AGRICULTURE IN MEDIEVAL GASSELTE

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CONTENTS

1. INTRODUCTION

1.1. The site

In this paper the results will be discussed of the examination of charred seeds and fruits from a medieval settlement near Gasselte, province of Drenthe, in the north of the Netherlands (fig. 1). About 500 m to the west of the village of Gasselte traces of ten farmsteads came to light during excavations carried out by the Biologisch-Archaeologisch Instituut in 1975-1977. An excavation report of this settlement site was published by Waterbolk and Harsema (1979) from which the following has been derived.

The farmsteads were situated in a north-south oriented row, apparently along a former road. The farmyards were bordered by shallow ditches, palisade trenches and rows of posts. Within each yard remains of houses, barns, sheds, sunken huts, granaries, corn- or hay-stacks and wells were found. The buildings had been repaired and renewed several times. The analysis of the settlement traces revealed that each farmstead had consisted of a principal building, combining the actual house with the byre, and a varying number of outhouses. Three types of farmhouses which succeeded each other in time could be established. On the basis of the development of the ground-plan of the principal building and of a shift of the latter within the farmyard four habitation phases have been distinguished by Waterbolk and Harsema (1979). The fields must have been laid out to the west of the settlement.

The pottery indicates that the habitation must have lasted from the middle of the 9th to the middle of the 12th century A.D. Two radiocarbon measurements which have so far been carried out for samples from Gasselte suggest a somewhat earlier dating.

1.2. The geographical situation

The site was located on the eastern flank of the "Drents plateau", the central plateau of Drenthe consisting of higher sandy soils often underlain by boulder clay or a boulder clay residue (stone layer). About 3 km to the east of the site, the higher soils pass into the Hunze depression, a broad ice-marginal valley. The settlement was founded at the head of a small transverse valley (fig. 1). On the ordnance survey map of c. 1850 the rivulet is still shown. According to the soil map (Bodemkaart van Nederland, 1977) fine loamy sands to fine sands poor in loam prevail in the vicinity of the settlement. Mr. J. Wieringa (Nedersachsisch Instituut, Groningen) informed us that at the locality of the site the soil is poor.

From the above it appears that three main topographic features can be distinguished in the Gasselte area: the higher sandy soils with the arable land, forest and perhaps heather fields; a west-east oriented valley with a small stream; and the Hunze depression with marshes and peat-bogs.

Dr. K.-H. Knörzer (Neuss, West Germany) kindly checked (and corrected!) the identification of some seed types. Ingelise M. Stuyts identified the heather stems. The drawings of the seeds and fruits were made by Mr. H. R. Roelink, while Mr. W. J. Dijkema prepared the other illustrations. Professor H. T. Waterbolk and Mr. H. Praamstra provided information on the origin of the samples. Mrs. G. Entjes-Nieborg assisted in the preparation of the manuscript. The English text was improved by Mrs. S. M. van Gelder-Ottway.

The analysis of the samples was carried out by RMP-V. Both authors are responsible for the seed identifications. WvZ prepared the text.

2. THE SAMPLES

2.1. Field and laboratory procedures

During the excavations fairly large soil samples (5,000-20,000 cc) were taken for botanical examination. In a few cases charred grains were observed in the field, but most soil samples originate from features without traces of carbonized seeds and fruits. Charred plant remains were retrieved in the laboratory by means of manual water flotation. The vegetable remains were recovered on a sieve with meshes of 0.5 mm. The majority of the recovered material consisted of charcoal among which smaller or larger numbers of carbonized seeds and fruits were present. Various samples did not yield any seeds. Only in sample 454 are charred grains pre-

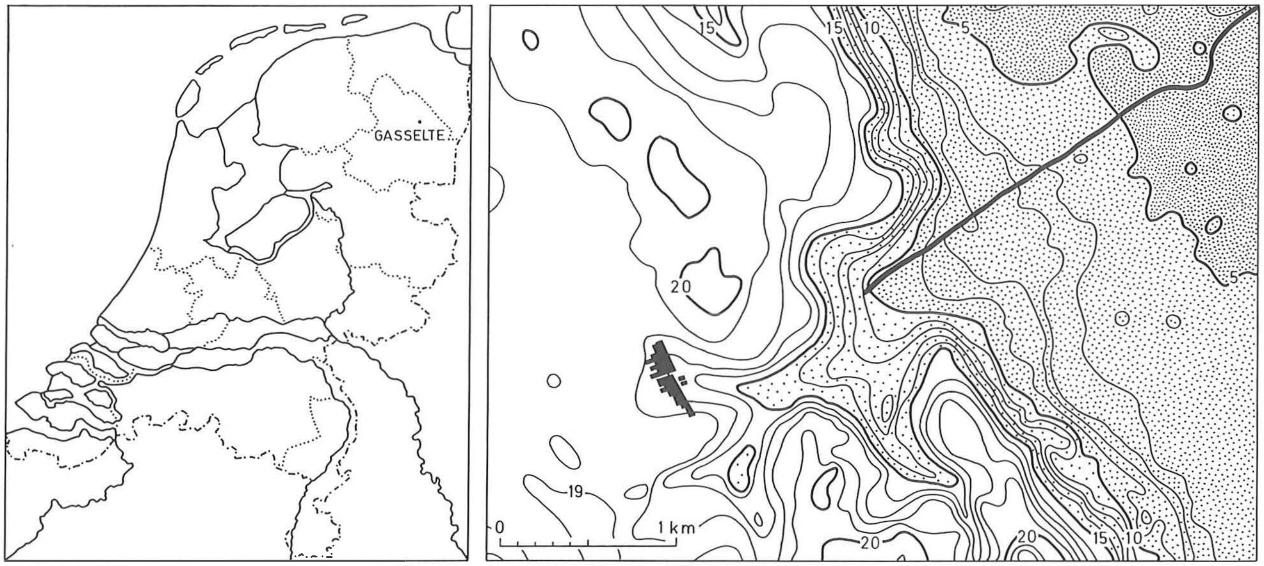

Fig. 1. Map of the Gasselte area. Contour lines are given for every metre. The excavated area is indicated in black. The site is located at the head of a small valley. The streamlet in this side valley no longer exists.

dominant (c. 60% by weight). Of this large charred grain sample $^1/_{15}$ part was examined. The other samples were analysed in their entirety.

Moreover, from the fill of post-holes and pits samples were taken with the primary purpose of obtaining charcoal for radiocarbon dating and wood identification. After having been dried these samples were sieved through screens with meshes of 1.5 mm and more. A cursory inspection of these charcoal samples showed that some of them contained cereal grains. For that reason also the dry-sieved samples have been examined for seeds and fruits.

Only charred plant remains were recovered from Gasselte. The local conditions (well-aerated, sandy soil, above the ground-water level) do not allow the preservation of non-carbonized plant remains. The fill at the bottom of the wells may have contained water-logged vegetable material, but no samples could be obtained from this type of soil.

Some particulars of the samples which yielded seeds and fruits are presented in table 1. Fairly often two or more samples are from one building; in such cases the samples are mainly from post-holes which form part of the same ground-plan. In table 2 it has been indicated which groups of samples belong to the same building. The results of the analyses are presented in table 3. The sclerotia of *Cenococcum geophilum*, fairly large numbers of which were found in some samples, are not shown in table 3. The examination of the charcoal will not be discussed in this paper.

Fairly large numbers of cereal grains have been measured. In those cases where the embryo had been preserved the radicle point has not been included in the measurement.

2.2. The origin of the samples

Most of the charred seed samples are from the fill of pits, ditches and post-holes. With pits one could possibly think of storage pits the contents of which were burnt, resulting in the carbonization of a smaller or larger number of grains. In this case the charred grains would be in a primary position, i.e. more or less at the spot where they had become carbonized. It is difficult to imagine how grains could have become carbonized in the sandy fill of post-holes. The grains must have been deposited there in a charred condition. This implies that they had been moved over some distance and that they were lying in a secondary position. The charred grains could have arrived in the post-hole after the post had been set up when the rest of the hole was filled up with soil. In this case the charred seeds

TABLE 1

Short description of samples which yielded charred seeds and fruits.
The numbers of the buildings refer to Waterbolk & Harsema (1979, fig. 6).

Number	Phase	Origin of sample	Treatment
3	4	post, barn 65	dry-sieved
10	3	post, house 67	flotation
12	3	post, house 67	flotation
31	4	post, granary 33	dry-sieved
43	1	pit inside house 77	flotation
44	1	small post-hole at inner side wall house 77	dry-sieved
46	1	wall post, house 77	flotation
49	2	well I	dry-sieved
63	1	central post, barn 68	flotation
64	1	wall post, barn 68	flotation
71	4	corner post, house 70	flotation
72	4	wall post, house 70, ^{14}C: A.D. 1020±60	flotation
73	4	wall post, house 70	flotation
74	4	wall post, house 70	flotation
89	4	corner post, house 70	flotation
91	4	outer post, house 70	dry-sieved
92	4	wall post, house 71	flotation
104	4	wall post, house 71	flotation
123	1	sunken hut 30	dry-sieved
186	1	pit beside outhouse 96	dry-sieved
266	2	pit beside barn 50	dry-sieved
295	2 or 3	pit beside houses 53 and 54	dry-sieved
296	2	foundation trench, house 53	flotation
304	2	pit inside house 53	dry-sieved
305	2	pit inside house 53	dry-sieved
311	2	foundation trench, house 53	dry-sieved
328	1	central post, barn 51	dry-sieved
329	1	central post, barn 51	dry-sieved
337	3	wall post, house 25	dry-sieved
376	2	central post, barn 34	dry-sieved
377	2	wall post, barn 34	dry-sieved
381	2	central post, barn 33	dry-sieved
396	3	wall post, barn 19	dry-sieved
397	4	pit inside barn 18	dry-sieved
403	2	byre ditch, house 24	dry-sieved
411	2	wall post, barn 28	dry-sieved
417	3	corner post, house 25	flotation
418	1	post, barn 27	flotation
428	2	byre ditch?, house 24	flotation
434	3	wall post, barn 19	dry-sieved
454	1	sunken hut 8	flotation
456	1	pit inside barn 22	dry-sieved
474	4	pit inside corn-stack 16	dry-sieved
533	?	pit in yard VII	dry-sieved
534	?	pit in yard VII	dry-sieved
537	3	corner post, house 102	dry-sieved
539	2	wall post, barn 101	flotation
540	2	wall post, barn 101	flotation
543	2	wall post, barn 101	flotation
544	3	post, house 102	flotation
545	3	post, house 102	flotation and dry-sieved
573	?	pit near granary 56	dry-sieved
574	3	wall post, house 109	dry-sieved

would date from (shortly) before the construction of the building concerned. It is also possible that the charred grains had been shovelled into the hole after the post had been pulled out, e.g. in repairing or demolishing the building. It is likely that the charred grains in virtually all samples, including those from pits, have been redeposited. Only sample 454, from a sunken hut, seems to constitute the remains of a grain supply which had been stored there.

Above it has been suggested that charred grains may predate the house to which the sample concerned is attributed. It is possible that the grains became carbonized during the burning down of the house or barn from the preceding building phase. The periodization of the settlement is largely based upon the succession of the farmhouse ground-plans (see 1.1.; Waterbolk and Harsema, 1979). This would imply that the sample should be attributed to the phase prior to that of the building concerned. In practice it is impossible to determine where the charred grains originated. In the theoretical case mentioned above the grains would very probably date from only shortly before the construction of the building. Moreover, the transition from one building phase to another was certainly not synchronous over the whole of the settlement. For these reasons, in attributing the charred grain samples to the same phase as that of the building concerned no appreciable mistakes will be made.

2.3. Floated and dry-sieved samples

As appears from table 3, the seed content of the dry-sieved samples is not wholly comparable with that of the floated samples. Small seeds, such as those of *Rumex acetosella*, *Chenopodium album*, *Spergula arvensis* and *Stellaria media*, which were found quite frequently in the flotation samples, are absent in the dry-sieved samples. Only larger types of field-weed seeds, such as *Polygonum convolvulus*, *Polygonum lapathifolium/persicaria* and *Vicia*, are fairly common in the dry-sieved samples. It is clear that this difference in seed content is due to the rather large-meshed screen used in the dry-sieving. That the differences in processing will very probably not have affected the recovery of the larger grains is suggested by sample 545. One part of this sample was submitted for flotation, whereas another part was dry-sieved. As is shown in table 4, there are no marked differences in the cereal grain percentages.

3. CULTIVATED PLANTS

3.1. The plant cultivation

The palaeobotanical evidence suggests that oats, rye and barley were the main crop plants of the inhabitants of the medieval settlement near Gasselte. From various samples considerable numbers of grains of one or more of these cereal species were recovered.

Most of the samples which yielded larger numbers of cereal grains are from the fill of post-holes. As has been discussed above, the carbonized grains in this fill were lying in a secondary position. After the kernels had become carbonized they were shovelled into the hole. This implies that these samples do not represent original grain supplies, but that after (and perhaps already during) the carbonization the kernels from different stacks may have become mixed. The fact that of two cereal species greater numbers of grains were found in one sample does not necessarily imply that a mixture of these species was grown. The Gasselte material

TABLE 2

Samples originating from the same building.
The numbers in bold type are flotation samples.

