DIET AND VEGETATION AT ANCIENT CARTHAGE
THE ARCHAEOBOTANICAL EVIDENCE

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1 INTRODUCTION

1.1 **History of the site**

The palaeobotanical study of ancient Carthage, eighteen km east-northeast of Tunis (Fig. 1), is the subject of the present publication. The name of Carthage strikes the imagination; it is associated with a glorious but also tragic past. By way of introduction, a brief outline of the history of this famous city is presented below.

An ancient tradition says that in 814 BC, a party of pioneers led by Princess Elisa fled Tyre in Lebanon, the homeland of the Phoenicians, and founded Carthage on a hilltop now called the Byrsa. They called the newly founded colony Qart Hadasht (new town) from which the name of Carthage is derived. Leaving aside what may be true of this story, Carthage was founded as a Phoenician trading colony, one of many across the Mediterranean. The earliest archaeological evidence so far of Phoenician occupation of the site dates back to the eighth century BC (Niemeyer 1992; Stager 1992). The colony developed into an independent and prosperous mercantile centre controlling overseas trade in the western Mediterranean. The eastern Mediterranean was under Greek control. In the third century BC, Carthage stood at the summit of its power. To protect their trade routes, large territories in the western Mediterranean basin had been colonised by the Carthaginians. Its powerful and lucrative trading empire ultimately led to its fall. Between 264 and 146 BC the Carthaginians fought three bitter wars with the Romans (the so-called Punic wars) for the hegemony over the western Mediterranean, which ended in a horrifying disaster: Punic Carthage was razed to the ground. As for the term 'Punic', the Romans referred to the inhabitants of Carthage as 'Puni' (= Phoenicians). The Carthaginians were not only clever merchants, they were also skilful agriculturists. A Punic handbook on agriculture, consisting of 28 volumes and attributed to a certain Mago, was translated into Greek and Latin, the latter by enactment of the senate of Rome.

Some hundred years after its fall, in the second half of the first century BC, Carthage was rebuilt by the Romans on the ruins of the Punic city. Under Roman sovereignty Carthage flourished as a transit port between Africa and Rome, it became the capital of Roman Africa, and it grew into one of the largest and richest cities of the Roman Empire. It no longer had political power, but with the advent of Christianity it became an important religious centre. In the fourth and fifth centuries AD the Roman grip on North Africa slackened, and in 439 Carthage was taken by the Vandals and made into the capital of the Vandal kingdom established in North Africa. The Vandals, in turn, were expelled by troops of the Eastern Roman Empire (with Byzantium, the present Istanbul, as capital), and from 533 to 697 Carthage was a Byzantine city. Finally, in 698 it was once again completely destroyed, now by the Arabs who brought the whole of North Africa under their authority. Under Vandal and Byzantine rule Carthage may never have regained the prosperity of the first few centuries AD.

At present little reminds one of the glorious past of Carthage. Remains of monumental architecture are scarce; most traces of ancient Carthage still preserved are buried beneath the surface. This should be no great surprise if one considers that in ancient times the city was more than once destroyed and that for centuries the ruins were used for quarrying building material. One may assume that from the beginning Carthage had a good (natural) harbour, which enabled its growth into a thriving and mighty trading port. It is still unknown where the early-Punic harbour was located. The classical harbours, which have survived up to the present and which play a very prominent part in the palaeobotanical study, date back to the middle of the fourth century BC at the earliest.

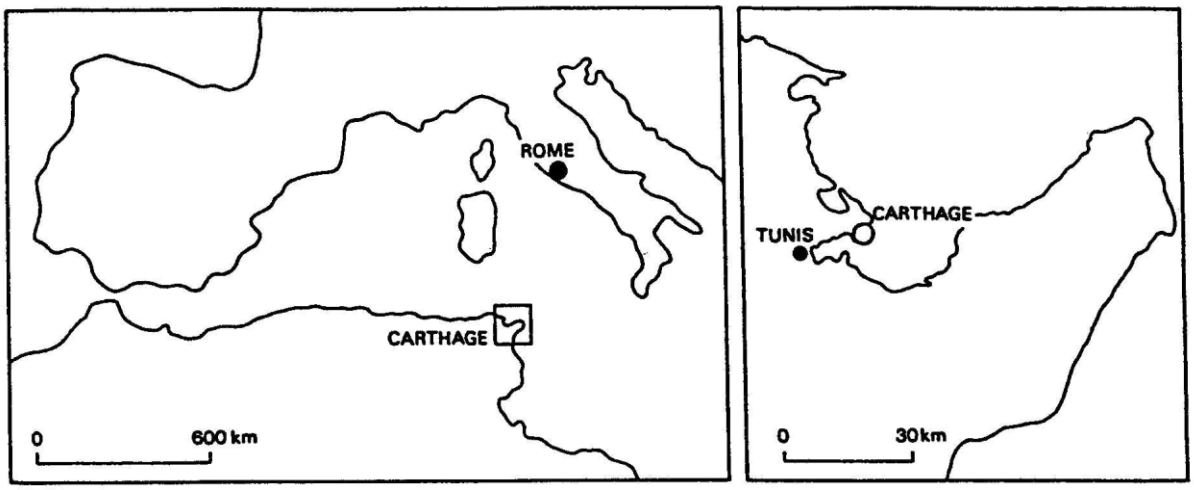

Figure 1. Location map of Carthage.

1.2 **The international 'Save Carthage' project**

By the early 1970's the strongly increased building activities on the site of ancient Carthage became a matter of grave concern. The archaeological potential of the site was seriously threatened. A program of archaeological rescue excavations in places that had not yet been built over was most urgent. Such a project was far too extensive to be coped with by Tunisian archaeologists alone. For that reason, under the aegis of the United Nations Educational, Scientific and Cultural Organization (UNESCO) an appeal was launched to the international community to participate in the 'Campagne internationale pour la sauvegarde et la mise en valeur du site de Carthage'. Host was the Tunisian Institut National d'Archéologie et d'Art (INAA), under its then director Dr. A. Beschouach. On behalf of the INAA the supervision of the project was in the hands of Dr. A. Ennabli, conservateur du site et du Musée de Carthage. A large number of archaeological institutions in Europe and America responded to the appeal, and in the mid 1970's excavations in the framework of the Save Carthage project began.

In 1977 the Biologisch-Archaeologisch Instituut (at present, Groningen Institute of Archaeology) of the University of Groningen became involved in the Save Carthage campaign. Through the Netherlands Ambassador in Tunisia and the Ministry of Education and Science the Groningen institute was approached with the request to contribute to the Carthage excavations by undertaking archaeobotanical research. The initiative came from the British and American excavators of the classical harbour sites, Professors Henry R. Hurst and Lawrence E. Stager, respectively. The request resulted in the participation of a Dutch mission in the Save Carthage project. The contribution of the Dutch (*in casu*, Groningen) team should consist of:

1. The study of macroscopic plant remains, such as seeds, fruits and wood, recovered from occupation deposits.
2. The palynological examination of sediments suited for the purpose.

The very modest Dutch mission should not carry out excavations itself, but in cooperation with the archaeological teams working in Carthage, samples for palaeobotanical examination should be secured at the sites concerned. The proposed sampling program turned out to be slightly too ambitious. In practice, it was impossible to carry out extensive sampling programs on all areas of excavation. As a result, some sites have far from satisfactorily been sampled for the study of archaeological plant remains. Admittedly, not all sites lent themselves equally well for archaeobotanical research. From a botanical point of view the two

harbour sites were the most rewarding, and here most effort was concentrated. In addition to the sampling by members of the Dutch team, samples were collected by the archaeologists of the various excavations.

Through 1977-1981, four seasons of fieldwork were spent in Carthage. Except for the pollen samples, the soil samples were treated in the field to concentrate the plant remains (see chapter 2). In addition to the sampling and sample treatment, fieldwork included the study of the vegetation in the (wide) surroundings of Carthage and the collecting of modern reference material (plants, pollen, seeds and wood). The Dutch participants in the archaeobotanical fieldwork included: Willem van Zeist (1977, 1978, 1979, 1981), Marijke van der Veen (1977, 1978) and Guus Lange (1978). In addition, members of the other teams have been most helpful.

The laboratory examination of the samples collected at Carthage was executed in the palaeobotanical department of the Groningen Institute of Archaeology.

1.3 **The area of the classical harbours**

By far the majority of the archaeobotanical data discussed in the present publication derive from deposits in the area of the circular and rectangular harbours, remains of which are still present in the form of a semi-circular and an oblong water basin, respectively. As an introduction to the discussion of the botanical study, the excavations of the harbour area are briefly reviewed here. The information presented below is taken mainly from the publications by Hurst & Stager (1978), Hurst (1979) and Stager (1992).

The harbours were constructed on an almost flat, coastal stretch of land. The natural sedimentation sequence in the area points to changes in the local environment in the course of time, but these changes have not (yet) been dated. A dry-land phase with wind-blown sand deposits was succeeded by a period when the area was a shallow lagoon, which must have been due to a (relative) sea-level rise. Thereupon, a marsh was found here as is suggested by a layer of black clay rich in organic remains. Finally the area became dry land again, either naturally or through the interference of man (see below).

The construction of the two harbours was not the first work of engineering in the area; on a much more modest scale it was preceded by the digging of the so-called Punic channel (see Fig. 2). With respect to this feature the following is quoted from Hurst and Stager (1978: 338). "The earliest possible harbour work in the area is a water channel some 15-20 m wide and c. 2 m deep. This was cut into the natural sand without any stone lining to its sides and bottom… It is uncertain whether it was first cut through the area in its marshy state and was therefore instrumental in changing the environment or whether it was subsequent to the marsh phase. It is, however, clear that this channel did not relate to the harbour topography which we know for the latest Punic and later periods. It extended north-south across the Ilot de l'Amirauté and southwards as far as the west side of the rectangular harbour… Sedimentary and molluscan evidence from its fill shows that the channel was linked with the open sea, so that it can be assumed to have continued further south to the Bay of Kram. The link with the sea and the size of the channel suggest it may have been used for navigation. Also a large *cippus* of Cap Bon sandstone which was found lying on the bottom of the channel above pieces of hewn timbers can be interpreted as having sunk with its raft or barge en route to the nearby Tophet."

It is uncertain when the Punic channel was cut, but its final silting is dated to the middle of the fourth century BC. The natural fill of the channel consisted of marine clay; large numbers of indigestible fruit seeds embedded in the sediment suggest that human excrement and possibly other rubbish had been disposed of in this waterway. At the circular

harbour site it could be established that the lower part of the channel fill consisted of grey clay which in the upper part gave way to dark clay rich in organic material.

The two harbours occupy together an area of some 1000 m north-south and 300 m east-west. The entrance to the harbours is thought to have been from the south, from the Bay of Kram, but so far no traces of a channel from this bay to the rectangular harbour have been found. The circular harbour had to be reached through the rectangular harbour, to which it was connected by a channel. The present connections with the sea are of recent date and have been made to improve the water circulation in the basins.

The rectangular harbour measured about 400 by 150 m and had an estimated depth of 2 m. The circular harbour had a diameter of some 300 m; the round island in the middle of the harbour, indicated as Ilot de l'Amirauté, measured 120 m in diameter. The construction of the two harbours required a major earthmoving operation. In excavating the rectangular harbour an estimated 120,000 m^3 of earth had to be removed, while some 115,000 m^3 of soil were excavated to make the circular harbour. The harbour basins were bordered by quay walls made up of blocks of Cap Bon sandstone. In the circular harbour, quay walls had been built at the edge of the harbour as well as around the island. A causeway gave access to the circular harbour from the north. It is not clear when the construction of the late-Punic harbours had begun: soon after the silting of the Punic channel in the middle of the fourth century or not until the third/second century BC?

In Punic times, the circular harbour functioned as a naval port. In the second century BC, stone shipsheds on the island as well as at the harbour's edge had capacity for 220 vessels. In the centre of the island stood an oblong building, the admiral's house, from which "the admiral could observe what was going on at sea". The rectangular harbour was the commercial port. On the west side of this harbour, remains of a Punic warehouse, c. 20 m long, were uncovered.

In rebuilding Carthage, the Romans restored the harbours, too. The function of the circular harbour had drastically changed in that it was no longer a naval port. The shipsheds from the Punic period were not rebuilt. The Punic structures on the island were robbed and a temple was built in the centre. Later, in the second/third century AD, the island was renovated and acquired a monumental character. It looks as though in Roman (and later?) times, the island had no harbour facilities (storage, loading and unloading of goods), but that it had another function. Already early in the Byzantine period, in the middle of the sixth century AD, the circular harbour may have fallen into disuse: the basin was no longer dredged regularly and silted up, to which man contributed by dumping much rubbish in the water.

Soon after the rebuilding of the city had begun, the rectangular harbour was put into operation again. It would become one of the principal ports of the Roman Empire. It played a major role in the shipment of the *annona*, the compulsory delivery of corn and later also oil, to Rome. A restructuring of the harbour basin was carried out in the first half of the second century AD, when the rectangular shape was transformed into an oblong hexagonal one: the two right-angled corners at the northern end of the basin were replaced by oblique ones by putting in new quay-wall sections (see Fig. 2). The final silting of the rectangular harbour, and consequently its abandonment, is dated to about AD 600, still a century before the Byzantine sovereignty over Carthage came to an end. Overseas trade seems to have declined greatly at Byzantine Carthage.

As has been mentioned above, the deposits in Punic channel and Byzantine harbours are not from periods when these installations were in full operation for navigation, but rather when they had fallen into disuse. Shipping must virtually have come to a standstill and the areas near channel and harbours had (largely) been abandoned, thus allowing vegetation to re-settle on the terrain.

1.4 **Previous reports**

In this section, published and some unpublished reports on plant remains from Carthage are briefly reviewed. With respect to the harbour area, mention should be made of the unpublished reports by Stewart (1976a, 1976b) on seeds and fruits from the fill of Punic channel and harbour basins. Some of the results of the pollen and seed examination of the rectangular harbour are discussed in papers by Van Zeist and Bottema (1983) and Bottema and Van Zeist (1985). Preliminary results from the circular harbour are presented in Van der Veen (1979). A note on plant remains from the north side of the circular harbour has appeared in Hurst (1994: 325; see also section 8.2).

The earliest floral remains from Carthage have been identified by Dr. H. Kroll (in Niemeyer et al. 1993: 240-241). They derive from a site at Carthage-Dermech excavated by a team of the University of Hamburg, and are dated to the eighth to sixth centuries BC (early-Punic period). Late-Punic levels at the Byrsa yielded small numbers of seeds (Van der Veen & Van Zeist 1982; see also section 8.4). Ford and Miller (1978) and Hoffman (1981) report on plant remains from the site at Carthage-Dermech excavated by the team of the University of Michigan. A summary of the results of the botanical examination of the site at Carthage-Salammbo, taken from the report by Stewart (1976b), is presented in Hurst and Roskams (1984: 257).

The archaeobotanical program of the Dutch mission included the examination of wood and wood charcoal. Unfortunately, it has not been possible to include in the present report the full results of the analysis of the wood and charcoal, but reference will be made to the results as given in Stuijts (1988 and 1991), where appropriate.

The authors regret the considerable delay in getting the final report on the examination of seeds, fruits and pollen from Carthage published. They hope that nevertheless the report will be a valuable contribution to the study of diet, plant cultivation and vegetation of Mediterranean North Africa in general and of Carthage in particular.

1.5 **Acknowledgements**

The collaboration with the Institut National d'Archéologie et d'Art of Tunis is gratefully acknowledged. Particularly Dr. A. Ennabli, who supervised the excavations at Carthage, has been most helpful. Dr. T. Zouari, Chef du Laboratoire d'Horticulture of the Institut National de la Recherche Agronomique de Tunisie, allowed us to consult the seed collection in the herbarium for the identification of seeds from ancient Carthage, and he placed a large number of modern seed samples at our disposal. Wood samples from Tunisia were received from Dr. M. Dahman, Chef de la Section du Bois of the Institut National de Recherches Forestières.

It is a pleasure to mention here the collaboration with the directors of the various excavations and their staffs, who rendered all possible assistance in the fieldwork and provided information on the sites and the samples: Professor H.R. Hurst (British mission: circular harbour, site B), Professor L.E. Stager (American ASOR team: rectangular harbour, Tophet), Professor S. Lancel (French excavations at the Byrsa), Professor F. Rakob (German mission: seaside residential area), and Dr. S. Dietz (Danish excavations at Falbe's site 90). Material support, in the form of food and lodging of a field assistant, was received from Professors H.R. Hurst and L.E. Stager. Additional information on samples from the rectangular harbour was provided by Dr. J.A. Greene (Cambridge, Mass.). Dr. H. Kroll (Kiel) kindly allowed us to look into unpublished data of his Carthage study.

Warm thanks are due to Mr. C.Th.R. van Baarda, the Netherlands ambassador in Tunisia, for his help and interest in our work at Carthage.

Dr. A.G. Lange participated in the fieldwork. In addition to the authors of the present report, Rita M. Palfenier-Vegter and E. van der Stoep took part in the examination of the Carthage samples. Critical seed identifications were discussed with Dr. R.T.J. Cappers. The illustrations were prepared by Gertie Entjes-Nieborg, G. Delger and J.H. Zwier. The English text was linguistically improved by Dr. Sheila M. Ottway (Oxford).

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2 THE SAMPLES: CONTEXT, PROCESSING, PRESENTATION OF RESULTS

Two types of samples are distinguished in the present study. In waterlogged, anaerobic sediments, seeds, fruits and other plant remains are preserved in a non-carbonised condition, while these sediments lend themselves also for pollen analysis. In well-aerated dry-land sediments, above the groundwater level, plant remains are usually preserved in a charred condition only. Non-charred plant remains are considered here (sub-)modern intrusions and are for that reason left out of consideration. Under extremely arid conditions, plant remains may be found in a desiccated state, but this does not apply to Carthage. Mineralised fig pips found in dry-land samples may have been of ancient age. Sediment samples taken for the examination of seeds, fruits, etc are called here seed samples; those secured for the examination of pollen grains and spores are indicated as pollen samples. The soil volumes of seed samples secured from waterlogged deposits varied from half a bucket to three buckets (c. 5 to 30 litres); those of the pollen samples were 10 to 20 millilitres. For the location of the sediment sections sampled for botanical examination, see Fig. 2.

2.1 **The Punic channel**

Two series of pollen and seed samples were secured from the fill of the Punic channel, one in the area of the circular harbour, the other in that of the rectangular harbour. The final silting of the Punic channel is dated to the middle of the fourth century BC.

