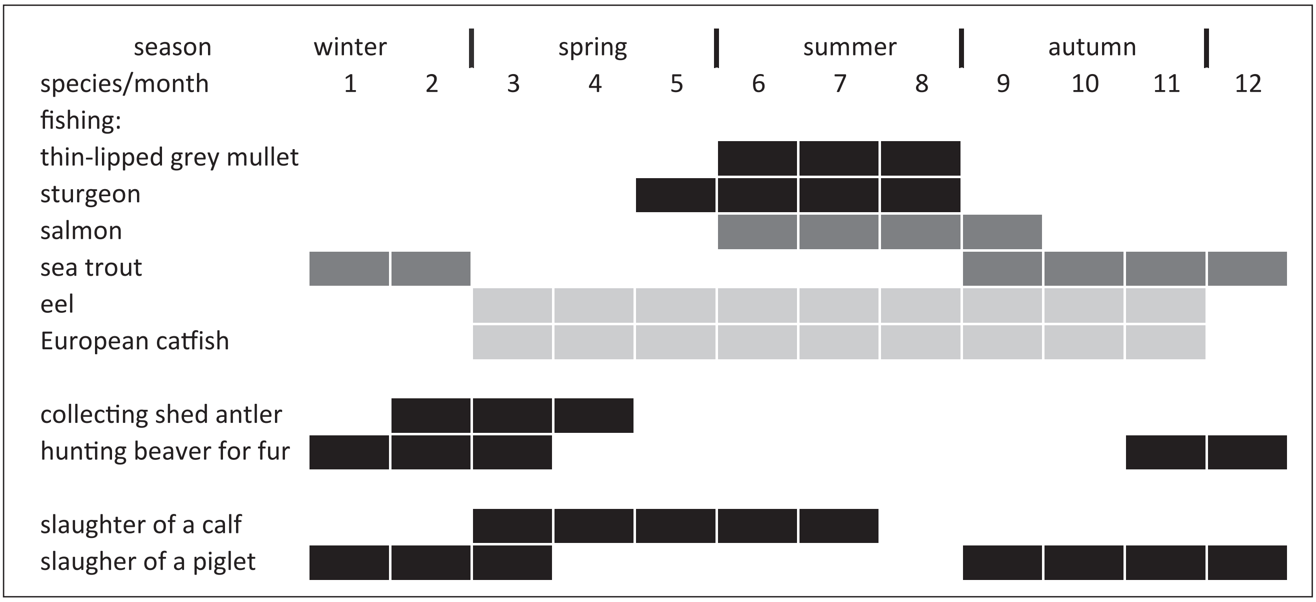

Fig. 7.3 Seasonal activities concerning animals. Black-stained months: activity only possible in these months; dark grey-stained months: depending of the species (salmon or sea-trout) fishing only possible in these months; light grey-stained months: activity best done in these months, but also possible in other months (diagram W. Prummel UG/GIA).

killed, if the month of birth is known. Recovered bones from all these animals may give information about the season humans did specific activities, such as fowling, fishing, collecting shed antlers or slaughtering. These seasonal data do not mean that humans were absent at a site during other seasons.

The thin-lipped grey mullet, a heat-loving fish species, was only present in the waters of the Swifterbant area in summer (Brinkhuizen, 2006: 466-467). Bones of this species therefore point to summer fishery. Sturgeon, salmon and sea trout are anadromous species. They grow up in the sea. When they are sexually mature, they migrate to their upstream spawning grounds, the same waters where they were born. Migration and spawning happen in a specific season. Spawning sturgeons will have been present in the Swifterbant waters in late spring and summer (Brinkhuizen, 2006: 466-467). Salmons migrate to the spawning grounds in summer or early autumn, sea trouts in autumn or winter (Brinkhuizen, 2006: 466-468). The salmon/sea trout remains therefore may indicate summer, autumn or winter fishery in the Swifterbant waters. Eel and European catfish were present in the Swifterbant waters throughout the year. They had to be actively traced in winter (Brinkhuizen, 1989: 111), so they were perhaps mainly caught during spring, summer and autumn.

Stags shed their antlers in February or March. The quality of a shed antler decreases within a few weeks due to taphonomic processes such as weathering and gnawing, so shed antlers had to be collected soon (Oversteegen *et al.*, 2001: 243-245). A worked fragment of a shed red deer antler (fig. 7.2) demonstrates that the antler was collected in February, March or April (Oversteegen *et al.*, 2001: 243-245).

The age data for beaver are not restricted enough to decide on the season of death (appendix 7.1). Its fur has its maximum thickness and thus best quality between late autumn and early spring (Zeiler, 1988b: 258-259). This means that the optimum part of the year to hunt beavers for their fur was that period. Otter fur tends to have the same quality throughout the year (Zeiler, 1988b: 259-260).

The absence of abrasion on an upper second milk premolar of a calf shows that the animal died before it was 3 months old. Assuming a calving period of March-April (Zeiler, 1988b: 257) the animal was killed between March and July. A mandible of a domestic pig with a low degree of wear of the lower milk premolars Pd2-4 comes from a pig that was slaughtered when 6-10 months old. Piglets will have been born in March, April or May (Zeiler, 1988b: 256). This piglet was then slaughtered between September and March (appendix 7.1).

Summarising, the information about the seasonal activity (fig. 7.3) suggests that human beings were active in the area in several seasons of the year and possibly throughout the year, although not necessarily in all years. Zeiler (1998b; 1997: 84-87) came to the same conclusion for the nearby site S3. The presence of grassland communities on the river banks demonstrated by Schepers (2014) are another argument that the river banks were regularly, best every year, and also in winter, used for grazing. If you would leave the area in autumn and return only in late spring, and not even every year, the riparian forest will recover.

7.3.6 Bone and antler processing

Various processed bone and antler fragments were found. They were divided into three categories:

Fig. 7.4 Pendant 1.3387 made out of a lower incisor of a wild boar (*Sus scrofa*). Scale 1:1 (photo H.Kranenburg).

Fig. 7.5 Pendant 1.3355 made out of a lower canine of a female wild boar (*Sus scrofa*). Scale 1:1 (photo H.Kranenburg).

Fig. 7.6 Tool 1.3554 made out of a cattle (*Bos taurus*) or aurochs (*Bos primigenius*) long bone fragment, possibly an awl. Scale 1:1 (photo H.Kranenburg).

Fig. 7.7 Fragment of bone tool 2.1432, made out of a diaphysis fragment of a metapodial of a large mammal. The object may have been a needle or an awl. Scale 3:1 (photo H.Kranenburg).

pendants, tools and manufacturing debris. All objects are indicated with the number of the trench (1 or 2) and findnumber.

Pendants

The two pendants found are both perforated wild boar teeth. Pendant 1.3387 is a perforated lower incisor of a wild boar (fig. 7.4). The perforation was made through the tip of the root. The edges of the perforation are smooth and rounded, indicating that the tooth was used as a pendant. A part of the tooth itself was later broken. Pendant 1.3355 is a perforated lower canine of a female wild boar (fig. 7.5). The root of the canine is hollow and was still open, which is an indication for the age of the female wild boar: 2.5-3 year old (Habermehl, 1985: 104). The root was perforated from one side. It was broken at the place of the perforation, after which the canine could no longer be used as a pendant. There is no evidence for an attempt to make a new perforation.

Tools

Six tools and three possible tools were found. Tool 1.3554 was longitudinally cleaved; the two ends are lacking (fig. 7.6). The large wall thickness of the bone fragment suggests that the tool, perhaps an awl, was made from a cattle or aurochs bone.

Fig. 7.8 Tool 2.4538, a knife made out of a lamella of lower canine of a male wild boar (*Sus scrofa*); top: outside aspect, bottom: inside of the canine. Scale 1:1 (photo H.Kranenburg).

Tool 2.1432 is a fragment of what probably was a needle or an awl (fig. 7.7). It was most probably a chip from the diaphysis of a metapodial of a large mammal (Louwe Kooijmans *et al.*, 2001: 313). The fragment is a little more than 1 cm long. Its round cross-section measures about 3 mm. The surface is shiny and polished, most likely a result of use. Small cuts of the manufacturing or finishing of the object are still visible.

Tool 2.4538 is a blade made from a lamella of a lower canine of a male wild boar (fig. 7.8). The blade has a wide part as handle and runs out in a narrow point, the actual knife. The smooth, rounded and glossy look of the blade indicates that it was often used. A similar knife was found on Swifterbant S3 (Bulten & Clason, 2001: 319-320).

Tool 2.5437 is a wide, flat needle (fig. 7.9). It was made of a long bone of a large mammal, probably a red deer metapodial. One end is a flat, blunt point, the other end is perforated. The implement broke at the place of the perforation, and was then discarded. The gloss on the needle indicates that it was used for some time before it broke. The tool may have been used to make or to repair fishing nets.

Tool 2.5537 is an awl made from a thick long bone of a large mammal (fig. 7.10); it has one rounded end, whereas the other end finishes as a thick, round point.

Tool 1.5541 was possibly made from a cattle tibia (fig. 7.11). One end is pointed, but it is not as beautifully symmetrical as the two previous ones. The other end looks unfinished. The side of the object that was the outer cortex of the bone is smooth by use, but the inner side is not.

Two bone fragments were perhaps tools. The first (2.459) is a very weathered large mammal bone fragment (fig. 7.12). Because of the narrow, double pointed shape it might have been an awl. The second

Fig. 7.9 Tool 2.5437, a wide, flat needle, made of a long bone fragment of a large mammal. Scale 1:1 (photo H.Kranenburg).

Fig. 7.10 Tool 2.5537, an awl, made out of a thick long bone fragment of a large mammal; above: view on the inside of the bone, below: view on the outside of the bone. Scale 1:1 (photo H.Kranenburg).

Fig. 7.11 Tool 1.5541, perhaps an awl, possibly made out of a cattle tibia (*Bos taurus*); above: outside of the bone, below: inside of the bone. Scale 1:1 (photo H.Kranenburg).

Fig. 7.12 Very worn pointed bone fragment 2.459, possibly an awl. Scale 1:1 (photo H.Kranenburg).

Fig. 7.13 Flat bone fragment 1.1414, pointed at one side, possibly an awl. Scale 2:1 (photo H.Kranenburg).

Fig. 7.14 Calcined part of a red deer (*Cervus elaphus*) metapodial, findnumber 2.3479, with cut marks of the splitting of the bone. Scale 2:1 (photo H.Kranenburg).

Fig. 7.15 Debris of red deer (*Cervus elaphus*) antler working, findnumber 1.1432. Scale 2:1 (photo H.Kranenburg).

Fig. 7.16 Fragment of a large mammal long bone, findnumber 1.3347, with grooves of bone working; above: outside, below: inside of the bone. Scale 2:1 (photo H.Kranenburg).

(1.1414) is a flat fragment of a bone that is clearly pointed at one end (fig. 7.13). The gloss on the object suggests that it was used, perhaps as an awl.

Number 2.3479 is a calcined fragment of a red deer metapodial (fig. 7.14). Cut marks are visible on the bone; they indicate the longitudinally splitting up of the metapodial, just as in 1.3406 (see below). This is an unfinished awl.

Manufacturing debris

Five fragments are waste from the manufacturing of bone and antler tools. Fragment 1.1432 is a piece of red deer antler (fig. 7.15). It is probably from the antler base. The cortex is hardly curved, which means that the antler was quite large. At one side the antler piece was made globular. At another side it seems to have been cut or trimmed. Why parts of this piece of antler were made globular is unclear, as well as in which production process these actions took place, or what the result should have been.

Fragment 1.3347 has longitudinal grooves (fig. 7.16). It is part of a thick large mammal bone. It is unclear in what tool making process this debris arose. The inside wall of the bone is stained black; the bone probably lay in a smouldering fire for some time.

Fragment 1.3406 is a piece of a red deer metatarsus, with grooves in the length of the bone (fig. 7.17). The longitudinal grooves are the result of the splitting of the metatarsus in two halves. An implement might have been made from each half. They could be divided further into 'diaphysis chips', from which for instance awls could be made (see tool 2.1432) (Louwe

Fig. 7.17 Fragment of a red deer (*Cervus elaphus*) metatarsus, findnumber 1.3406, with grooves made to split the bone to get 'diaphysis chips'. Scale 1:1 (photo H.Kranenburg).

Fig. 7.18 Bone fragment with grooves of bone working, findnumber 2.454. Scale 2:1 (photo H.Kranenburg).

Kooijmans *et al*., 2001: 313). The grooves are the result of carving in the bone with flint tools to split the bone.

Fragment 1.3545 is the base of a shed red deer antler (fig. 7.2). It comes from a 12-13 years old stag. The beam was broken just above the burr; about half of the brow tine is still present. Notches are present on the fracture of the brow tine (see fig. 7.2, left). The end of the brow tine was probably removed to make a large awl or a mount for an implement out of it. Notches are also present in the basis of the removed beam. The beam was partly cut and then obliquely broken off (fig. 7.2, right). This was presumably a preparation to make an antler axe (Louwe Kooijmans *et al*., 2001: 292).

Fragment 2.454 has grooves in the length of the bone (fig. 7.18). It is unclear from which manufacturing process this waste piece comes.

7.4 Discussion

7.4.1 The use of domestic and wild animals

The hand collected material (table 7.2) suggests that mammals were much more important on S4 (94% of numbers of remains, 97% of bone weight) than birds (1% of numbers of remains, 0.2% of bone weight) and fishes (5% of numbers of remains, 3% of bone weight). The birds are perhaps underrepresented in the hand collected material because of the fragility of their bones. Bird and fish remains are perhaps better represented in the sieved material, but this was not studied apart from the fish remains from 30 squares. However, many small mammal bone fragments are among the sieved material. Most meat eaten will have been mammal meat. Fishes played an important role in the food supply as well, judging from the large number of fish remains from the small number of squares studied. Birds were presumably hardly an important food source.

The higher numbers of remains of domestic mammals than of wild mammals in the hand collected material (respectively 46.3%, and 37.6% of the identified mammal remains) suggest that domestic mammals were slightly more important than wild mammals. The bones that could not be further identified than as domestic pig or wild boar or cattle or aurochs and the many unidentified mammal remains, however, might influence the share of domestic and wild mammals in one or the other direction (table 7.2).

Cattle and domestic pigs gave the largest contributions to the diet and probably to the provision of skins as well. Sheep were kept in very small numbers. Their meat was eaten and their skins were used. Dogs were held in small numbers. They were skinned and perhaps occasionally or even regularly consumed. A few cattle bones were used for tool production. Beaver, red deer, wild boar and otter delivered most of the wild mammal meat and skins on S4. Badger, fox, hare, brown bear and mole will have been captured for their furs, but rarely. Red deer delivered antlers and long bones for tool production. Wild boar incisors and canines were made into pendants and tools. Wild mammal teeth and bones were more often selected for tool production than those from domestic mammals. The same phenomenon was met on S3 (Bulten & Clason, 2001) and S2 (Prummel *et al*., 2009).