Phase	Samples	Building
1	**43**, 44, **46**	house 77
1	**63, 64**	barn 68
1	328, 329	barn 51
2	**296**, 304, 305, 311	house 53
2	376, 377	barn 34
2	403, **428**	house 24
2	**539, 540, 543**	barn 101
3	**10, 12**	house 67
3	337, **417**	house 25
3	396, 434	barn 19
3	537, **544, 545**	house 102
4	**71, 72, 73, 74, 89,** 91, **92, 104**	house 71

TABLE 3

Numbers of seeds, fruits and other plant remains from Gasselte. The numbers in bold type are flotation samples. fr = fragment; + = present; cf. = identification uncertain

Sample number	**43**	**46**	**63**	**64**	**418**	**454**	44	186	123	328	329	456	**539**	**540**	**543**	**428**	403	311	304	305	**296**	49	266	381	376	377	411
Phase	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Avena sativa/strigosa	1	1	–	–	720	70	–	–	2	–	3	85	6	8	1	1130	100	4	–	–	–	1	5	–	–	–	–
Secale cereale	36	–	–	–	161	6575	11	½	7	1	6	320	915	477	–	151	7	11	3	1	750	3	1	–	1	½	½
Hordeum vulgare	2	2	–	1	3110	195	–	–	4	1	4	18	317	353	40	1040	190	15	½	–	2½	3	3	1	2	–	–
Triticum dicoccum[1]	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Triticum dicoccum/aestivum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Panicum miliaceum	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Linum usitatissimum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Vicia faba var. minuta	–	–	–	–	–	1½	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pisum sativum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	½	–	–	–	–	–	–	–	–	–	–
Anethum graveolens	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Satureja hortensis	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Corylus	–	–	–	–	–	fr	–	–	–	–	–	–	–	fr	–	–	–	–	–	–	fr	–	–	–	–	–	–
Fragaria vesca	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–
Prunus spinosa	–	¼	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Quercus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Polygonum convolvulus	–	4	4	–	13	15	–	–	–	–	–	1	4	2	–	39	6	–	–	–	4	–	–	–	–	–	–
Polygonum lapathifolium/persicaria	3	11	22	1	79	21	–	–	–	–	1	12	19	20	–	50	13	1	7	–	28	–	1	–	–	–	–
Polygonum aviculare	2	4	2	1	1	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	1	–	–	–	–	–	–
Polygonum hydropiper	–	–	1	–	2½	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rumex acetosella	260	55	85	18	–	18	–	–	–	–	–	–	1	5	1	1	–	–	–	–	19	–	–	–	–	–	–
Rumex obtusifolius	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chenopodium album	1	11	12	–	17	–	–	–	–	–	–	–	7	3	–	9	–	–	–	–	10	–	–	–	–	–	–
Spergula arvensis	16	8	4	1	–	1	–	–	–	–	–	–	2	1	–	–	–	–	–	–	5	–	–	–	–	–	–
Raphanus raphanistrum	–	1	–	–	16	–	–	–	–	–	–	–	3	1	–	45	2	–	–	–	–	–	–	–	–	–	–
Stellaria media	–	4	2	1	–	–	–	–	–	–	–	–	1	1	–	1	–	–	–	–	–	–	–	–	–	–	–
Scleranthus annuus[2]	–	–	1	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Anagallis arvensis	–	–	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Viola cf. arvensis	2	1	1	–	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–
Potentilla reptans	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rhinanthus cf. minor	–	1	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–
Plantago lanceolata	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–
Sherardia arvensis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Stachys arvensis	–	–	–	–	5	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–
Bromus mollis/secalinus	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Centaurea cyanus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Knautia arvensis	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ranunculus acris	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Convolvulus arvensis	–	–	–	–	2	3	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
Lotus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Fumaria officinalis	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Euphorbia helioscopia	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ballota nigra	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Galeopsis cf. tetrahit	–	–	⅓	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Melandrium album/rubrum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Euphrasia	2	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Vicia hirsuta	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–
Vicia sativa ssp. angustifolia	–	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	–	–	–	3	–	–	–	–	–	–
Vicia spec.	3	1	1	1	–	2	–	–	–	–	1½	10	2	–	–	½	1	–	–	–	1	–	–	–	1	–	–
Echinochloa crus-galli	–	–	–	cf.1	3	20	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1	–	–	–	–	–	–
Digitaria ischaemum	3	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Setaria viridis/italica	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
cf. Poa pratensis/trivialis	10	50	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Poa annua	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Gramineae indet.	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–
Menyanthes trifoliata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Galium palustre	–	–	–	–	–	1	–	–	–	–	–	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–
Eleocharis	1	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–
Carex serotina-type	–	–	3	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carex inflata/vesicaria-type	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carex otrubae-type	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carex spec.	–	1	–	–	–	1	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Cyperaceae indet.	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–
cf. Phragmites australis[3]	+	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	+	–	–	–	–	–	–
Calluna vulgaris[4]	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	+	–	–	–	–	–	–
Erica tetralix[5]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–

[1] Spikelet forks in samples 63 and 73
[2] Calyces; in samples 72 and 74 also one seed
[3] Stem fragments
[4] Leafed stem tips in samples 43 and 428; flower in sample 296
[5] Leaves

10	12	417	337	544	545	537	396	434	574	71	72	73	74	89	92	104	91	3	31	397	474	295	533	534	573
3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	phase 2 of 3	?	?	?
½	4	1	1	2370	433	35	16	2	-	4575	5275	2160	2750	9	55	25	250	-	-	-	-	15	38	7	-
-	10	320	33	6	2	2	1	-	1	45	1170	74	198	2	32	12	145	2	-	-	1	145	38	55	-
-	1	11	17	2560	322	60	3	-	-	22	124	39	60	11	22	2	75	-	-	1	-	38	8	3	-
-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	1	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
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-	1	-	-	11	2	2½	3	-	-	61	50	21	32	-	-	1	2	-	2	-	-	2	4	-	-
-	3	½	-	40	8	1	23	2	-	22	25	16	22	6	5	3	3	1	-	-	-	2	7	2	-
-	-	-	-	-	1	-	-	-	-	5	6	-	2	-	-	-	-	-	-	-	-	-	1	-	-
-	-	-	-	5	1	-	-	-	-	65	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
-	8	1	-	1	1	-	-	-	-	3000	800	400	525	5	10	17	-	-	-	-	-	-	-	-	-
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provides convincing evidence for the cultivation of separate crop plants. Thus, in samples 454, 296, 417, 71 and 73, one species accounts for 95% and more of the cereal grains (table 5). The small numbers of grains of the other two cereals in the samples mentioned above may be due to secondary mixing, but it is equally well possible that they occurred in the field as a minor admixture to the main crop. In consequence of crop rotation one can expect contamination with the species grown on the same field in the preceding years. In some cases it is probable that the grains in one sample originated from different stacks. Thus, samples 539 and 540 are from two adjacent post-holes of the same house (fig. 2). The different proportions of *Secale* and *Hordeum* in both samples point to separate supplies of rye and barley which afterwards became mixed to some extent. Samples 72, 73 and 74 are from the fill of the holes of three consecutive wall posts (fig. 2). The differences in the proportions of oats and rye suggest that originally at least two different stacks were present. In conclusion, it is justified to assume that barley, rye and oats were grown separately at Gasselte, although, on the other hand, it cannot be excluded that at the same time mixtures of cereal species (maslin) were grown.

Above it has been suggested that crop rotation could have been practised by the Gasselte farmers. One wonders whether a possible succession of crop plants, the rotation cycle, could be deduced from the available palaeobotanical evidence. In this connection reference can be made to the Slavonic fortified site (*Burg*) of Tornow in Lausitz (East Germany) where Jäger (1966) succeeded in determining the most likely crop rotation cycle. At Tornow the conditions were very favourable in this respect. Both strongholds (*Burg* A and *Burg* B) were destroyed in a conflagration. From the remains of the second period a great number of charred seed samples could be obtained. The carbonized grains are from the harvest of one year. Moreover, during and after the fire only slight mixing of the different

TABLE 4

Comparison of cereal grains in floated and dry-sieved portion of sample 545.

	floated		dry-sieved	
	numbers	%	numbers	%
Avena	433	*57.2*	130	*54.2*
Hordeum	322	*42.5*	110	*45.8*
Secale	2	*0.3*	•	•

TABLE 5

Percentages of crop plant species. The frequencies are shown as percentages of the sum of the crop plant fruits. Average values are the means of the relative frequencies.

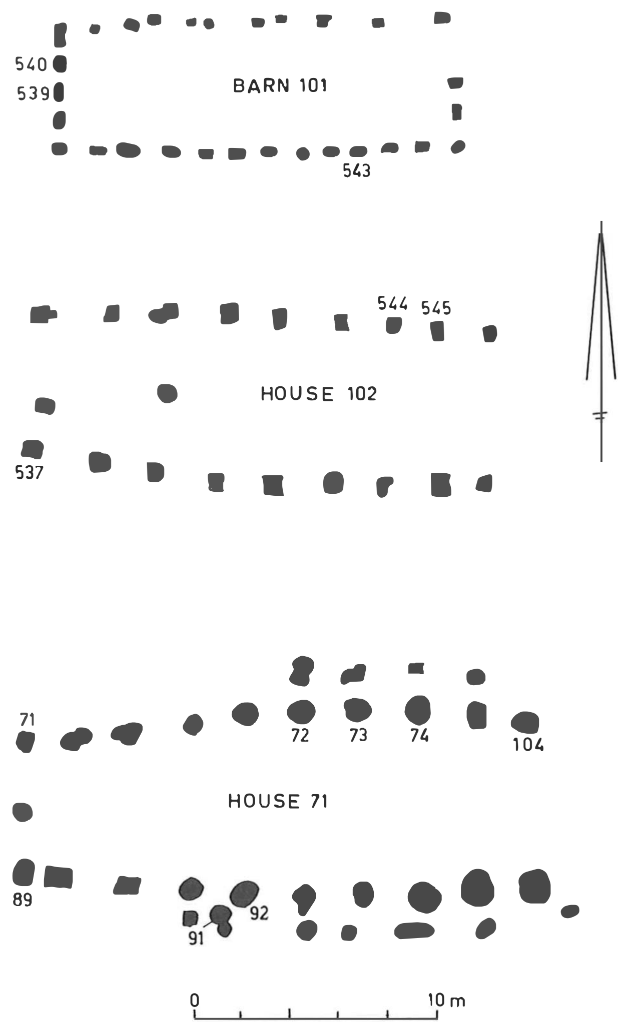
	phase 1				phase 2					
	418	454	456	aver.	539	540	428	403	296	aver.
Avena sativa/strigosa	18.0	1.0	20.1	13.0	0.5	1.0	48.7	33.6	•	16.8
Secale cereale	4.0	96.1	75.7	58.4	73.9	56.9	6.5	2.4	99.7	47.9
Hordeum vulgare	77.9	2.9	4.3	28.3	25.6	42.1	44.8	63.9	0.3	35.3
Triticum dicoccum/aestivum	•	•	•	•	•	•	•	•	•	•
Panicum miliaceum	•	+	•	+	•	•	•	•	•	•
Linum usitatissimum	•	•	•	•	•	•	•	•	•	•
Vicia faba	•	+	•	+	•	•	•	•	•	•
Pisum sativum	•	•	•	•	•	•	•	02	•	+

grain supplies had taken place. Out of 73 charred grain samples from the second period (*Burg* B), 64 consisted of predominantly one species with an admixture of one or more other cereals. From the combinations of main crop and admixture the succession in which the crop plants were grown could be deduced.

One may doubt whether the Gasselte material allows any conclusion concerning possible crop rotation. This is due to the fact that only very few samples consist of predominantly one species with a minor admixture of one or two other cereals. The combination of samples 454, 296, 417, 71, 73 and 74 suggests a rotation cycle: *Hordeum* → *Secale* → *Avena*. It should, however, be emphasized that this conclusion is based upon too small a number of samples which, moreover, date from different phases. One may not a priori assume that a crop rotation cycle did not change in the course of 400 years. Consequently, one would do better to refrain from conclusions concerning a possible crop rotation cycle at Gasselte.

One should likewise be reticent to conclude any shifts in the relative importance of oats, barley and rye in the course of the habitation. In table 5 the relative frequencies are presented of the crop plants in samples which yielded larger numbers oorrins. Moreover, for each phase the mean percentages are shown. From this table it may be tempting to conclude that in phases 1 and 2 rye was quantitatively the most important cereal, whereas in phase 4 oats were dominant. One should, however, consider the fact that there are only a few samples per phase and that all samples from phase 4 are from the same

Fig. 2. Ground-plans of a few buildings which yielded more than one charred grain sample.



		phase 3						phase 4			
417	544	545	537	aver.	71	72	73	74	92	91	aver.
0.3	48.0	57.2	36.1	35.2	98.6	80.3	95.0	91.4	50.5	53.1	77.9
95.5	0.1	0.3	2.1	24.4	1.0	17.8	3.3	6.6	29.4	30.8	14.8
3.3	51.9	42.5	61.9	39.7	0.5	1.9	1.7	2.0	20.2	15.9	7.0
•	•	•	•	•	•	•	+	•	•	0.2	+
•	•	•	•	•	•	•	•	•	•	•	•
0.9	•	•	•	0.2	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•

house (table 2, fig. 2). Samples 534 and 540 (phase 2) and 544 and 545 (phase 3) are likewise from one house. It is clear that conclusions concerning possible changes in the proportions of the major cereals in the course of time are not justified by the available evidence. Other questions, such as the manuring of the fields and whether fallowing was practised, must equally remain unanswered.

3.2. Avena (fig. 15)

In addition to *Avena sativa*, the less-known oat cultivar *Avena strigosa* has been established for Gasselte. A distinction between the carbonized grains of these two oat species is only possible if the flower bases are preserved. It is true that, on the average, the kernels of *A. strigosa* are smaller than those of *A. sativa*, but the size frequency distribution curves of both types overlap to a large extent (cf. Behre, 1973).

As for the flower bases, the following should be remarked. The spikelets of *A. sativa* contain usually two fertile florets each developing one grain. The lemma of the lower (first) floret of the spikelet may bear an awn, but in many varieties the first floret is awnless. The upper (second) floret is never awned. In *A. strigosa*, on the other hand, both florets of one spikelet have a twisted geniculate awn. In *A. sativa*, the bases of the lower florets show a fairly broad fracture surface; the bases of the upper florets are narrower (fig. 3). In *A. strigosa* the flower bases are always narrow. In carbonzied material the (partly) hulled grains of *A. strigosa* can be distinguished from those of *A. sativa* by the following features. The flower bases of *A. strigosa* are still narrower than those of the upper florets of *A. sativa* and they usually terminate in a point. If a sufficiently large part of the lemma is preserved, the remains of the awn, or at least the depression indicating the former presence of the awn, can be observed in *A. strigosa* (fig. 3).