At the circular harbour site, the fill of the channel was sampled in a trench (AIV) opened up in 1977 and enlarged and deepened in 1978 (Fig. 2:2). Because of problems with the groundwater the bottom of the channel could not be reached in the excavation trench, but has been determined through a boring. The lower part of the sediment consisted of greyish brown clay, which in the upper half gave way to black clay. Both layers were rich in organic material. The pollen and seed samples examined are listed in Table 1, which also shows the (approximate) correlation between the two types of samples. Many more pollen samples have been secured than were analysed. The time-consuming analyses necessitated a selection of the samples to be examined. This holds also for the other sediment sections from the harbour area.

The samples secured in 1977 from an exposed section of the fill of the Punic channel in the area of the rectangular harbour (Fig. 2:8) and examined for pollen or macroscopic plant remains are shown in Table 2.

2.2 **The Roman harbour sediment**

Waterlogged sediment, to a thickness of c. 1.60 m, and consisting of grey to dark-grey clay with large quantities of shells and shell fragments, was trapped between an old and new quay-wall section of the rectangular harbour (Fig. 2:4). It concerns here a reconstruction of the harbour basin at its northern end (see section 1.3). The sediment, dated to the first half of the second century AD, was not an *in situ* deposit, but it must have originated from elsewhere and have been dumped here to fill up the empty space. One wonders whether such a sediment is suitable for palaeobotanical analysis. Curiously, from the pollen and seed records (Table 8, Fig. 8) one would not guess that they are from a highly disturbed deposit. They appear to provide reliable information on vegetation and food-plant consumption in Roman (second century AD) times. As no other waterlogged Roman sediment was available, the results have

to be accepted as such. In seed samples A, B and C, from above present-day sea level (see Table 2), only small numbers of non-carbonised seeds were found. See also section 6.6.

2.3 **The Byzantine harbours**

The final silting of the circular and rectangular Byzantine harbours, and consequently the abandonment of these installations, did not take place at the same time. The Byzantine fill of the circular harbour is dated to the mid-sixth century AD (c. AD 550), that of the rectangular harbour to about AD 600.

The fill of the Byzantine circular harbour was sampled in an excavation trench (A VII) opened up on the north side of the island, against the Roman quay wall (Fig. 2:1). Here, too, the sampling was carried out in two successive years (1977, 1978) and there were problems with the groundwater. The larger part of the fill near the quay wall consisted of clayey organic sediment which contained large quantities of pottery. It appears that rubbish had been tipped over the quay wall onto the harbour which had fallen into disuse. The layers above the organic harbour fill contained much rubble (stones and other building material) and must have been brought up by man to improve the stability of the soil. Most of the samples listed in Table 1 under Byzantine harbour were from the clayey organic sediment. Of the samples from the deposits above the organic harbour fill, only sample A77 VII/262 yielded a fair number of seeds. The layer concerned is thought to have accumulated below the contemporary sea level. A few samples from the sandy base of the harbour fill were almost devoid of seeds.

The sediment in the Byzantine rectangular harbour was sampled at three locations (Fig. 2:5-7). Here no large numbers of potsherds were found embedded in the harbour fill. Only in the upper levels of the fill at locus GH2.072 (Fig. 2:6), rubble and large stones were found which, however, may have originated from waste that had been brought up afterwards. In this connection it should be mentioned that after the harbour installations were no longer in use, a series of pottery kilns had been set up along the harbour (Stager 1977). In general, sedimentation in the harbour basin must have occurred gradually under quiet conditions. The sediment consisted of dark-blue clay turning brown in the upper levels. The samples examined are listed in Table 2.

2.4 **The Byzantine well**

The excavation of the late-Byzantine fill of a well on the island in the circular harbour met with great difficulties because of the rapidly rising groundwater (Fig. 2:3). Some seed samples were taken from the organic fill of the well; others came from the contents of jars embedded in the fill. The volumes of the samples have not been recorded. Of fourteen samples secured for palaeobotanical examination, nine have been examined (listed in Table 1). The results are discussed in chapter 7.

2.5 **Charred seed samples**

Included in the present study are charred seed samples from the circular harbour and from sites outside the harbour area (Tophet, etc.) discussed in chapter 8. At the circular harbour, charred seeds were recovered from Punic occupation deposits, dating to the 4th/3rd century BC, and from destruction layers of the Punic shipsheds (146 BC). Only one of the samples from the circular harbour yielded more than a modest number of seeds. The volumes of soil floated here were 1-2 buckets (c. 10-20 litres).

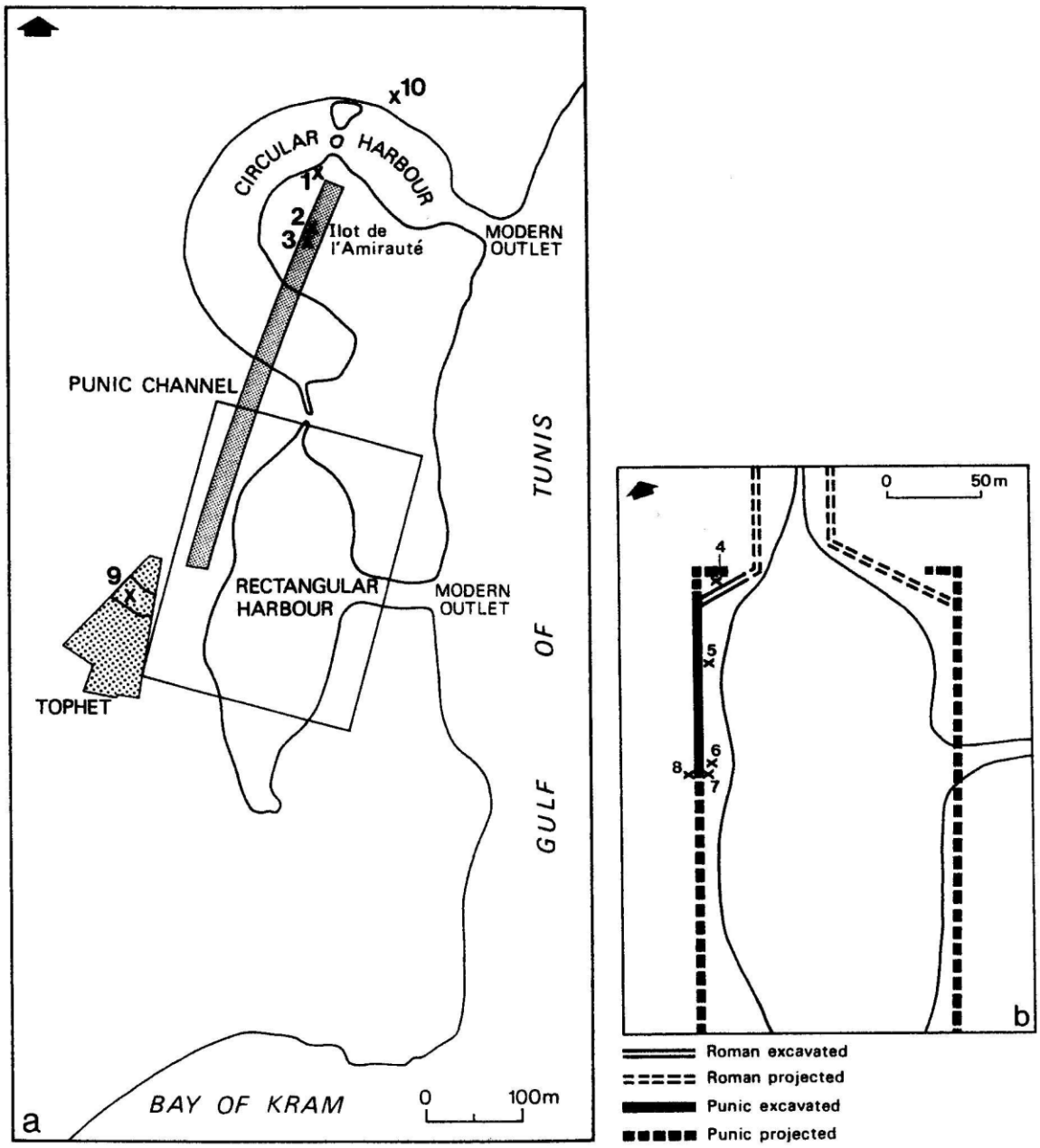

Figure 2. The area of the ancient circular (naval) and rectangular (commercial) harbours, with the location of the Punic channel, the sediment sections sampled for botanical examination, the Tophet and site B. The framed area in the left figure (a) is shown in more detail in the right figure (b), in which the (projected) quay-wall is indicated. Redrawn from Hurst & Stager (1978: Fig. 2) and Van Zeist & Bottema (1983: Fig. 1).

1 Trench AVII (Byzantine harbour)
2 Trench AIV (Punic channel)
3 Trench AIII (Byzantine well)
4 Locus II.2 (Roman sediment)
5 Locus KL12.053 (Byzantine harbour)
6 Locus GH2.072 (Byzantine harbour)
7 Locus G1.060 (Byzantine harbour)
8 Locus E1.070 (Punic channel)
9 Tophet, area excavated by the ASOR team
10 Site B, at the north side of the circular harbour

2.6 **Field processing of the samples**

2.6.1 Waterlogged samples

Most of the waterlogged samples were treated in the field in the following way. The samples were left to soak in a tub with water to which washing powder (Omo), which has an oxidising effect, had been added. During soaking the samples were stirred regularly so that lumps of clay disintegrated more rapidly. Thereupon the samples were washed through a set of two (1.0 and 0.5 mm meshes) or three (2.0, 1.0 and 0.5 mm meshes) sieves, placed one on top of the other. The wet residues were stored separately in plastic bags for examination at the Groningen Institute of Archaeology.

In 1977, a different method was applied at the circular harbour site. The seeds that floated to the surface of the tub, in which the sample had been left to soak, were scooped off and poured into a 0.5 mm mesh sieve. The rest of the sample was sieved through an oil drum in which a 1.0 mm mesh had been constructed. This technique, a modification of Struever's flotation scheme, was applied at Carthage by Robert B. Stewart during the 1976 field season.

2.6.2 Dry-land samples

Charred seeds and wood charcoal were recovered from samples of occupational soil by a simple water separation method. A few handfuls of soil were placed in a plastic basin which was subsequently filled with water. Charred material which had started to float was poured off into a 5 mm mesh sieve. This procedure was repeated until the whole of the sample had been processed. Prior to storage the flotation residue was left to dry gently. A somewhat different method was used at the circular harbour during the 1977 field season. In this case the samples were floated using the oil drum, this time with a 1.5 mm mesh inside. Organic material floating in the water was scooped off and poured through a 0.5 mm mesh sieve. Where necessary, prior to flotation the soil samples were left to dry because water-saturated charred seeds do not float well.

During the 1977 field season, the water used at the circular harbour for the processing of the samples was salty. For that reason, the residues were rinsed with tap water (in the expedition house) prior to further handling.

2.7 **Laboratory procedures and presentation of the results**

2.7.1 Waterlogged samples

Each of the two or three fractions of a sample resulting from the processing in the field was wholly or in part examined for seeds, fruits and other plant remains. The numbers of seeds etc. shown in the tables of waterlogged samples are those corresponding to five litres of sediment. This should enable a quantitative comparison between samples, although it is not always clear what quantitative differences between samples may mean. This procedure implies that the numbers of seeds presented in the tables may be considerably higher than those actually counted. Often the numbers of seeds retrieved from the 1.0 and 0.5 mm fractions had to be multiplied by a certain factor to make them correspond to five litres of sediment. By way of exception, the numbers of seeds etc. from the Roman harbour sediment are calculated per ten litres of soil (Table 8). It is assumed here that because of the large numbers of shells in this deposit, the seed content of ten litres of soil (one bucket) would quantitatively correspond to that of five litres of soil of the other harbour and channel sediment sections. Admittedly, this is not a particularly well-founded assumption, but it is, to

some extent, supported by the comparatively low seed concentrations in samples from the Roman deposit. Similarly, the seed frequencies of one of the samples from the fill of the Byzantine circular harbour (Table 4: A77/263) have been 'corrected' for the large number of potsherds in the sample concerned. As of the samples from the Byzantine well the volumes processed had not been recorded, the numbers of seeds etc. could not be expressed per unit volume of sediment. For that reason, here the numbers of seeds counted are converted to the numbers corresponding to the whole or part of the sample concerned (Table 5).

Conspicuous differences as well as striking similarities between sediment sections find expression in the histograms of Figs. 3 and 4, in which the frequencies of a selected number of seed types are presented.

In Tables 3-5 and 7-10, the plant taxa are arranged according to economic use (groups 1 and 2) and ecological affinity (groups 3-8). It is true that such a grouping carries an element of arbitrariness with it as taxa, which could not be identified to the species level, may be represented in diverse habitats. In fact, several taxa have been listed under group 8 (taxa of uncertain ecological affinity). Nevertheless, the grouping presented here provides a fair picture of the main types of vegetation established for the harbour area. Hand-picked seeds from the circular harbour (seeds observed and secured in the field by the excavators) are shown in Table 11.

In the tables, the minimum value given is 1 (one). In fact, the (calculated) value may be much smaller. For instance, a fragment corresponding to no more than 1/10 of a nut is listed as 1. A plus-sign (+) indicates plant remains other than seeds, e.g. leaves. The term 'seeds' as used in the present paper includes anatomically-defined fruits as well.

2.7.2 Charred seed samples

The analyses of charred seed samples from the circular harbour are presented in Table 6. The results of the examination of samples from the Tophet and other sites discussed in chapter 8 are shown in Tables 16-20.

2.7.3 Pollen samples

The pollen samples were prepared with the heavy liquid method, using a bromoform alcohol mixture of specific gravity 2.0. After acetolysis according to Erdtman (Faegri & Iversen 1989: 79-80) the residue was stained with safranine and embedded in silicone oil. The samples from the fill of Punic channel and the two harbours display a high charcoal content and yielded relatively low numbers of pollen grains. Pollen preservation is reasonably good. The low pollen concentration could point to a rapid sedimentation, but the numbers of seeds retrieved suggest that this should not have been a question of a few years only.

The identification of the pollen types in the Carthage samples is based upon the pollen reference collection of the Eastern Mediterranean and the Near East in the Groningen laboratory. In addition, the pollen atlases of Reille (1992, 1998) were consulted. However, the flora of Tunisia differs from those of the Near East and the European side of the Mediterranean. As a consequence, for some of the pollen types distinguished a North African plant name may have been more appropriate than the ones presented in Tables 12 and 13 (see below).

The frequencies of a selected number of pollen types are shown in Figs. 5-10. The frequencies of the pollen types are expressed as percentages of the sum of all pollen types counted in the sample concerned (except those of water plants and fern spores). The pollen taxa identified from the circular and rectangular harbours are listed in Tables 12 and 13, respectively. Pollen identifications are usually not beyond the genus level, which is a serious handicap in attributing pollen taxa to one of the ecological groups distinguished. Hence, a

relatively large number of pollen taxa are listed under group 8 (taxa of uncertain ecological affinity).

English names of cultivated plants and of a great number of wild plant taxa identified from Carthage are given in the Appendix.

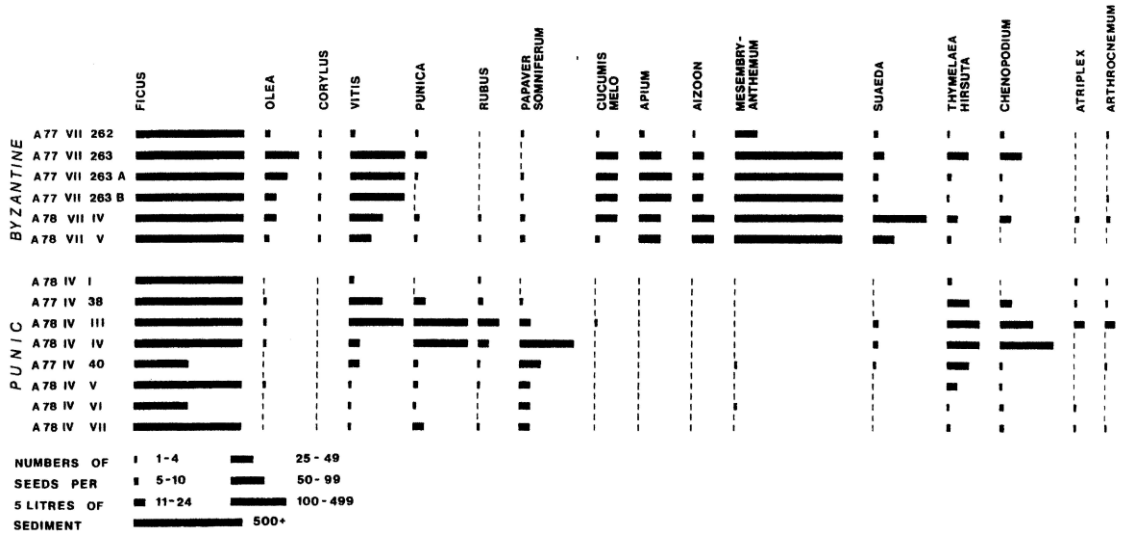

Figure 3. Circular harbour. Histogram showing the frequencies of a selected number of seed types from the Punic channel and the Byzantine harbour.