7.4.2 Diachronic development in the use of animals

The general characteristics of the S4 bone material were discussed above. Possible diachronic developments in the use of animals are discussed in this section (table 7.6). To this end the finds are grouped into three units (1-3) where unit 1 comprises the top three spits, unit 2 comprises spits 4-6 and unit 3 encompasses spits 7-9 and the cultivated field. Due to the small number of identified bird bones, this discussion deals with mammal and fish bones only. The proportion of the various mammal species across the three analytical units does not reveal major changes over time, with two exceptions. The proportion of cattle bones in unit 2 is double that for units 1 and 3 – when expressed in bone numbers. In weight percentages, the proportions are rather similar. This suggests that we should be cautious in interpreting these changes in terms of human behaviour. The proportion of beaver increases from unit 2 to 1, both in numbers and in weight. This might indicate an increase in the exploitation of this animal during unit 1. The identified fish species are remarkably homogeneous across the three units: European catfish and pike dominate the fish species in the hand collected material.[10]

10 Cyprinids and eel are more common than European catfish and pike in the combined hand collected and sieved material (see 7.3.4).

Table 7.6 Overview of the hand collected bone material, subdivided per unit of analysis.

	Unit 1				Unit 2				Unit 3				Total			
Species	**Number**	**%**	**Weight (g)**	**%**	**Number**	**%**	**Weight (g)**	**%**	**Number**	**%**	**Weight (g)**	**%**	**Number**	**%**	**Weight (g)**	**%**
Mammals																
Canis familiaris, dog	10	3.2	5.6	0.9	11	3.6	10.0	0.8					21	3.2	15.6	6.2
Sus domesticus, pig	42	13.6	42.3	6.6	50	16.5	74.4	5.9	4	9	3.5	2.3	96	14.6	120.2	47.9
Bos taurus, cattle	54	17.5	298.7	46.3	102	33.7	564.4	45.1	7	15	48.9	31.7	163	24.7	912.0	363.2
Ovis aries, sheep					2	0.7	4.9	0.4					2	0.3	4.9	2.0
Ovis aries/Capra hircus, sheep/goat	13	4.2	14.0	2.2	11	3.6	10.3	0.8	3	6	5.5	3.6	27	4.1	29.8	11.9
Sus domesticus/scrofa, pig/wild boar	37	12.0	40.1	6.2	32	10.6	58.6	4.7	18	38	47.7	30.9	87	13.2	146.4	58.3
Bos taurus/primigenius, cattle/aurochs	4	1.3	6.1	0.9	7	2.3	35.0	2.8	2	4	16.1	10.4	13	2.0	57.2	22.8
Castor fiber, beaver	67	21.7	62.9	9.8	14	4.6	39.3	3.1	2	4	0.7	0.5	83	12.6	102.9	41.0
Lutra lutra, otter	7	2.3	6.9	1.1	14	4.6	19.1	1.5	4	9	3.0	1.9	25	3.8	29.0	11.5
Meles meles, badger	1	0.3	5.9	0.9									1	0.2	5.9	2.3
cf. *Lepus europaeus*, hare	1	0.3	0.4	0.1									1	0.2	0.4	0.2
Unknown mouse					1	0.3	0.0	0.0					1	0.2	0.0	0.0
Talpa europaea, mole	1	0.3	0.5	0.1									1	0.2	0.5	0.2
Vulpes vulpes, fox	1	0.3	0.6	0.1									1	0.2	0.6	0.2
Ursus arctos, brown bear	1	0.3	1.9	0.3									1	0.2	1.9	0.8
Sus scrofa, wild boar	21	6.8	50.8	7.9	13	4.3	81.4	6.5	5	11	20.4	13.2	39	5.9	152.6	60.8
Cervus elaphus, red deer	49	15.9	108.2	16.8	45	14.9	339.6	27.1	2	4	8.6	5.6	96	14.6	456.4	181.8
Bos primigenius, aurochs					1	0.3	14.8	1.2					1	0.2	14.8	5.9
Total identified mammals	**309**	**100.0**	**644.9**	**100.0**	**303**	**100.0**	**1251.8**	**100.0**	**47**	**100**	**154.4**	**100.0**	**659**	**100.0**	**2051.1**	**816.8**
Size cattle/horse/red deer	129		160.5		136		228.1		10		17.2		275		405.8	
Size sheep/goat/pig	119		79.2		70		60.9		38		23.2		227		163.3	
Mammal, size unknown	2689		811.8		1288		531.8		277		97.6		4254		1441.2	
Small mammal	9		2.0		5		1.4						14		3.4	
Birds																
Podiceps cristatus, great crested grebe					1		1.4						1		1.4	
Anas platyrhynchos, mallard									1		2.3		1		2.3	
Unknown duck	1		0.4										1		0.4	
Unknown bird	7		0.9		22		2.9		1		0.1		30		3.9	
Fish																
Acipenser sp., sturgeon					17	14.3	9.4	11.0	2	13	1.0	7	19	11.6	10.4	9.4
Salmo salar/trutta, salmon/sea trout					1	0.8	0.1	0.1					1	0.6	0.1	0.1
Esox lucius, pike	15	50	4.2	37	40	33.6	8.9	10.4	6	40	2.0	14	61	37.2	15.1	13.6
Cyprinidae, cyprinids	4	13	0.2	2	4	3.4	0.8	0.9	1	7	0.2	1	9	5.5	1.2	1.1
Abramis brama, bream					1	0.8	0.0	0.0					1	0.6	0.0	0.0
Tinca tinca, tench					1	0.8	0.4	0.5					1	0.6	0.4	0.4
Silurus glanis, Eureopean catfish	9	30	6.7	59	52	43.7	66.0	77.1	6	40	11.0	77	67	40.9	83.7	75.3
Anguilla anguilla, eel	1	3	0.1	1									1	0.6	0.1	0.1
Perca fluviatilis, perch					3	2.5	0.0	0.0					3	1.8	0.0	0.0
Liza ramada, thin-lipped grey mullet	1	3	0.2	2									1	0.6	0.2	0.2
Total identified fish	**30**	**100**	**11.4**	**100**	**119**	**100.0**	**85.6**	**100.0**	**15**	**100**	**14.2**	**100**	**164**	**100.0**	**111.2**	**100.0**
Unknown fish	21		1.5		54		4.7		52		1.9		127		8.1	

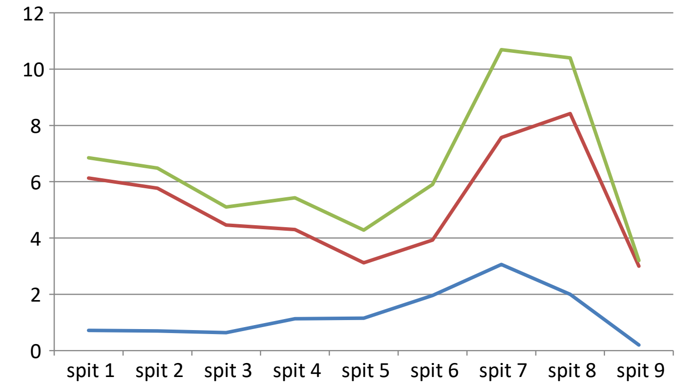

Fig. 7.19 Average number of identified remains per square per spit (blue), average number of unidentified remains per square per spit (red) and average number of all remains per square per spit (green).

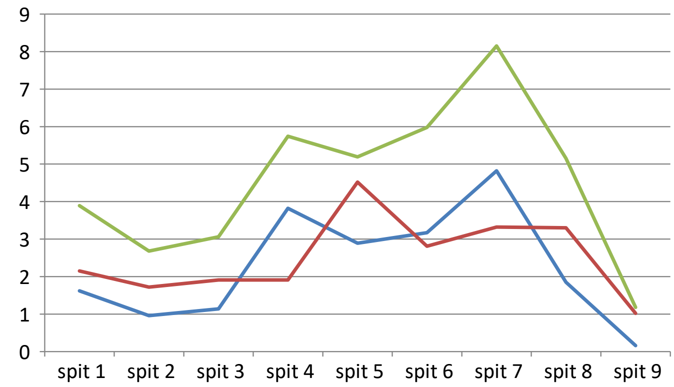

Fig. 7.20 Average weight (g) of identified remains per square per spit (blue), average weight (g) of unidentified remains per square per spit (red) and average weight of all remans per square per spit (green).

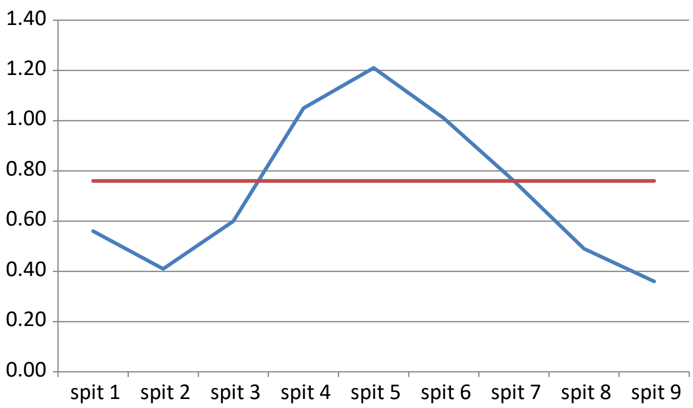

Fig. 7.21 Average weight (g) of the bone fragments per spit (blue) and in general (red).

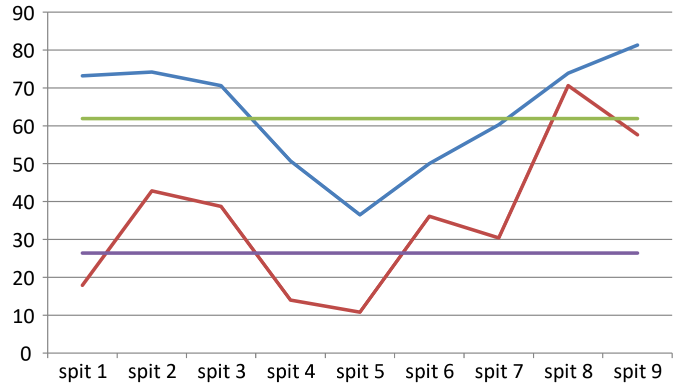

Fig. 7.22 Percentage of calcined fragments per spit (blue) weight percentage of calcined fragments per spit (red) compared to the average percentage of calcined fragments (green) and the average weight percentage of calcined fragments (purple).

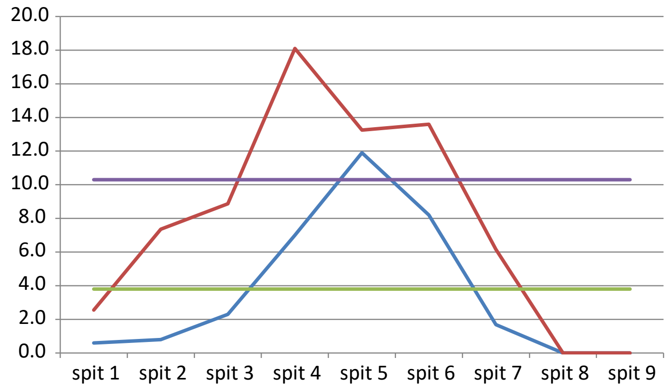

Fig. 7.23 Percentages of weathered bone fragments per spit (blue), weight percentage of weathered bone fragments per spit (red) compared to average percentage of weathered bone fragments (green) and average weight percentage of weathered bone fragments (purple).

There are more patterns to be found in the build-up of layer 5. These patterns were analysed grouping the data per spit (figs. 7.19-7.23). These patterns arose between the time of killing of the animals and the excavation, and are therefore of taphonomic nature. There are clear differences in terms of number of (identified and unidentified) remains, the bone weight, the proportion of calcinated bones and the proportion of weathered bones. An explanation for the high proportions of unburnt bone in spits 4-6 (unit 2), and therefore for the high average bone weights and the high percentages of identified bones in these spits is that refuse was deposited more quickly during the build-up of unit 2 than before (unit 3) and later (unit 1). All materials, including bones, were probably faster covered during the formation of unit 2 than before or afterwards. Unburnt bones therefore had a larger chance to be preserved in unit 2 than in the other unts.

7.4.3 Comparison with the animal remains of S2 and S3

The bone materials from S2 (Prummel *et al.*, 2009), S3 (Zeiler, 1997) and S4 were compared to establish to which degree the activities on these three sites corresponded. The animal species demonstrated and the count and weight percentages in which they were found are largely the same (table 7.7), suggesting a similar site function. The animal remains from layer 5 of S4 therefore will have been food and bone and antler processing debris from a dwelling place, just like those of S2 and S3. A striking difference between S2 and S4 is the ratio between the numbers

Table 7.7 Comparison of the various Swifterbant bone assemblages-1. Data from Prummel *et al.*, 2009 (S2-GIA: table 5; S2-RIJP: table 9 and S2-BAI: table 10); Zeiler, 1997: tables 3, 4 and 72 (S3-BAI); Brinkhuizen, 1976: table I (S3-BAI); table 7.2 and Hullegie, 2009.

	S2-GIA		S2-RIJP				S2-BAI				S3-BAI				S4-GIA			
method of collecting	**sieved (2 mm)**		**hand collected**		**sieved (? mm)**		**hand collected**		**sieved (3 mm)**		**hand collected**		**sieved (3 mm)**		**hand collected**		**sieved (2 mm)**	
	Number	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**
dog	1	2					3	1.0	1	0.4	49	1.3	8	2.6	22	3.3		
domestic pig	11	27	6	14			59	19.7	49	21.1	34	0.9			99	14.6		
cattle	1	2	1	2			8	2.7	2	0.9	321	8.7	2	0.7	163	24.1		
sheep and sheep/goat			4	9	1	50					9	0.2			29	4.3		
domestic pig/ wild boar	2	5	4	9			85	28.3	71	30.6	2062	55.6	152	49.5	92	13.6		
cattle/aurochs											1	0.0			17	2.5		
beaver	15	37	17	39	1	50	65	21.7	46	19.8	491	13.2	45	14.7	85	12.6		
otter			3	7			11	3.7	15	6.5	511	13.8	87	28.3	25	3.7		
wild boar	1	2	3	7			55	18.3	44	19.0	45	1.2	2	0.7	41	6.1		
red deer	2	5	6	14			13	4.3			118	3.2	3	1.0	96	14.2		
aurochs											2	0.1			1	0.1		
other wild mammals	8	20					1	0.3	4	1.7	64	1.7	8	2.6	6	0.9		
Total identi-fied mammals	**41**	**100**	**44**	**100**	**2**	**100**	**300**	**100.0**	**232**	**100.0**	**3707**	**100.0**	**307**	**100.0**	**676**	**100.0**		
total mammals	?		133		21		1161		6529		5878		5696		5485			
identified mammals	41	?	44	33	2	10	300	26.0	232	4.0	3707	63.0	307	5.0	676	12.0		
total birds	?		2		1		15		46		279		1135		56			
identified birds	1	?	0	0	0	0	0	0	7	15	181	65	458	40	25	45		
total fishes	?		1		1		7				611		3825		318		532	
identified fishes	133	?	1	100	0	0	0	0			434	71	2632	69	20	6	407	77
% identified mammals. birds. fish		4		32		9		25		4		?		?		12		
% burnt		79		66		66		?		?		15		?		73		23
	Weight		**Weight**		**Weight**		**Weight**		**Weight**		**Weight**		**Weight**		**Weight**		**Weight**	
average weight of a fragment in g	0.06		1.04		0.25		1.59		0.25		5.12		2.56		0.76		0.01	
groups used to calculate the average weight: m: mammals. b: birds. c: fish	m+b+f		m+b+f		m+b+f		m+b+f		m+b		m+b		m+b		m+b+f		f	

of remains of domestic pig and cattle. This ratio is approximately 11:1 in S2; for S4 it is 1:1.6. Cattle were at least as important as domestic pigs on S4, or even more important, while domestic pig was the most important livestock species at S2 (Prummel *et al*., 2009: 32). The domestic pig : cattle ratio cannot be calculated for S3 because most of the *Sus* bones were not further identified than as domestic pig or wild boar (Zeiler, 1997). Cattle bones are also quite numerous in the S3 hand collected material (table 7.7). If no taphonomic factors are responsible for this difference in the domestic pig : cattle ratio, cattle husbandry was more important on S4 than on S2. Not only the proportion of cattle bones at S4 stands out, there are also strikingly high proportions of red deer (only matched in the hand collected material from S2-RIJP), mirrored by a small proportion of beaver (shared with the two S3 assemblages). These differences are interpreted within a framework in which all three sites had a similar site function.