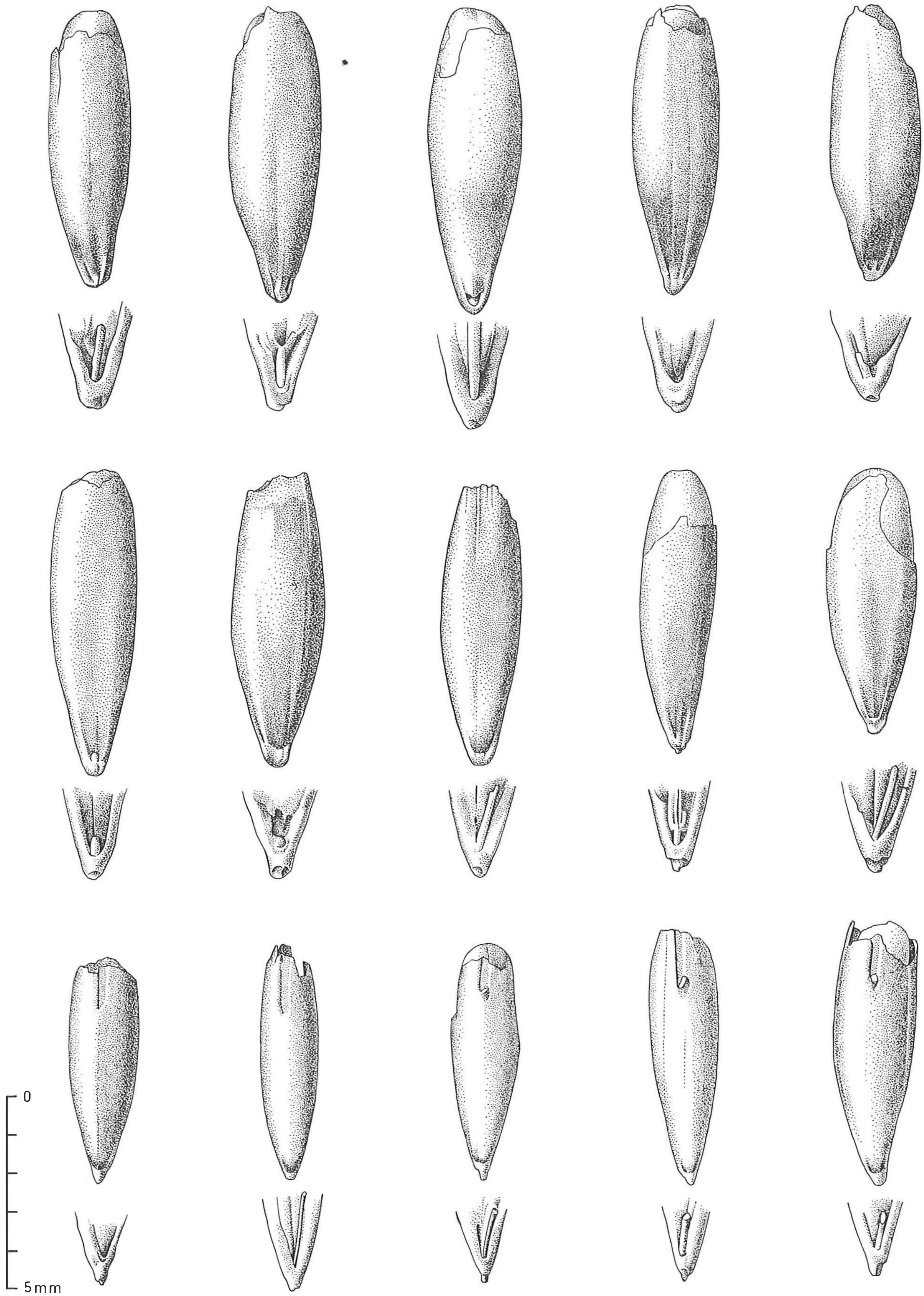
In the Gasselte material, a satisfactory separation could be made between *A. sativa* and *A. strigosa* (table 6). The distinction between the lower and upper florets of *A. sativa* proved to be much more difficult. Many carbonized flower bases were morphologically intermediate between typical specimens of lower and upper florets as depicted in fig. 3. Consequently, a quantitative separation between the two types has not been attempted. No remains of awns were observed on the *A. sativa* grains from Gasselte suggesting that an awnless variety was grown.

The palaeobotanical evidence suggests that it was not until the last phase of habitation that *A. strigosa* became a more important crop plant at Gasselte (table 6). It is a pity that sample 544 (phase 3) yielded only 39 flower bases while in sample 428 with 1130 oat grains (phase 2) not a single specimen with a flower base was found. For that reason it cannot be ascertained whether *A. strigosa* was already present before phase 3 and whether or not it was only an insignificant admixture during phase 3. It is not certain whether during phase 4 *A. strigosa* was grown separately or whether it was cultivated together with *A. sativa*. The varying proportions of *A. strigosa* in samples 71, 72, 73 and 74 could point to separate stacks of both oat species which after the carbonization became mixed. On the other hand, samples 71, 72, 73 and 74 differ among each other in preservation and in the relative numbers of flower bases (4.4 to 19.9%), suggesting that in these samples more than one supply of *A. sativa* (and *A. strigosa*) is represented. This leaves the possibility that mixtures of both oat species were grown. Up to the present *A. strigosa* constitutes a crop plant on its own, although its cultivation has decreased considerably.

From samples with fairly large numbers of oat grains 50 to 100 naked kernels have been selected for measurement. The results are shown in table 6 and fig. 4. The mean size of the oat grains does not differ markedly in the various samples. The frequency distribution curves equally do not point to conspicuous differences in the oats in the samples concerned. The oats from sample 428 score the highest mean length as well as the greatest 100 grain weight. Varying soil and weather conditions can easily have accounted for the differences in mean grain size. In no case do the measurements suggest any tendency towards a larger or smaller grain size in the course of the habitation.

For Middels, Behre (1973) has demonstrated

Fig. 3. *Avena* from sample 71. Upper row: *A. sativa*, lower floret; middle row: *A. sativa*, upper floret; lower row: *A. strigosa*.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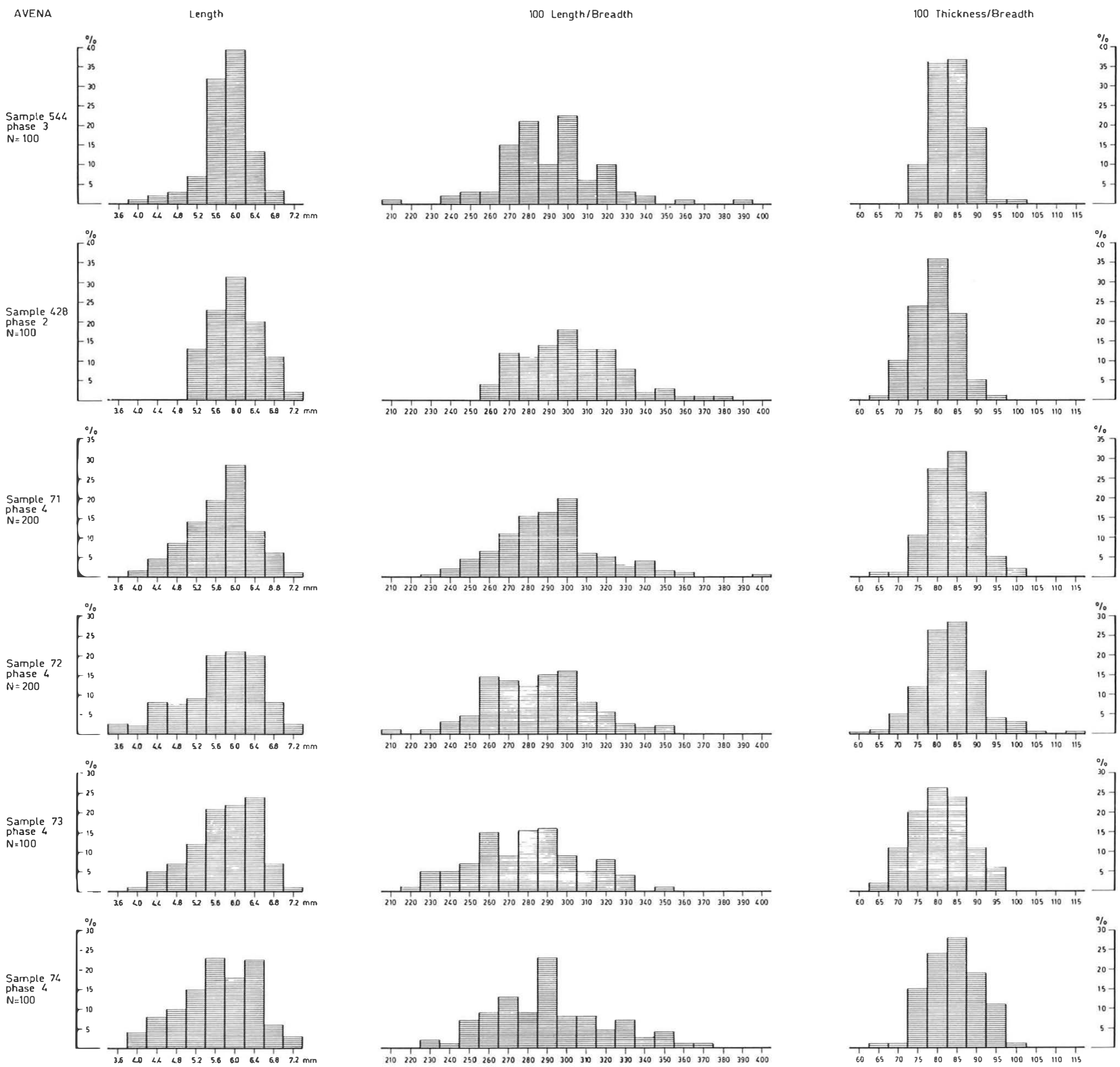


Fig. 4. Frequency distribution graphs for *Avena*.

that, on average, the carbonized grains of *A. strigosa* are smaller than those of *A. sativa*. In this connection it was interesting to see whether this difference in mean size of the two *Avena* species would find expression in the dimensions of oat grains from samples 71 and 72. As the proportion of *A. strigosa* in sample 71 is higher than that in sample 72 (30 and 21%, respectively) one could expect a lower average size for sample 71. As is clear from table 6 and fig. 4 the average dimensions of the oat grains in sample 71 are not smaller than those in sample 72; sample 71 shows even a significantly higher 100 grain weight value than sample 72. One wonders whether the possible effect of a higher proportion of *A. strigosa* on the average grain size could have been compensated for by a better quality of the crop.

Jessen and Helbaek (1944) mention the presence of grains of *A. strigosa* in pre-Roman and Roman Iron Age sites in England. In the Netherlands this oat species has so far not been found in prehistoric sites, but a medieval occurrence of *A. strigosa* has been reported by Zeven (1976). The find concerned was recovered from a building trench at the Veerweg in Wageningen. The exact locality of this find, which on the basis of the pottery is dated between A.D. 800-1200, is not known. The material has been examined by the late Professor K. Jessen (Copenhagen). The find consists of "numerous" grains or seeds (no numbers, proportions or weights are given) of *Avena sativa*, *A. strigosa* (with its variants *A. brevis* and/or *A. nudibrevis*), *Hordeum vulgare* and *Vicia sativa* (ssp. *angustifolia* and ssp. *sativa*), while in addition some weed species, such as *Polygonum lapathifolium*, *Bromus mollis* and *Rumex crispus*, are represented.

Behre (1973) found *Avena strigosa* among the carbonized grains and seeds recovered from the lowermost floor of the church of Middels, 13 km north-

TABLE 6

Dimensions in mm and index values for *Avena*.
Numbers and percentages of flower bases of *A. sativa* and *A. strigosa*.

sample	numbers of grains measured	100 grain weight in mg		L	B	T	100L:B	100T:B	(grains with) flower bases A. strigosa numbers	%	A. sativa numbers	%
418 (phase 1)	50	600	min.	4.0	1.5	1.3	208	65	–		26	
			aver.	5.67	2.02	1.64	282	80				
			max.	7.0	2.5	2.1	370	96				
428 (phase 2)	100	830	min.	5.0	1.6	1.2	259	66	–		–	
			aver.	5.99	2.00	1.58	301	80				
			max.	7.2	2.3	1.9	378	95				
544 (phase 3)	100	600	min.	4.0	1.5	1.2	208	74	1		38	
			aver.	5.79	1.99	1.65	291	83				
			max.	7.0	2.4	1.9	389	100				
71 (phase 4)	200	655	min.	3.9	1.4	1.2	233	64	274	*30.1*	637	*69.9*
			aver.	5.72	1.99	1.67	290	84				
			max.	7.4	2.6	2.2	405	100				
72 (phase 4)	200	575	min.	3.4	1.2	1.1	212	62	49	*20.9*	185	*79.1*
			aver.	5.69	2.02	1.66	284	83				
			max.	7.3	2.8	2.3	350	116				
73 (phase 4)	100	535	min.	4.1	1.6	1.2	215	63	59	*26.9*	160	*73.1*
			aver.	5.80	2.09	1.64	279	81				
			max.	7.2	2.6	2.2	350	96				
74 (phase 4)	100	575	min.	4.0	1.5	1.3	231	66	83	*26.8*	227	*73.2*
			aver.	5.75	1.99	1.67	290	84				
			max.	7.4	2.6	2.6	370	100				
403 (phase 2)		570										
91 (phase 4)		430										

TABLE 7

Dimensions in mm and index values for *Hordeum.*

sample	numbers of grains measured	100 grain weight in mg		L	B	T	100 L:B	100 T:B
418 (phase 1)	100	840	min.	4.6	2.3	1.7	158	61
			aver.	5.56	2.93	2.23	191	76
			max.	7.0	3.5	2.7	238	89
428 (phase 2)	100	1200	min.	4.6	2.4	1.8	167	59
			aver.	5.92	2.87	2.21	206	77
			max.	7.0	3.9	2.7	241	83
544 (phase 3)	100	960	min.	4.4	2.3	1.5	158	63
			aver.	5.45	2.78	2.14	197	77
			max.	6.8	3.3	2.7	250	85
454 (phase 1)		935						
403 (phase 2)		905						
539 (phase 2)		680						
540 (phase 2)		640						
545 (phase 3)		835						
72 (phase 4)		1130						

east of Aurich (Ostfriesland), in Northwest Germany. On the grounds of the archaeological evidence this find is dated to c. A.D. 1000, which dating is confirmed by a radiocarbon measurement of charred grain.

At Archsum, on Sylt, in North Germany, Kroll (1975) could establish the presence of *A. strigosa* in layers dating from the migration period (5th to 7th cent.) and from the Viking period (8th to 10th cent.).