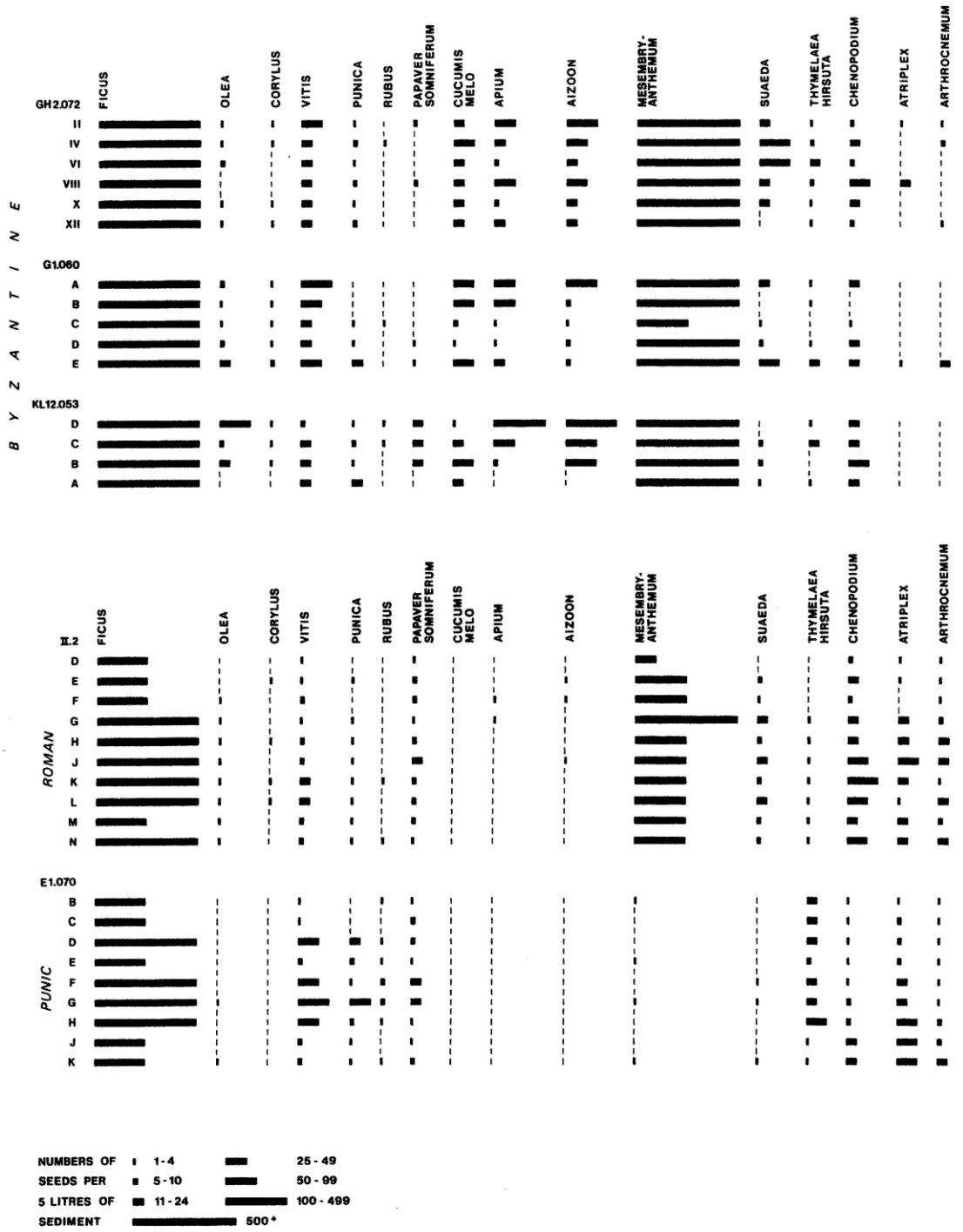

Figure 4. Rectangular harbour. Histogram showing the frequencies of a selected number of seed types from the Punic channel, the Roman deposit and from the fill of the Byzantine harbour. The numbers of seeds from the Roman deposit are calculated per 10 litres of sediment.

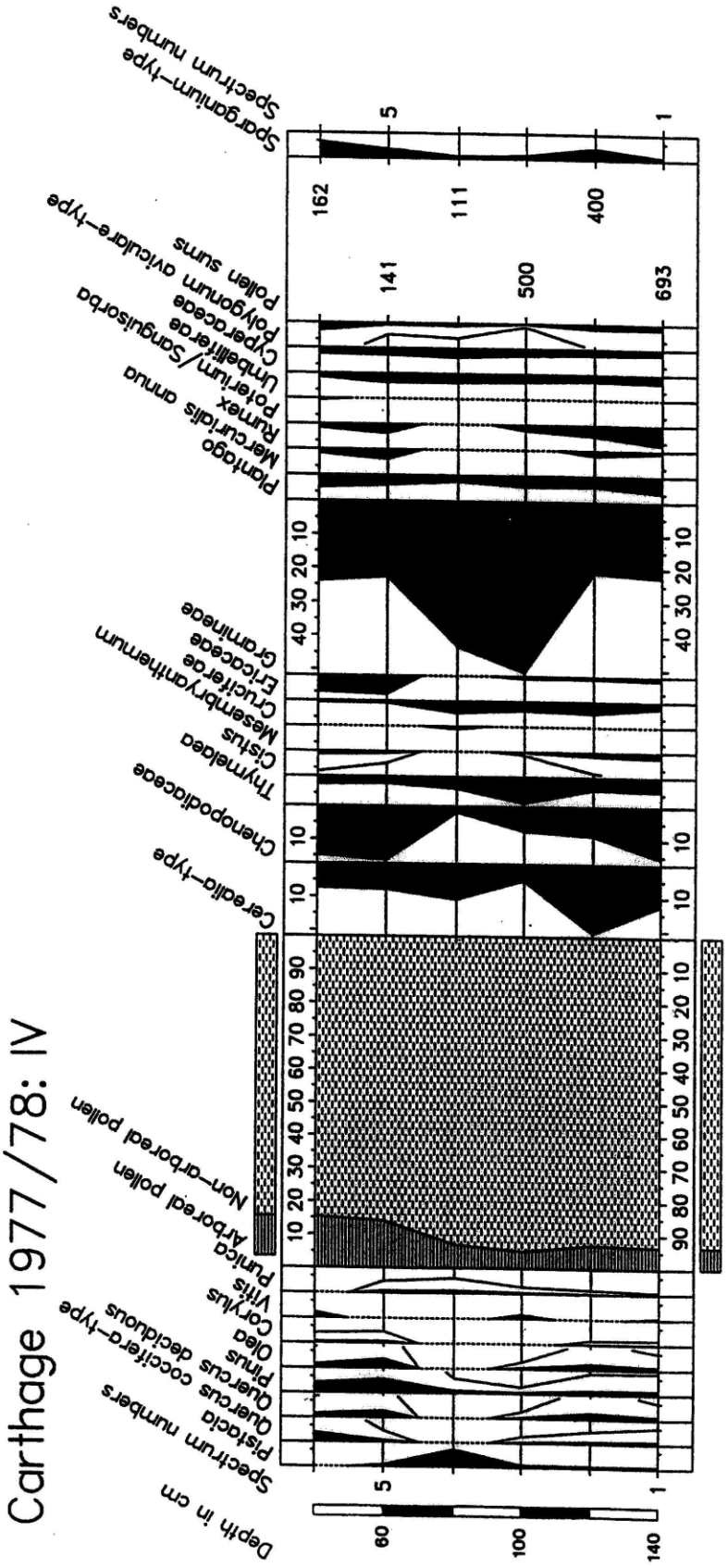

Figure 5. Circular harbour. Pollen diagram prepared for samples from the Punic channel. A selected number of pollen types are shown. Depth is in centimetres below sea level.

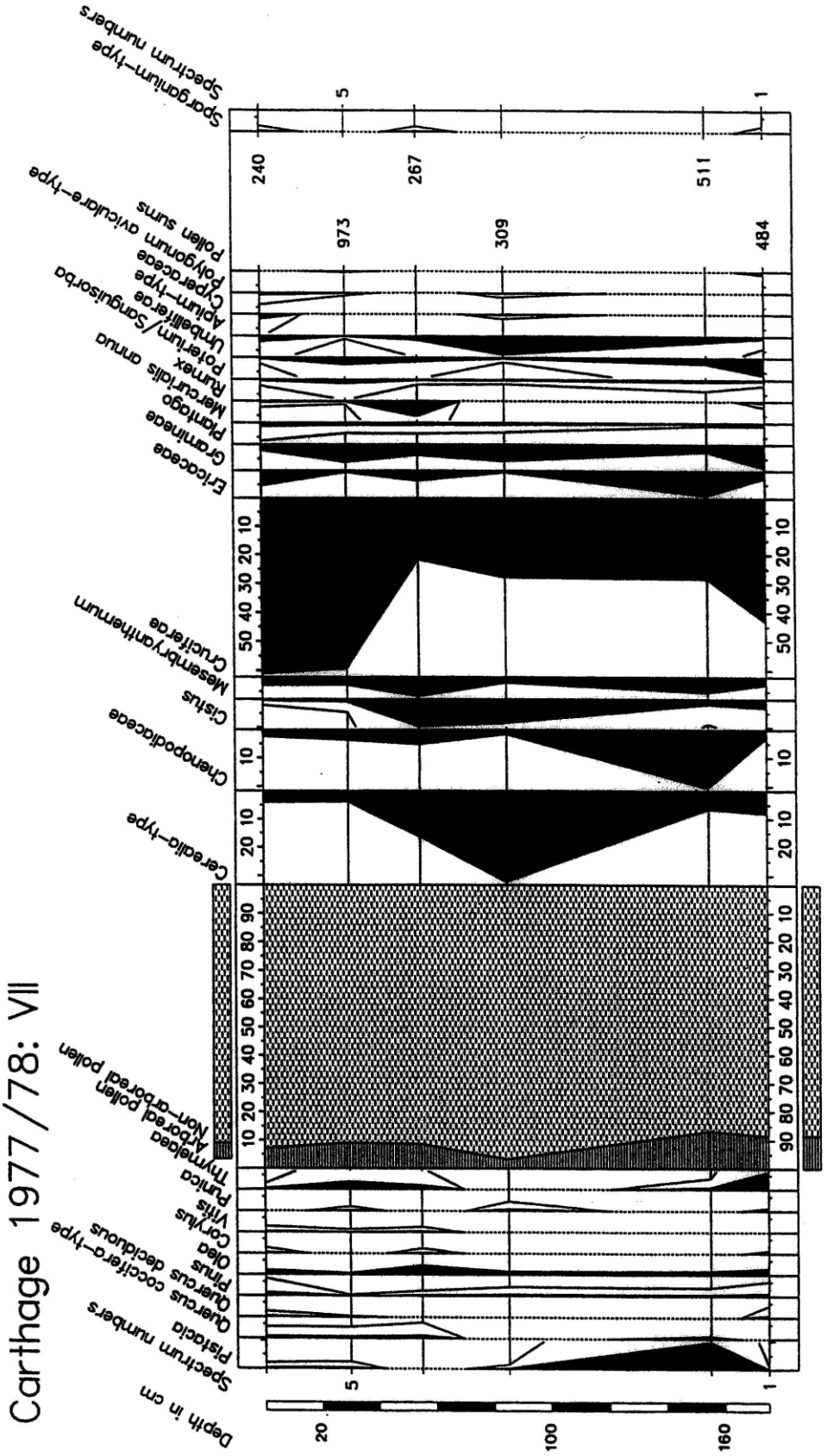

Figure 6. Circular harbour. Pollen diagram prepared for samples from the fill of the Byzantine harbour. See caption of Fig. 5.

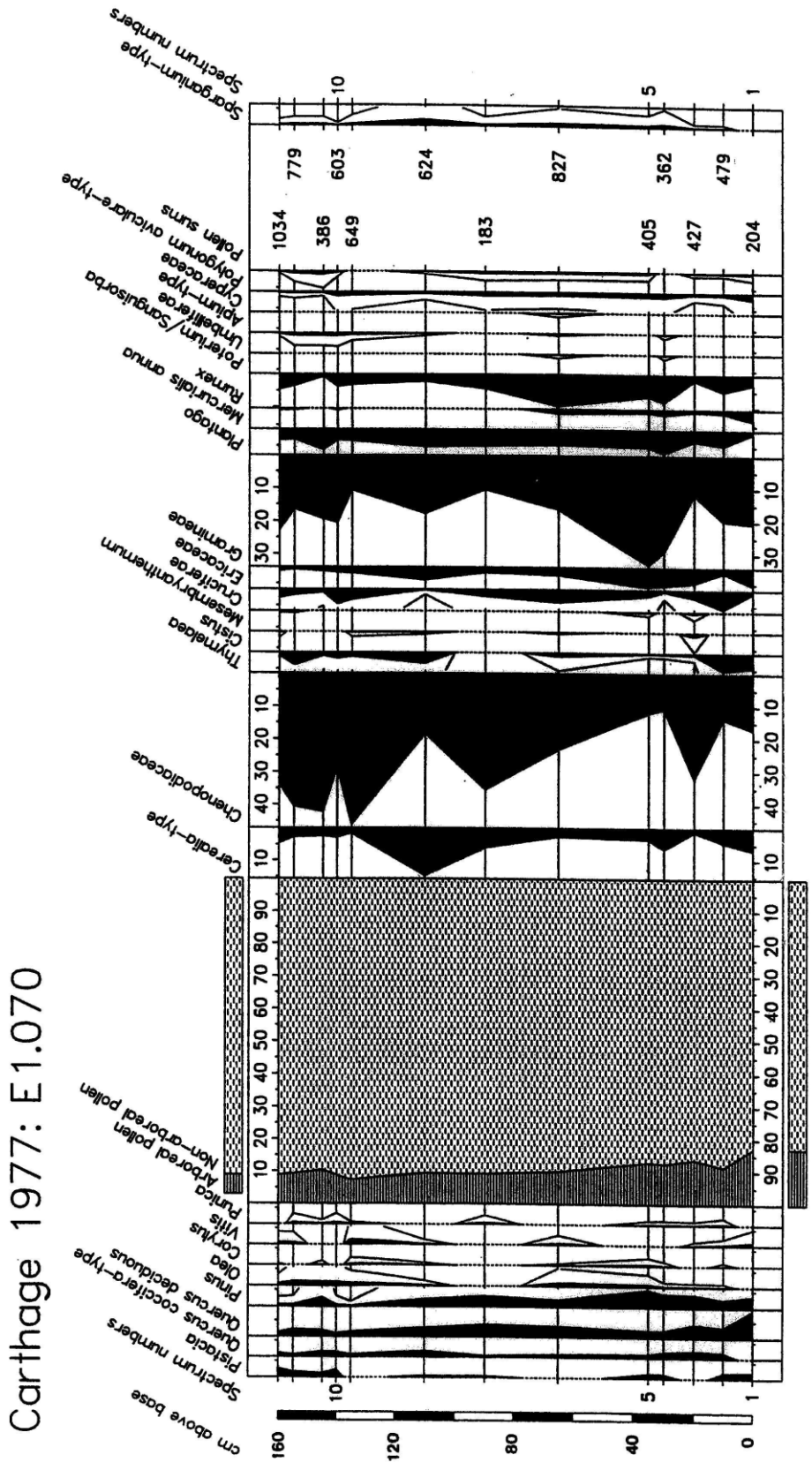

Figure 7. Rectangular harbour. Pollen diagram prepared for samples from the Punic channel. A selected number of pollen types are shown. Depth is in centimetres above base of sediment.

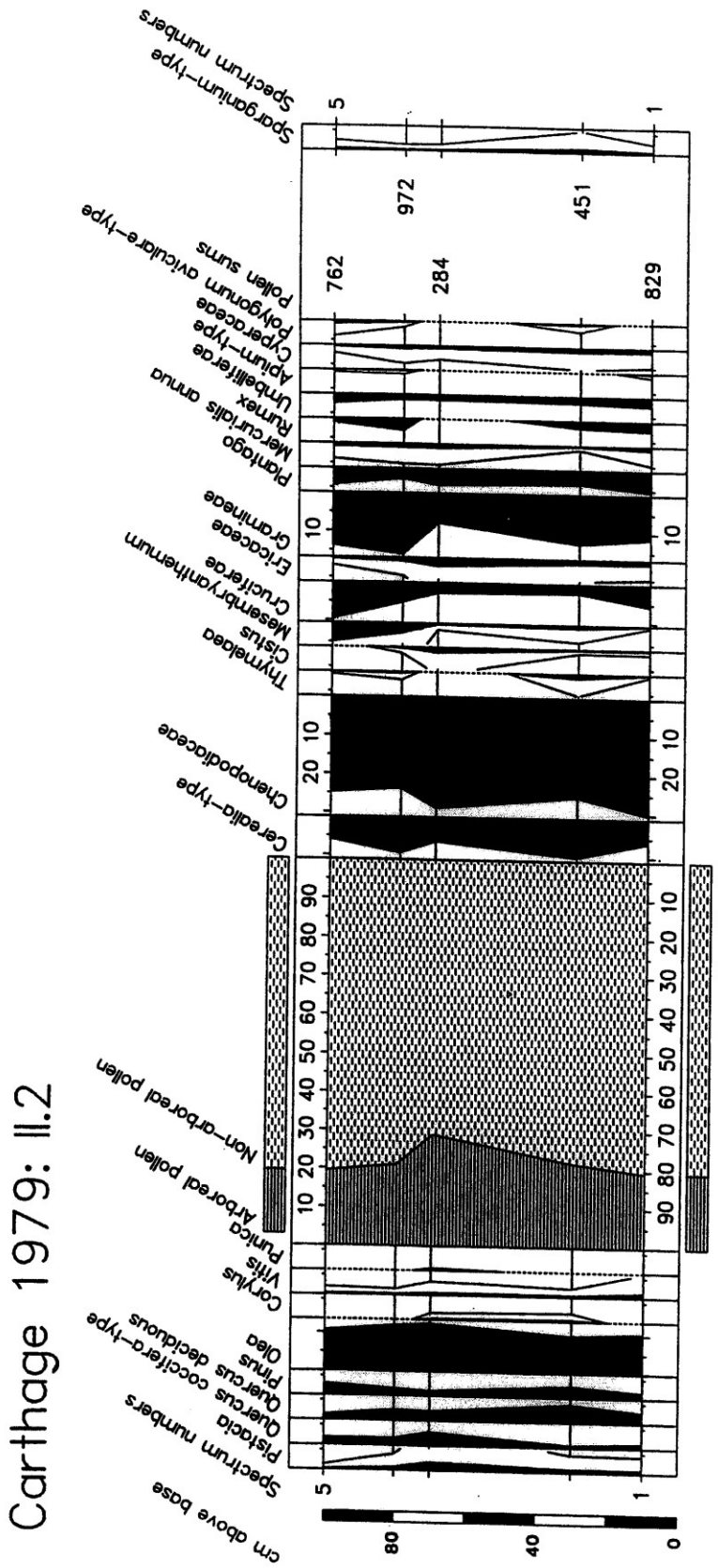

Figure 8. Rectangular harbour. Pollen diagram prepared for samples from the Roman harbour deposit. See caption of Fig. 7.