Well-preserved bird bones from S3 originated from the creeks between S3 and S4 and alongside S3 (Clason & Brinkhuizen, 1978: 76-77). They were not as squashed as the small bird bone fragments from the site S3 itself. Because of the presence of bird bones from the creeks high proportions of the S3 bird remains could be identified to species (65% in the hand collected bird material and 40% in the sieved material (table 7.7)). The same will hold true for the remains of wild mammals and fishes from S3: 63% of the mammal remains and 71% of the fish remains in the S3 hand collected material could be identified to species (Brinkhuizen, 1976; Clason & Brinkhuizen, 1978; Zeiler, 1997) (table 7.7).

The patterns above are also the result of the differences in find collection method (see table 7.7). At the S2-GIA excavation all soil was sieved over a 2 mm mesh sieve. The bone material is very fragmented (average weight 0.06 g) and largely burnt (79%). These characteristics resulted in large numbers of small, mainly unidentifiable bone fragments (identification ratio 4%). Similar scores are found in the other sieved assemblages. The identification ratios of the hand collected materials of S2-RIJP and S2-BAI are quite high: 32% and 25%, thanks to the relatively large size of the bone fragments studied. For S3, these percentages are even much higher and here the mesh size was 3 mm. Moreover, the S3 assemblage partly comes from the small creek between S3 and S4 and from the creek that runs alongside S3 (Clason & Brinkhuizen, 1978: 71; De Roever, 2004: fig. 4; Zeiler, 1997: 16). The bones from these creeks are much better preserved than those from the S3 settlement itself: they were less trampled by humans and animals and underwent less weathering.[11]

7.5 Conclusions

The hand collected bone material from layer 5 of S4 is highly fragmented due to the butchering of animals, burning, weathering and trampling. More than 70% of the bone material is burnt, most of it calcined. Only 12% of the animal remains could be identified. Layer 5 can be subdivided into three parts on the basis of taphonomy: the lowest part with a high proportion of burnt bones (unit 3), the middle part with less burnt bones and more unburnt bones, part of which were weathered (unit 2), and the upper part with again high proportions of burnt bones (unit 1). A faster deposition may be the reason that more bone fragments per square were found in unit 2 than in the other parts of the find layer and that they are better preserved and therefore better identifiable.

The full package of Neolithic domestic animals was kept: dog, cattle, domestic pig and sheep(/goat). Cattle delivered most meat of all domestic mammals. Domestic pig followed immediately. Sheep played virtually no role in the food economy. MtDNA analysis on four teeth morphologically identified as domestic pig, domestic pig/wild boar (two) and wild boar, showed that all four teeth belonged to animals of European mtDNA haplotypes (Krause-Kyora *et al*., 2010; Krause-Kyora, 2011).[12]

Eleven wild mammal species were found. Beaver, red deer, wild boar and otter were the main species. They were not only eaten, but were also important as providers of raw materials, such as fur, antlers, bones and teeth. All wild mammal species were hunted for more than just their meat. Bones of wild and domestic mammals and red deer antlers were used for tool production. Wild boar teeth were used to make pendants and a knife. Beaver and red deer were perhaps more important in the upper two or three spits than before.

Few bird bones were found. Ducks were the most captured birds. The low number of bird bones will partly be due to the poor preservation, especially due to burning and trampling. More data about the use of birds might have been available if all squares had been sieved and all sieved samples had been studied.

Fish played a complementary role in the diet, but the poor preservation may lead us to underestimate the importance of fishing. European catfish, pike, cyprinids, eel and sturgeon were the most often captured species. Butchery refuse as well as waste of meals are represented among the fish remains. The

11 Personal communication J.T. Zeiler.
12 Personal communication B. Krause-Kyora.

demonstrated fish species all live in fresh water, in the bream zone of the river system.

Seasonal information for several wild and domestic animals suggests that people were active on S4 at least in summer and in late winter and spring. The area was perhaps used for animal husbandry, hunting and fishing in all seasons of the year, but not necessarily in all years in all seasons.

The differences between the animal remains from S2, S3 and S4 are mainly of taphonomic nature. The demonstrated animal species largely correspond. Cattle, pig, beaver, wild boar and red deer were the most important mammal species at all three sites. Cattle husbandry was perhaps more important on S4 (and S3) than on S2.

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Appendix 7.1 The available age data per species and skeletal element, with information about the season of the hand collected animal remains (age data after Habermehl, 1975; 1985: Iregren & Stenflo, 1982; Zeiler, 1987; 1998a).

Findnumber	Species	Skeletal element	Age	Season
1487	Beaver, *Castor fiber*	phalanx 2	< 2 years	
P043	Beaver, *Castor fiber*	scapula	< 2 years	
6544	Beaver, *Castor fiber*	cervical vertebra	unfused	
1484	Beaver, *Castor fiber*	fibula	< 2 years	
476	Beaver, *Castor fiber*	metacarpus	> 2 years	
1491	Beaver, *Castor fiber*	epistropheus	> 2 years	
1422	Beaver, *Castor fiber*	femur	> 2 years	
556	Beaver, *Castor fiber*	metatarsus	> 2 years	
1496	Beaver, *Castor fiber*	radius	< 2 years	
1475	Beaver, *Castor fiber*	radius	< 2 years	
1196	Beaver, *Castor fiber*	radius	> 2 years	
2503	Beaver, *Castor fiber*	tibia	> 2 years	
4395	Beaver, *Castor fiber*	humerus	> 2 years	
387	Beaver, *Castor fiber*	maxilla	subadult/adult	
3545	Red deer, *Cervus elaphus*	antler	12-13 years	
1463	Dog, *Canis familiaris*	metapodial	>5-7 months	
5439	Otter, *Lutra lutra*	femur	> 18 months	
1325	Otter, *Lutra lutra*	calcaneus	fused	
1444	Sheep/goat, *Ovis aries/Capra hircus*	ulna	< 3.5 years	
4459	Sheep/goat, *Ovis aries/Capra hircus*	femur	< 3-3.5 years	
2472	Cattle, *Bos taurus*	maxilla Pd2	< 3 months	March - July
2462	Cattle, *Bos taurus*	mandible	19-24 months	
4482	Pig, *Sus domesticus*	mandible Pd 234 M1	6-10 months	September-March
5504	Pig, *Sus domesticus*	metapodial	< 2 years	
2432	Pig, *Sus domesticus*	phalanx 2	< 1 year	
1533	Pig, *Sus domesticus*	metapodial	< 2 years	
1524	Pig, *Sus domesticus*	metatarsus	< 2 years	
1485	Pig, *Sus domesticus*	vertebra	< 4-7 years	
1432	Pig, *Sus domesticus*	metacarpus	< 2 years	
1545	Pig, *Sus domesticus*	metatarsus	< 2 years	
1314	Pig, *Sus domesticus*	phalanx 2	> 1 year	
1465	Pig, *Sus domesticus*	phalanx 2	> 1 year	
1314	Pig, *Sus domesticus*	phalanx 2	> 1 year	
1367	Pig, *Sus domesticus*	tibia	< 3.5 years	
480	Pig, *Sus domesticus*	maxilla P4	> 5 years	
2526	Wild boar, *Sus scrofa*	mandible M2	> 13 months	
2382	Wild boar, *Sus scrofa*	metapodial	> 31-35 months	
1465	Wild boar, *Sus scrofa*	phalanx 2	< 19-23 months	
1337	Wild boar, *Sus scrofa*	fibula	> 5 years	
6510	Wild boar, *Sus scrofa*	metapodial	< 31-35 months	
6510	Wild boar, *Sus scrofa*	metatarsus 5	< 31-35 months	
1392	Wild boar, *Sus scrofa*	phalanx 1	> 31-35 months	
3387	Wild boar, *Sus scrofa*	I	4-5 years	
3355	Wild boar, *Sus scrofa*	I 1	> 4-6 years	
1466	Wild boar, *Sus scrofa*	calcaneus	< ca. 4 years	

	Species	Skeletal element	Age based on pig	Age based on wild boar
1465	Pig/wild boar, *Sus domesticus/Sus scrofa*	metacarpus 3	< 2 years	< 31-35 months
1535	Pig/wild boar, *Sus domesticus/Sus scrofa*	phalanx 2	> 1 year	> 19-23 months
490-499	Pig/wild boar, *Sus domesticus/Sus scrofa*	radius	< 3.5 years	< 5 years
6520	Pig/wild boar, *Sus domesticus/Sus scrofa*	metapodial	< 2 years	< 31-35 months
2386	Pig/wild boar, *Sus domesticus/Sus scrofa*	metapodial	< 2 years	< 31-35 months
277	Pig/wild boar, *Sus domesticus/Sus scrofa*	caudal vertebra	< 4-6 à 7 years	.
7548	Pig/wild boar, *Sus domesticus/Sus scrofa*	fibula	< 2-2.5 years	< 5 years
1487	Pig/wild boar, *Sus domesticus/Sus scrofa*	metacarpus	< 2 years	< 31-35 months
2386	Pig/wild boar, *Sus domesticus/Sus scrofa*	metapodial	< 2 years	< 31-35 months
5513	Pig/wild boar, *Sus domesticus/Sus scrofa*	phalanx 1	< 2 years	< 31-35 months
2396	Pig/wild boar, *Sus domesticus/Sus scrofa*	phalanx 1	> 2 years	> 31-35 months
466	Pig/wild boar, *Sus domesticus/Sus scrofa*	phalanx 1	< 2 years	< 31-35 months

Appendix 7.2 Hand collected animal remains. Bone measurements in mm after the systems of Von den Driesch (1976, mammals and birds), Habermehl (1985: 34-35, red deer antler) and Brinkhuizen (1989: 92, fig. 5.16, pike).

Trench	Findnumber	Species	Element	Measurements (mm)			
2	412	domestic pig	maxilla M1	length M1 16.1			
2	3419	domestic pig/ wild boar	maxilla M1	length 20.1	width 14.2		
.	P025	domestic pig/ wild boar	maxilla M3 and M2	length M3 40.0	length M2 23.0		
1	485	domestic pig/ wild boar	phalanx 3	DLS 27.5	Ld 27.2		
1	556	beaver	metatarsus	Bd 10.0			
1	4396	otter	mandible M2	length M2 14.0			
2	4491	wild boar	mandible Pd4	length 21.5	width 9.6		
2	4491	wild boar	mandible M1	length 21.1	width 11.9		
1	999066 section east	wild boar	mandible M3	width 18.0			
1	2382	wild boar	metapodial	Bd 22.2			
1	3545	red deer, age about 12-13 years	shed antler	largest diameter burr 61.4	largest diameter shed area 46.0 (75%)	minimum diameter burr 52.2	minimum diameter shed area 44.6 (8%)
1	386	red deer	centrotarsale	GB 41.0			
1	6577	mallard	humerus	Bd 10.5	SC 7.1		
.	P048	pike	parasphenoideum	psp.sm.m.b. 2.9	total length 15.5 cm		

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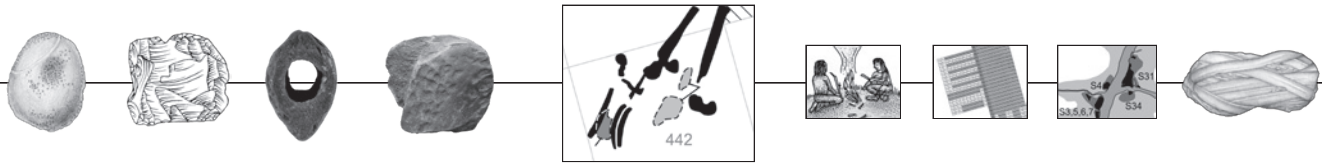

The human remains

E. Smits[1]

8.1 Introduction

During the 2005 excavation, a human skull was discovered. Lack of time prevented further excavation in the course of that campaign. In 2006, the remainder of the grave was excavated. Although the skeleton was damaged and incomplete, the bones yielded valuable information on the burial posture, the age at death and the health of this individual. In the same campaign, a skull fragment was found in the creek fill.

8.2 Description of the remains

The burial

The excavation history of this skeleton is unlucky. The skull was found in the final days of fieldwork in 2005. During its recovery, the upper part of the remainder of the skeleton was somewhat disturbed. Later, when the animal bones assembled from this spit were examined, the bones of the human skeleton's lower legs were discovered among them (fig. 8.1). In 2006, the adjoining area was excavated. The lower legs and skull were found at a higher level, indicating that the body had been placed in a bowl-shaped pit, with the torso lying somewhat lower than the extremities. The outline of the pit was not visible, suggesting that it was dug into settlement layer 5 and back-filled with material from this same settlement layer. This indicates that the burial dates to a relatively late stage of the occupation. Some 10 cm west of the left knee, a small amber bead was found (fig. 8.2). Because this is the only amber find from S and amber beads are a typical grave good for the Swifterbant culture (Raemaekers *et al.,* 2009), we consider this bead to be a grave good belonging to the burial. In 2015, prior to the finding of the skull, the remains of an upright wooden pole were found in what was later revealed as the chest area. It may have marked the position of the burial, but it may also be unrelated to the burial.