The finds from Wageningen, Gasselte and Middels indicate that about A.D. 1000, *A. strigosa* was grown in Northwest Germany and in the Netherlands, either as a separate crop plant or mixed with *A. sativa*. It is likely that the cultivation of this species was confined to rather poor, sandy soils. More to the north, already at an earlier date *A. strigosa* seems to have been cultivated.

It is very striking that in spite of the fairly large numbers of oat flower bases not a single specimen with the characteristic oval articulation scar of *Avena fatua* was found. This could suggest that wild oat did not occur at all or that it was very rare in the fields of the Gasselte farmers. This is somewhat surprising because *A. fatua* has been recorded for various prehistoric sites in the north of the Netherlands, and at present wild oat is still an obnoxious weed in some areas. Therefore, the apparent absence of *A. fatua* at Gasselte is a phenomenon which cannot easily be explained. Behre (1973) mentions the same for Middels (see above), where among 573 oat grains with a flower base, wild oat is not represented. *A. fatua* is equally not reported for the medieval grain find from Wageningen (Zeven 1976).

3.3. Hordeum (fig. 16)

The hulled barley at Gasselte seems to be all of the six-rowed type *(Hordeum vulgare)*. Many more or less distinctly lop-sided grains were observed. In most of the grains the palea and lemma had largely or completely disappeared as a result of the carbonization. For measurements well to fairly well preserved kernels without remains of palea or lemma were selected (table 7, fig. 5). In a small number of barley grains the lemma base had still been preserved (table 8). Altogether 40 lemma bases show the horseshoe-shaped depression characteristic of the lax-eared variety of *Hordeum vulgare*, whereas in 3 lemma bases a transverse crease could be observed. One may conclude that the barley at Gasselte was predominantly of the nodding type, but that

TABLE 8

Type of impression on the lemma base of ***Hordeum vulgare***.

sample	horseshoe-shaped	transverse crease
418 (phase 1)	21	2
539 (phase 2)	1	•
540 (phase 2)	7	•
544 (phase 3)	1	1
71 (phase 4)	1	•
72 (phase 4)	5	•
73 (phase 4)	3	•
74 (phase 4)	1	•
Total	**40**	**3**

the dense-eared variety occurred as well. No rachis internodes were found.

The 100 grain weights show a considerable variation, viz. from 640 to 1200 mg (table 7). For the barley from Elisenhof, Behre (1976, table 1) de-

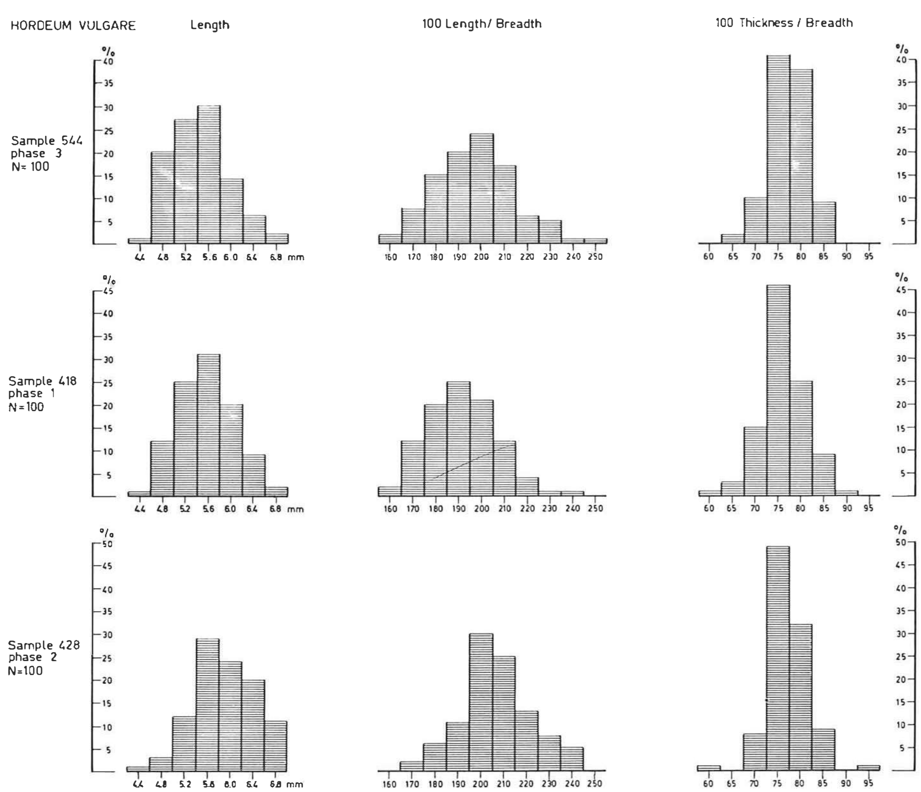


Fig. 5. Frequency distribution graphs for *Hordeum vulgare*.

termined 100 grain weights ranging from 320 tot 896 mg. In the Elisenhof barley no correlation exists between weight and size of the kernels. Consequently, Behre wonders whether in carbonized material 100 grain weight values are meaningful. In modern cereals the 100 grain weight is of great importance, but it seems that the conditions under which the carbonization took place determined greatly the weight of the charred kernels. On the other hand, it is striking that sample 428 with the greatest mean grain size shows the highest 100 grain weight.

In sample 296 (phase 2) one small grain of naked barley (3.6 × 1.9 × 1.7 mm) was found (fig. 9:4). It is clear that this single grain does not in itself point to the cultivation of *Hordeum vulgare* var. *nudum* by the Gasselte farmers. It seems that after c. 500 B.C. naked barley was no longer grown in the (north of the) Netherlands (Van Zeist (1968) 1970, p. 159). It is possible that the naked barley at Gas-

TABLE 9

Dimensions in mm and index values for *Secale*.

sample	numbers of grains measured	100 grain weight in mg		L	B	T	100 L:B	100 T:B
454 (phase 1)	200	700	min.	3.9	1.4	1.4	192	74
			aver.	5.34	2.02	1.82	266	91
			max.	7.4	2.6	2.2	400	119
296 (phase 2)	100	475	min.	3.6	1.4	1.3	176	69
			aver.	4.93	2.00	1.82	248	91
			max.	6.3	2.5	2.3	348	112
539 (phase 2)	100	500	min.	3.9	1.4	1.3	197	74
			aver.	5.24	1.91	1.70	279	90
			max.	6.6	2.6	2.2	384	114
540 (phase 2)	40	475	min.	4.2	1.4	1.3	221	78
			aver.	5.17	1.91	1.70	275	89
			max.	6.3	2.2	2.0	350	112
72 (phase 4)	100	575	min.	4.4	1.6	1.4	190	77
			aver.	5.36	2.15	1.95	252	91
			max.	6.4	2.6	2.4	354	112
456 (phase 1)		485						
295 (phase 2/3)		605						
417 (phase 3)		675						
91 (phase 4)		540						

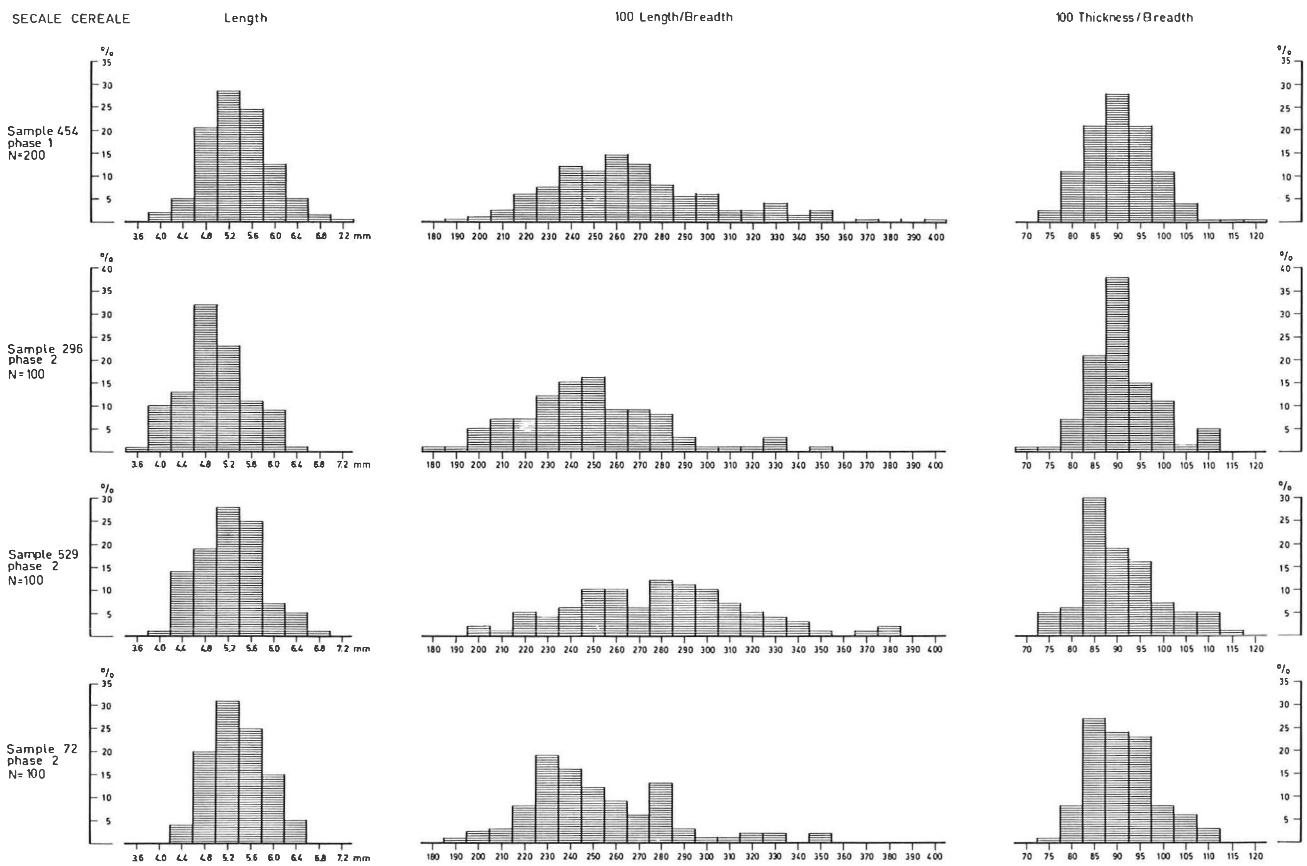


Fig. 6. Frequency distribution graphs for *Secale cereale*.

selte had originated locally, as a mutant of the hulled variety.

3.4. Secale (fig. 17)

As with oats and barley, the preservation of the rye grains differs markedly from sample to sample, and even within one and the same sample well preserved as well as seriously deformed specimens were found. As is usual in domestic rye, a great variation in the shape of the grains was observed; slender as well as plump kernels occur, which finds expression in the L:B index values (table 9, fig. 6). On average, no great differences in the dimensions of the rye grains were recorded and no tendency towards a larger or smaller grain size in the course of the habitation is suggested by the measurements. Below (chapter 5) the dimensions of the Gasselte rye grains will be compared with those of other medieval sites.

3.5. Other food plants

In samples 63 (phase 1) and 73 (phase 4) *Triticum dicoccum* (emmer wheat) is represented by a spikelet fork, while in sample 91 (phase 4) a grain of this wheat species was found. Two *Triticum* grains in sample 73 could belong either to *T. dicoccum* or to *T. aestivum* (bread wheat). It is not likely that *Triticum* was grown intentionally by the Gasselte farmers. The same is true for *Panicum miliaceum*, one grain of which was recovered from the large rye sample 454. It is striking that in the examined part of this sample a relatively large number of fruits of *Echinochloa crus-galli* was present. Although during the Iron Age, broomcorn millet must have been a rather common crop plant in the Netherlands, there is as yet no palaeobotanical evidence for its cultivation in medieval times in this area and in Northwest Germany. On the other hand, in Slavonic settlements in Central and East Europe *Panicum* grains are found in great quantities.

Altogether 5 seeds of *Linum usitatissimum* were recovered from samples 10, 12 and 417 (3.8 × 1.9, 3.7 × 1.8, 3.4 × 1.7, 3.3 × 1.7 mm). In spite of the small number of seeds one may assume that flax was cultivated at Gasselte. In this respect one should take into consideration that apparently charred linseeds provide a very incomplete if not misleading picture of flax cultivation in earlier times. In contrast to non-carbonized seeds and other remains of *Linum* which may be fairly numerous in water-logged occupation layers (e.g. in the *terpen* of the coastal areas of the north of the Netherlands and of Northwest Germany), charred linseeds are mostly rare or completely absent. The question whether flax was grown only temporarily, during phase 3, or whether it was a permanent constituent of the crop plant assortment of the Gasselte farmers, must remain unanswered.

Two leguminous crop plants are represented at Gasselte, be it very scarcely. The $^1/_{15}$ part of sample 454 which was examined yielded $1^1/_2$ seeds of Celtic bean (*Vicia faba* var. *minuta*), but from the remaining part of the sample a few more beans were selected for measuring: 7.10 (5.9 — 9.3) × 5.38 (4.8 — 6.7) × 5.32 (4.8 — 6.6) mm for 8 specimens. Although the Celtic beans occur as a minor admixture in a rye sample, one may assume that at least in the early stages of habitation *Vicia faba* was cultivated. It is not likely that this species could have maintained itself as a weed in grain fields.

The identification of half the leguminous seed, with a diameter of 3.9 mm, in sample 403 (phase 2) as *Pisum sativum* is reliable. The leguminous seed fragments in sample 295 (phase 2 or 3) are attributed to *Pisum sativum* with some reserve. The size of the fragments, 3 to 4 mm in diameter, was decisive. The same holds for the pea fragment in sample 417 (phase 3).

3.6. Spices or medicinal plants

Two species are represented at Gasselte which are used as spice (kitchen herb) and to which also curative properties are ascribed. Neither species is native to West Europe, but they can be grown here. For this reason their presence at Gasselte points to cultivation by the local population.

3.6.1. *Anethum graveolens*

Only one fruit of this species was found (sample 454). The lateral wings have not been preserved. Moreover, in the carbonized specimen the longitudinal ribs are no longer visible as such, but, instead, the oil tubes show up as ribs (fig. 7: 9). Nevertheless this fruit (2.1 mm long) could be identified as that of *Anethum graveolens*. Of dill, the seeds are used as spice and for medicinal purposes.