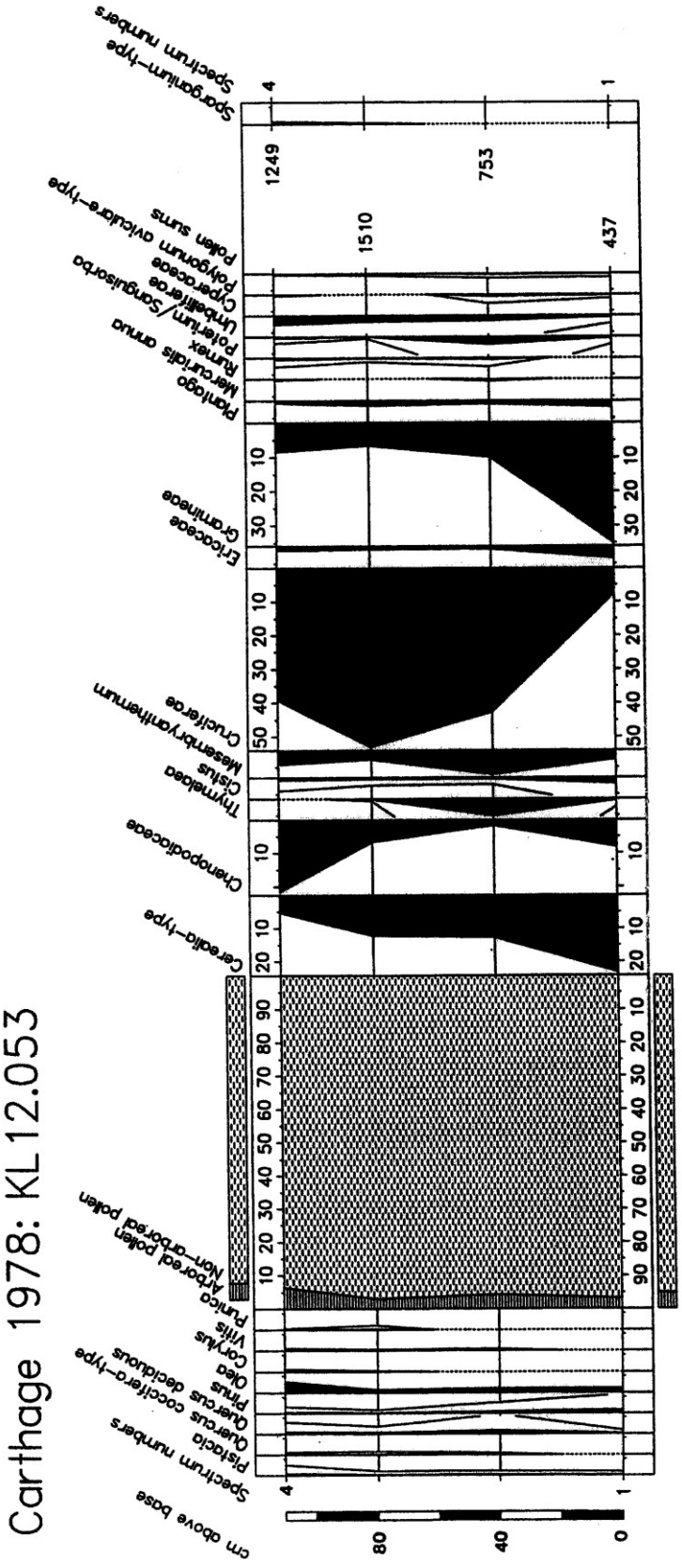

Figure 9. Rectangular harbour. Pollen diagram prepared for samples from the fill of the Byzantine harbour at locus KL12.053. See caption of Fig. 7.

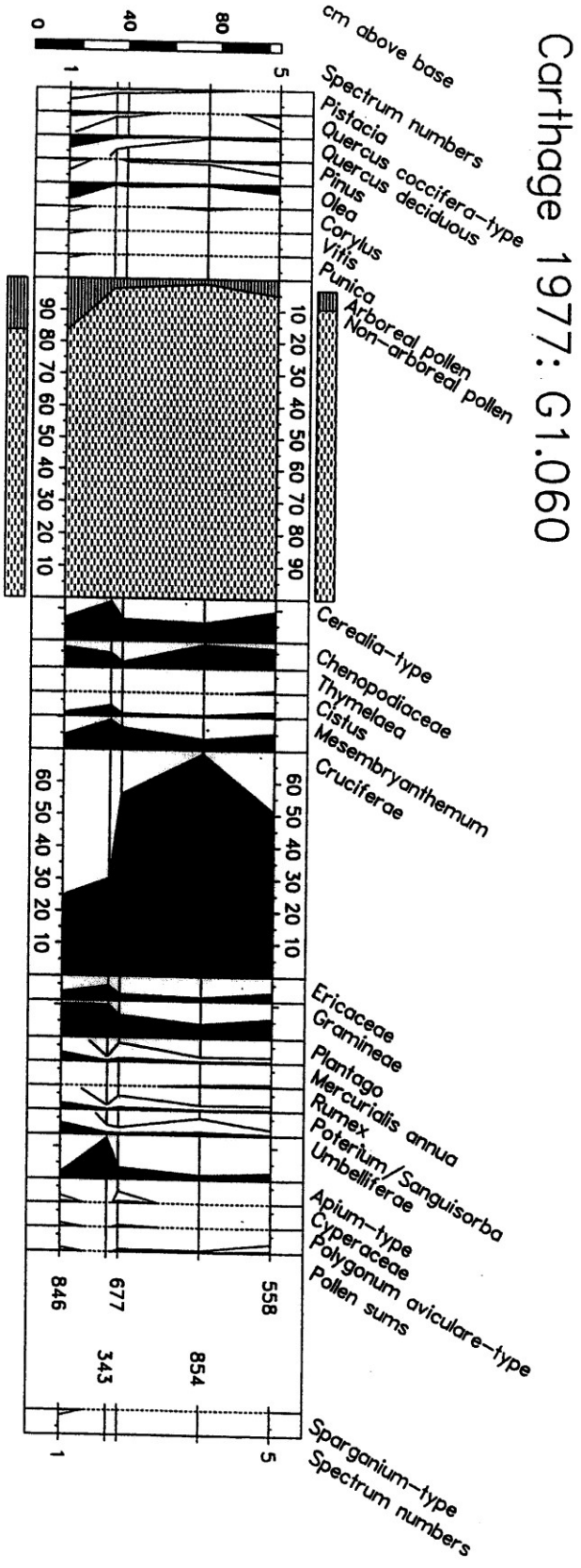

Figure 10. Rectangular harbour. Pollen diagram prepared for samples from the fill of the Byzantine harbour at locus G1.060. See caption of Fig. 7.

3 ORIGIN OF PLANT REMAINS

Prior to the discussion of the plant taxa identified from Carthage in terms of economic use and environmental conditions, some comments should be made on the way pollen, seeds and other plant macro-remains may have become incorporated in the waterlogged deposits of the Punic channel and the two harbours. After all, by far the majority of the archaeobotanical information obtained from Carthage is derived from these sediments. Apart from the seeds of a few species which may have occurred in the saline water of channel and harbours, the plant remains preserved in these deposits must have been carried in from nearby and further away.

3.1 **Plant macro-remains**

In his report on the botanical examination of the rectangular harbour site, Stewart (1976) claims that the plant inventory (he found) is suggestive of harbour-side activity. According to Stewart, the plant remains in these sediments are largely from human faeces "flushed through the drains into the harbours". Pips of fig, grape, pomegranate and blackberry (*Rubus*) might pass through the digestive tract without damage. Fruits and nuts, such as peach, plum, hazelnut and walnut, might have been carried to the quay side and consumed on the spot, after which fruitstones and broken nutshells ended up in the water. In particular the large numbers of fig pips may have induced Stewart to suggest that the plant material in the harbour sediments mostly represents human faeces. In evaluating the large numbers of fig pips, one should take into account that one fig contains up to a few hundreds of pips. Thus, rotten figs dumped in the water may already account for considerable numbers of pips in the sediment. Be this as it may, one may safely assume that human faeces contributed to the plant remains embedded in the waterlogged sediment, but this was certainly not the only source. This conclusion is based upon the large numbers of non-food plant seeds we found in addition to the remains of fruits and nuts. It is true that weed seeds, which occurred as impurities in food prepared for human consumption, may have been excreted rather undamaged and subsequently deposited in the channel or harbour. However, it is unlikely that more than small numbers of seeds of wild plant species in the harbour sediment came from human faeces. By far the greatest variety of seeds and other remains of wild plant species must have found their way to channel and harbour along other routes.

In the present report the line is taken that the majority of the wild plant species represented in the archaeological seed record were from the local vegetation, in and near the harbour area. Seeds of plants growing near the (abandoned) channel and harbour basins may have dropped directly into the water or may have been washed in after they had fallen on the ground. Whole plants or parts thereof may have ended up in the water after they had died off. It is less clear how seeds of plants at some distance from channel and harbour basin found their way to the water. One suggestion is that seeds were transported in the intestines of sheep and/or goats and excreted in or near the water. It is well known that sheep/goat droppings may contain seeds which had passed through the digestive tract of these animals. It is true that no such droppings were found in the samples examined, but these may have fallen apart in the water. In an archaeological context, sheep/goat droppings are preserved mainly in a charred condition. One wonders to what extent donkeys may have contributed to the dispersal of seeds through their dung.

Remains of plant material that had been gathered for one purpose or another (fuel, litter, animal fodder) may eventually have been disposed of in the water together with other

refuse. Is it feasible to hypothesise that after the growing season dead plants or parts thereof were blown away by the wind, as a result of which some came to rest in the water and sank to the bottom? What was the role of the sea which had free access to channel and harbours? It is known that seeds are transported by sea currents over large distances. Could it be that seeds and other plant remains had been carried in by the sea? Seeds adapted to dissemination by the wind may have been blown in from quite some distance. An example of such a seed type identified from Carthage is *Typha angustifolia* (lesser reedmace).

From the above it appears that one can only speculate on the various ways along which seeds of wild plants may have ended up in the channel and harbour sediments. However, the numbers as well as the variety of seeds secured suggest that the vegetation of the area is reasonably well represented in the archaeological plant record.

With respect to the Byzantine well, it is suggested in chapter 7 that large quantities of plant waste were dumped in the well. Originally plant material may have made up the greater part of the fill of the well. Here there was no question of a partly natural sedimentation as was the case with the Punic channel and the harbours.

3.2 **Pollen**

The pollen grains preserved in the channel and harbour deposits may equally well have derived from the local as from the regional vegetation. Wind-pollinated species display a high pollen production combined with a good dispersal. In particular pollen of wind-pollinated trees may be transported through the air over several hundreds of kilometres and more (long-distance transport). Examples of wind-pollinated non-tree taxa represented at Carthage are Chenopodiaceae (Goosefoot Family), Gramineae (grasses), *Plantago* (plantain) and *Rumex* (dock, sorrel): see Figs. 5-10. Insect-pollinated and self-pollinating species, on the other hand, release only small numbers of pollen or almost no pollen in the air. As a consequence, these species are usually (heavily) under-represented in the pollen record: the proportion of the species in the pollen precipitation (pollen rain) is much smaller than that in the vegetation. Relatively high pollen values of insect-pollinated taxa in sediment samples may indicate that the species concerned occurred close to the place where the pollen was deposited.

Pollen is not only transported through the air, but at Carthage it may also have been washed into channel and harbours from the surroundings. In addition, pollen may have ended up in the water with human faeces, just as is assumed for pips of various fruits (see above).

4 FOOD PLANTS AND OTHER USEFUL SPECIES

In this chapter comments are made on food plants and some other species of economic interest identified from Carthage. Most of the species discussed here are listed in groups 1 and 2 ('Annual crop plants' and 'Cultivated and wild fruits and nuts') of the tables presenting the analyses of the waterlogged sediments. In addition, some taxa listed in one of the other groups may have been cultivated for the seeds, leaves or roots. Additional information on food plants, in particular on cereals and pulses, is obtained from charred seed samples (Tables 6, 16-20). The pollen record provides evidence of a few useful species not represented by plant macro-remains.

4.1 **Cereals**

Although the waterlogged deposits of the Punic channel and the two harbours yielded most of the archaeobotanical evidence discussed in the present report, they do not tell us much about the role of cereals at Carthage. Cereal grains are preserved mainly in a charred condition, and in waterlogged sediments carbonised plant remains are usually scarce. In addition, preparation of food, by means of which cereal grains and seeds of other food plants may have become carbonised, would usually not have been carried out in the harbour area but rather in residential quarters. Information on cereals (and pulses) comes particularly from dry-land archaeological contexts. The richest charred seed sample recovered from the harbour area is from an occupation level above the fill of the Punic channel (Table 6: sample IV/262). Appreciable numbers of carbonised cereal grains (and other seeds) were retrieved from the remains of a 6th/7th century AD domestic dwelling at the site on the Avenue Bourguiba, Salammbo, excavated by the British team (Stewart 1976b), and from a medieval (11th-13th century AD) ashy deposit at the Byrsa (Table 19).

It is suggested that some of the seeds and fruits preserved in the fill of channel and harbours had arrived there with human faeces (section 3.1). This makes one wonder whether bran (seed-coat) fragments of cereals were found in these deposits. Evidence from temperate Europe (England, Germany, Holland) has shown that in accumulations of human faeces, particularly in the fill of latrines, remains of seed-coats of cereals can be quite numerous and, to a certain degree, allow identification of the kinds of corn consumed. No bran fragments were recognised at Carthage. This does not necessarily invalidate the suggestion of the deposition of human faeces. One could speculate that the flour used in the preparation of food had been finely ground and sifted, as a result of which no recognisable bran fragments were present. However, this may apply to flour used for pastries and such-like, but not to that from which ordinary bread was made. It is more likely that the channel and harbour sediments were unfavourable for the preservation of cereal bran, for instance, because they were deposited in a saline environment (open access to the sea). In this connection it should be mentioned that only very few waterlogged seeds of wild grasses were found, suggesting that in these sediments, conditions for the preservation of the seed-coat of wild (and cultivated) grasses were poor (see 'Gramineae' in chapter 5).

Most of the wheat grains identified from Carthage are of free-threshing or naked wheat. In principle two naked wheat species come into consideration: tetraploid hard wheat (*Triticum durum*), with 28 chromosomes, and hexaploid bread wheat (*Triticum aestivum*), with 42 chromosomes. Charred grains do no allow a distinction between the two naked wheat species, hence the designation *Triticum durum/aestivum*. Hard wheat, which is the most com-

mon wheat in the Mediterranean basin, with prevailing mild, rainy winters and warm, dry summers, would be the most likely candidate for Carthage. Bread wheat is well adapted to continental conditions and sub-humid temperate climates (Zohary 1969, 1971), but is grown also in the Mediterranean area.

A few wheat grains from the Punic channel have been attributed to emmer wheat, *Triticum dicoccum* (Tables 3 and 7). This is a hulled wheat which in prehistoric times was widely grown, but which in later times was largely replaced by free-threshing wheat and other cereals. In hulled wheat the grains are firmly enclosed by stiff glumes (hulls) and are not released in threshing. An additional treatment is necessary to free the grains from the hulls. H. Kroll (in Niemeyer et al. 1993: 240-241) reports emmer wheat from early-Punic levels (8th-6th century BC) at Carthage-Dermech. A late-Punic context at the Byrsa yielded two probably emmer-wheat grains (Table 19). Two wheat grains from the bottom sediment in a cistern, dated to the 6th/7th century AD, have tentatively been identified as *Triticum dicoccum* (Hoffman 1981). Certainly identified emmer wheat is recorded from Punic levels only.

The replacement of emmer wheat by free-threshing wheat must be seen in connection with improved agricultural methods and with the necessity to greatly increase the production, not only to feed a growing population, but also to comply with the obligation imposed by the Roman authority to deliver corn for shipment to Rome.

The barley (*Hordeum*) grains identified from Carthage are of the hulled type. In hulled barley the glumes not only firmly enclose the kernel, but they are fused with the grain. The barley from Carthage has, with some reserve, been attributed to the six-rowed form, *Hordeum vulgare*. For the medieval level at the Byrsa, the identification as *H. vulgare* is supported by rachis internodes (Table 19). Barley may have been used as animal fodder as well as for human consumption and the preparation of beer.

No traces of broomcorn millet (*Panicum miliaceum*) and foxtail millet (*Setaria italica*) were found. Particularly in the interior of Tunisia, where the climate is almost too dry for the cultivation of barley and wheat, millets could have been grown profitably. There is no evidence of import of rice (*Oryza sativa*) in Roman and post-Roman times.

In contrast to the small numbers of cereal grains secured, Cerealia-type pollen shows (comparatively) high values in the channel and harbour deposits (Figs. 5-10). The Cerealia pollen type is distinguishable from that of most other grasses by the larger size, over 40µ (micron), and the pronounced annulus (thickened ring) around the pore. Admittedly, some wild grasses produce likewise Cerealia-type pollen, but one may safely assume that the majority of the Cerealia-type pollen at Carthage are of cereals, which in this case must be barley and wheat. In fact, the wall structure of the Cerealia-type pollen at Carthage is characteristic of the *Triticum/Hordeum*-type. How can the high Cerealia-type percentages be explained? In past and modern pollen samples the proportions of Cerealia-type pollen usually remain under 1-2%. Barley and wheat are self-pollinating, implying that only small numbers of pollen grains are released in the air. In these cereals most of the pollen stays inside the glumes (the hulls enclosing the cereal grains). It is therefore unlikely that more than an occasional cereal pollen grain had been carried in by the wind, even if at the time corn-fields were found within a reasonably short distance from the harbour area. Most likely, the cereal pollen was largely derived from human faeces that had ended up in the water (section 3.1). Cereal pollen may have been present in the bread and other farinaceous food consumed by the Carthaginians, and the resistant pollen walls may have passed through the digestive tract undamaged (Bottema & Woldring 1994).

With respect to the potential of northern Tunisia for cereal cultivation, the following should be remarked. In Roman times, Tunisia was one of the granaries of Rome, and much corn was shipped to Rome through the harbour of Carthage. The considerable production of corn (on large estates) suggests that in northern Tunisia conditions for cereal growing were

quite good. However, this may have been true only to a certain extent. In a large part of northern Tunisia soil moisture may have been a limiting factor. As is indicated on the map of present-day vegetation and land use of Tunisia by Gaussen and Vernet (1958), fallowing is practised in a broad zone through the north of the country. To increase the moisture content of the soil, the rain-fed fields are left fallow every other year. In this way the crop can profit from the extra moisture held over from the previous winter rains. There is no reason to assume that in Roman times, conditions for arable farming were more favourable than at present. Consequently, at least in part of the corn-producing area only half of the arable land may have been under cultivation at the same time.

4.2 **Pulses**

Like cereal grains, pulse-crop seeds have survived in a carbonised condition only. Almost the whole Old World pulse-crop assemblage has been recorded from Carthage, be it that not all species may have occurred at the same time. Among the pulse-crop species, lentil (*Lens culinaris*) is best represented at Carthage. It has been identified from all levels examined for plant remains, from early-Punic levels at Carthage-Dermech (Kroll in Niemeyer et al. 1993) to medieval (11th-13th century AD) occupation at the Byrsa (Table 19). Among the seeds secured from the Tophet, lentil is by far the most numerous (Table 16).

One seed of bitter vetch (*Vicia ervilia*) was identified by Stewart (1976b) from a Punic context in the circular harbour area (A76 XI), and we found a few seeds of this species in Punic levels at the Byrsa (Table 19) and Falbe's site 90 (Table 20). In addition, the Roman harbour sediment yielded two seeds (Table 8). Many more bitter vetch seeds were recovered by Stewart (1976b) from the 6th/7th century AD domestic dwelling at the site on the Avenue Bourguiba mentioned above (4.1). In Byzantine Carthage, bitter vetch may still have been utilised for human consumption, as was done in prehistoric times. At present the plant is grown only as stock feed. Bitter vetch seeds are toxic to man, but the poisonous substance can be removed by soaking the seeds in water before cooking.