The skeletal remains were heavily damaged and incomplete. The cranium was fragmented, but most of the cranial vault, the viscero-cranial part of the skull with the orbits, and the mandible were present. The thoracic region was mostly incomplete. Only some vertebrae, fragments of ribs and some pelvic bones could be recovered. The extremities were represented by some diaphyseal parts of the upper arms and of the upper and lower legs, as well as one metacarpal and one phalange of the hand. The condition of these remaining bones, however, was fairly good. The mineralization and the eruption of the deciduous and permanent teeth indicate an age of c. 7 years (± 24 months), based on Ubelaker, 1984. Estimation of the diaphyseal length was possible for only two long bones: the humerus (14.5 cm) and the femur (22.3 cm). These data would indicate an age at death of c. 3-4 years (Maresh, 1955). Because of the incompleteness of the bones, these age-at-death data are not regarded as reliable. The ossification of the second vertebra (dens axis) points to a minimum age of c. 8 years (Robinson, 1920; Scheuer & Black, 2000). Based on the dentition and the ossification parameter, the age at death of this individual is estimated to be c. 7-8 years.

A sieve-like bone structure was observed in the roof of both orbits. This pathological bone change is described in the literature as *cribra orbitalia* and is mostly associated with anaemia (Carli-Thiele, 1996; Ortner, 2003). Anaemia may be the result of a number of pathological conditions, but whether the anaemia experienced by this child related to the cause of death remains uncertain.

The isolated cranial fragment

An isolated cranial fragment was discovered in the creek fill. It is the right parietal bone, on which the coronal, sagittal and lambdoid sutures are visible. The robustness indicates an adult individual, but as all sutures are still open, the age at death must lie in earlier adulthood, approximately 20-40 years. There is one feature that can be used for sex diagnosis, namely, the parietal tubera, which are here

1 e.smits@uva.nl; University of Amsterdam / Amsterdam Archaeological Centre, Turfdraagsterpad 9, 1012 XT Amsterdam, the Netherlands.

evaluated as masculine. Because only one feature of this skeleton can be used for this analysis, the result of the sex determination was recorded as 'male?' (WEA, 1980). On the external table of the cranial fragment, several scratches are present. There is no bone reaction, which means they must have been caused around the time of death or post-mortem. While it is obvious that these traces were not caused by root intrusion and that they do not relate to cutting injuries, their origin remains unknown.

8.3 Conclusions

Human skeletal remains are frequently found at sites of the Swifterbant culture. Here, the remains from Swifterbant S2 and S3 are of direct importance because of their proximity in time and space. In total, 10 human burials were found at S2 (Meiklejohn & Constandse-Westermann, 1978). S2-V and S2-VI are a double grave. S2-VIII-1 and -2 are also a double grave, with S2-VIII-2 being a partial skeleton comprising three rib fragments. Apart from the human remains found in graves, two human bones found among the settlement debris may be considered to have resulted from some specific treatment of the dead. At S3, no burials were found, but two isolated human bones were present.

The S4 skeletal remains are part of a larger corpus of at least 42 human burials[3] and various 'isolated bones' from the Swifterbant culture; 26 of these burials derive from the various sites in the Swifterbant area. This larger corpus has allowed for a definition of the Swifterbant cultural rules regarding death and burial (Raemaekers *et al.,* 2009). The Swifterbant mortuary ritual appears to consist of three basic options.

The first option practiced is inhumation. The age and sex profile of the inhumations does not indicate that selection on the basis of age or sex took place, although it appears that children's graves are underrepresented. The 42 burials include five children. Their age at death was c. 3.5-4 years (S2-VIII-1), c. 7 years (both Zoelen-III and S4), 6-10 years (P14-5) and 9-14 years (Urk 7-III), suggesting that high infant mortality is not reflected in the burial record. The burials were often clustered spatially and may have been marked in some way at the ground surface, judging from the near absence of disturbed graves.

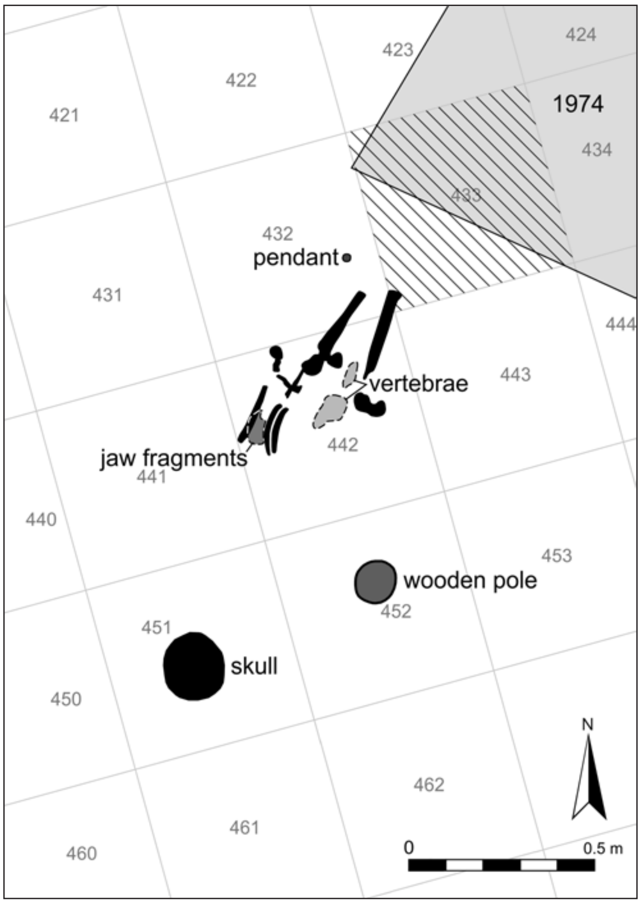

Fig. 8.1 Grave Swifterbant S4-I. Hatched: zone where leg bones were collected (map E. Bolhuis, UG/GIA).

Perhaps the presence of a wooden pole next to the grave at S4 and a similar find at grave P14-5 (a child of similar age) is another clue that the graves were marked. Four of the five children's graves are spatially associated with the grave of an adult individual, either as part of a double burial or located near the grave of an adult. Only one grave of an infant, the grave from S4, seems to have been in an isolated location. Most deceased were buried in supine position, with few grave goods.

The second option is that of death rituals leading to either the occurrence of loose bones among settlement debris or to *pars pro toto* burials. The third option practiced is that of rituals that are invisible in the archaeological record. While it is unclear whether all juveniles and adults were buried, it is clear that not all infants (up to c. 5 years) were buried. Judging from the absence of burials for this age group, dead infants were treated in such a way that they did not enter the archaeological record.

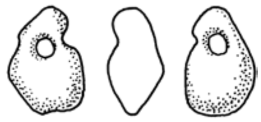

Fig. 8.2 Amber pendant from grave S4-I. Scale 1:1 (after Devriendt, 2014: plate 29).

3 Raemaekers *et al.,* 2009 present 37 human burials. This number was augmented with five burials from Schokland-P14 (Ten Anscher, 2012: 314-361). While Ten Anscher presents 15 graves dated to the period Swifterbant/Pre-Drouwen (c. 4400-3700 cal. BC), the lack of stratigraphy and reliable dates urge more caution with respect to dating and hence cultural affiliation. The five graves included here are all ^{14}C dated to the period 4450-3710 cal. BC (Lanting & van der Plicht, 1999/2000: 59; Ten Anscher, 2012; 317-325). These are graves 3, 4-1, 4-2, 4-cluster 3 and 5.

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9

Features and spatial analysis

J. Geuverink[1]

9.1 Introduction

This chapter will discuss all of the features found during the 2005-2007 excavations and relate them to the spatial patterns of the different find categories. Features found in the 1974 excavation will also be discussed, but these will not be taken into account in the overall spatial analysis of the site due to the absence of comparable spatial information. The aim of this chapter is to distinguish activity areas within the site on the basis of the spatial patterns exhibited by the features and the different find categories.

9.2 Features

The excavation yielded 88 features, which were subdivided into several subcategories (table 9.1): posts and postholes, hearths and charcoal marks, a burial, a cultivated field, and three tidal marks. With the exception of the cultivated field and five of the postholes, all features are related to the main cultural layer, layer 5 (see chapter 2 for description of layers).

Posts and postholes

Posts and postholes make up the largest group of features. They were found dispersed over the site, with a main concentration to the south of the 1974 trench. While this concentration is possibly the result of more extensive research in this area (the number of excavated spits; fig. 9.2), it is clear that far fewer postholes were found in the area north of the 1974 trench. The posts and postholes were generally found in the lower spits. We cannot know whether this also holds for the area directly southwest of this concentration, as hardly any research has taken place in this area. A single post was found in the 1974 excavation (Deckers, 1979); its location is close to the main cluster of hearths (see below).

The postholes have an average depth of 22 cm (range 5-55 cm) and an average diameter of 6 cm (range 2-10 cm; fig. 9.3). There are no apparent structures, with the exception of a line of posts that was already visible in the natural clay above the cultural layer. These posts formed a somewhat straight line, which may be interpreted as a fence structure. They are certainly younger than the cultural layer, as they were dug in from above. Their age has not been determined.

The density of postholes at S4 is comparable to that at neighbouring S3. There, a linear pattern suggests the presence of a small house plan (De Roever, 2004: appendix 1; see also Devriendt, 2014: 189-197). At both sites, the postholes seem concentrated at the highest part of the creek bank.

Hearths and charcoal marks

The second-largest group of features at the site consists of hearths and charcoal marks. The hearths consist of thin, red-coloured patches of burnt clay less than 1 m in diameter. Most hearths were found to the south of the 1974 trench, while one hearth was found to the north. During the 1974 excavation, a single hearth was found (Deckers, 1979). As a rule, the hearths are shallow. Ten have a measured depth of less than 5 cm, and only one of the hearth deposits is thicker, with a depth of 13 cm. No depth measurement was taken for the twelfth hearth. The hearths were all found in spits 3-5. The building material for the hearths is similar to that observed at S3, but a major difference is that at S3 there are also hearths that were rebuilt several times, judging from the number of pancake-like clay discs positioned one on top of the other (Deckers *et al.,* 1980: 132, fig. 11). Both charcoal marks were found in the same area as the hearths. The charcoal marks are interpreted as dumps of material cleaned from the hearths.

Burial

While no burial pit was found, it is intriguing to note that an erect wooden pole was found close to the burial. Although contemporaneity cannot be ascertained, this spatial nearness may indicate that the pole marked the grave. The existence of marked graves in the Swifterbant culture has been proposed previously (De Roever, 2004: 25-26; Raemaekers *et al.,* 2009: 541). See further chapter 8.

1 j.geuverink@gmail.com.

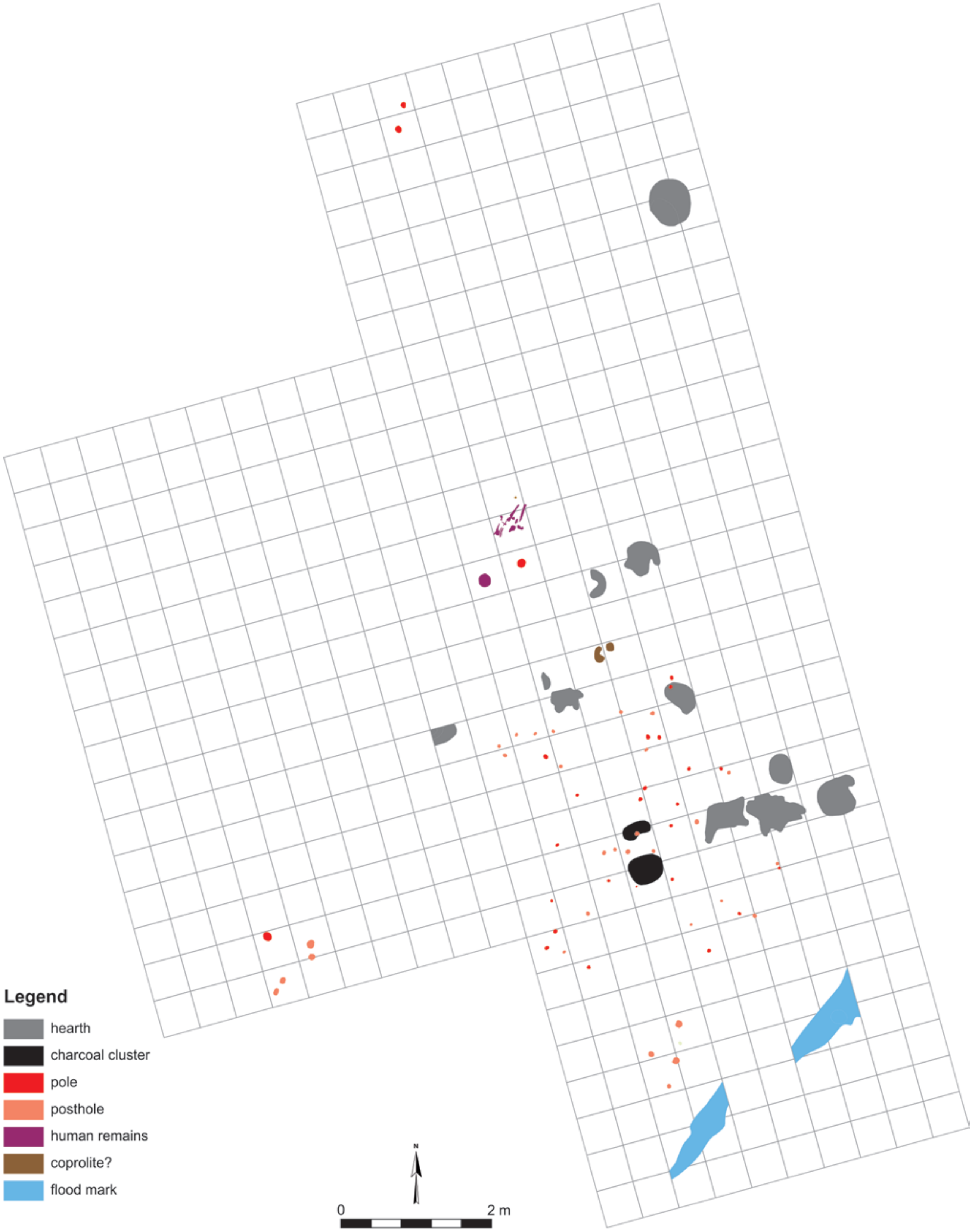

Fig. 9.1 Overview of all features at Swifterbant S4 (map E. Bolhuis, UG/GIA).

Cultivated field

Layer 3 of the site is decalcified clay containing large amounts of partially burnt organic material. The dark grey, heavy clay is mixed with plant and archaeological material from underlying layer 2 and shows indications of bioturbation. This layer was identified as the cultivated field of S4 during the 2007 fieldwork. The layer was excavated over an area of 5x10 m, and extensive coring outside this area established that its surface extends over a minimum of some 200 m^2 (see chapter 2 for layer description).