3.6.2. *Satureja hortensis*

The oval fruits have a domed dorsal side and a roof-shaped ventral side. The lower end is pointed (fig. 7: 3, 4). The charred fruits show a finely reticulate surface pattern. Two fruits of *Satureja hortensis* were recovered (samples 46 and 74). One specimen has been measured: 1.30 × 0.95 × 0.85 mm; the other broke prematurely. The hashed leaves of *Satureja* serve for flavouring food, while a leaf extract is used as medicine.

4. WILD PLANTS

4.1. Some remarks on seeds and fruits of wild plants

In this section some of the seeds and fruits found at Gasselte will be discussed briefly. Types which are generally known and which do not give occasion to particular remarks have not been included in the discussion.

4.1.1. *Polygonum lapathifolium/persicaria*

Because of poor preservation (puffing, damage) it was often impossible to distinguish between the fruits of *P. lapathifolium* and *P. persicaria*. For that reason these species are presented here as one type. The presence of both *Polygonum* species could be ascertained.

4.1.2. *Polygonum hydropiper*

The fruits of *P. hydropiper* are distinguished from those of *P. lapathifolium/persicaria* by the acuminate upper end and by the finely striate surface pattern. In some specimens a part of the calyx with the characteristic glands (warts) was still present.

4.1.3. *Scleranthus annuus*

In addition to the characteristic calyces (fig. 7: 13, 15), two seeds of *Scleranthus annuus* were found. The seeds are ovate in outline, with beaked upper end and rounded lower end. Surface with 10 longitudinal ridges (fig. 7: 14). Dimensions of both seeds: 1.3 × 0.8 and 1.2 × 0.8 mm.

4.1.4. *Viola cf. arvensis*

Fruits ovate in outline, more or less circular in cross-section (fig. 7: 1, 2). The lateral outgrowth at the pointed upper end is sometimes still visible in the charred fruits. The lower end with the hilum is rounded. The carbonized fruits of *Viola tricolor*, *V. arvensis* and *V. canina* cannot be distinguished from one another. Most likely *V. arvensis (V. tricolor* subsp. *arvensis)* is concerned here. Five fruits were measured: 1.56 (1.4-1.6) × 0.87 (0.8-0.9) mm.

4.1.5. *Vicia*

Most of the *Vicia* seeds have been poorly preserved. Only for specimens in which the hilum is still present could the species be determined. Seeds with a long, narrow hilum have been identified as *Vicia hirsuta*. Seeds with a wedge-shaped hilum have been attributed to *Vicia sativa* ssp. *angustifolia*.

4.1.6. *Convolvulus arvensis*

The seeds of *Convolvulus arvensis* are three-sided in cross-section. Two sides are flat, the other (outer) side is domed. At the lower end of the seed a round to oval hilum is present. The seed wall has a warty surface structure (fig. 8: 7). Four specimens were measured: 3.4 × 2.1, 3.2 × 2.2, 3.0 × 2.2 and 2.9 × 2.2 mm.

4.1.7. *Rhinanthus cf. minor*

Flat, ear-shaped seeds. The wing which surrounds the larger part of the seed has not been preserved in the carbonized specimens. Three of the four *Rhinanthus* seeds found at Gasselte were more or less swollen (not the one depicted in fig. 8: 8!). The size of the seeds (2.6 × 1.8, 2.6 × 1.6, 2.6 × 1.6, 1.8 × 1.3 mm) points to *Rhinanthus minor*.

4.1.8. *Euphrasia*

In charred seeds the seed wall has disappeared. The "inner" seeds are oblong, with a truncated upper end and a pointed lower end. At the surface a fine, transverse striation is visible. This is the same pattern as on the seed wall, but the inner seeds do not have the longitudinal ribs. The length of 5 inner seeds varies from 1.0 to 1.2 mm.

4.1.9. *Ballota nigra*

Obovate nutlets with rounded upper end and pointed lower end. The ventral side is roof-shaped, the dorsal side is somewhat domed (fig. 8: 9). The fruit surface is smooth. Two fruits of *Ballota nigra* were recovered from sample 63 (phase 1): 2.2 × 1.2 and 2.1 × 1.0 mm.

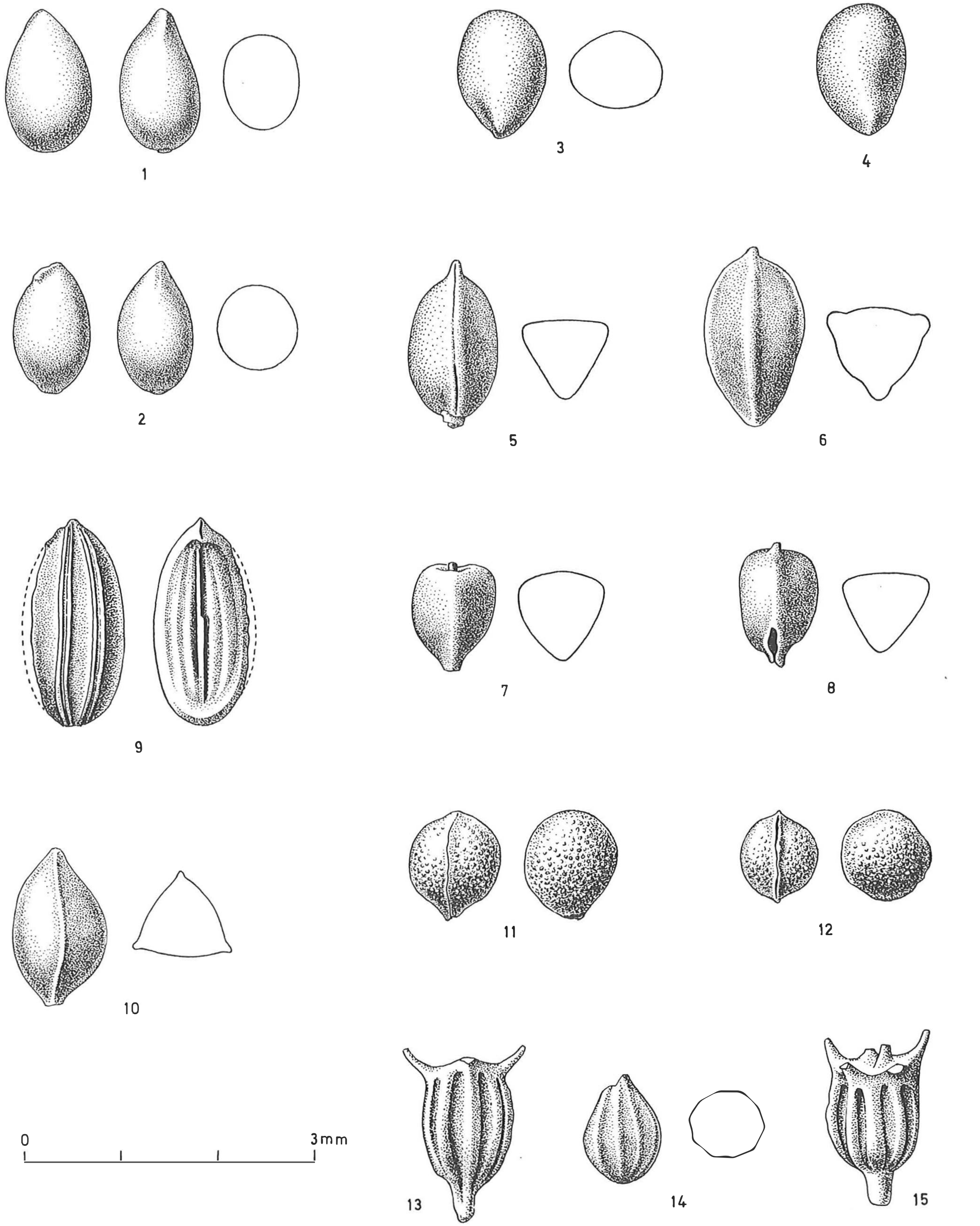
4.1.10. *Stachys arvensis*

The obovate nutlets have a roof-shaped ventral side and a domed dorsal side. The lower end is pointed (fig. 8: 10). The surface is covered with small warts which in carbonized fruits may largely have disappeared. Nine fruits measure 2.27 (1.8-2.6) × 1.62 (1.4-1.8) mm.

4.1.11. *Sherardia arvensis*

In the charred fruits of *Sherardia arvensis* the hairy,

Fig. 7. 1: *Viola* cf. *arvensis* (43); 2: *Viola* cf. *arvensis* (454); 3: *Satureja hortensis* (46); 4: *Satureja hortensis* (74); 5-6: *Carex inflata/vesicaria*-type (544); 7: *Carex serotina*-type (64); 8: *Carex serotina*-type (63); 9: *Anethum graveolens* (454); 10: *Rumex obtusifolius* (72); 11-12: *Spergula arvensis* (73); 13: *Scleranthus annuus*, calyx (72); 14: *Scleranthus annuus*, seed (72); 15: *Scleranthus annuus*, calyx (71).



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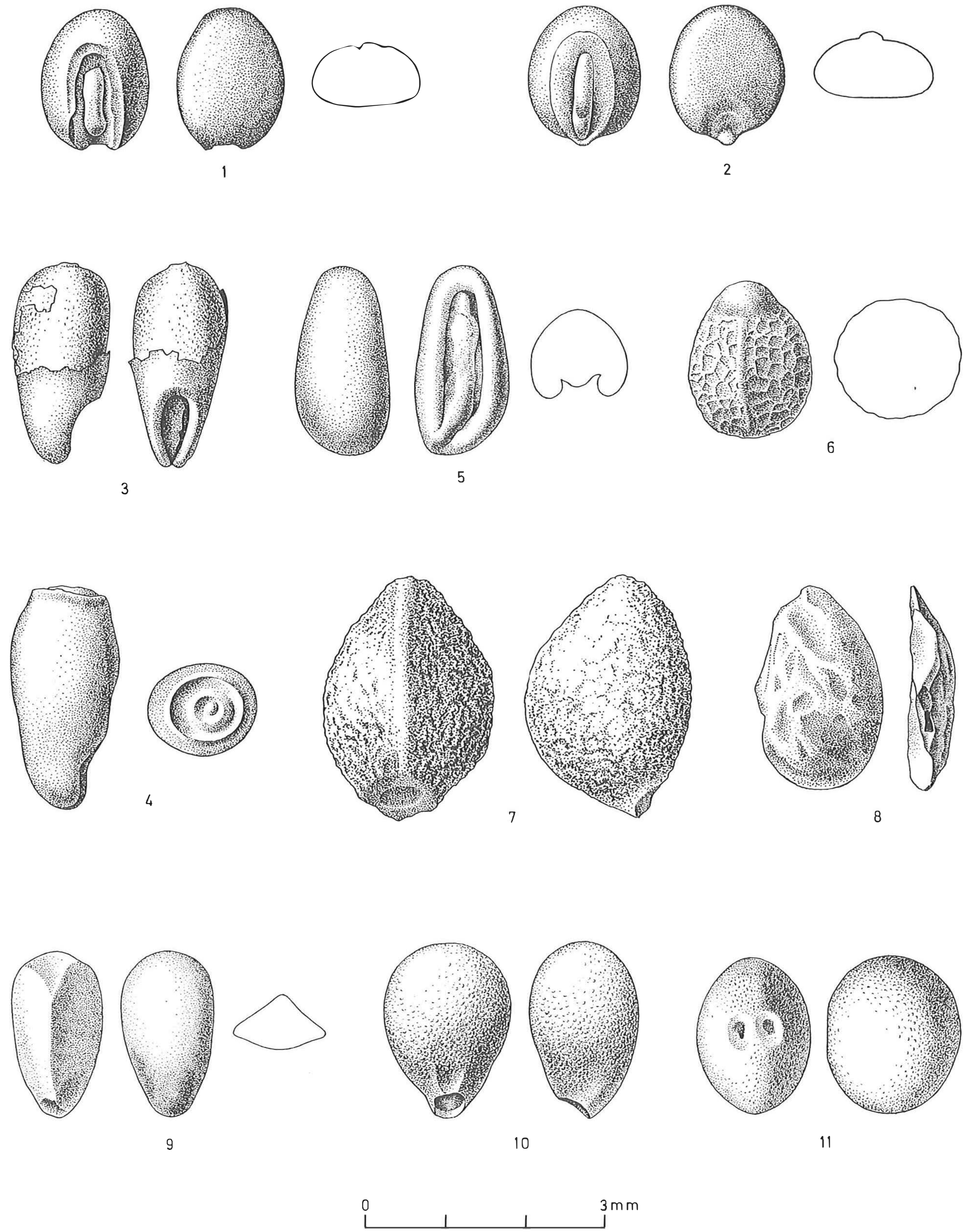
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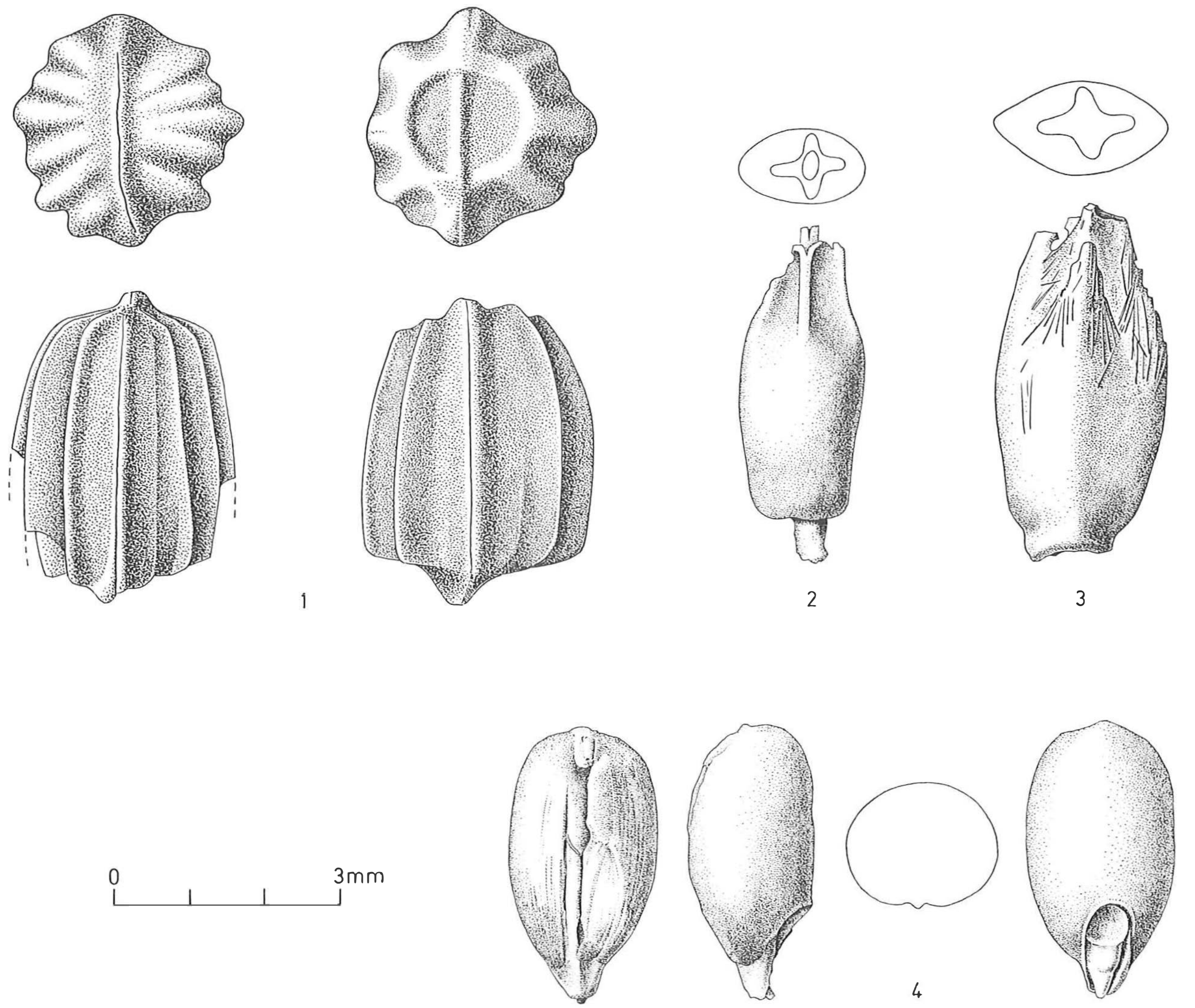