The 6th/7th century domestic dwelling (Stewart 1976b) yielded also seeds of grass pea (*Lathyrus sativus*) and chickpea (*Cicer arietinum*). The seeds of grass pea, too, contain a poisonous substance which should be removed before being prepared for human consumption. A few pulse seeds (lentil, chickpea, grass pea) were recovered by Ford and Miller (1978) and Hoffman (1981) from 5-7th century AD levels at the site excavated by the team of the University of Michigan.

A few seeds of pea (*Pisum sativum*) and one of broad bean (*Vicia faba*) were retrieved from 4th century BC levels at the Tophet (Table 16). The broad bean (6.4 mm) is of the small-seeded form (*V. faba* var. *minor*) which, in fact, is the only form found in prehistoric and early-historical sites. Broad bean and pea have been identified also from early-Punic levels at Carthage-Dermech (Kroll in Niemeyer et al. 1993). In addition, the medieval ashy deposit at the Byrsa yielded one pea seed (Table 19).

One may assume that in addition to cereals, pulses played a prominent part in the diet of the inhabitants of Carthage. They formed an important source of protein.

4.3 **Oil plants**

"The olive, *Olea europaea* L., is the most prominent, and economically perhaps the most important classical fruit tree of the Mediterranean basin… Since the Bronze Age, the wealth of many Mediterranean peoples centred around the cultivation of olives, which provided valuable storage oil as well as edible fruits. Olive oil was used in eating and cooking, as well as for ointment and lighting. Because of its excellent keeping qualities, it served as a principal

article of commerce." (quoted from Zohary & Hopf 2000: 145) Olive cultivation is thought to have been introduced into the western Mediterranean in the first millennium BC (Boardman 1976).

The small numbers of olive stones recovered from the Punic channel (Tables 3 and 7) suggest that at fourth century Carthage, olive cultivation was at most of moderate importance. In the fill of the Byzantine harbours, on the other hand, olive is well represented in the seed record (Tables 4, 9, 10), suggesting that at that time olive was more widely cultivated. The Roman sediment in the rectangular harbour takes up an intermediate position with respect to olive-stone frequencies (Table 8). Stewart (1976a) found small numbers of olive stones in the fill of the Punic channel (locus E1.070), but large quantities in waterlogged sediment (locus E1.069) stratigraphically above the Punic channel and dated to 4th century-146 BC. The charred seed record obtained from the Tophet (Table 16) does not tell us much about the actual role of olive in the food economy of fourth century Carthage. Was olive really of only moderate importance in the period representing the final silting up of the Punic channel? We may never know, but the wood used as fuel for the pyre in the Tophet does not support such an assumption. Among the charred wood retrieved from 6th to 4th century BC urns, that of olive is by far predominant (Stuijts 1991), indicating that olive yards must have been quite common. In conclusion, one should not rule out the possibility that at fourth century BC Carthage, olive was of much greater importance than is suggested by the few olive stones secured from the Punic channel.

In post-Punic times, olives were grown not only for local consumption, but also for exportation. Thus, from the second century AD, the *annona*, the annual payment in kind to Rome, consisted partly of olive oil, because not enough of it was produced in Italy.

Olive has a good production as well as dispersal of pollen and one wonders whether the pollen record can provide more information on the role of olive in Punic Carthage. Unfortunately, the pollen evidence is not conclusive: olive-pollen values are low, not only in the fill of the Punic channel (Figs. 5 and 7), but also in the Byzantine sediment sections (Figs. 6, 9, 10). Thus, the good representation of olive in the Byzantine seed record is not corroborated by relatively high olive-pollen values. The highest olive-pollen values were obtained from the Roman sediment (Fig. 8), which yielded distinctly smaller numbers of olive stones than the Byzantine harbour deposits. Apparently not only the extent of olive cultivation (the olive acreage), but also the distance of olive yards from the harbour area played a part in the proportion of olive in the local pollen precipitation (see also section 6.6).

According to the map of the natural potential vegetation (Fig. 1, discussed in section 6.1), originally wild olive would have been found at a relatively short distance from Carthage. However, in Punic times and later, in the Carthage area the original vegetation with wild olive must have been under cultivation. After all, this was good farm-land. For that reason, it is unlikely that wild olive has contributed substantially to the pollen deposited in the waterlogged sediments.

The high-caloric waste of olive pressing, consisting of pulp and stone fragments, may have been used as fuel. Neef (1990) mentions that this waste, mixed with sheep/goat dung, was used as fuel in a village in the Jordan Valley. Comparison of the olive-stone fragments in a modern ash sample from a 'taboon' (bread oven) in this village with the remains of olive stones in ash deposits of a few ancient settlement sites suggests that the practice of using the waste of olive pressing as fuel dates back to the fourth millennium BC. It must have been common practice in the distribution area of olive cultivation. As for Carthage, the examination of mortar samples from Roman and later levels led Ford and Miller (1978) to the conclusion that ashes, including olive stones, straw and chaff, had been used as temper for making mortar. The ash may have come from the kilns which reduced the limestone for mortar, but this remains uncertain. Be this as it may, it seems fair to assume that at Carthage, too, the

waste of olive pressing was used as fuel, not so much in the city itself, but rather in the countryside where the olive presses were found.

Opium poppy (*Papaver somniferum*) is fairly well represented in the seed record, but no pollen of *Papaver* has been identified. The climate of the Carthage area, with warm, dry summers, is well suited for the cultivation of opium poppy. The species is grown for two purposes. Opium is extracted from the exudation obtained by making incisions in the unripe seed capsules. The small seeds, which do not contain opium, are a much appreciated ingredient in food preparation, for instance, sprinkled on bread and as stuffing in pastry. In addition, oil is extracted from the seeds. As the medicinal properties of opium, for instance, as a pain killer, were known in antiquity, it is possible that also in Carthage opium was utilised as such. The *Papaver* values as shown in Figs. 3 and 4 suggest that in Byzantine times, the importance of opium poppy had declined markedly, although the *Papaver* frequencies in section KL12 of the rectangular harbour to some extent invalidate such a conclusion. Moreover, the good representation of opium poppy in the fill of the Byzantine well (Table 5) indicates that at least up to AD 700, the species had continued to be cultivated in the Carthage area.

The role of flax or linseed (*Linum usitatissimum*) in the economy of Carthage is not clear. The species is represented in all three periods (Punic, Roman, Byzantine), but by a few seeds only, among which one charred specimen (Table 6), and some seed-capsule fragments (Table 10). It looks as if flax seeds were not consumed to any great extent, for instance, as an ingredient of dishes. Cooking oil is obtained from linseed by cold pressing (Zohary & Hopf 2000: 126), but it is not likely that at Carthage there was any demand for this product, because olive oil, which is a better-quality consumption oil, was available. One wonders whether flax was grown here primarily for its fibres (fabrication of linen cloth).

From the fill of the Punic channel a pollen grain of sesame (*Sesamum indicum*) has been identified (Table 13). Sesame seeds uncovered from Iron Age (c. 800 BC) levels at Deir Alla in Jordan (Neef 1989) suggest that the Phoenicians were acquainted with this oil crop. The single pollen grain does not necessarily imply that sesame was cultivated at Punic Carthage, but the seeds or the oil may have been imported (from the Levant?). Pollen adhering to the seeds or present in the oil may have ended up in the Punic channel after it had passed through the human digestive tract.

4.4 **Condiments**

The aromatic seeds of dill (*Anethum graveolens*), coriander (*Coriandrum sativum*) and fennel (*Foeniculum vulgare*), of the Carrot Family (Umbelliferae), are used in seasoning dishes. If locally cultivated also the fresh leaves of dill and fennel may have been used in food preparation. As will be argued below (chapter 5: *Apium*), it is assumed here that celery (*Apium graveolens*) occurred wild in the vicinity of the (abandoned) Byzantine harbours, where the species must have been quite common. As a matter of fact, the leaves of wild celery could have been gathered by the local inhabitants. The seeds of celery are not used in the kitchen. It should be mentioned here that in Byzantine times, celery had been cultivated already for centuries.

4.5 **Fruits**

Two species discussed here under the heading ‘fruits’ are not fruit trees but annuals. One such an annual fruit crop is melon, *Cucumis melo.* The seeds of melon show a fair resemblance to those of cucumber (*Cucumis sativus*), but the *Cucumis* seeds from Carthage could convincingly be identified as those of *C. melo* (cf. Frank & Stika 1988: 48-49). Admittedly, it is not

certain whether melon at Carthage has to be classified among fruits or vegetables. Non-sweet green-fruited forms were eaten as cucumbers, for instance, the chate melons which are well known from pharaonic Egypt. Sweet melons, which are thought to be more advanced forms, were already known to the Greeks (cf. Zohary & Hopf 2000: 194). Melons, sweet or non-sweet, must have been popular in Byzantine Carthage, but were hardly or not consumed in Punic and Roman times. One melon seed was retrieved from the Punic channel (Table 3) and none from Roman sediment. Local cultivation is attested by a *Cucumis* pollen grain in a sample from the Byzantine rectangular harbour (Table 13).

Pollen of *Citrullus* (Table 13) may have been of cultivated watermelon, *Citrullus lanatus* (*C. vulgaris*), but wild colocynth (*Citrullus colocynthus*), a species of sandy deserts and semi-deserts in North Africa and west Asia, should not be ruled out. The bitter fruits of colocynth are unfit for human consumption but are collected for their medicinal value (a strong purgative). Factual evidence (finds of seeds) for the cultivation of watermelon in the Nile Valley dates back to the early second millennium BC (cf. Zohary & Hopf 2000: 193).

Punic Carthage was renowned for its high standard of fruit cultivation, and the seed record suggests that in Roman and Byzantine times, fruit growing was of equally great importance. In evaluating the large numbers of fig (*Ficus carica*) pips recovered, it should be taken into consideration that each fig fruit may contain several hundreds of pips. Nevertheless one may safely assume that fig was much consumed in Carthage. In a dried form fig can be kept for a long time, thus being available for consumption the whole year around. Pollen of fig has not been found, but this is not really surprising if one considers the fertilisation mechanism of *Ficus*, in which no pollen is released outside the fruit.

Equally grape (*Vitis vinifera*) must have been of major importance. The grape pips preserved in the waterlogged sediments may mainly have been of fresh or dried fruits that had been consumed by man, but one may assume that grape cultivation was aimed primarily at the production of wine. Vineyards may have taken up a considerable acreage, but unfortunately the pollen evidence is not very informative in this respect. In contrast to the wild species, cultivated *Vitis* is seriously under-represented in the pollen rain: surface samples taken in vineyards gave very small numbers of *Vitis* pollen (S. Bottema, unpublished; H. Woldring, unpublished). Punic *Vitis*-pollen values are, on average, slightly higher than those obtained from Byzantine sediment samples, suggesting that in Punic times vineyards were found nearer to Carthage.

Other cultivated fruit-trees included pomegranate (*Punica granatum*), mulberry (*Morus nigra*), plum (*Prunus domestica*) and peach (*Prunus persica*). Pomegranate, a spiny shrub or small tree, forms part of the traditional Mediterranean fruit-tree assemblage. Although the Roman name of pomegranate, *Malum Punicum*, refers to Punic Carthage, the species is of Southwest Asian origin, where it was taken into cultivation in the third millennium BC or earlier (Zohary & Spiegel-Roy 1975). The pips of pomegranate are much better represented than the pollen of this species, which can be explained by the poor pollen dispersal of *Punica*.

The seeds (pips) of black mulberry (*Morus nigra*) cannot be distinguished from those of white mulberry (*Morus alba*). It is likely that black mulberry, with purple, raspberry-like fruits, is concerned here. White mulberry was formerly much planted for its foliage that was used to feed silk-worms.

Peach (*Prunus persica*) is a native of China, where it was taken into cultivation. This fruit-tree reached the Mediterranean basin from Persia (Iran), hence its name *Prunus persica*. We identified peach fruit-stones from the Byzantine harbours only (Tables 4 and 11), but Stewart (1976a, 1976b) reports stones from the Punic channel (mid-fourth century BC). The earliest find so far of peach in the Mediterranean region is from seventh century BC Samos (Kučan 1995).

Opinions on the origin of domesticated plum (*Prunus domestica*) differ (Zohary & Hopf 2000: 179-180), but it looks as though plum cultivation was initiated in Europe. The Romans, who developed various plum varieties (which are propagated by grafting only), may have introduced this fruit tree into North Africa, but finds of plum stones are confined to Byzantine Carthage (Tables 4 and 9).

A few fruitstones of *Cordia myxa* (Egyptian plum) were recovered from the fill of the Byzantine rectangular harbour (Tables 9 and 10). Other archaeological finds of *Cordia myxa* are from Egypt, where this fruit has been recorded from tombs (cf. Darby et al. 1977: 707) and from sites in the Eastern Desert (Cappers 1999; Van der Veen 1999). The role of Egyptian plum at Byzantine Carthage is not clear: was the species locally cultivated or was it an import product?

A pollen grain of *Citrus* in one of the samples from the Punic channel (Table 12: group 2) points to the cultivation of citron (*Citrus medica*) in the Carthage area. This is the only *Citrus* species which seems to come into consideration here. By the end of the fourth century BC, the cultivation of citron was well established in the East Mediterranean region. Other *Citrus* species appear to have arrived in the Mediterranean basin much later (Zohary & Hopf 2000: 184-185).

Wild fruit types identified from Carthage include blackberry (*Rubus*), hawthorn (*Crataegus laevigata*) and a jujube species (*Ziziphus lotus*). The blackberry pips are most likely of *Rubus ulmifolius*, a common bramble species in North Africa (Quézel & Santa 1962-1963: 455). The evidence from the circular harbour suggests that blackberries were more intensively gathered in Punic times than in the Byzantine period (Fig. 3), but in the samples from the rectangular harbour the difference between the two periods with respect to *Rubus* is less prominent (Fig. 4). Here, *Rubus* is only moderately represented in the Punic sediment, although still better than in the Roman and Byzantine deposits. It seems that after Punic times blackberry was only occasionally consumed.

Crataegus laevigata is a thorny shrub or small tree with red-skinned fruits, about 1 cm large, which are not particularly tasty. *Ziziphus lotus* is a spiny shrub with globular, yellow fruits, about 1 cm in diameter. The fruits of this jujube species are reported to be eaten by the poor (Polunin & Huxley 1970: 122). We found only a few *Ziziphus* stones, but more were recovered by Stewart (1976a, 1976b) from the Punic channel. The species is absent from the Byzantine harbours.

There is no archaeobotanical evidence of date (*Phoenix dactylifera*). Dates could have been imported from oasis sites in the North-African desert and from Egypt. One may assume that the thick-walled fruitstones would have been preserved in a waterlogged condition.

Although not a fruit tree, mention is made here of *Fraxinus ornus* (manna ash). Pollen of *Fraxinus ornus* in Punic, Roman and Byzantine deposits (Tables 12 and 13: group 2) points to the occurrence of the tree in the area. Manna ash is not native to North Africa, but the tree may have been planted locally. From this tree a sweetish exudation called manna is obtained by making incisions in the bark. The dried-up exudation is used as food as well as for medicinal purposes (Von Wiesner 1928: 2063). According to Polunin & Huxley (1970: 144) the tree is cultivated in Sicily and Calabria for its manna.

4.6 **Nuts**

Of the nuts listed in group 2 of Tables 3-5 and 7-10, only almond (*Amygdalus communis*) may have been cultivated in the Carthage area. Hazel (*Corylus avellana, C. maxima*) and walnut (*Juglans regia*) did not occur in the deciduous forest of Tunisia and it is unlikely that these nut species were cultivated locally. It is true that *Corylus* occurs fairly regularly in the pollen record, be it in small numbers only (Figs. 5-10), but this cannot be considered evidence of

local cultivation. Hazel has such a good pollen production and dispersal that the pollen finds can justifiably be ascribed to long-distance transport from across the Mediterranean. Similarly, a few *Juglans* pollen grains counted in one of the Byzantine samples (Table 13) may have been carried in from quite some distance. No wood of *Corylus* or *Juglans* has been recorded (Stuijts 1988). Walnut and hazelnut may have been imported from temperate Europe and/or Turkey. We found no nutshell remains of these two species in samples from the Punic channel, but Stewart (1976a) reports a few hazelnuts from this feature. In addition, hazelnut fragments were recovered from a Punic context in the seaside residential area (Table 18: 2). In Punic times, walnut and hazelnut may still have been a rare commodity at Carthage, to be more commonly consumed in Roman and Byzantine times.

Most likely the seeds of stone pine (*Pinus pinea*), too, were an import product. The culinary use of stone-pine seeds in Rome is well documented, for instance, in the cookery-book of Apicius (cf. Kislev 1988). Stone pine is relatively well represented in the samples from the Tophet (Table 16). The Punic finds of stone-pine seeds illustrate contacts with the western Mediterranean, where the Carthaginians had colonies.

Nuts of *Pistacia lentiscus* (mastic tree), a common constituent of Mediterranean maquis, were retrieved from Punic and Roman deposits (Tables 3, 7, 8: group 7). The resin (mastic) obtained from incisions made in the bark of this shrub is used in folk medicine and as chewing gum. The oil extracted from the berries is edible and used for illumination (Polunin & Huxley 1970: 119).

The *Castanea* pollen type (Table 13: group 2) gives occasion to the following comment. The climate of the Carthage area is unfit for the cultivation of *Castanea sativa* (sweet chestnut), which requires more humid conditions. The distribution of sweet chestnut in North Africa is confined to the mountains of north-east Algeria (l'Edough near Bône) and north-west Tunisia (Aïn Draham) (Rikli 1943: 358). In North Africa and other western Mediterranean countries sweet chestnut is probably not a genuinely wild element, but was introduced by humans and subsequently naturalised. Be this as it may, *Castanea* pollen identified from Carthage cannot have been of local origin, but must have been blown in from north-west Tunisia or farther away. There is no evidence of the consumption of sweet chestnut by the Carthaginians.

4.7 **Other cultivated plants**

Two seeds of safflower (*Carthamus tinctorius*) were uncovered from the Roman harbour sediment (Table 8). From the yellow-red flower heads (compound flowers) of this species, safflower carmine, a red, water-insoluble dye, is extracted. In the past, safflower carmine was widely used to dye textiles. In addition, two *Carthamus* spec. seeds were recovered from the Byzantine rectangular harbour (Table 9). *Carthamus lanatus* and *C. coeruleus* are common species of uncultivated ground (Quézel & Santa 1962-1963: 1038, 1040). A few *Carthamus* pollen grains are listed under group 3 in Tables 12 and 13.