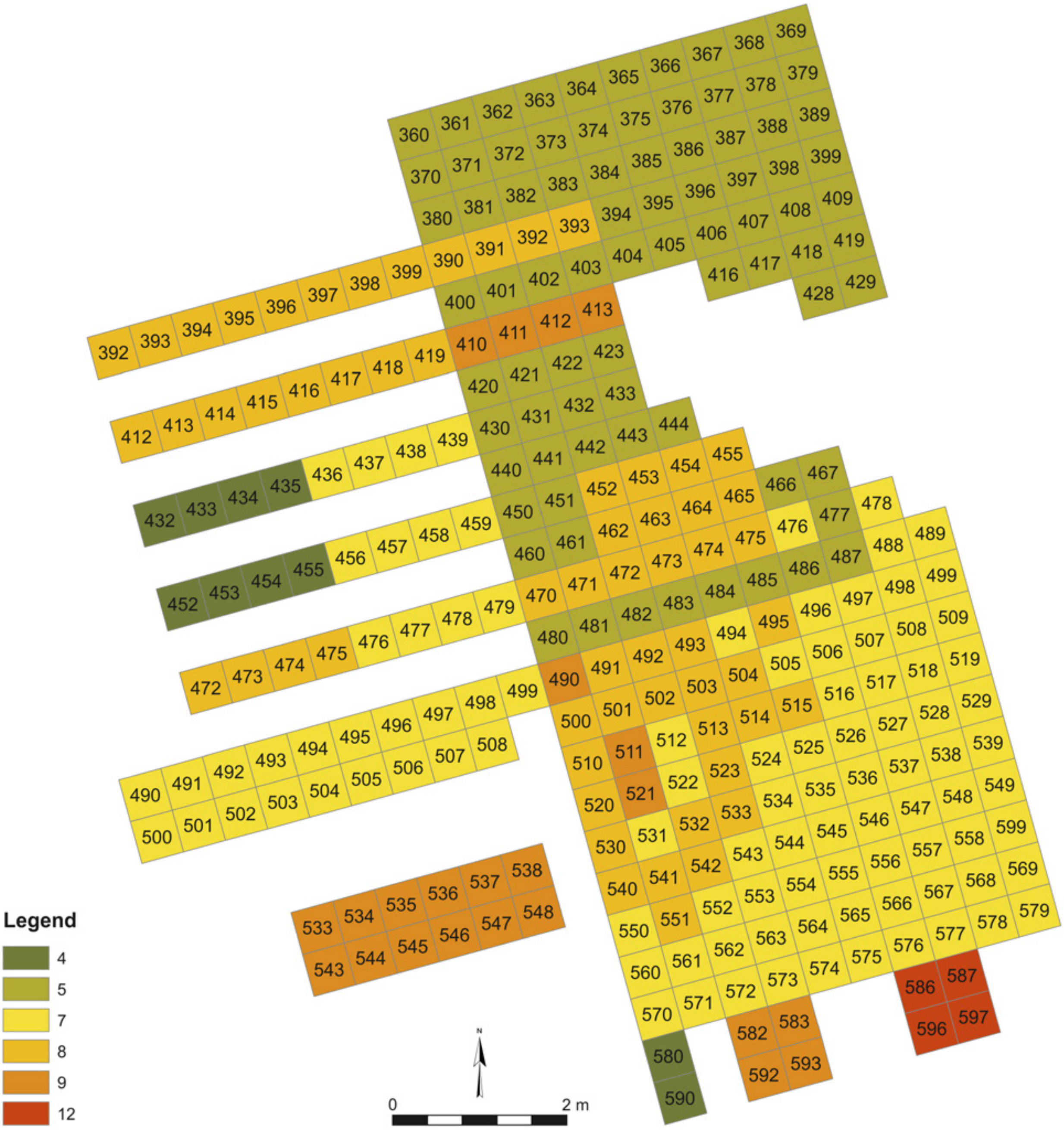

Fig. 9.2 Number of excavated spits per square (map E. Bolhuis, UG/GIA).

Tidal marks

Three tidal marks were found close to the creek (see chapter 6). They are evidence of a complex interplay of sedimentation of material that had washed in from the creek system and material that had eroded from the settlement area. As a result, an extensive spectrum of plant remains was found, which proved useful to analyse vegetation and plant exploitation (see chapter 6).

9.3 Spatial analysis

While the aim of the spatial analysis was to identify activity zones on the site, we quickly concluded that the excavated area of the site is too small and fragmented to distinguish between different zones (fig. 9.1). The fragmented state of the excavated surface means that edge effects strongly influence the visualisations during spatial analysis. As a result, interpretations of spatial patterns should be restricted. The spatial analysis includes the distribution of bone, flint, stone and pottery. The spatial analysis further consists of three types of analysis (figs. 9.4-9.7), whereby we explicitly follow the routines developed for the spatial analysis of settlements of the Corded Ware culture (Nobles, 2016).

Square analysis involves plotting the weight of pottery and bone finds per square and the number of flint and stone finds per square.

Density analysis involves analysing the kernel density of the finds using a grid with a 1.3 m radius

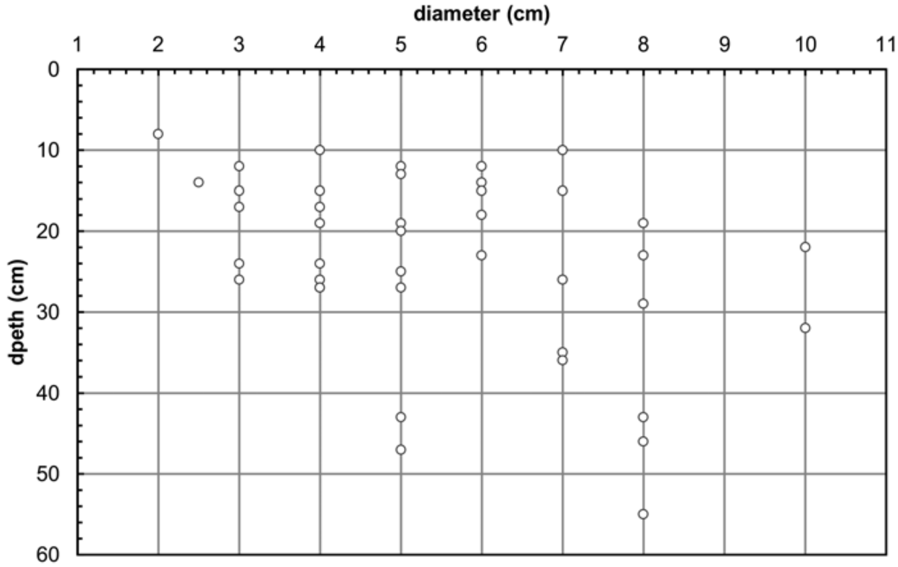

Fig. 9.3 Depths and widths of postholes (chart E. Bolhuis, UG/GIA).

Table 9.1 Number and proportion of features by type.

Features	Number	%
Posts in postholes	38	43
Posthole	32	36
Hearth	12	14
Charcoal mark	2	2
Burial	1	1
Tidal mark	3	3
Total	**88**	**100**

per point. All neighbouring squares within this grid are used to calculate the density of this point.

Hotspot analysis involves using ArcGIS to calculate the Getis-Ord Gi* statistic for each square. High values indicate clustering; low values indicate no clustering.

Fig. 9.2 illustrates the number of excavated spits per square; this number corresponds to the thickness of the cultural layer. It illustrates that certain parts of the site were more extensively excavated than others, thus creating the possibility of a clustering occurring in those squares with more layers excavated. This bias has not been corrected for in the following analysis. Spatial analysis of Swifterbant S4 is further complicated by the fact that the 1974 trench splits the site in two and that the excavation lay-out in trench 2 makes cluster analysis near impossible. Another reason for irregularities is high-weight single finds, such as heavy bones or pieces of pottery. Such irregularities can and have been addressed in the analysis and do not cause as many problems as the excavation methods or the 1974 trench. However, all these issues limit the potential of spatial analysis and restrict the conclusions drawn here.

Flint

A total of 1484 flint artefacts larger in diameter than 1 cm were collected through both hand collecting and sieving. Since the excavation methods limited sieving to rows 8 and 9 of trench 1, a distortion was bound to appear. Therefore, we chose to restrict the spatial analysis to finds larger than 10 mm, thus excluding those artefacts that would only have been found by sieving. We realise that this analysis thus largely excludes the category of chips, an important part of the waste material. Flint artefacts are found over a large part of the site, as most excavated squares yielded flint finds (fig. 9.4). The analysis suggests the presence of four clusters. These clusters are partly caused by the excavation lay-out and the location of the 1974 trench. When we take these distortions into account, two clusters remain: a big cluster spanning most of the site but concentrating in the zones with hearths and a smaller cluster situated on the bank of the creek. From this it can be concluded that flint material is distributed over a large area of the site and that no single dense cluster was present. A further spatial analysis was carried out on the subcategories flakes, blades, all tools, waste, scrapers and cores. This did not produce additional insights.

Stone

Like flint, stone is distributed all over the site (fig. 9.5). When we zoom in, we can see that stone is mainly situated in trench 1, whereas only 8 squares in trench 2 yield stone artefacts. The clustering is similar to that of flint. Again like flint, the subcategories of stone artefacts (e.g. flakes, tools) do not cluster in certain areas of the site. This analysis leads to the conclusion that stone can be found on practically the entire site.

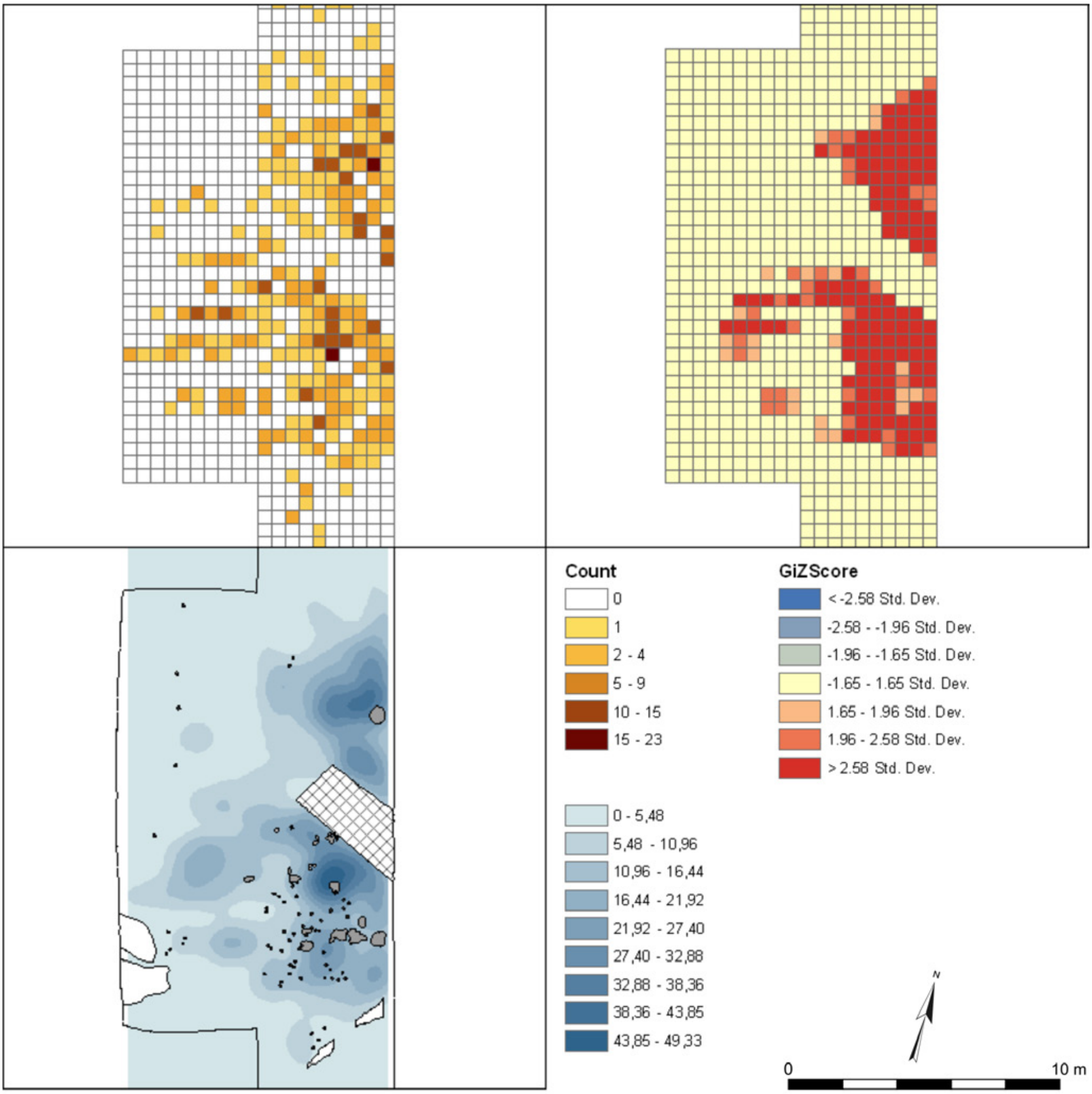

Fig. 9.4 Distribution of flint artefacts by count (map J. Geuverink).

Bone

Spatial analysis of bone was even more hampered by the sieving strategy than was that of flint. Rows 8 and 9 were left out of the analysis completely; only the hand-collected finds were included in the analysis. The results are presented in fig. 9.6. They show that bone was found all over the site. Bone material does not cluster on the bank area near the creek, in contrast to flint. A spatial analysis of single species of animals does not help to define areas. Such analysis was carried out for domesticated pig, wild boar and both categories combined (other mammals were not found in sufficient quantities to be used in spatial analysis). The only types of species that cluster in a single area are fish, which appear to cluster in the western-most part of trench 2. One could conclude from this that this area may have been used for the processing of fish or as a dump area. It is intriguing to note that fish remains were found away from the most densely used area, suggesting that fish remains were not something to keep close at hand.