Fig. 9. 1: *Raphanus raphanistrum* (418); 2: *Knautia arvensis* (454); 3: *Knautia arvensis* (72); 4: *Hordeum vulgare* var. *nudum* (296).

toothed calyx has not been preserved (fig. 10: 2). The fruits are oval in outline with a truncated upper end. In the broad furrow at the ventral side a longitudinal ridge can be observed. The lateral sides and the domed dorsal side show a striate surface pattern. This species is represented in a few samples from phase 4. Dimensions for 5 specimens: 1.62 (1.4-18) × 1.03 (0.8-1.1) × 0.92 (0.8-1.0) mm.

Fig. 8. 1-2: *Echinochloa crus-galli* (454); 3-4: *Centaurea cyanus* (72); 5: *Plantago lanceolata* (73); 6: *Euphorbia helioscopia* (545); 7: *Convolvulus arvensis* (454); 8: *Rhinanthus* cf. *minor* (454); 9: *Ballota nigra* (63); 10: *Stachys arvensis* (71); 11: *Fumaria officinalis* (539).

4.1.12. *Knautia arvensis*

Oblong, compressed fruits with truncated upper and lower end. Characteristic of the fruits of *Knautia arvensis* are the four pronounced ridges (wings) at the upper end (fig. 9: 2, 3). The stiff hairs are sometimes still preserved. Three fruits of this type were found: 3.9 × 1.8 × 1.2, 3.9 × 1.7 × 1.0 and c. 4.6 × 2.2 × 1.3 mm.

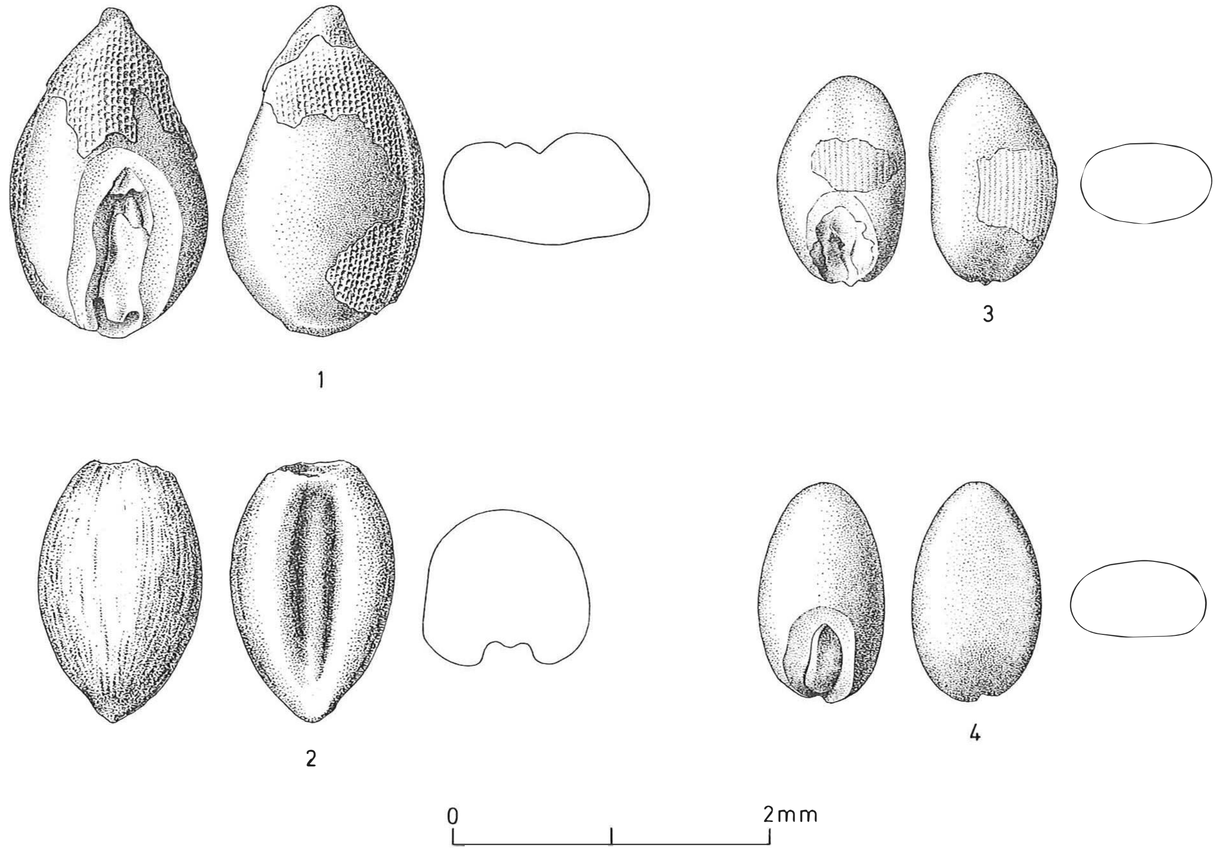


Fig. 10. 1: *Setaria viridis/italica* (544); 2: *Sherardia arvensis* (71); 3: *Digitaria ischaemum* (454); 4: *Digitaria ischaemum* (72).

4.1.13. *Centaurea cyanus*

Oblong achenes with truncated upper end and slightly tapering lower end. The lateral crescent-shaped indentation near the lower end, in which the hilum is found, extends over about $^1/_3$ of the length of the fruit (fig. 8: 3, 4). *Centaurea cyanus* is represented only in samples from phase 4. For 6 specimens the dimensions were determined: 2.63 (2.3-3.0) × 1.13 (1.0-1.2) mm.

4.1.14. *Carex*

Three types have been distinguished among the *Carex* nutlets from Gasselte.

Carex serotina-type fruits (fig. 7: 7, 8) are three-sided, obovate in outline. The upper part narrows abruptly into the style base. Length and breadth for 9 specimens from sample 544 measure 1.30 (1.2-1.5) and 0.94 (0.8-1.1) mm, respectively.

Carex inflata/vesicaria-type fruits (fig. 7: 5, 6) are three-sided, obovate to elliptic in outline, with a stipitate base. The upper part narrows more gradually into the style base. Length 1.60 (1.4-1.8) mm, breadth 0.87 (0.7-1.0) mm for 13 specimens from sample 544.

One *Carex otrubae*-type nutlet was found in sample 544 (1.5 × 1.1 mm). The charred *Carex* fruits are markedly smaller than modern and fossil, non-carbonized specimens.

4.1.15. *Millet-type fruits*

This category includes the caryopses of *Panicum*, *Digitaria*, *Echinochloa* and *Setaria*. An identification key for carbonized, naked millet-type fruits has been published by Knörzer (1971).

Panicum miliaceum is represented by one grain in sample 454 (see 3.5.).

Caryopses of *Echinochloa crus-galli* were found in various samples, but only sample 454 yielded a somewhat larger number of fruits of this species. The grains of *Echinochloa* are oval in outline with rounded upper and lower end. The ventral side is flat, whereas the dorsal side is domed. The oblong radicle shield extends over about $^3/_4$ of the dorsal side (fig. 8: 1, 2). For 11 specimens from sample 454 the dimensions were obtained: length 1.64 (1.3-2.0) mm, breadth 1.31 (1.1-1.5) mm.

Of *Digitaria (Panicum) ischaemum* only a few fruits were recovered. The caryopses of this species are more slender than those of *Echinochloa crus-galli*. The radicle shields extend over $^1/_3$ to $^2/_5$ of the dorsal side (fig. 10: 3, 4). Three fairly well preserved specimens have been measured: 1.3 × 0.8, 1.5 × 0.8, 1.4 × 0.8 mm.

In sample 544 a fruit of *Setaria viridis/italica* was found. Characteristic of this type are the long and relatively narrow radicle shield and the papillose surface of the palea and lemma (fig. 10: 1).

4.2. The ecological significance of the wild plants

From a superficial inspection of table 3 it is already clear that the majority of the wild plants are weeds from fields, waste places and roadsides. This also finds expression in table 10 in which it is indicated which syntaxonomic units are suggested by the plant species, seeds or fruits of which were recovered from the Gasselte samples. Only higher syntaxonomic units (classes) are shown. It has not been attempted to arrive at the reconstruction of lower syntaxonomic units, such as associations or orders. A plus sign indicates whether the species at the left side of the table is found in one or more of the phytosociological units deduced for Gasselte.

In table 10 the results of all samples from Gasselte have been combined. Before each plant name it is indicated in which of the four phases distinguished at Gasselte the species concerned is represented. One could wonder whether it is justified to combine samples which may differ from each other in age by several hundreds of years. However, from table 10 it appears that in each phase the postulated syntaxonomic units are represented by a smaller or larger number of species. Consequently,

TABLE 10

Vegetation types established for Gasselte.

Phases		Chenopodietea	Secalinetea	Molinio-Arrhenatheretea	Phragmitetea
1,2,3,4	Polygonum lapathif./persicaria	+	•	•	•
1, 3,4	Polygonum hydropiper	+	•	•	•
1,2,3,4	Polygonum aviculare	+	•	•	•
4	Rumex obtusifolius	+	•	•	•
1,2,3,4	Chenopodium album	+	•	•	•
1,2, 4	Stellaria media	+	•	•	•
1, 4	Anagallis arvensis	+	•	•	•
1,2,3,4	Stachys arvensis	+	•	•	•
1,2	Convolvulus arvensis	+	•	•	•
2	Fumaria officinalis	+	•	•	•
3	Euphorbia helioscopia	+	•	•	•
1	Ballota nigra	+	•	•	•
1	Galeopsis cf. tetrahit	+	•	•	•
4	Melandrium album/rubrum	+	•	•	•
1,2,3,4	Echinochloa crus-galli	+	•	•	•
1, 4	Digitaria ischaemum	+	•	•	•
4	Poa annua	+	•	•	•
1,2,3,4	Rumex acetosella	+	+	•	•
1,2,3,4	Spergula arvensis	+	+	•	•
1,2,3,4	Raphanus raphanistrum	+	+	•	•
1,2,3,4	Polygonum convolvulus	•	+	•	•
1,2,3,4	Scleranthus annuus	•	+	•	•
1,2	Viola cf. arvensis	•	+	•	•
4	Sherardia arvensis	•	+	•	•
1, 3,4	Bromus cf. secalinus	•	+	•	•
4	Centaurea cyanus	•	+	•	•
1, 4	Euphrasia	•	+	•	•
2,3,4	Vicia hirsuta	•	+	•	•
1,2,3,4	Vicia sativa ssp. angustifolia	•	+	•	•
1, 3,4	Potentilla reptans	•	•	+	•
1,2	Rhinanthus cf. minor	•	•	+	•
1,2,3,4	Plantago lanceolata	•	•	+	•
1, 4	Knautia arvensis	•	•	+	•
4	Ranunculus acris	•	•	+	•
1, 4	Poa pratensis/trivialis	•	•	+	•
1,2, 4	Galium palustre	•	•	•	+
1,2,3,4	Eleocharis	•	•	•	+
1, 3,4	Carex serotina	•	•	•	+
3	Carex inflata/vesicaria	•	•	•	+
3	Carex otrubae	•	•	•	+
3	Menyanthes trifoliata	•	•	•	+
1,2,3,4	Phragmites australis	•	•	•	+

a subdivision into phases would not have led to a more differentiated result.

The class of the Secalinetea comprises weed associations from winter-grain fields indicating that at least part of the cereal crop plants at Gasselte were winter-sown, i.e. sown in the autumn. Some particular attention should be paid to *Centaurea cyanus*, which became such a characteristic plant in winter-grain fields on sandy soils. It is striking that this species is only represented in phase 4, suggesting that cornflower did not arrive in the north of the Netherlands until c. A.D. 1000. The conspicuous absence of *Avena fatua*, a characteristic species of the Secalinetea, has already been discussed (3.2.). The absence of Secalinetea species, such as *Agrostemma githago*, *Sinapis arvensis* and *Papaver rhoeas*, may be due to the rather acid soil conditions at Gasselte (see below).