The pollen type indicated as *Humulus/Cannabis* (Tables 12 and 13: group 1) is most likely of cultivated *Cannabis sativa* (hemp) because wild *Humulus lupulus* (hop), a species of brushwood and moist to wet forest (swamp forest), is not reported from North Africa (Quézel & Santa 1962-1963). Hemp fibres, obtained from the bast of the stem, may have been utilised for the manufacture of sails and rope.

Punic and Roman sediment sections yielded each one *Ricinus* pollen grain (Table 13). Castor oil, obtained from the seeds of *Ricinus communis*, is reported by Greek authors from Egypt, where it was used in lighting (Darby et al. 1977:782). In former times castor oil was used in medicine, mainly as a purgative.

4.8 **Possibly cultivated plants**

The following plant taxa could have been cultivated in the Carthage area, but could just as well have formed part of the wild vegetation.

Beta, probably *Beta vulgaris* (beet), is represented in samples from the circular harbour site (Tables 3-5: group 8). Two compound fruits were found (Table 3: sample 77/40 and Table 5: sample 385/101). In *Beta*, two or more one-seeded fruits are connate at the base, forming a compound fruit. In addition, loose lids (each of the one-seeded fruits is closed by a lid) have been identified. *Beta* (*vulgaris*) is listed among the wild plant taxa, but its status at Carthage, wild or cultivated, is uncertain. Literary sources document the cultivation of *Beta vulgaris* for the leaves as well as for the tap roots in classical times (Körber-Grohne 1987: 211-212). Cultivars with swollen roots are thought to have appeared later. Wild forms of *B. vulgaris* occur as weeds of cultivation, while subsp. *maritima* is distributed in the Mediterranean basin, the Near East and the Atlantic coastal belt of Europe (Zohary & Hopf 2000: 200-201).

The species identity of the *Brassica* and *Sinapis* seed types, listed under group 3, is uncertain. Wild forms, like black mustard (*Brassica nigra*) and charlock (*Sinapis arvensis*), may be concerned here, but cultivated species should not be ruled out: cabbage (*Brassica oleracea*), turnip (*Brassica campestris*), white mustard (*Sinapis alba*).

A great number of wild *Daucus* species are found in North Africa (Quézel & Santa 1962-1963: 659-663), but it should not be ruled out that the *Daucus* seeds identified (group 8) are of cultivated carrot, *Daucus carota* subsp. *sativa*.

Cichorium intybus (chicory) could have been cultivated as a vegetable crop (not so much for the tap root used to make a coffee surrogate). In the wild the species is found on roadsides and uncultivated ground (group 3).

Portulaca oleracea (purslane) is a tread-resistant, prostrate herb of waste ground, but it is also cultivated as a vegetable (group 3).

5 NOTES ON WILD PLANT TAXA

In this chapter comments are made on some of the wild plant taxa represented in the seed and pollen records included in the present paper. Brief information on the ecology of the other taxa can be obtained from Tables 3-5, 7-10, 12 and 13, in which the wild plant taxa are arranged according to ecological affinity. Most of the information presented below is taken from Quézel & Santa (1962-1963: Nouvelle flore de l'Algérie) and Polunin & Huxley (1970: Flowers of the Mediterranean).

Aizoon (*hispanicum*). Most likely the *Aizoon* seeds recovered are of *A. hispanicum*, an annual plant with succulent leaves. This species is reported from dry grasslands (Quézel & Santa: 310), but also from saline soils. At Carthage, the species may have occurred in brackish habitats.

Amaranthus. At present, various *Amaranthus* species are found in North Africa, but only *A. lividus* (*A. blitum*) and *A. graecizans* (*A. angustifolius*) are of Old World origin, both species of cultivated and waste ground (Quézel & Santa: 305).

Ambrosia maritima. The presence of *Ambrosia* at Carthage is somewhat surprising in that, according to Quézel & Santa (p. 953), this plant is thought to be an adventive in North Africa. However, the subfossil seeds perfectly match those of *A. maritima*, suggesting that the species is indigenous to the area. *A. maritima* occurs on sandy sea shores ('sables maritimes').

Apium (*graveolens*). A species identification of the subfossil *Apium* seeds appeared problematic. Two species may come into consideration, viz. *Apium graveolens* and *A. nodiflorum* (*Heliosciadium nodiflorum*). Most likely the *Apium* seeds at Carthage are of *A. graveolens* (celery), a biennial herb, up to 90 cm high, with small whitish flowers in umbels. In the wild, the species is found particularly in damp grassy places near the sea (brackish habitats). It is less likely that *A. nodiflorum* (fool's watercress) occurred in the harbour area because this species is not salt-tolerant. As *A. graveolens* is also cultivated, it was at first assumed that the cultivated form is concerned here. However, on second thoughts this assumption was rejected. As celery is not grown for the seeds but for the vegetative parts (turnips, leaves, thickened stems, depending on the cultivated variety), the rather great numbers of *Apium* seeds are difficult to explain in terms of cultivated forms. In consequence, it is more likely that the seeds are of wild celery which must have been quite common in the vicinity of the Byzantine harbours (see discussion in section 6.3). Only small numbers of *Apium*-type pollen grains were counted (Figs. 6-8, 10).

Arthrocnemum macrostachyum is a succulent, much branched shrub of saline habitats, up to 150 cm high (Quézel & Santa: 293). The plant shows a fair resemblance to *Salicornia fruticosa*, a shrubby glasswort species also found near Carthage (see below).

Atriplex. The identification of subfossil *Atriplex* seeds to the species level is problematic. On the analogy of the *Atriplex* seeds reported from a great number of archaeological sites in temperate Europe, the Carthage specimens were initially indicated as *Atriplex prostrata*/*patula* (spear-leaved/common orache). Both, *A. prostrata* (*A. hastata*) and *A. patula* are species of disturbed habitats, rich in nitrates. On second thoughts the question arose whether other

Atriplex species might be involved. One such a candidate is *A. halimus* (shrubby orache), a shrub of up to 2 m high, which is found in salty places, on the coast as well as in the interior and which is still common near Carthage. In fact, samples from Roman sediment in the rectangular harbour (Table 8: group 5) yielded fruiting bracts of *A. halimus*, some of them still enclosing a seed. Although there is firm evidence of *A. halimus* only for the Roman period, one may assume that the species is represented in the Punic and Byzantine periods as well. Small numbers of fruiting bracts recovered from a few samples from the Byzantine well (Table 5) remind one of those of *A. rosea* (the match is far from perfect). *Atriplex rosea* is a species of saline soil, rich in nitrates. As the species identity of most of the seeds is uncertain (a few could confidently be attributed to *A. halimus*), in Tables 3-5 and 7-10, *Atriplex* is listed under group 8 (taxa of uncertain ecological affinity).

Bupleurum (*lancifolium*). Various *Bupleurum* species are reported from North Africa, but only few of them are quite common (Quézel & Santa: 653-655). The seeds recovered from Carthage match those of *Bupleurum lancifolium* (*B. subovatum*), a plant of cultivated fields.

Calendula (*arvensis*). Most likely the *Calendula* seeds found at Carthage are of *C. arvensis*. This small-flowered, orange marigold is a common weed of arable fields, vineyards and waste ground (Polunin & Huxley: 187-188).

Centaurea. The *Centaurea solstitialis* pollen type includes *Centaurea calcitrapa* (Tables 7 and 8), a common weed of cultivation and waste ground in North Africa (Quézel & Santa: 1028).

Chenopodiaceae. This pollen type includes various taxa represented in the seed record, such as *Arthrocnemum, Atriplex, Chenopodium*, *Suaeda* and *Amaranthus*. The latter is not of the Goosefoot Family, but its pollen cannot be distinguished from that of most Chenopodiaceae. In Chenopodiaceae, the production as well as the dispersal of pollen are usually quite good.

Chenopodium. Two types are recognised among the *Chenopodium* seeds recovered from Carthage. The seeds of *Ch. album* cannot be distinguished from those of *Ch. opulifolium*, hence the designation *Chenopodium album*/*opulifolium*. In fact, Quézel and Santa (p. 292) consider the two species as subspecies of *Ch. album* (subsp. *album* and *opulifolium*), but in most other flora works they are treated as separate species. Both are weeds of cultivated and waste ground. *Chenopodium murale*, the other type distinguished, is likewise a weed of disturbed ground; in addition it is found on stony soil and at the foot of stone walls.

Chrysanthemum. A large number of *Chrysanthemum* species are reported from North Africa (Quézel & Santa: 982-988). One seed type could confidently be attributed to *Chrysanthemum coronarium*, an annual plant, up to 80 cm high, with large golden-yellow flowers (up to 6 cm across). It is a species of arable fields and waste ground (Polunin & Huxley: 187). A second *Chrysanthemum* seed type shows a fair resemblance to that of *C. segetum*, a weed of cultivation with bright yellow, daisy-like flowers, but the species identity is not certain. *Matricaria*-type pollen (Tables 12 and 13: group 3) includes *Chrysanthemum*.

Cistus is regularly represented in the pollen record; it shows continuous curves in most of the pollen diagrams from Carthage. On the other hand, *Cistus* seeds are scarce: a few seeds were recovered from the fill of the Punic channel (Table 7). Various *Cistus* species, mainly low shrubs, are typical of Mediterranean maquis.

Coronopus squamatus is a prostrate herb (lying flat on the ground) which is found on damp soil. The species is tread resistant and salt tolerant, for which reason it is listed here under group 5 (salt-marsh species, etc.).

Cruciferae. Various taxa of this family are represented in the seed record, but here attention is paid to the pollen. Some of the Cruciferous pollen is identified as *Brassica* type, whereas others show more affinity to that of *Sinapis*. However, the majority of the Cruciferous pollen is of another, smaller type, averaging 20µ in diameter, with a relatively thick wall and a rather coarse reticulate surface pattern. The high Cruciferae pollen values in the samples from the Byzantine harbours (Figs. 6, 9, 10) suggest that at least locally the species concerned was quite common (see section 6.5).

Cyperaceae are only moderately represented in both the pollen and seed record. Various Cyperaceous seed types were identified: *Carex otrubae* type, *Carex vesicaria* type, *Cladium mariscus*, *Cyperus* and *Eleocharis palustris* are plants of moist to wet places, while *Scirpus maritimus* and *Scirpus lacustris* subsp. *glaucus* are marsh plants which are found in a brackish as well as in a freshwater environment.

Emex spinosa is a stout herb which occurs as a weed of waste ground. During fieldwork, the plant was observed on the terrain of the rectangular harbour, together with other species identified from ancient Carthage.

Erica multiflora. Leaves, seeds and flowers of *Erica* could all be identified as those of *Erica multiflora*, a common heath species of coastal maquis. It is likely that the Ericaceae pollen in the channel and harbour deposits (Figs. 5-10) is of this *Erica* species.

Euphorbia. Three *Euphorbia* species have been identified: *E. helioscopia, E. chamaesyce* and *E. paralias*. The latter, represented by one seed only (Table 9), occurs on sands by the sea.

Glaucium. In addition to *Glaucium corniculatum*, a species of cultivated fields and waste places, *G. flavum* is represented in the seed record (Tables 9 and 10). *G. flavum* is found on littoral sands (Polunin & Huxley: 75-76).

Gramineae. Wild grasses are well represented in the pollen record, but, except for the Roman sediment, not so much in the seed record of channel and harbour deposits. It looks as if at Carthage conditions were unfavourable for the preservation of grass seeds in a waterlogged state. Only few non-carbonised grass seeds were found. Almost all grass seeds secured were in a charred condition. Unfortunately, most of the charred grass seeds in the Roman harbour sediment could not be identified beyond the family level.

Heliotropium (*europaeum*). The *Heliotropium* seeds recovered are most likely of *H. europaeum*, a hairy annual, 10 to 35(50) cm high. The small, white or lilac flowers are in tight, spirally coiled clusters. It is a species of cultivated fields and waste ground (Polunin & Huxley: 149).

Hyoscyamus (*albus*). The seeds do not permit a species identification, but most likely they are of *Hyoscyamus albus*, a common species of waste places in North Africa (Quézel & Santa: 824).

Inula viscosa type. The subfossil seeds correspond with those of *I. viscosa* in the seed reference collection, but another *Inula* species may be concerned here, e.g. *I. crithmoides* which is a plant of saline habitats (Quézel & Santa: 940). *Senecio*-type pollen counted at Carthage probably includes *Inula*.

Juniperus phoenicea (Phoenician juniper) is represented by leafed stem fragments. At first the archaeological remains were thought to belong to *Cupressus sempervirens* (Italian cypress), but a close comparison with modern reference material collected in Tunisia turned the scale to *Juniperus phoenicea*, a common shrub of the maquis on the Cap Bon peninsula.

Linum. This seed type is distinctly smaller than that of cultivated flax (*Linum usitatissimum*) discussed in section 4.3. It makes no sense to speculate on the species identity of the wild flax seeds at Carthage. Several wild *Linum* species occur in grassy places.

Lolium. A fair number of *Lolium temulentum* seeds were recovered from charred seed sample A77 IV/262 (Table 6). In addition, a few seeds of this type were secured from other samples (Tables 9, 10, 16, 17). *L. temulentum* is a typical cornfield weed. Two waterlogged samples each yielded one charred *Lolium perenne*-type seed (Tables 3 and 5), which includes a few species of grassy places. *L. perenne* itself is tread resistant.

Malva nicaeensis. Several *Malva* species are found in North Africa (Quézel & Santa: 625-628), three of which were observed in the area of the circular and rectangular harbours. However, there is archaeobotanical evidence of *M. nicaeensis* only, which is a species of waste ground.

Medicago is represented by remains of the characteristic, coiled pods. A considerable number of *Medicago* species is reported from North Africa (Quézel & Santa: 496-502).

Mentha type. The species identity of this seed type is still problematic. The seed record suggests that at least in the vicinity of the Punic channel, the species concerned must have been fairly common. At first, this type was indicated as *Mentha*/*Thymus* type, but after a close inspection of the seeds of various *Thymus* species, *Thymus* was rejected. The subfossil seeds show most resemblance to those of *Mentha pulegium*, a species of damp habitats and periodically inundated ground. *Mentha/Thymus*-type pollen (Tables 12 and 13: group 8) probably corresponds with this seed type.

Mesembryanthemum. Two species come into consideration, viz. *Mesembryanthemum nodiflorum* and *M. crystallinum*. They are spreading annual plants, up to 30 cm high, with succulent (fleshy) leaves and daisy-like flowers. Both species are found in salt marshes and on sands and rocks by the sea (Polunin & Huxley: 60). Other *Mesembryanthemum* species at present found in the Mediterranean basin are introduced from the Cape (South Africa). There is a fair correspondence between the pollen and seed records of *Mesembryanthemum*. The *Mesembryanthemum* pollen type is distinguished from that of *Aizoon*, of the same family as *Mesembryanthemum* (Aizoaceae) and represented as seed, on the basis of the apertures: tetracolpate versus syncolpate pollen.

Pinus. *Pinus halepensis* and *P. pinaster* (*P. maritima*) are represented particularly in the wood and wood charcoal record (Stuijts 1988, 1991), but, in addition, one or a few seeds of these pine species and some cone scales were recovered. Pine cones, with the seeds, could inadvertently have been brought in with the timber. On the other hand, they may have been collected

on purpose, to be used in religious ceremonies (cf. Kislev 1988). The two pine species may have occurred naturally on the Cap Bon peninsula, but probably not in any quantity. Otherwise much higher *Pinus*-pollen values were to be expected (Figs. 5-10). Of *Pinus pinea* (stone pine), the seeds were imported for culinary use (see section 4.6).

Pistacia lentiscus is a spreading evergreen shrub which sometimes grows into a small tree (Polunin & Huxley: 119). It is a common constituent of Mediterranean maquis. One may assume that the *Pistacia* pollen in the fill of channel and harbours is of *P. lentiscus*.

Plantago is fairly well represented in the pollen record (Figs. 5-10). Up to five different types of *Plantago* pollen have been distinguished: *coronopus* type, *lanceolata* type, *maritima* type, *media* type, *ovata* type. On the other hand, finds of plantain seeds are rare: only two samples yielded each one seed, listed under group 4 in Tables 7 and 8.

Polygonum. Almost all *Polygonum* seeds identified from the harbour sites are of *P. aviculare*, a weedy annual of disturbed soil and characteristic of the vegetation of frequently trodden places. The species is also represented in the pollen record (Figs. 5-10).

Poterium/Sanguisorba. The species identity of this pollen type is somewhat enigmatic. At first it was assumed that it was derived (mainly) from *Poterium* (*Sarcopoterium*) *spinosum*, a common, spiny shrub of (degraded) Mediterranean maquis. However, according to Polunin and Huxley (p. 85), this species of East Mediterranean distribution does not occur in North Africa. As the most likely candidate it remains *Sanguisorba minor* (salad burnet), a species of dry, grassy places and brushwood (Quézel & Santa: 452). No seeds of either *Poterium* or *Sanguisorba* were found.

Quercus. Two types of *Quercus* pollen are distinguished. *Quercus coccifera* type includes *Q. coccifera* (kermes oak) and *Q. ilex* (holm oak). The most likely candidates for the deciduous-oak pollen type (*Quercus* deciduous) are *Q. faginea* (Portuguese oak) and *Q. suber* (cork oak), which are both found in northern Tunisia.

Ranunculus. Most of the *Ranunculus* seeds identified from Carthage are of *R. sardous*, a species of saltish grassland which occurs also as a weed of cultivation. The *Ranunculus sceleratus* pollen type (Tables 12 and 13: group 5) includes *R. sardous*. *Ranunculus arvensis* (Table 9: group 3) is a species of arable fields, while *R. repens* and *R. muricatus* (Tables 9 and 10: group 6) are reported from damp places and ditches (Quézel & Santa: 373-374).

Raphanus raphanistrum is a weed of cultivated fields and waste ground. Characteristic of this species are the beaded pods, breaking at the joints. It was these pod segments that were preserved in the waterlogged deposits.

Rapistrum rugosum is a yellow-flowered annual weed of arable fields and waste ground. Of this species, the characteristic globose, ribbed seed capsules were found.

Reseda. Three species are represented in the seed record. *Reseda lutea* and *R. luteola* both have long spikes of yellow-green flowers, while in *Reseda alba* the flowers are white. All three *Reseda* species are found in disturbed habitats.

Salicornia. It is likely that the *Salicornia* seeds are of *S. fruticosa*, a perennial, shrubby salt-marsh species. *S. europaea*, an annual species common on European coasts, is rare in North Africa (Quézel & Santa: 293-294).