Pottery

Unlike the above-mentioned categories of artefacts, pottery does appear to cluster in two separate groups (fig. 9.7). Apart from the clustering in the area south of the 1974 trench, where the majority of the hearths are, there appears to be a separate clustering south of the solitary hearth. While these two clusters are split by the 1974 trench, it is important to stress that pottery does not cluster right up to this trench, leading to the conclusion that these

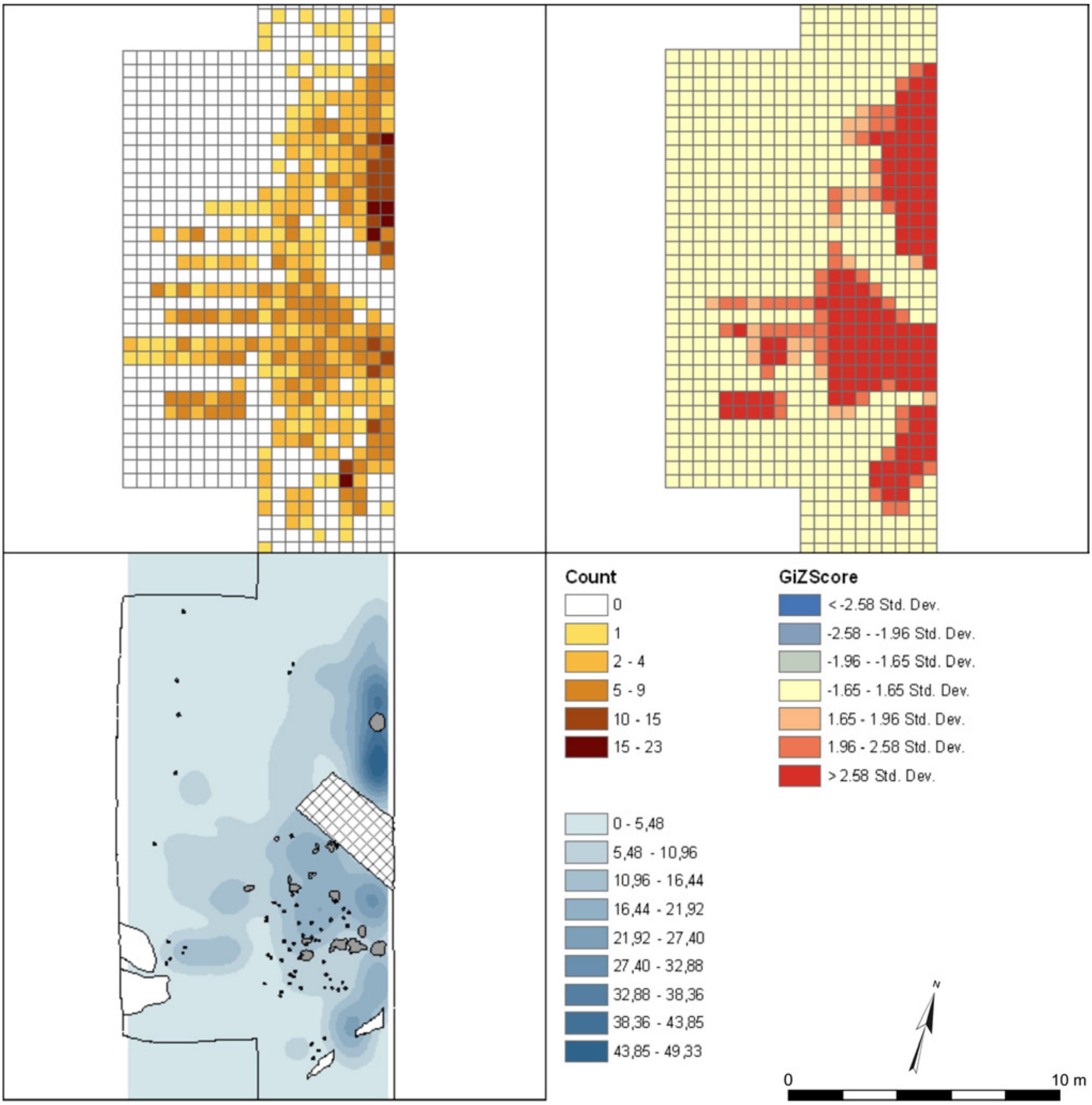

Fig. 9.5 Distribution of stone artefacts by count (map J. Geuverink).

two clusters are separate and not an artefact of the 1974 trench disturbance in the spatial patterns. A difference can also be seen in some subcategories. Sherds with rim decoration were found both north and south of the 1974 trench, while sherds with body decoration were only found south of the 1974 trench. A similar distribution appears when we look at different types of pottery temper. Sherds only tempered with grit are distributed in the southern part of the site, while sherds only tempered with plant material are distributed equally across the site.

9.4 Conclusions

Based on the features alone, little can be said about the use of space at Swifterbant S4. Most features were found in the area to the south of the 1974 excavation. Excavation was discontinued when spits no longer produced finds, resulting in the excavation of fewer spits in the water meadows zone. This strategy is optimal for delimiting the collection of find material but may lead to a feature map with low density in the water meadows zone. To counter this potential problem, the 20 cm underlying the lowermost excavated spits in the zone north of the 1974 trench were surveyed with the use of an excavator. No features were found with this strategy.

Based on the spatial analysis presented above, we can divide the site into two different areas, named hearth zone 1 and hearth zone 2. Hearth zone 1 is constituted of the single hearth in the north of the site and is identified through the presence of flint, stone and bone and a near-absence of pottery.

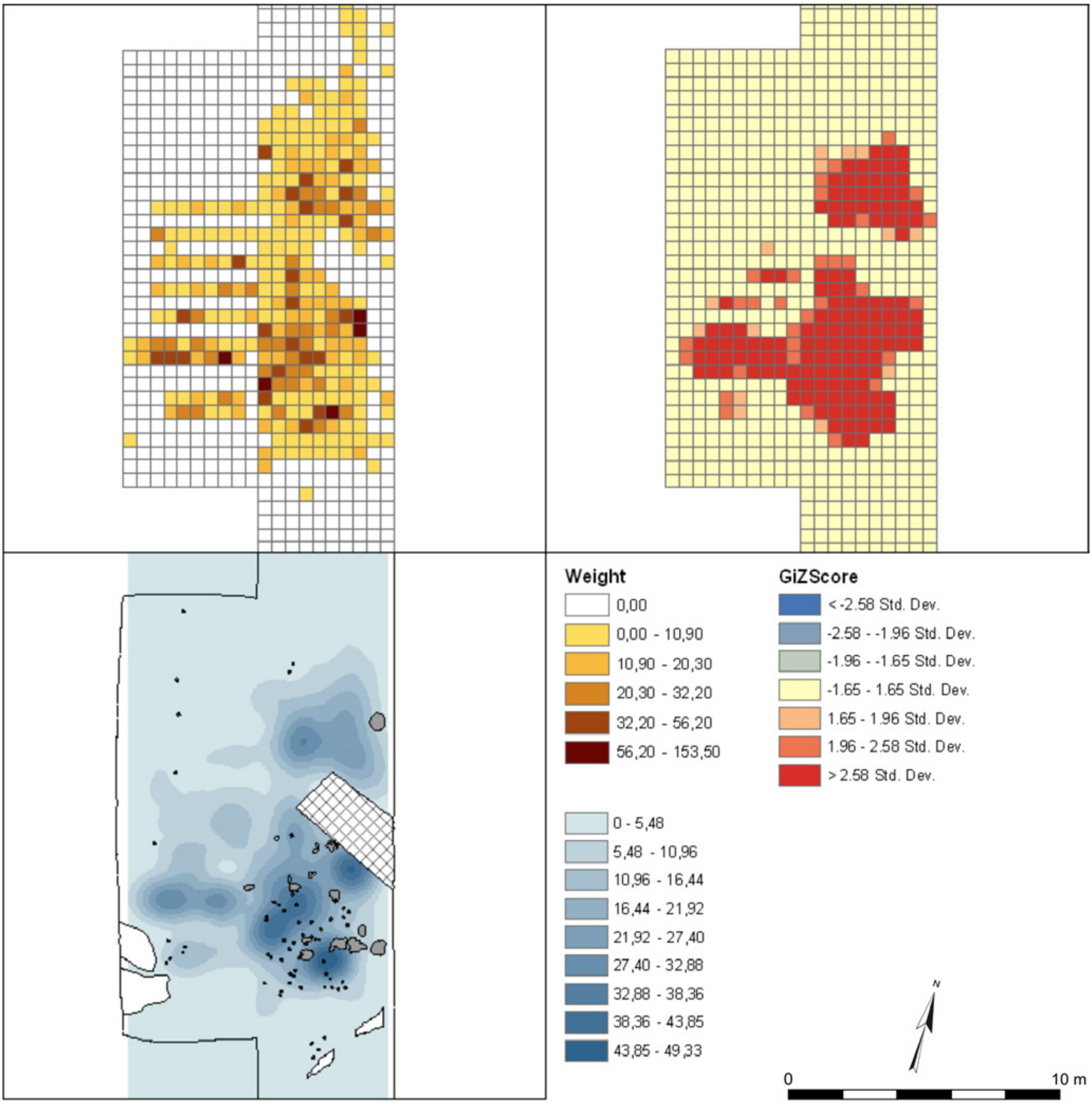

Fig. 9.6 Distribution of animal remains by weight (g) (map J. Geuverink).

Hearth zone 2 is the group of hearths south of the 1974 trench. Here all four find categories are present.

On the basis of the landscape zoning, the site may be divided into four areas (fig. 9.8). These are the creek, the slope, the bank and the water meadows. Apart from the part of a human skull (chapter 8), no archaeological remains come from the creek. Flint is the only category of finds clustering on the slope (compare Deckers, 1979: fig. 3). While stone is found in small numbers, pottery and bone are absent here. This absence is intriguing in view of the main concentration of bone and pottery in the nearby hearth zone 2: one would expect to find trampled pottery or bone on the slope. Four postholes were found on the slope. The main part of the site is the bank, where all of the hearths and the majority of the postholes are located. It is also the area of the main concentrations of the different find categories. At a deeper level, it is also the location of the cultivated field. On the bank, two different subzones are distinguished, hearth zones 1 and 2, as described above. In terms of features, these two subzones are also distinguishable. The only feature found in zone 1 is a hearth, while zone 2 yielded numerous posts and postholes, hearths and other features. Partly this is due to the excavation strategy, because zone 2 was excavated

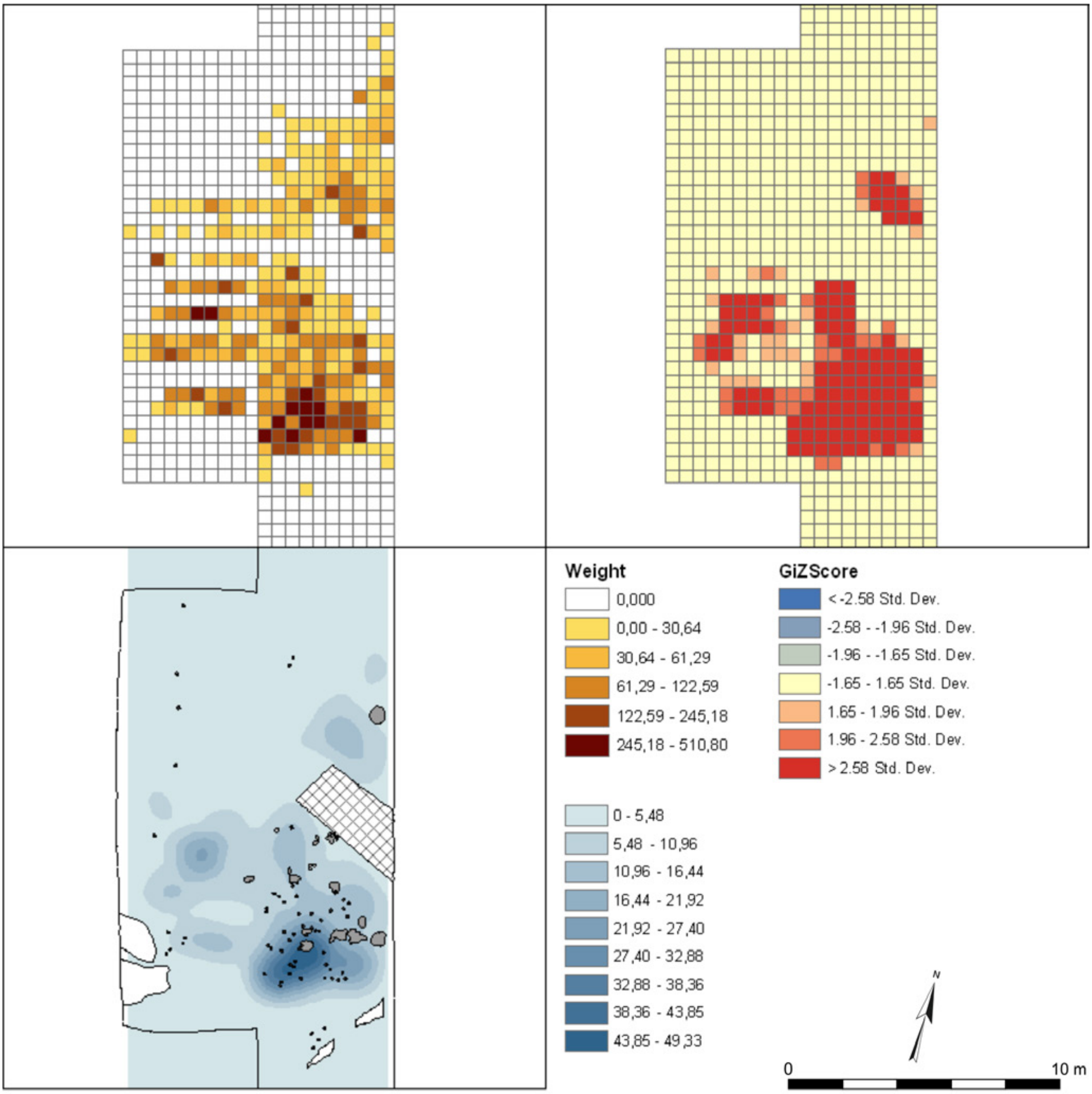

Fig. 9.7 Distribution of ceramics by weight (g) (map J. Geuverink).

far more extensively. The high number of posts and postholes in zone 2 is certainly the result of this, but because the 11 hearths were found in the occupation layer, which was also fully excavated in zone 1, the difference in hearth density cannot be related to excavation strategy. Few finds were made in the final zone of the site, the water meadows. This is partly due to the fact that only two or three spits were excavated. However, the reason no more spits were excavated was because few finds were made. The archaeological remains include some stone and flint and five postholes.

The use of space at S4 seems more similar to that of its neighbour, site S3, than to that of site S2, located at the main creek. De Roever (2004: appendices 1-7, 9) presents a series of maps of the spatial distribution of the features and finds from both sites. It is clear that S2 stands out from S3 and S4 as a result of its burials, its limited number of postholes and the absence of hearths. It also has a lower density of flint and stone than do S3 and S4. The similarities between S3 and S4 in terms of their features and spatial patterns are striking.

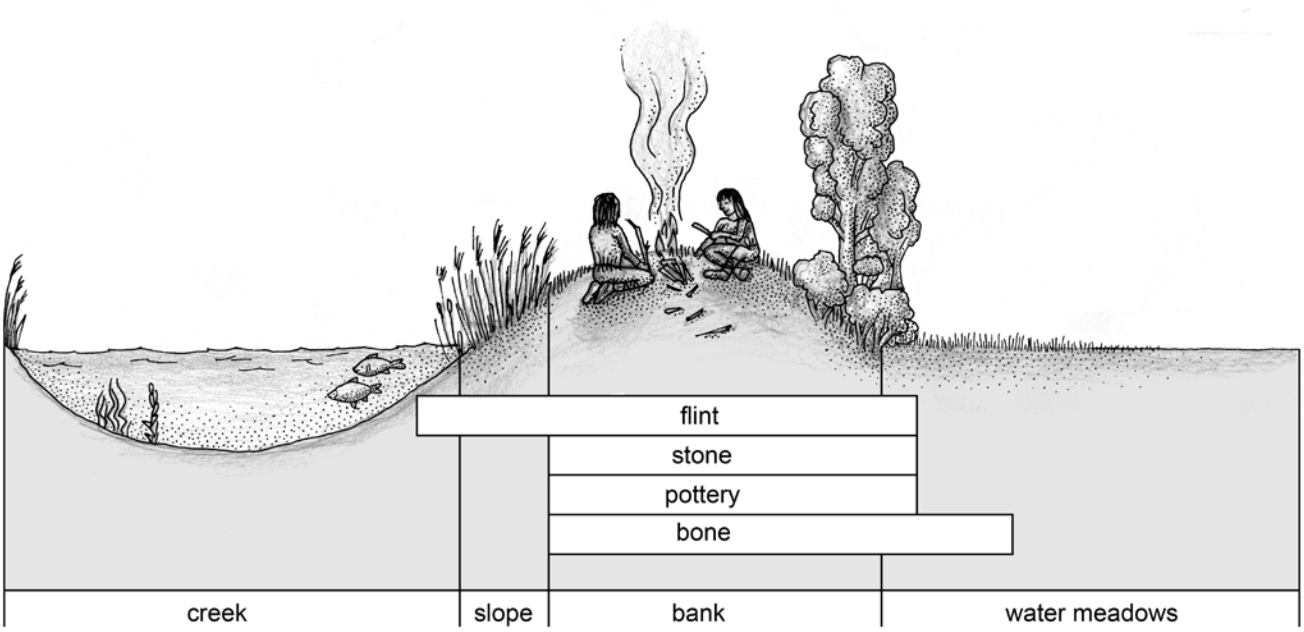

Fig. 9.8 Schematic cross-section of S4 in combination with the spatial distribution of four categories of material culture (drawing S.E. Boersma, UG/GIA).