Plant communities from summer-grain fields, root-crop fields and ruderal (nitrate-rich) habitats are included in the class of the Chenopodietea. Some of the species listed under this class, such as *Spergula arvensis*, *Raphanus raphanistrum*, *Anagallis arvensis*, *Stachys arvensis* and *Fumaria officinalis*, were most likely confined to fields, but many others may have grown on waste ground in and near the settlement as well. The complete absence of the *Atriplex hastata/patula* seed-type could indicate that vegetations of ruderal habitats were not common at Gasselte. For both *Atriplex* species are abundant in waste places, on refuse heaps and such-like. In this connection it should be mentioned that seeds of *Urtica dioica*, another plant from nitrate-rich, disturbed habitats, have equally not been found.

Spergula arvensis, *Scleranthus annuus*, *Rumex acetosella*, *Viola arvensis* and *Digitaria ischaemum* point to fairly acid soils. The botanical evidence is in conformity with the present-day soil conditions in the area (1.2.). It should be mentioned that, on the other hand, the evidence for the presence of *Sherardia arvensis* in the fields of the Gasselte farmers cannot easily be reconciled with acid soil conditions. This species prefers clayey and calcareous soils. *Polygonum hydropiper* could indicate that the fields extended into lower-lying, moist places.

In addition to the species from fields and other disturbed soils, a rather small number of plants from other habitats is represented. The grassland species (Molinio-Arrhenatheretea) were probably found in the small valley to the east of the settlement (fig. 1) or in other moist places. The grassland vegetation is not a natural one, but must have come into existence after the clearing of the forest. The marsh-plant species established for Gasselte (Phragmitetea) probably occurred in and near the streamlet at the bottom of the valley, but some of them may have originated from the Hunze depression. In this connection mention should be made of the fact that in various samples stem fragments were found which are at least in part of reed *(Phragmites australis)*. For distinguishing between reed and straw well-preserved stem nodes are required. In *Phragmites* the nodes have axillary buds which are lacking in straw (cf. Körber-Grohne, 1967, p. 136). For a few stem fragments it could be ascertained that they are of reed.

Calluna vulgaris and *Erica tetralix* are heathland species. The charred heather stems, which in a few samples occurred in somewhat larger numbers, may point to the use of *Calluna* for roofing.

4.3. Wild fruits

Remains of the wild fruits are very scarce. Hazel is represented by a few nutshell fragments, a part of the fruit stone of *Pinus spinosa* was recovered, and one pip of (wild) strawberry is present. These fruits could have been collected in the vicinity of the site. The charred acorns from sample 573 could give rise to the question whether in medieval Gasselte acorns were still gathered for human consumption. Finds of charred acorns suggest that in prehistoric times these fruits served as food for man (cf. Knörzer, 1972; van Zeist (1968) 1970). Unfortunately, it is uncertain whether the pit from which sample 573 was taken belongs to the Gasselte settlement, which makes a further discussion irrelevant.

5. COMPARISON WITH OTHER SITES

5.1. The crop plant assortment in medieval times

The plant husbandry of Gasselte is no isolated case, and it is self-evident that it should be compared with that of other medieval sites. Synthesis of the botanical evidence obtained from various sites should lead to the reconstruction of the plant hus-

TABLE 11

Crop plant species in medieval sites. The location of the sites is indicated in fig. 11.

+++ = very common; ++ = common; + = present; r = rare.

	Archsum, Sylt (8th-10th cent.)[1]	Elisenhof (8th-10th cent.)[2]	Haithabu (8th-10th cent.)[3]	Middels (c. A.D. 1000)[4]	Gasselte (A.D. 850-1150)	Odoorn (5th-9th cent.)[5]	Den Burg (6th-9th cent.)[6]	Wageningen (9th-12th cent.)[7]	Kootwijk (A.D. 750-1000)[8]	Dorestad (8th-9th cent.)[9]
Number of samples	38	> 68	5	6	53	8	1	1	7	7
Secale cereale	+++	r	+++	+++	+++	+++	+++	•	++	++
Hordeum vulgare/distichum	+++	+++	+++	+	+++	+	++	+++	++	+++
Avena sativa/strigosa	+++	++	+	++	+++	?	•	+++	++	++
Triticum aestivum/dicoccum	r	r	+	•	r	r	•	•	•	+
Linum usitatissimum	r	++	r	++	r	•	•	•	++	•
Vicia faba	r	+++	+	•	r	•	•	•	•	r
Pisum sativum	•	•	•	•	r	•	•	•	•	r

1 Kroll 1975, tables 12 and 13
2 Behre 1975, 1976
3 Behre 1973
4 Behre 1969
5 van Zeist (1968) 1970, table 53
6 van Zeist (1968) 1970, table 55
7 Zeven 1976
8 Pals & van Geel (1976) 1978
9 van Zeist 1969

bandry in a larger area. About 10 years ago no other sites would have been available for comparison with medieval Gasselte. Since then the results of the palaeoethnobotanical examination of a number of medieval settlements in the Netherlands and in North and Northwest Germany have been published. In table 11, the relative crop plant frequencies in the sites concerned are presented. The location of the sites is shown in fig. 11.

In evaluating the data presented in table 11, the following should be taken into consideration. The relative frequencies are more or less impressionistic figures or at best rough estimates. The degree in which the botanical evidence may be considered to be representative varies greatly among the sites concerned. From Wageningen and Den Burg only one sample was examined, whereas the information for Archsum, Elisenhof and Gasselte is based upon a great number of samples. The sites are not wholly contemporaneous, but they fall within a time range of 600 to 700 years, with a concentration in the 8th to 10th centuries A.D. Moreover, samples from one and the same site may differ in age by several hundreds of years. The sites included in table 11 are scattered over a large area (fig. 11). Finally, the soil conditions in the vicinity of the sites under consideration are not the same. Predominantly sandy soils occur near Middels, Gasselte, Odoorn, Den Burg, Wageningen and Kootwijk. Sandy loam and loamy sand are reported for the vicinity of Haithabu. Archsum, on the island of Sylt, is situated on a sand ridge, surrounded on three sides by salt marshes. The prehistoric and early historic habitation of Archsum ranges from the late Neolithic to A.D. 1000. In table 11, only Viking Age data are included for Archsum. The inhabitants of Elisenhof had to make a living in the brackish environment of a salt marsh area with clayey soils. Near Dorestad agriculture would have been practised on stream-ridge soils *(stroomrug-gronden)*: well-aerated, calcareous, sandy clays.

In spite of the differences mentioned above, some general features of plant cultivation during the middle ages emerge from table 11. Rye, oats and barley must have been the most common cereal crop plants in the area under consideration. The absence of rye in Wageningen and of oats in Den Burg may be due to the fact that the botanical information of both sites is based upon only one sample. For Odoorn it could not be ascertained whether wild or domestic oat is concerned there. At Elisenhof, the brackish soil conditions were unsuitable for rye cultivation. Barley has been cultivated in the area since the Neolithic, but rye did not become an important crop plant until early medieval times. In the coastal area, the cultivation of oats may have started in the first centuries A.D. (Feddersen Wierde, Körber-Grohne 1967). The possible role of *Avena strigosa* has been discussed above (3.2.).

Triticum dicoccum, which played such a prominent part in the economy of prehistoric farmers, seems to have virtually disappeared from the area in early medieval times. On the sandy soils, emmer wheat was replaced by rye and oats. Only in areas with loamy or clayey non-saline soils, such as in the vicinity of Dorestad and Haithabu, bread wheat *(Triticum aestivum)* may at least partly have taken the place of emmer wheat. It is striking that *Panicum miliaceum* very probably did not form part of the crop plant assortment of the medieval farmers in the area under consideration. As has already been mentioned above (3.5.), broomcorn millet was one of the major crop plants in Slavonic settlements of

Fig. 11. Location of sites mentioned in table 11.

Central and East Europe, dated to the 7th-12th centuries A.D.

The representation of linseed *(Linum usitatissimum)* varies much more than that of the cereals. This may be due to a great extent to the fact that apparently for linseeds the chances of becoming carbonized were much smaller than for cereals. Only from Middels were a considerable number of charred linseeds recovered; nearly all linseeds from Elisenhof and Kootwijk, in which sites *Linum* is well represented, are non-carbonized. Although the available palaeobotanical evidence does certainly not justify the conclusion that flax was grown everywhere in the middle ages, one may assume that at least locally or regionally it was an important crop plant.

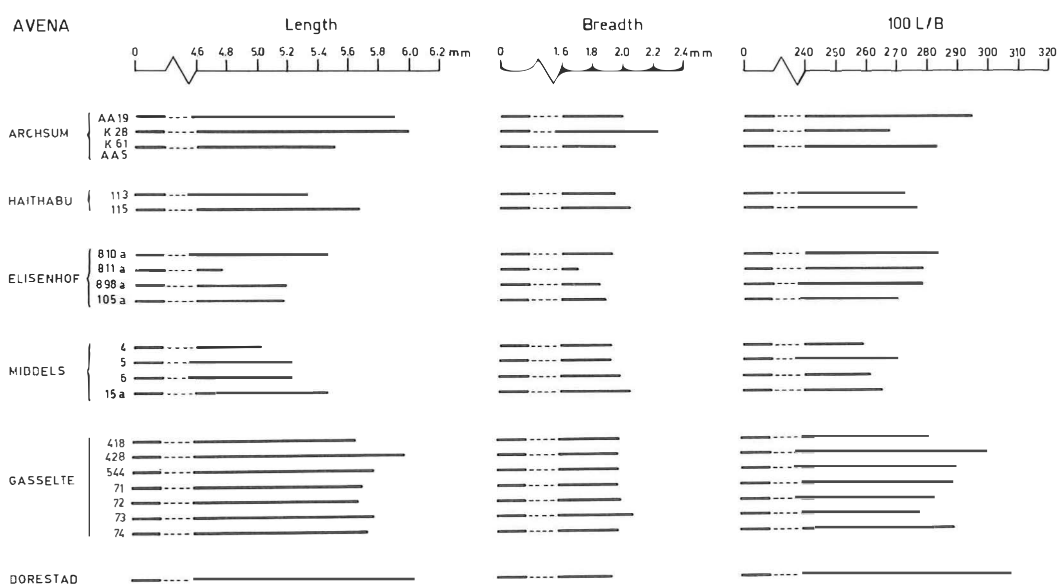
The evaluation of charred Celtic beans in terms of the economic importance of this species in earlier times is likewise difficult. The majority of the remains of *Vicia faba* recovered at Elisenhof consists of non-carbonized seeds, pods and stems. Only about 19% of the beans was carbonized. Körber-Grohne (1967) arrived at a similar result for the Feddersen Wierde (1st to 4th centuries A.D.): compared to the non-carbonized remains of *Vicia faba*, the numbers of charred beans were small. The evidence from Elisenhof and the Feddersen Wierde suggests that Celtic bean may seriously be under-represented in the charred seed record, that is under-represented in proportion to cereals. It is true that finds consisting of a great number of Celtic beans have been reported (cf. Schultze-Motel, 1972), but they are an exception. It seems justified to assume that in medieval times, *Vicia faba* was cultivated not only in the brackish environment of the coastal salt marsh areas, but also in the interior of the Netherlands and of Northwest and North Germany. It is doubtful whether in the economy of inland sites Celtic bean played as important a part as in that of coastal sites. Table 11 suggests that *Pisum sativum* did not constitute a widespread and common crop plant, but that it was locally grown.

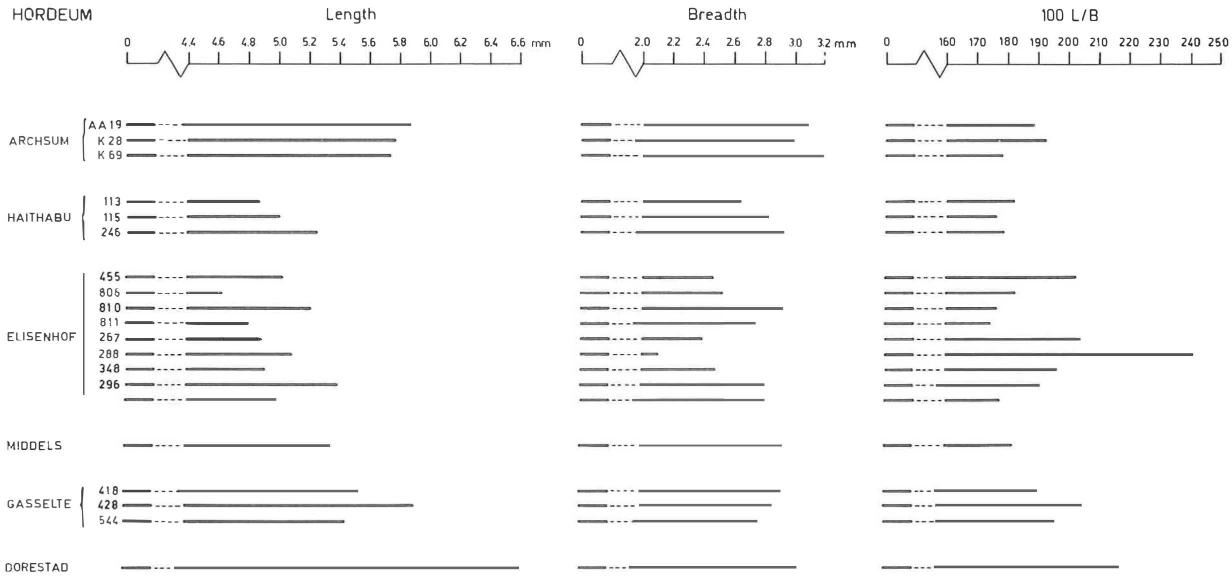
5.2. Comparison of grain sizes

In this section the dimensions of oats, barley and rye from Gasselte will be compared with those from the other medieval sites included in table 11. In this connection it should be mentioned that for Den Burg, Wageningen and Kootwijk no measurements are (yet) available.

One may wonder whether it would have been appropriate to start with a discussion on the kind of

Fig. 12. Mean dimensions for *Avena* from various sites. Only measurements of naked grains are presented in this figure.