Silene is fairly well represented in the Carthage seed record. A very large number of *Silene* species are found in North Africa (Quézel & Santa: 336-350). It has not been attempted to identify *Silene* seeds to the species level, except those of *Silene cucubalus* (*S. vulgaris*), a species of cultivated and waste ground (Tables 4, 7, 9, 10).

Silybum marianum is a robust thistle, 1-2 m high, with large (4-8 cm) purple flower heads surrounded by sharp-pointed bracts (Polunin & Huxley: 190). This species of waste ground is represented particularly in the fill of the Byzantine well (Table 5).

Solanum. Various samples yielded seeds of *Solanum nigrum*, a common weed of cultivation and waste places. *Solanum dulcamara*, a clambering perennial species of hedges and damp places, is represented in three samples only (Tables 4 and 9).

Suaeda. By far the majority of the *Suaeda* seeds are of the *S. fruticosa* type. *S. fruticosa* is a shrub of saline soil, up to 1 m high. A few *Suaeda* seeds may have been of *Suaeda maritima*, an annual salt-marsh species.

Thymelaea hirsuta is a much branched shrub, up to 1 m high. It is a species of sandy and rocky places not far from the sea (Polunin & Huxley: 132), but is common also in the interior. The species is fairly well represented in both the seed and pollen records.

Typha angustifolia. The *Typha* seeds recovered (Tables 4 and 10) must be of *Typha angustifolia*, a tall marsh plant which is fairly common in Tunisia. The other possible candidate, *Typha latifolia*, is very rare in Tunisia (Cuénod 1954: 36 and 265). The *Sparganium* pollen type of Figs. 5-10 is most likely of *T. angustifolia*.

Umbelliferae pollen as shown in Figs. 5-10 includes various types. Only *Apium*-type pollen is presented separately. At least some of the Umbelliferous pollen types identified correspond with seed types found at Carthage. There is an obvious relation between *Apium*-type pollen and *Apium* (*graveolens*) seeds, while *Bupleurum*-type pollen most likely corresponds with *Bupleurum* (*lancifolium*) seeds. *Bunium*-type pollen includes *Ammi visnaga* and *Anethum graveolens*, both present as seed. In addition to the ones mentioned above and in section 4.4 (Condiments), more Umbelliferous species have been identified, among which, *Bifora testiculata*, *Capnophyllum peregrinum* and *Tordylium apulum*, all three with very characteristic seeds. One may well say that Umbelliferae (Carrot Family) are represented by a fair number of seed and pollen types.

Urtica. The three *Urtica* species identified from Carthage (*U. membranacea*, *U. pilulifera* and *U. urens*) are found on waste, disturbed ground. *U. membranacea* and *U. urens* occur also as weeds of cultivation (Quézel & Santa: 278). Although pollen dispersal is thought to be quite good, *Urtica* is represented in the pollen record by a few grains of *U. pilulifera* only. The small (10μ) and fragile pollen grains appear to be poorly preserved in the channel and harbour deposits.

Valerianella. Almost all *Valerianella* seeds recovered match those of *Valerianella morisonii* in the seed reference collection, but it cannot be ruled out that other *Valerianella* species in

Tunisia have similar seeds. One *Valerianella vesicaria*-type seed was found (Table 7). According to Quézel & Santa (pp. 884-887), all *Valerianella* species recorded from Algeria are found in grassy places.

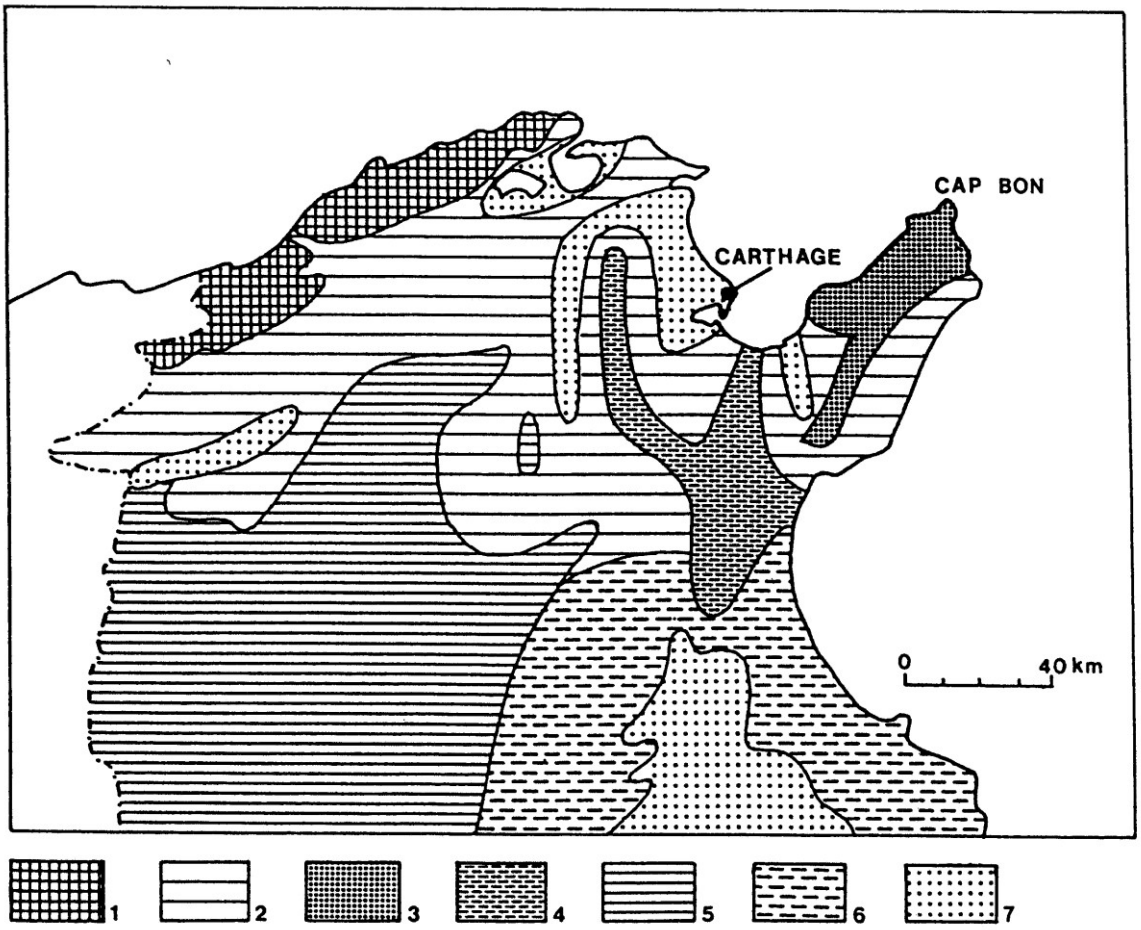

Figure 11. Map of the potential natural vegetation of northern Tunisia. After Gaussen & Vernet (1958) and Giessner (1979: Map 3).

1 Forests of deciduous and evergreen oak (*Quercus faginea*, *Quercus suber*)
2 Evergreen Mediterranean woodland with wild olive and mastic tree (*Pistacia lentiscus*)
3 Evergreen Mediterranean kermes-oak (*Quercus coccifera*) woodland
4 *Callitris articulata* woodland
5 Aleppo pine (*Pinus halepensis*) woodland
6 Shrub and dwarf-shrub steppe with *Artemisia herba-alba* and *Ziziphus lotus*
7 Halophytic vegetation

6 THE VEGETATION

6.1 **The regional vegetation**

As has been discussed in chapter 3, the majority of the seeds and other macro-remains of wild plant taxa preserved in the waterlogged sediments must be of plants that were found in the vicinity of the Punic channel and the two harbours. Pollen grains of wild and cultivated plants, on the other hand, may have been blown in from quite some distance. This means that information on the regional vegetation should be derived primarily from the pollen record. With respect to the regional vegetation of the past, it may be useful to pay attention to the natural potential vegetation of the northern part of Tunisia (Fig. 11). Under natural potential vegetation is understood the vegetation which, under the present-day climatic conditions, would be found in the absence of man and his domestic animals. It may be evident that there is an element of speculation in reconstructing the natural vegetation of regions which have been under intensive human influence for thousands of years.

In the north of Tunisia, forest of cork oak (*Quercus suber*) is predominant, while above 800 m, with a mean annual precipitation of more than 1000 mm, deciduous Portuguese oak (*Quercus faginea*) is found. Cork-oak forests may be considered semi-natural as they are maintained by man for the cork. Woodland with wild olive (*Olea europaea* var. *oleaster*) and mastic tree (*Pistacia lentiscus*) as leading species (Oleo-lentiscetum) forms an extensive belt in northern Tunisia. [Under woodland is understood here open forest with an undergrowth of brushwood.] A large part of the Cap Bon peninsula is assumed to have been covered by kermes-oak (*Quercus coccifera*) woodland, while west and south-west of the peninsula *Callitris* (a juniper-like tree) woodland constitutes the natural potential vegetation. Woodland with Aleppo pine (*Pinus halepensis*) and holm oak (*Quercus ilex*) in the tree canopy is thought to occur naturally in the interior. Halophytic vegetation is present not only in coastal zones but also in inland basins. Saline conditions were found around Carthage, but there was no question of one vast, almost uninterrupted salt-marsh area as is suggested by the map.

At present only little is left of the original plant cover. In many places the vegetation has completely been removed to make place for arable land, orchards and olive-yards. In other places the original vegetation is seriously degraded as a result of grazing, especially by sheep and goat, firewood collecting and burning. In Punic and following periods, too, the natural vegetation had been affected by man, be it perhaps not yet on such a large scale as at present. It is likely that already in classical times, much *Callitris* and kermes-oak woodland had been converted to maquis (low shrub vegetation), while large stretches of land were under cultivation.

In the pollen diagrams prepared from the waterlogged sediments (Figs. 5-10), herbaceous pollen values are by far dominant. Total arboreal pollen values usually fluctuate between 5 and 18%; only the Roman sediment section yielded higher values: around 20%, with a maximum of 28%. The high herbaceous pollen values must in no small measure be due to the local vegetation on and near the harbour terrain. On the other hand, one may safely assume that, except for orchards, in the whole of the Carthage area, tree growth was scarce if not largely absent. Much of the tree pollen in the harbour deposits must have originated from further away (see group 7 in Tables 12 and 13). Thus, it is unlikely that deciduous oak (*Quercus suber*/*faginea*) was found in the Carthage area. As has already been mentioned (section 4.6), pollen of hazel (*Corylus*) must have been carried in from across the Mediterranean. Had pine (*Pinus*) and evergreen oak (*Quercus coccifera*/*ilex*) been present in

the vicinity of Carthage, much higher pollen values of these taxa were to be expected. These two pollen types, too, may have been blown in from (quite) some distance. Some *Pinus halepensis* may have been found on the Cap Bon peninsula, but most of the pine pollen at Carthage must have originated from the Aleppo pine-holm oak woodland in the interior (Fig. 11). *Pistacia* (*lentiscus*) may occasionally have occurred locally (see section 6.2), while *Olea* (olive), *Vitis* (grape-vine) and *Punica* (pomegranate) were cultivated.

The circular harbour site shows a striking difference in grass-pollen values (Gramineae) between the Punic channel and the Byzantine harbour. Grass-pollen values are markedly high (20-50%) in the Punic sediment samples, but much lower (2-8%) in those from the fill of the Byzantine harbour. The rectangular harbour shows a largely corresponding picture, although here the difference in grass-pollen percentages between the two periods is less pronounced. Grass-pollen frequencies obtained from the Roman sediment section are, on average, intermediate between the Punic and Byzantine values. The scarce representation of grasses in the seed record of most of the sediment sections examined does not necessarily mean that grasses hardly played a part in the local vegetation. It seems that non-carbonised grass seeds are poorly preserved in the saline waterlogged sediment at Carthage. Grasses are comparatively well represented in the Roman sediment, but exclusively in a charred condition. At least part of the grass pollen may have been blown in from further away, from secondary steppe vegetation to the west and south of Carthage. This was not original steppe, but steppe-like vegetation which, through the interference of man and his domestic animals, had replaced the woodland which occurred here naturally (see Fig. 11). It was primarily used as grazing land. Other steppe elements identified from Carthage are *Artemisia herba-alba*, *Noaea* and *Calligonum* (Tables 12 and 13: sub-group 4a). One wonders whether the lower grass-pollen values in the (Roman and) Byzantine sediment sections could indicate that part of this secondary steppe had been brought into cultivation and that the grazing-land area had shifted further away from Carthage.

Chenopodiaceae pollen must at least in part have been produced by the local vegetation (see below), but salt-marshes at some distance may likewise have contributed to the chenopod pollen in the harbour deposits. *Alnus glutinosa* (alder) and *Ulmus campestris* (elm), both represented in the pollen and wood (Stuijts 1988) records, may have been found along water courses.

It is unlikely that Italian or funeral cypress (*Cupressus sempervirens*) was more than occasionally found in the Carthage area, although in classical times this tree of East Mediterranean origin was already widely planted in the Mediterranean region. At least, the coniferous leafed stem remains recovered are of Phoenician juniper (*Juniperus phoenicea*) and not of cypress. The *Cupressus* wood identified from Carthage (Stuijts 1988,1991) was probably not of local origin, but imported from elsewhere; the hard and durable cypress wood was used in shipbuilding.

6.2 **Mediterranean maquis**

Except pine (*Pinus*), the species listed in Tables 3, 4, 7-10) under maquis and woods (group 7) are typical of Mediterranean maquis such as is found on the Cap Bon peninsula. At present no maquis vegetation occurs in the area of the classical harbours, and one wonders whether in ancient times this was any different. In that case the remains of maquis species retrieved from the waterlogged deposits must have originated from elsewhere, most likely from the Cap Bon peninsula. Some seeds and other remains may have been brought down by the sea (see chapter 3), but most of them must have ended up in the harbour sediments through the action of man. In this connection the following should be mentioned. French lavender (*Lavandula stoechas*) is a very aromatic plant which was well known as a medicinal plant in ancient times

(Polunin & Huxley 1970: 159). In classical times, rosemary (*Rosmarinus officinalis*) was important in religious ceremonies and public festivities, while myrtle (*Myrtus communis*) was a symbol of love and peace (Polunin & Huxley 1970: 158 and 134, respectively). *Erica multiflora*, a heath species, may have been gathered for its pretty flowers. Stems and branches of Phoenician juniper (*Juniperus phoenicea*) may have been used as firewood, but also as timber (at least the stems); the wood is very durable. A very common constituent of Mediterranean maquis represented in the pollen record is *Quercus coccifera* (kermes oak). One may assume that the majority of the *Quercus coccifera*-type pollen identified from Carthage is of kermes oak. Holm oak (*Q. ilex*) was found at a much greater distance from the site. Characteristic of the maquis are also *Arbutus* (*unedo*) and *Phillyrea* (*angustifolia*), both represented in the pollen record only.

The evidence from the Byzantine well, to be discussed in chapter 7, suggests that also in the past no maquis vegetation was found in the harbour area. Among the plant taxa identified from the fill of the well no maquis species are represented (Table 5). The pollen record, on the other hand, indicates that some maquis species may, at least occasionally, have been found on the harbour grounds. *Pistacia* values of 5.4% in spectrum 4 of the Punic channel (Fig. 5) and of 9.8% in spectrum 2 of the Byzantine circular harbour (Fig. 6) point to a local occurrence of *P. lentiscus* (mastic tree) near the channel and the circular harbour. In this connection it should be taken into account that in general *P. lentiscus* is underrepresented in the pollen rain, as is attested by surface-sample studies (Bottema, unpublished). In fact, only one or a few shrubs could already have caused the relatively high pollen values. It is not clear to what extent Ericaceae pollen values of 5% and more, as were obtained in a few samples from the Punic channel (Figs. 5 and 7) and the Byzantine circular harbour (Fig. 6), are indicative of a local occurrence of *Erica multiflora*. Similarly, a local occurrence of *Cistus* is suggested by comparatively high pollen values in samples 3 and 4 of the Byzantine circular harbour (Fig. 6). *Cistus* (rock-rose) species are known to spread vigorously in places where the maquis has severely been affected by fuel collecting, intensive grazing and burning. No seeds of *Cistus* were recovered from the circular harbour, but the Punic channel at the west side of the rectangular harbour yielded a few seeds of this genus (Table 7). In conclusion, one should consider the possibility that maquis species had (temporarily) settled on the (largely abandoned) harbour terrain.

Table 14. Representation of maquis taxa in the seed records of the circular and rectangular harbours.
\+ present
++ moderately represented

Period	Punic		Roman	Byzantine			
Locus	AIV	E1.070	II.2	AVII	GH2.070	G1.060	KL12.053
Table	3	7	8	4	10	9	9
Cistus	-	+	-	-	-	-	-
Erica multiflora	++	+	+	++	++	+	++
Juniperus phoenicea	++	+	+	+	-	+	++
Lavandula stoechas	++	+	+	++	++	++	++
Myrtus communis	+	-	++	++	++	++	++
Pinus halepensis	+	+	+	-	-	-	-
Pinus, scales	+	-	+	+	-	+	+
Rosmarinus officinalis	++	++	+	+	++	+	++

In Table 14, the representation of maquis species in the channel and harbour deposits is summarised. In defining the frequency indications as given in Table 14 (and in Table 15, discussed in section 6.3), allowance has been made for the numbers of samples in which the species concerned is represented as well as for the numbers of seeds. Admittedly, the

frequency indications are, to some extent, arbitrary. As is clear from Table 14, *Pistacia lentiscus* is absent from the Byzantine period: nuts of this species were found in Punic and Roman deposits, but not in the fill of the Byzantine harbours. The pollen evidence shows a corresponding picture. Leaving aside the two abnormally high *Pistacia* pollen counts mentioned above, mean values in the Byzantine deposits are about 0.4%, whereas in the Punic and Roman sediment sections they range from 0.7 to over 1%. A few more differences are suggested by Table 14. Thus, *Myrtus* is better represented in the Roman and Byzantine harbour deposits than in the fill of the Punic channel. *Lavandula* is best represented in the Byzantine period. Nuts of *Pinus halepensis* were not recovered from Byzantine deposits, but, on the other hand, the latter did yield a few pine scales. The differences mentioned above could point to (man-induced) changes in the composition of the maquis on the Cap Bon peninsula, but they could just as well have been the result of changes in man's preference for certain species to be gathered (for whatever purpose).

6.3 **Vegetation of saline soil**

It may be no surprise that various salt-marsh and other salt-tolerant species are represented in the seed record. The Punic channel and the harbours were sited on almost flat land on the coast, where saline conditions may have prevailed. The groundwater must have been at least brackish and salt water may occasionally have flooded (part of) the area. Some of the species listed under group 5 are typical salt-marsh species, which are confined to saline habitats and which cannot maintain themselves in a fresh-water environment, e.g. *Arthrocnemum macrostachyum*, *Salicornia fruticosa* and *Suaeda fruticosa*. Examples of species which tolerate saline conditions but which are found also in a fresh-water environment include *Aizoon hispanicum*, *Ranunculus sardous* and *Thymelaea hirsuta*.