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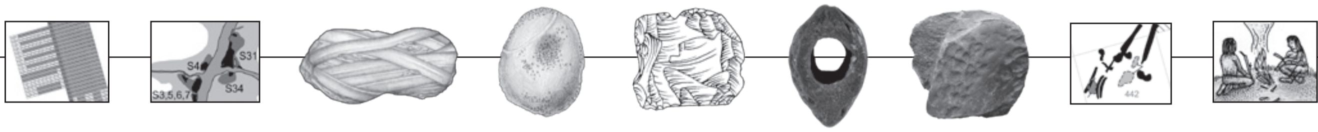

Conclusions

D.C.M. Raemaekers[1] & J.P. de Roever[2]

10.1 Introduction

In this final chapter, we bring together the results of the previous chapters. The recent work at Swifterbant S4 was carried out within an explicit research framework, with the ambition to contribute to the main research topics that had been left unanswered by the fieldwork and by the analyses carried out previously. Here, we will focus on the gains of the project, using the three themes identified in chapter 1 as the storyline.

10.2 Theme 1: Landscape, exploitation and site function

Swifterbant S4 is a site located on the creek bank of small river system, on the freshwater side of an estuary that was connected to the North Sea (Schepers & Woltinge; chapter 2). While the clay that built up the area is of marine origin, all botanical and zoological data indicate that S4 was only under brackish influence during storm events. The rest of the time, it was a freshwater system. Reeds and various club species grew along the creek bank, while the natural vegetation of the creek banks was dominated by willow carr and alder carr (Schepers & Bottema-Mac Gillavry; chapter 6).

Human impact on the natural vegetation resulted in a ruderal vegetation in which arable weed communities developed, while the water meadows turned into a grazing zone dominated by grasses. The cereal cultivation practiced was based on two types of cereals, emmer wheat and naked barley. Both are present in many of the sampled squares, implying that cereal cultivation and consumption took place on a regular basis. However, it remains difficult to assess the proportion of cereals in the diet. Other plant resources were exploited as well, such as hazelnuts, acorns, roots of lesser celandine and sea club-rush, and crap apple (Schepers & Bottema-Mac Gillavry; chapter 6). A similarly broad spectrum of animal resources was exploited. The domestic animals cattle, pig, sheep and dog are all represented, of which cattle was probably the most important in terms of contribution to the diet. Hunted animals include beaver, red deer, wild boar and otter. Although it is difficult to determine the relative importance of the animal species found, the small number of bird bones may indicate the restricted importance of fowling. Fish and bird remains are probably underrepresented in our assemblage due to both the relatively poor preservation and the recovery techniques used (Kranenburg & Prummel; chapter 7).

The settlement function of the site is attested by various find categories, including the many broken and burnt bones (Kranenburg & Prummel; chapter 7), the many ceramic sherds (Raemaekers *et al.*; chapter 3) and the wide variety of flint and stone tools (Devriendt; chapters 4 and 5). While site function can be proposed on the basis of the remains from S4 proper, it is more useful to discuss this topic in a comparative way, in which the other three excavated river bank sites (S2, S3 and S51) are incorporated into the analysis as well (table 10.1). This comparison indicates that S3 and S4 are nearest neighbours, both in terms of spatial proximity and in terms of site aspects. S3 and S4 are located along the cross-roads of a secondary and tertiary creek, whereas S2 and S51 are located along the primary creek. During the analysis of the S4 finds, this impression of similarity became so strong that we initiated a dedicated coring campaign to try to find out whether the small creek branch between the two sites may post-date the occupation and whether S3 and S4 should thus be considered a single site. This question could not be answered (Schepers & Woltinge; chapter 2). Here, we conclude that S3 and S4 may *de facto* have functioned as a single site. The interpretation of S4 (and S3) can be based on various aspects of these two sites, with S2 providing the counterpart of the comparison. The contribution of S51 to this comparison is limited due to its small assemblage size and restricted area of excavation.

1 d.c.m.raemaekers@rug.nl; University of Groningen / Groningen Institute of Archaeology; Poststraat 6, 9712 ER Groningen, the Netherlands.
2 paulienderoever@hotmail.com.

Table 10.1 A comparison of site characteristics of S2, S3, S4 and S51. Based on the various chapters in this volume and the reference cited therein.

		S2		S3		S4	
Zoology		**Number**	**%**	**Number**	**%**	**Number**	**%**
dog				3	1.0	22	3.3
domestic pig		6	14	59	19.7	99	14.6
cattle		1	2	8	2.7	163	24.1
sheep and sheep/goat		4	9			29	4.3
domestic pig/wild boar		4	9	85	28.3	92	13.6
cattle/aurochs						17	2.5
beaver		17	39	65	21.7	85	12.6
otter		3	7	11	3.7	25	3.7
wild boar		3	7	55	18.3	41	6.1
red deer		6	14	13	4.3	96	14.2
aurochs						1	0.1
other wild mammals				1	0.3	6	0.9
Total identified mammals		**44**	**100**	**300**	**100.0**	**676**	**100.0**
Ceramics		**Number**	**%**	**Number**	**%**	**Number**	**%**
Temper	Stone grit & plant	129	36	110	28	963	67.9
	Stone grit	69	19	19	5	318	22.4
	Plant	153	43	259	67	84	5.9
	Rest	0	0	0	0	52	3.7
Coiling	Coiling visible	119	31	68	17	346	24.4
	U-joins	94	79	56	82	119	34.4
	Hb-joins	25	21	12	18	227	65.6
Body	Body sherds	380		400		1241	
	Decorated body sherds	8		41		44	
	Body decoration		2		10		3.5
	Of which on shoulder	8	100	27	65	20	45
Rim	Rim sherds	7		74		114	
	Decorated rim sherds	3		43			45
	Rim decoration		43		58		40
	Of which on inner face	3	100	22	61	48	42
	Of which on upper face		0	3	8	56	49
	Of which on outer face		0	9	25	5	4
	Of which on more than one face		0	2	6	8	7
Totals		**380**		**400**		**1418**	

The comparison of the zoological data (Kranenburg & Prummel; chapter 7) makes clear that the same taxa were found at all sites. If we focus on pig and cattle (wild and/or domestic), it is clear that their abundance varies greatly across the three sites compared in table 10.1. The near absence of cattle bones at S2 is in stark contrast with their abundant presence at S4, where more than a quarter of the mammal bones identified are of cattle. This may be an important functional difference, which begs for further analysis on the cattle skeletal elements found across the sites. Such an analysis may indicate a difference in consumption versus butchering activities.

The ceramic assemblages from S2, S3 and S4 are quite varied (Raemaekers *et al.*; chapter 3) within the general framework of the Swifterbant culture (cf. De Roever, 2004). The ceramic characteristics listed in table 10.1 do not provide clues concerning differentiation in site function.

The same holds true for the stone artefacts: The assemblages have similar percentages of non-flint stone tools and similar percentages of the different types of non-flint stone tools (Devriendt; chapter 4). In contrast, the flint artefacts differ (Devriendt; chapter 5). S4 and S3 have a higher percentage of debitage material, suggesting that tool production and re-tooling was more common there. In contrast, at S2 and S51, more emphasis is found on the use of tools. The flint tool assemblages again place S3 and S4 together, with a similar proportion of scrapers. Intriguingly, S51has an even higher proportion of scrapers, suggesting that hide working was a relatively important activity to take place there. At S2, scrapers are not the most abundant tool type, but, rather, tools created on blades. Differences in another tool type stand out as well. Borers are relatively common at S2, but rare at S4 and S3 and absent at S51.

Table 10.1 Continued.

	S2		S3		S4		S51	
Stone artefacts	**Number**	**% ≥ 3 g**	**Number**	**% ≥ 3 g**	**Number**	**% ≥ 3 g**	**Number**	**% ≥ 3 g**
Debitage material	**192**	**36.2**	**951**	**42.2**	**167**	**30.0**	**24**	**47.1**
Tools	**37**	**7.0**	**244**	**10.8**	**51**	**9.2**	**10**	**19.6**
	Number	%	Number	%	Number	%	Number	%
Hammers	6	29	95	36	13	28	3	33
Anvils	6	29	102	38	19	40	3	33
Grinding stones	9	43	68	26	15	32	3	33
Total	**21**	**100**	**265**	**100**	**47**	**100**	**9**	**100**
Flint artefacts	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**
Debitage material	**505**	**49.2**	**11147**	**68.9**	**918**	**61.9**	**83**	**54.6**
Tools	**198**	**19.3**	**1420**	**8.8**	**163**	**11.0**	**27**	**17.8**
Scrapers	28	14.1	435	30.6	49	30.1	13	48.1
Borers	12	6.1	27	1.9	3	1.8		
Rounded pieces	9	4.5	41	2.9	10	6.1		
Trapezoid pieces	7	3.5	40	2.8	6	3.7	2	7.4
Transverse arrowheads	1	0.5	6	0.4				
Tools on flake	23	11.6	205	14.4	14	8.6	2	7.4
Tools on blade	59	29.8	209	14.7	24	14.7	5	18.5
Tools on other blanks	7	3.5	53	3.7	5	3.1		
Indet. tools	4	2.0	14	1.0	5	3.1	1	3.7
Indet. tool fragments	38	19.2	247	17.4	44	27.0	2	7.4
Retouched chips	10	5.1	143	10.1	3	1.8	2	7.4
Other site characteristics	**Number**	**%**	**Number**	**%**	**Number**	**%**	**Number**	**%**
Burials	9		0		1		0	
Number of post holes	10		650		70		0	
Number of house plans	0		1		0		0	
Number of hearths	0		many		14		1	

More contrast is seen in the features. The most striking aspect of S2 are the nine burials – a site characteristic not documented at S3 and S51. The single burial from S4 (Smits; chapter 8) deviates from 'textbook' Swifterbant burials: It concerns the only child burial at the sites in the Swifterbant area in which burial remains from an adult are absent (Raemaekers *et al*., 2009). The occurrence of postholes again stresses the singular position of S2: This site lacks the scatter of postholes found at S3 and S4. Instead, it has a single row of 10 postholes. The postholes scatter at S3 comprises a house plan (ca. 4.5 × 8 m; De Roever, 2004: 34); probably a series of wooden constructions was built at this spot during the site's occupation (Devriendt, 2013: 189-197). The posthole scatter at S4 is too limited in extent and number to interpret.

We conclude that most site characteristics indicate that settlement activities took place at all four sites. We might call all sites settlement sites, but we would like to stress that while at S3 and S4 all site characteristics are related to settlement activities, at S2 and S51 this is not the case. While S51 is poorly known, the dominance of scrapers suggests that this site was important for hide working. At S2, the burials, in combination with the absence of a posthole scatter, suggest a more episodic occupation. Visits were certainly related to the burial activities, but one might also envisage that the finds scatter results from site visits, rather than extended periods of use.

10.3 Theme 2: Temporal developments in site function

The site function of S4 is relatively complex and varied through time (Schepers & Woltinge; chapter 2). The build-up of the site indicates that the site's biography started with the deposition of reed materials, in which typical settlement debris was found. This layer became covered with a clay layer, which was subsequently used as a cultivated field. The major anthropogenic layer on top of this field was the main focus of the excavation and yielded almost all the finds and features presented in this volume. It is evidence of recurrent practices that can comfortably be labelled settlement activities. During this phase of its build-up and use, the site was also used for (a single) burial (Smits; chapter 8). The soil micromorphological analysis proposes that several additional cultivation levels are embedded in the layer (Huisman *et al*., 2009). One additional cultivated level was documented above the anthropogenic layer, suggesting that this particular exploitation of the site (i.e. its use as a cultivated field) continued after its abandonment as a settlement

Fig. 10.1 The S2 cultivated field, as documented in 1964. The caption reads (our translation) "Research of the prehistoric settlement at plot G42 [=S2]. Random mix of the black culture layer [=layer 5] with the grey river bank clay [=layer 4], at the contact area of both, in the western part of the excavation trench. 6-11-'64" (collection Batavialand).

site (Huisman & Raemaekers, 2014). This interplay between site functions is not restricted to S4, but can also be found at S2 and S3. At S3, where the site stratigraphy is very similar to S4, a well-preserved cultivated field was documented in the same stratigraphic position (Huisman & Raemaekers, 2014). At S2, a cultivated field was documented in 1964 but not recognised as such at the time (fig. 10.1).

The 50 cm thick anthropogenic layer 5 was excavated in 5 cm spits, which allowed us to determine that the ceramic characteristics change from bottom to top. These trends suggest that the mixing of finds as a result of trampling was not complete (Raemaekers *et al.*; chapter 3). With all other find categories, we studied trends in terms of three spatial units (each comprising three spits) to see if there were developments in site function during the build-up of layer 5. The results are rather limited. No trends were observed in the stone artefacts, while a refit from a rare diabase axe comprised only fragments from the top unit, strengthening our idea that these units might be helpful in the study of trends (Devriendt; chapter 4). The flint artefacts do not provide any evidence for changes in site function (Devriendt; chapter 5). The botanical analysis does show a significant change: Starting with spit 4, emmer wheat is present in a larger proportion of the samples than in the lower spits. This increase may be interpreted in terms of a change in the local environment favouring emmer wheat cultivation and/or in (the increase of) the import and consumption of emmer wheat (Schepers and Bottema-Mac Gillavry; chapter 6). We do not consider this change to indicate a change in site function. The zoological material also shows one intriguing change: the proportion of bones from beaver increases from ca. 4% in units 2 and 3 to ca. 22% in unit 1, at the top of layer 5, suggesting that in this last stage of occupation the exploitation of beaver became more important. On the basis of the observation of cut marks on beaver bones from S3, it was proposed that these animals were exploited for their fur (Zeiler, 1987). A similar specialised activity is proposed here. In all, there is little evidence for changes in site function during the build-up of layer 5.