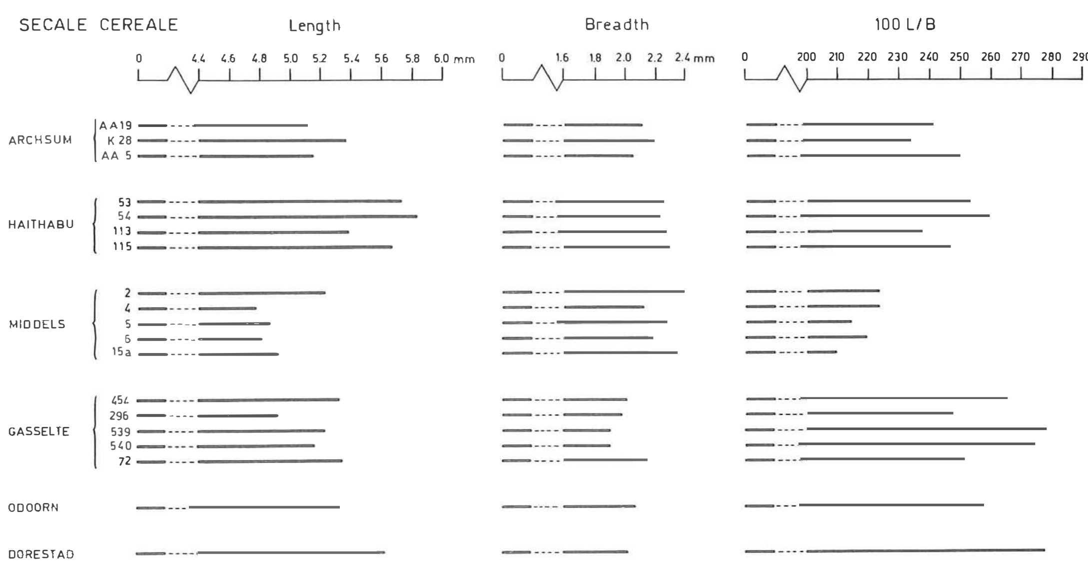




information one expects to obtain from such a comparison. How far is it meaningful to compare dimensions of cereal grains (and of other fruits and seeds) from different sites? Are differences in dimensions due to differences in environmental conditions such as soil and weather, or do they rather point to different varieties or races? Instead of starting from specific questions we shall rather discuss what conclusions and comments can be justified by

Fig. 13. Mean dimensions for *Hordeum* from various sites. Only measurements of grains without palea and lemma are presented in this figure.

Fig. 14. Mean dimensions for *Secale cereale* from various sites.



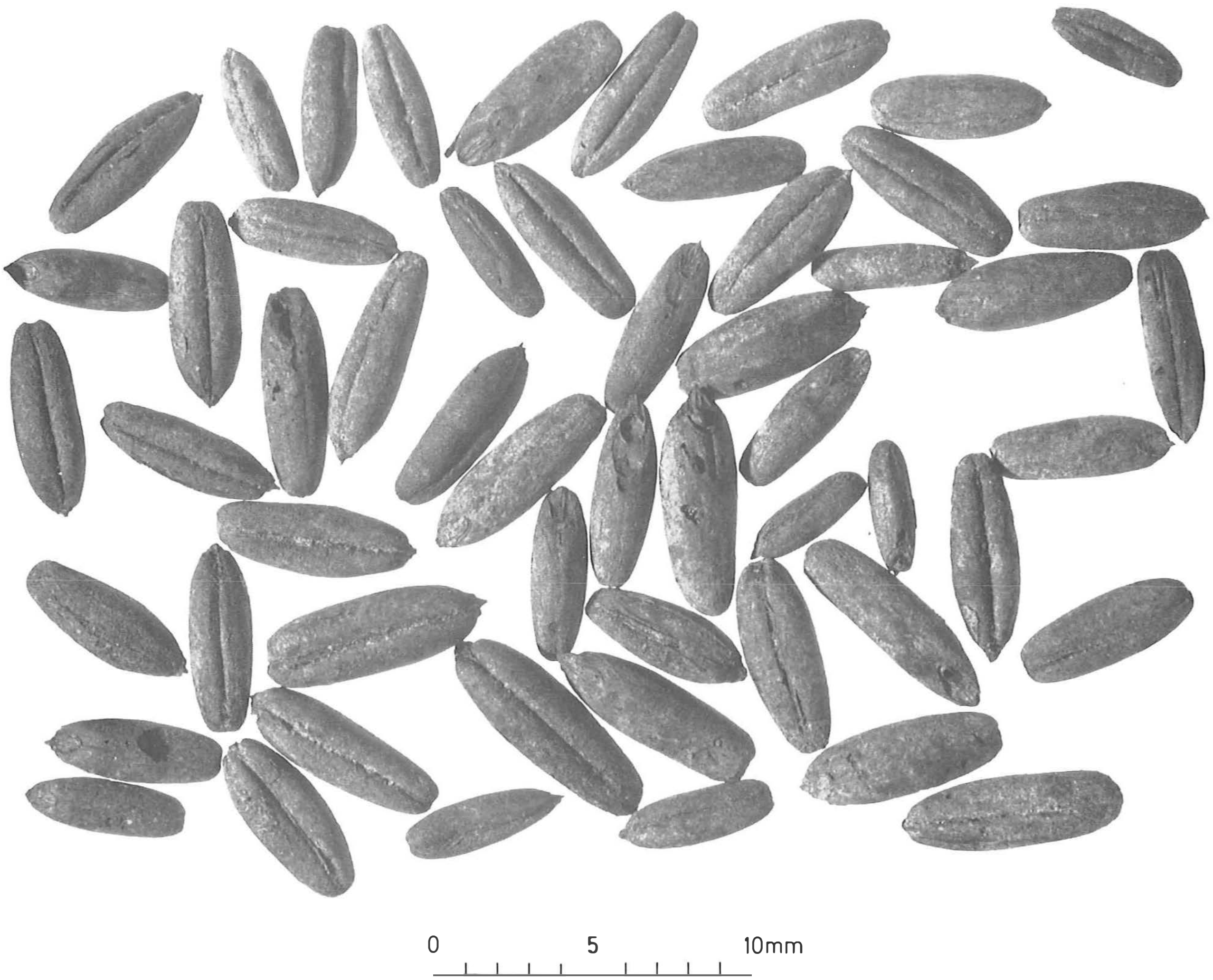


Fig. 15. *Avena sativa/strigosa*, sample 71.

the measurements. This discussion will be far from exhaustive. It is mainly intended to evoke some more discussion on this subject. In the last few years fairly large numbers of measurements of seeds and fruits have been published, but so far these data have been drawn very little into the discussion.

The comparison of the dimensions will be confined to length, breadth and L:B index. In figs. 12-14 these values are presented for oats, barley and rye. It goes without saying that for the cereals concerned the length is most indicative of the size (volume) of the grains. In addition to the length, the breadth is an important measurement; a smaller length can, at least in part, be compensated for by a greater breadth. It is true that the volume of the grains is also dependent on the thickness, but for a comparison of sizes – in other words, in discussing relative grain sizes – the thickness is of less importance, at least in the case of oat, barley and rye kernels. Grain weights should be well suited for comparing grain sizes, but apparently this does not work for carbonized grains (see 3.3.). For this reason 100 grain weights are not shown in figs. 12-14. The presentation of the L:B index values may appear to be somewhat superfluous as they are not independent data. However, these values have proved to be very useful in comparing grain sizes.

The average size of the oat grains from Gasselte is

Fig. 16. *Hordeum vulgare*, sample 428.

exceeded by those from Dorestad and Archsum (fig. 12). The oat grains from Dorestad show the highest mean L:B index value indicating that they are most slender on the average. The average length of the oats from Middels, Elisenhof and Haithabu is not only less than that from Gasselte, the grains of the former sites are also plumper (they show lower L:B index values).

It is clear that there are differences in the average dimensions of the oat grains from the various sites. It is tempting to ascribe the greater average length of the Dorestad oats to the favourable soil conditions in the vicinity of that site. On the other hand, the slenderness of the Dorestad grains cannot easily be explained as the result of good soil, but this points rather to differences in the oat varieties grown at Dorestad and the other sites. A similar explanation forces itself in comparing the oats from Gasselte and Middels, two sites with comparable soil conditions. The average length of the oats from Middels is distinctly less than that from Gasselte, but the breadth is about the same, implying plumper kernels at Middels. In view of the clayey soils near Elisenhof the relatively small size of the oat grains from that site may seem astonishing at first sight, but the salinity of the soil may have had an unfavourable influence on the quality of the crop. The fact that *Avena strigosa* was present in some sites and not in others could account for part

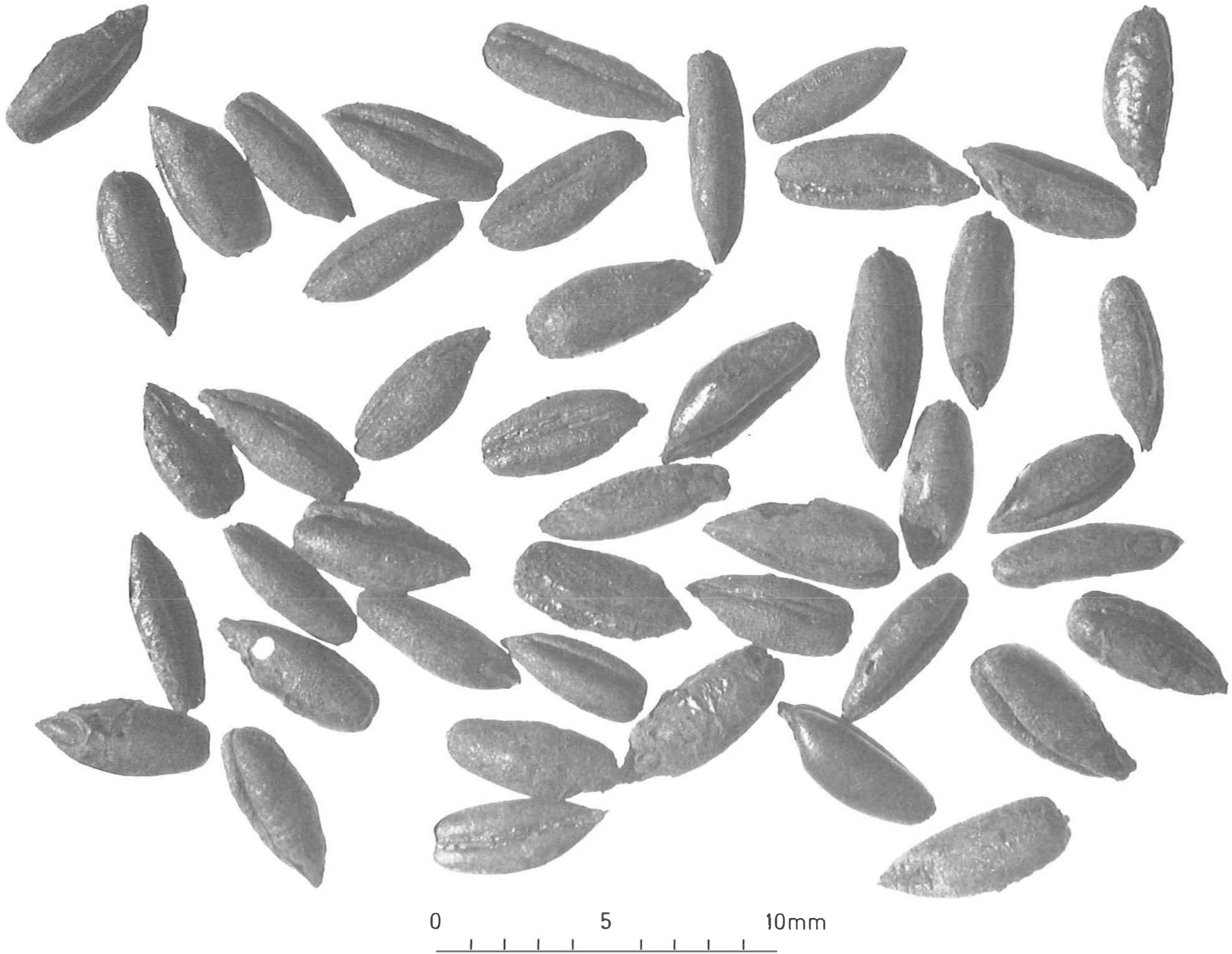


Fig. 17. *Secale cereale*, sample 72.

of the differences in mean dimensions. As for Gasselte a possible effect of *Avena strigosa* on the mean dimensions of oat grains could not be demonstrated (3.2.), it is not meaningful to draw this factor into the discussion.

The dimensions of the barley grains (fig. 13) provide a picture which in broad outline is comparable to that for oats. Dorestad has conspicuously large barley grains which, again, is in conformity with the favourable soil conditions. It should, however, also be taken into consideration that the Dorestad barley is *Hordeum distichum*, whereas for the other sites *Hordeum vulgare* is concerned. The barley grains from Middels are, on average, somewhat smaller as well as plumper than those from Gasselte. The same has been established for the oat grains from the two sites. The barley from Elisenhof has a rather small average grain size, probably due to the saline soil conditions. One wonders whether the widely varying mean length and mean L:B index values at Elisenhof reflect the effects of fluctuating weather conditions. Thus, dry summers must particularly have had an adverse effect because of the increase in the salinity of the soil. The barley from Haithabu is comparatively small. This small grain size seems difficult to reconcile with the fairly good soil conditions (loamy sand to sandy loam) in the Haithabu area (see below).

With respect to the dimensions for rye kernels presented in fig. 14 the following can be remarked. There is a striking difference between the rye from Gasselte and Middels. The rye grains from Middels are, on average, shorter than those from Gasselte, but at the same time the former show a greater average width. As is clear from the L:B index values, the Middels rye is conspicuously plumper than that from Gasselte. Rye grains usually show a great variation in shape; short and plump as well as long and slender grains occur in the same sample. It seems that in the rye grown by the Middels farmers the proportion of plump grains is considerably greater than at Gasselte and the other sites represented in fig. 14. This may point to different varieties.

The quality of the rye grains from Haithabu is only equalled by that from Dorestad. This suggests that at Haithabu conditions were favourable for cereal cultivation as may be expected for an area with sandy loam and loamy sand soils. As has been mentioned above the barley from Haithabu has a rather small grain size which is difficult to explain in terms of unfavourable growing conditions. The large size of the Haithabu rye indicates that, indeed, other factors than the quality of the soil must be held responsible for the rather small size of the barley grains. In contrast to barley and oats which show a comparatively large grain size at Archsum, the rye from that site is rather small-grained.

From the brief discussion of the dimensions of the cereal grains it seems evident that in addition to soil and weather conditions, differences in crop plant varieties may account for the variation in size and shape of the kernels. In any case it is clear that no simple explanation for the differences in the average dimensions of the grains presents itself from the available data.

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