One unexpected side effect of this analysis is that various other trends were found, not related to site function. These trends primarily concern the increase in find density of both stone and flint artefacts (Devriendt; chapters 4 and 5). This pattern was also found at S3, where it was interpreted as a consequence of a sequence of freezing and thawing that resulted in the upwards movement of artefacts (De Roever, 2004: 33). Various aspects of the bone

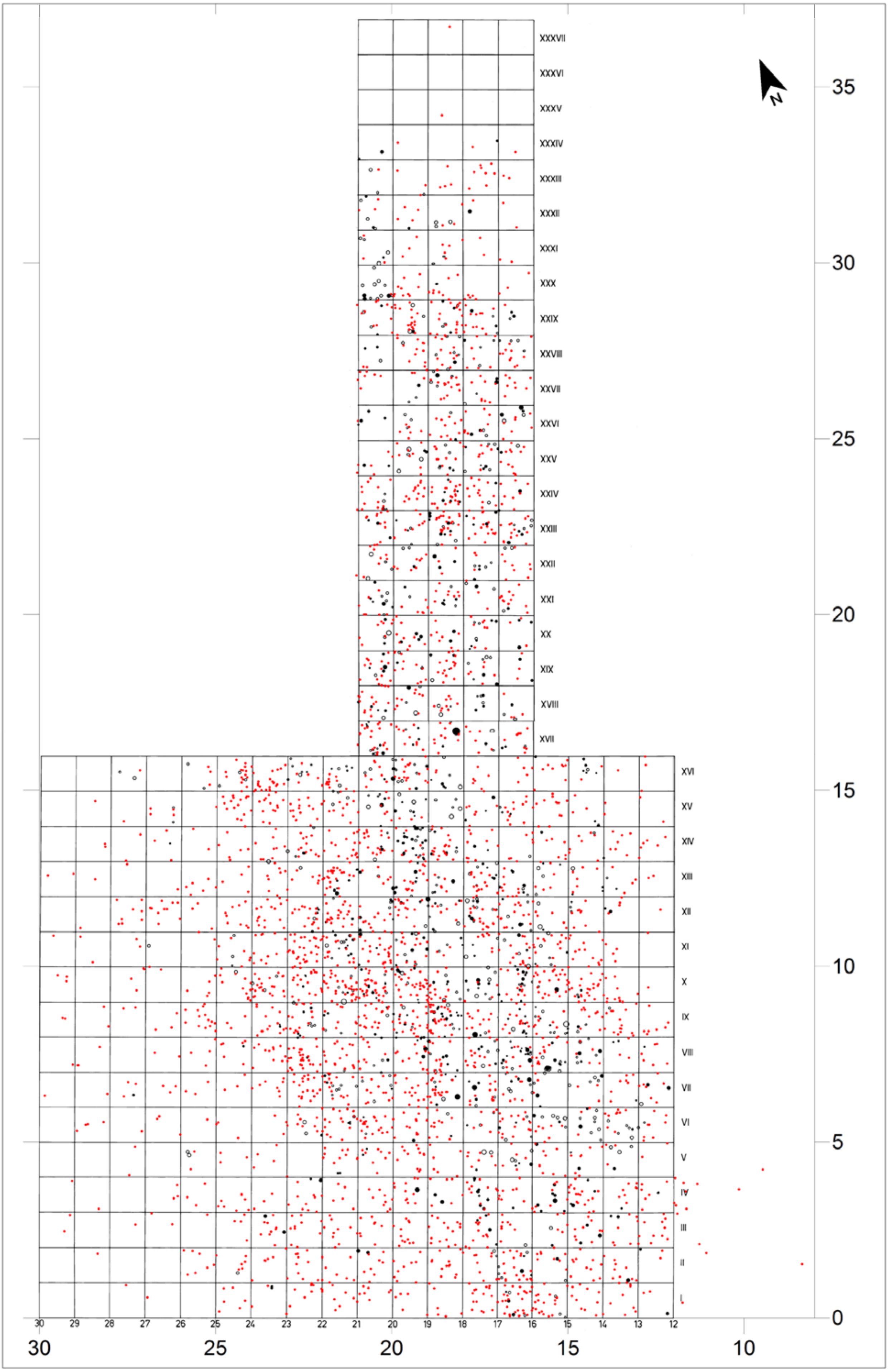

Fig. 10.2 Distribution of 3D documented stone artefacts and postholes at Swifterbant S3 (Devriendt, 2013: fig. 4.28).

assemblage also show trends (Kraneburg & Prummel; chapter 7). There is variation in the density of the identified bone remains, the average bone weight, and the proportion of calcined and weathered bones. All these observations may be related to changes in the intensity with which the site was used, changes in the speed of the build-up of layer 5, or both.

10.4 Theme 3: The use of space

The use of space has been analysed on the basis of the distribution patterns of various find categories (Geuverink; chapter 9). Due to the fragmented character of our excavation – resulting from the 'disturbance' of the 1974 excavation and the test trenches in trench 2 – this analysis suffered from edge effects and has not produced meaningful insights into the use of space. The general conclusion is that the density of finds correlates with the density of features, suggesting that there was a central part of the site where most activities took place and that the frequency of activities decreased in the periphery of the site.

We are limited in our interpretations by the poor quality of our dataset for spatial analysis. We note that Swifterbant sites with more potential for spatial analysis also display an intriguing lack of spatial structure. Activity areas are not easily discerned, and all sites give the impression of a continuous spread of material culture, without distinct artefact clusters that can be related to specific activities (figs 10.2-10.5). It may well be that this lack of spatial structure is a cultural characteristic of the Swifterbant culture.

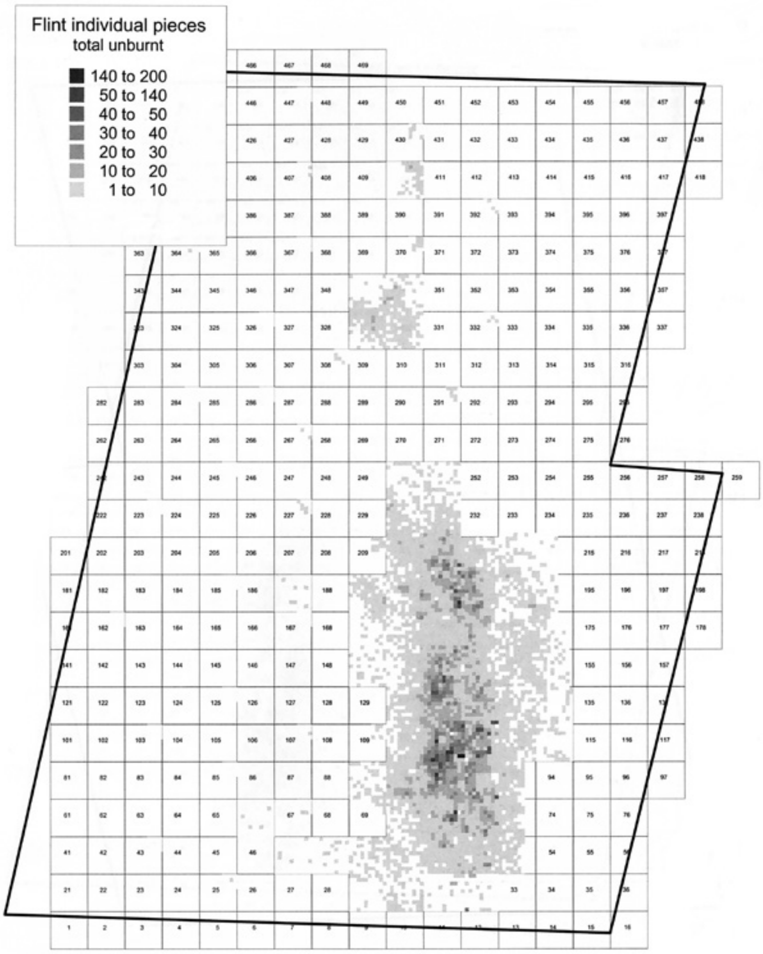

Fig. 10.3 Density distribution of unburnt flint >10 mm at Hoge Vaart-A27 (from Peeters, 2007: fig. 4.22).

10.5 Looking ahead

The S4 excavation was carried out on the basis of the research questions we had set ourselves. The excavation methodology we adopted has allowed us to address some issues to a great extent, but future fieldwork could make use of our experiences to develop a better excavation strategy. We propose three improvements. The main shortcoming of the S4 excavation is that it did not allow meaningful spatial analysis. With hindsight, we realize we should have orientated our grid to follow the orientation of the 1974 excavation trench and that we should have extended the excavation in trench 2 to include the areas between the excavated strips. This would have greatly improved the extent and reliability of our spatial analysis. The second improvement would be to sample for soil micromorphology to study the temporal relation between the grave and the find scatter. As it is, it remains an open question whether the grave was dug during the build-up of layer 5 or was, instead, dug into this layer after its build-up had ended.

Any future excavators in the Swifterbant region will be quite fortunate because they will be able to build on the great research history in the area, which allows a very detailed estimation of its future potential. This potential can be developed through new fieldwork, but also through more detailed analysis of the existing dataset. For the most part, we used relatively traditional approaches, which may be summarised as identification. But one can do so much more with ceramics, stone and flint artefacts and botanical, zoological and human remains. Such detailed analysis is already underway at GIA. Özge Demirci carried out lipid analysis on a selection of S4 ceramics. Her analysis gives more insight into the meals produced in the pots, thus bringing together the ceramic, botanical and zoological datasets.[3] A new project focuses on the start of animal husbandry in the area of the Swifterbant culture,

3 Her PhD project (2016-2019) is part of a Marie Sklodowska-Curie European Joint Doctoral Training Program, funded by the European Union's EU Framework program for Research and Innovation Horizon 2020 under Grant Agreement No 676154 (ArchSci2020 program).

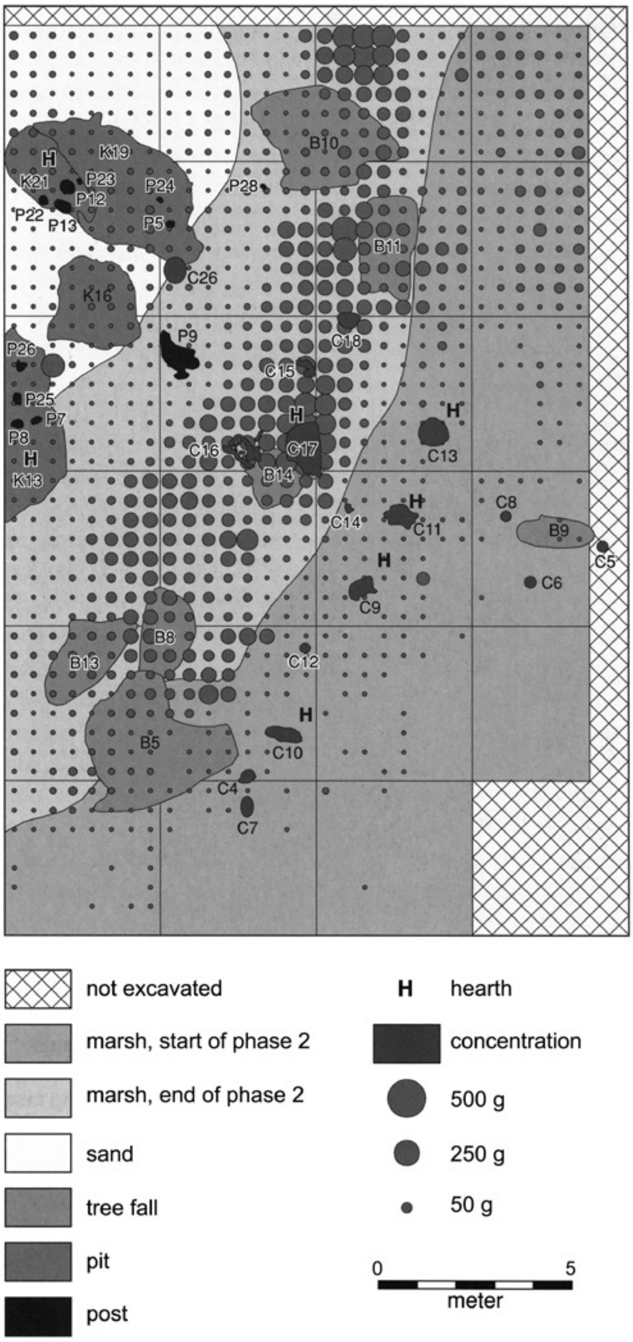

Fig. 10.4 Density distribution of charcoal at Hardinxveld-Giessendam De Bruin phase 2 (dots) (from Louwe Kooijmans, 2001: fig. 14.5).

with sub-projects dealing with a higher resolution of site chronologies, aDNA analysis of cattle and pig remains, and isotopic analysis of remains of the same species in order to gain more knowledge about their diet and mobility.[4] The future of Swifterbant research is already underway.

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4 This project (2020-2022) is financed by the Dutch Science Foundation/Nederlandse Organisatie voor Wetenschappelijk Onderzoek (NWO) and comprises two PhD's (sub-projects 1 and 2) and a postdoc (sub-project 3), project number 406.18.HW.026.

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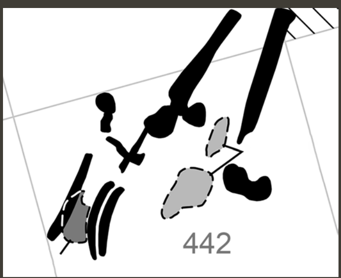
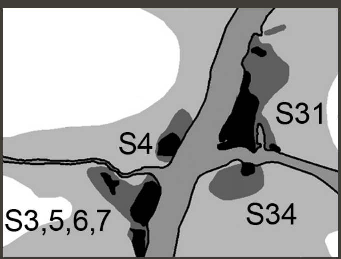
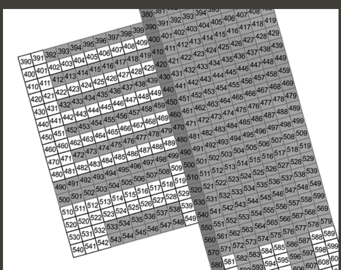
This publication presents the results of the 2005–2007 excavations at Swifterbant S4, carried out by the Groningen Institute of Archaeology. S4 is a well-preserved Neolithic wetland site (c. 4300–4000 cal. BC) located within the Swifterbant river system in the Netherlands. We present the landscape setting, the various finds categories and the spatial patterns with three research themes in mind. Theme 1 concerns the environmental setting, subsistence and site function. We conclude that the Swifterbant hunter-gatherer-farmers exploited a mosaic-type landscape. Theme 2 deals with developments in site function during the occupation and exploitation history of the site. This analysis leads to the observation that episodes of cultivation and settlement alternated at S4. Theme 3, the use of space, was difficult to study due to the fragmented nature of the excavation plan. This site monograph makes Swifterbant-S4 the most comprehensively published site of the Swifterbant river system.







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