Table 15. Representation of Chenopodiaceae taxa in the seed records of the circular and rectangular harbours. In addition, the ranges and mean values of Chenopodiaceous pollen percentages are shown.
\+ present
++ moderately represented
+++ well represented

Period	Punic		Roman	Byzantine			
Locus	AIV	E1.070	II.2	AVII	GH2.072	G1.060	KL12.053
Table	3	7	8	4	10	9	9
Atriplex	++	+++	+++	+	+	+	-
Chenopodium album	++	+	+++	++	++	++	+
Chenopodium murale	+++	+++	+++	+++	+++	++	+++
Arthrocnemum	++	+++	+++	++	++	+	-
Salicornia	+	++	+	+	+	+	-
Suaeda	++	+	+++	+++	+++	+++	+++
Chenopodiaceae pollen							
Figure	9	5	6	10		8	7
Range in %	3-16	11-46	24-30	2-21		2-8	4-22
Mean value in %	11	27	27	6		5	11

We do not know whether originally, before the construction of the Punic channel, the whole of the harbour terrain was covered by salt-marsh vegetation or only part of it. Be this as it may, it is likely that as a result of human disturbances the original salt-marsh vegetation was pushed back to unused corners. On the other hand, in periods when activities in the harbour area had greatly declined, salt-marsh vegetation may have regained ground. Changes in the proportion of particular species in the salt-marsh vegetation find expression in Table

15, in which the frequency designations of Chenopodiaceae taxa in the various sediment sections are shown. Of the taxa listed in Table 15, *Chenopodium album/opulifolium* and *Ch. murale* are not salt-marsh taxa but species of waste ground (see section 6.5). From Table 15 it appears that *Suaeda* is much better represented in the Roman and Byzantine sediment sections than in the Punic channel, while *Arthrocnemum* is less well represented in the fill of the Byzantine harbours than in Punic and Roman deposits. The role of salt-tolerant *Atriplex halimus* (shrubby orache) in the local vegetation is somewhat uncertain. As has already been discussed (chapter 5: *Atriplex*), some of the *Atriplex* seeds recovered from the harbour area may have been of *Atriplex prostrata* and/or *A. patula*, both species of waste ground (see section 6.5). In fact, only the Roman sediment yielded firm evidence of *A. halimus* in the form of fruiting bracts (Table 8). As the numbers of *Atriplex* seeds recovered from the Roman sediment section are quite high, it may be not too far-fetched to assume that *A. halimus* was a common constituent of the vegetation of the harbour area. Similarly, the comparatively high *Atriplex* seed frequencies obtained from the fill of the Punic channel may point to a common occurrence of shrubby orache. On the other hand, the rather scarce representation of *Atriplex* in the seed records of the Byzantine harbours indicates that at that time *A. halimus* was at most of minor importance.

In addition to seed frequencies, Chenopodiaceae (Goosefoot Family) pollen values are summarised in Table 15. At the circular harbour site mean chenopod pollen values are 11 and 6% for the channel (AIV) and Byzantine harbour (AVII), respectively, while at the rectangular harbour site a mean value of 27% was obtained for both the Punic (E1.070) and Roman (II.2) deposits as against 5 and 11% for the two Byzantine sediment sections examined for pollen. It is clear that chenopod pollen values are distinctly lower in the Byzantine period than in Punic and Roman times. A comparison between the seed and pollen frequencies of Table 15 suggests that the decrease in Chenopodiaceae pollen values may largely have been due to the strongly reduced proportion of *Atriplex* (*halimus*) in the local vegetation. In the Byzantine sediment sections, *Chenopodium* seed frequencies are not significantly lower than in the Punic deposits, while the decline in *Arthrocnemum* is compensated for by the increase in *Suaeda*.

Thymelaea hirsuta, well represented in both the pollen and seed records, may have been found on the sandy sea-shore, behind which the flat harbour terrain was situated. Here *Thymelaea* was probably joined by a few other species characteristic of sands by the sea: *Ambrosia maritima*, *Glaucium flavum* and *Euphorbia paralias* (sub-group 5a). *Eryngium*-type pollen (Tables 12 and 13: group 5) is possibly of *Eryngium maritimum* (sea holly), likewise a species of coastal sands. The fair representation of *Thymelaea* suggests that the species was not confined to the sea shore, but that it occurred as well in other parts of the harbour area. At present, *Thymelaea hirsuta* grows together with *Atriplex halimus* in the Carthage area, and it may have been the same in ancient times.

The club-rush species *Scirpus maritimus* and *Scirpus lacustris* ssp. *glaucus* may have occurred along ditches and pools with brackish water. *Ruppia maritima* and *Zannichellia palustris* are submerged water plants which are found particularly in brackish water.

Aizoon hispanicum, *Apium graveolens* and *Mesembryanthemum* show (relatively) high seed frequencies in the Byzantine harbours, but are (almost) absent from the Punic channel (Figs. 3 and 4). Apparently, edaphic conditions which favoured the growth of these species were not found in the area of the Punic channel. One wonders whether these particular edaphic conditions, in one way or another, were the result of the construction (and reconstruction) of the harbour, involving an enormous displacement of soil. In this connection it may be mentioned that in 1981, large patches of *Mesembryanthemum nodiflorum* were observed on the sand of the artificial island in the circular harbour. It is tempting to assume that *Mesembryanthemum*, *Aizoon* and *Apium* formed part of a particular type of vegetation of

disturbed, saline soil. This does not mean that this inferred plant community had settled as such in the harbour area. As is evident from Fig. 4, *Mesembryanthemum* was common here already in Roman times, but the other two species did not expand in the harbour area until Byzantine times. *Mesembryanthemum* is an example of a fair correspondence between pollen and seed records: hardly present in Punic deposits and relatively high frequencies in the Roman and Byzantine harbour samples. *Apium* and *Aizoon* are hardly or not represented in the pollen record.

6.4 **Marsh and water plants**

Freshwater marsh plants identified from Carthage include *Alisma plantago-aquatica* (common water-plantain), *Eleocharis palustris* (common spike-rush), *Phragmites australis* (reed) and *Typha angustifolia* (lesser reedmace). *Conium maculatum* (hemlock) is listed here among the marsh plants, but the species occurs also in damp, disturbed habitats. With respect to the marsh plants (group 6), there is a striking difference between the seed records of the Punic channel and the Byzantine harbours. In the fill of the Byzantine harbours various species of this group are represented, be it usually by low numbers of seeds (Tables 4, 9, 10), but from the Punic channel they are almost absent (Tables 3 and 7). The Roman deposit (Table 8) takes up an intermediate position with respect to the representation of marsh and water plants. The above suggests that in Byzantine times, and probably also in Roman times, freshwater marsh, perhaps with open water during part of the year, was present not too far away from the harbour area. One should not think here of extensive marshlands, but rather of small pockets with groundwater at or near the surface and/or of narrow strips along streams.

The near-absence of wetland species from the Punic seed record does not necessarily mean that at that time no freshwater marsh vegetation was found in the far surroundings. *Sparganium*-type pollen, which includes *Typha angustifolia*, suggests that also in Punic times, freshwater marsh occurred in the area. One of the marsh-plant taxa represented in the pollen record only is *Lythrum* (loosestrife). Various *Lythrum* species are reported from North Africa, (almost) all of damp ground (Quézel & Santa 1963: 634).

The comparatively good representation of marshland species in the Byzantine period points to a change in the hydrological conditions of the area. One wonders whether this change was related to a rise in sea level, impeding the drainage of the area.

6.5 **Vegetation of disturbed ground**

By far the largest category of plants is that of species that are found in places where as a result of ploughing, digging, building activities and such like the soil has more or less seriously been disturbed (group 3). There are various kinds of man-induced, disturbed habitats, such as arable fields, gardens, roadsides and waste places. The weed flora of cornfields is different from that of root-crop plots and vegetable gardens. Frequently trodden places show a characteristic combination of tread-resistant plants. In places of disturbed soil which are not (intensively) utilised a more or less luxuriant weed vegetation can develop. An example of such an abandoned terrain is that of the rectangular harbour at the time of the excavations. Here a rich and diversified vegetation was found, several species of which are represented in the harbour sediments.

Various species, such as, *Chenopodium album*/*opulifolium*, *Ch. murale*, *Hyoscyamus albus*, *Malva nicaeensis*, *Marrubium vulgare*, *Solanum nigrum* and *Stellaria media*, are typical of waste, disturbed soil and may therefore be expected to have been found on the (largely) abandoned harbour terrain. In addition, a fair number of species listed under group 3 form part of the weed vegetation of arable fields. For example, *Adonis aestivalis*, *Ammi*

visnaga, *Calendula arvensis*, *Chrysanthemum coronarium* and *Rapistrum rugosum*, but many more species of group 3 occur as arable weed. This raises the question of whether seeds of these species could have been carried in as impurities of the corn crop. This may, indeed, not be ruled out, but it is very likely that most, if not all, arable weed species attested archaeobotanically were found in the local vegetation of the harbour terrain. In support of this suggestion the following should be remarked. Most weeds of cultivated fields are reported to occur also in waste places. There are no indications that threshing remains and crop-cleaning residues, which could have included field-weed seeds, ended up in the Punic channel and/or harbours. Weeds of arable fields, such as *Chrysanthemum coronarium*, *Heliotropium europaeum* and *Mercurialis annua*, show high frequencies in samples from the Byzantine well, indicating that they formed part of the vegetation of the (abandoned) harbour terrain (see discussion in chapter 7). In conclusion, one may take the line that the species listed under group 3 were found in the harbour area.

It will be clear that the species of group 3 did not form one specific type of vegetation, but that depending on the local conditions the species composition must have differed. Tread-resistant species identified from the two harbour sites include *Poa annua*, *Polygonum aviculare*, *Portulaca oleracea*, *Coronopus squamatus* (group 5) and *Lolium perenne* (group 4). The species listed under group 4 are thought to have occurred in dry places that were grazed. One could think here of man-made habitats, such as roadsides and embankments, which may both have been found on or near the harbour terrain. As a matter of fact, the species of group 4 could have been listed just as well under group 3. A separate group has been distinguished here, because in the flora works consulted the species concerned are specifically mentioned as occurring in dry, grassy places ('pâturages arides'). *Plantago* (plantain), listed among the species of 'grassy places', gives occasion to the following comment.

Plantago is an example of a serious discrepancy between the seed and pollen evidence. Of this taxon only two seeds were retrieved (Tables 7 and 8), but its pollen was found in all samples examined. In the Punic and Roman sediment sections *Plantago* pollen values are even comparatively high. Five different types of *Plantago* pollen are distinguished at Carthage (see *Plantago* in chapter 5), indicating that various plantain species are represented. One of the potential habitats of *Plantago* is that of dry, grassy places, but plantain species may have occurred in other places, too. It is true that *Plantago* is known to have a good pollen dispersal, but its poor representation in the seed record is puzzling. Could it be that the waterlogged channel and harbour deposits were not particularly suitable for the preservation of plantain seeds, just as for the preservation of uncharred grass seeds?

Cruciferae (Cabbage Family) present us with another problem. Cruciferous pollen shows 'normal' values in the samples from the Punic and Roman deposits (Figs. 5, 7 and 8), but high to very high percentages in those from the fill of the two Byzantine harbours (Figs. 6, 9 and 10), suggesting that at least one of the species of this family was locally very abundant. In this connection it should be taken into account that insect-pollinated Cruciferae have a moderate pollen dispersal. Various types of Cruciferous seeds are distinguished at Carthage: *Brassica*, *Capsella bursa-pastoris*, *Coronopus squamatus*, *Raphanus raphanistrum*, *Rapistrum rugosum* and *Sinapis*. Cruciferous seed types are certainly not better represented in the Byzantine harbour deposits than in the Punic channel and the Roman sediment section. One wonders whether the Cruciferous species concerned had colonised the quay-wall of the abandoned harbour, so that its pollen dropped right into the water. This could explain the extremely high pollen frequencies in some of the samples, but one is left with the question of why fair numbers of seeds of this species had not equally ended up in the harbour sediment. Although there is a difference of about 50 years between the final silting of the circular and the rectangular harbour (dated to about AD 550 and 600, respectively), the two harbours show

the same high Cruciferous pollen frequencies. On the whole, no significant differences in the vegetation of the two Byzantine harbour sites are evident from the pollen and seed records. Admittedly, there are some differences of a quantitative nature (differences in seed frequencies) between the two harbours, but similar differences are found also between the three series of samples from the fill of the rectangular harbour. Compare, for instance, the *Hyoscyamus* seed frequencies in Table 9 with those in Table 10.

On the other hand, the two seed records obtained from the fill of the Punic channel do point to some local differences in vegetation. Thus, *Euphorbia chamaesyce* (group 4) shows a high sample frequency in Table 7 (rectangular harbour site), but is absent from the seed record presented in Table 3 (circular harbour site). *Chrysanthemum* (two types) shows the opposite: reasonably well represented in Table 3 but not found in the other channel sediment section (Table 7).

A striking difference between periods is made up by the considerably larger number of taxa of waste ground in the Byzantine period (see also Table 23). The question arises as to what extent this increase illustrates the enrichment of the synanthropic flora of North Africa as a result of the (unintentional) introduction of various new species. A similar development has been recorded from early-historical Europe, where it was clearly linked with changes in farming practices.

In conclusion, from the comparison between the Punic, Roman and Byzantine pollen and seed records it appears that the three periods have a great many wild plant taxa in common. With the exception of that of marshy soil, the same types of vegetation could be determined for each of the periods, although there are differences in species composition. On the (abandoned) harbour terrain, vegetation of brackish soil and waste ground must have prevailed, whereas Mediterranean maquis and freshwater marsh vegetation may have been found at some distance from the harbour.

6 **The Roman harbour sediment**

As has been discussed above (section 2.2), the Roman sediment, between the old and new quay-wall sections, was not a more or less natural harbour deposit. It was mixed, disturbed sediment, carried in by man, as a result of which nothing is known about the original stratification of pollen and seeds. Nevertheless, the pollen and seed records obtained from this sediment section look quite normal, fully comparable with the Punic and Byzantine pollen and seed evidence. As with the other waterlogged sediment sections, in the Roman seed record, too, species of disturbed ground (group 3) form by far the largest category. Of the deposits in the Punic channel and Byzantine harbours it is assumed that they represent periods when activities at the waterfront had largely come to a standstill, as a result of which vegetation of waste ground could expand. However, the partial reconstruction of the harbour basin must rather have been a period of intensive activity, and for that reason it is most unlikely that the Roman sediment had been dredged up from the harbour itself. One should rather think of a place outside the harbour area, from where the waterlogged sediment had been taken. As for ‘waterlogged’, it is evident that in this deposit, conditions for the preservation of non-carbonised plant remains should have been favourable. Otherwise hardly any pollen and seeds would have been found in the Roman harbour fill. In the pollen diagram prepared from the Roman sediment (Fig. 8) *Olea* (olive) values are considerably higher than in the other pollen records from the harbour area. This may point to the presence of olive yards not far from the spot from where the displaced soil originated.

7 THE BYZANTINE WELL

Attention will be paid here to the seed record of the Byzantine well presented in Table 5. Some of the samples listed in this table (nos. 360, 385, 393) are from the sediment in the well, whereas the other samples are from the contents of jars which were laying in the fill of the well. As the sample volumes floated had not been recorded, the numbers of seeds could not be expressed here per unit volume of sediment (as is done for the samples from the channel and harbour deposits).

It is obvious to compare the data obtained from the well with those from the circular harbour basin. Are there differences between the seed records of the two Byzantine contexts? The fill of the well is dated to about AD 700, which makes it 100 to 150 years later than the Byzantine harbour deposit which should be c. 525-550 (H.R. Hurst, personal communication). A comparison between Tables 4 (harbour) and 5 (well) shows that the total number of taxa identified from the well is smaller than that established for the Byzantine harbour, viz. 70 and 99 taxa, respectively. Species of maquis and woods (group 7) are conspicuously absent from the well. The number of taxa of waste ground etc. (group 3), on the other hand, is at least as large as that in Table 4, and most of the taxa of waste ground recorded from the well are represented also in the Byzantine harbour. Thus, in this respect there is not much difference between the seed records of Byzantine well and harbour. However, a striking difference between the two is made up by the high to very high seed frequencies of various taxa of waste ground in the well samples, e.g. *Chenopodium album/opulifolium*, *Chrysanthemum coronarium* and *Mercurialis annua*. How should we interpret these large numbers of seeds; is there a satisfactory explanation? Could it be that the seeds had been gathered on purpose and stored in the jars? When the jars were thrown in the well, part of the contents fell out and became embedded in the fill of the well. This could explain why samples from the sediment in the well show equally large numbers of seeds as those from the contents of jars. However, there are several arguments which plead against this hypothesis.

In the first place, for what purpose could the seeds of the wild plant species have been collected? In this connection one may think primarily of the use of plants as food and for medicinal purposes. Of the species represented by large numbers of seeds, only of *Chenopodium album* are the seeds known to have served as (famine) food from prehistoric up to modern times. *Calendula arvensis*, *Fumaria*, *Malva*, *Marrubium vulgare*, *Mercurialis annua* and *Urtica* are known as medicinal plants, but of these species not the seeds but the green parts and/or the flowers are used for the preparation of medicine (of *Urtica* also the roots). Only of *Hyoscyamus niger* (there is no information for *H. albus*) and *Silybum marianum* are the seeds reported to have medicinal properties, this in addition to other parts of these plants (cf. Braun & Frohne 1994). The seeds of species like *Chrysanthemum coronarium* and *Heliotropium europaeum* are not mentioned as being used for the preparation of either food or medicine. In conclusion, of only a few species with high seed frequencies could one imagine that there was some use in collecting and storing the seeds. As a matter of fact, of many wild plant species the leaves and/or roots are still consumed by humans, but this should not find expression in large numbers of seeds.

If the seeds had already been collected for one purpose or another, why then had they not been stored separately? These mixtures of seeds are of no use, neither for the preparation of food or medicine nor for sowing (which in all probability was not done with wild plants).

Thirdly, assuming that seed mixtures were indeed stored in jars, why then had these jars, with their valuable contents, been dumped in the well?

From the above it may be clear that the suggestion that the seeds had been stored in the jars leaves us with various questions. As an alternative explanation the following may be brought forward. In this case we take the line that the seeds in the fill of the jars were there not in a primary but in a secondary position. In other words, the seeds had ended up in the jars after the latter had been dumped in the well. In the course of time the jars had become filled with the sediment in which they were embedded. So how can the extraordinarily large numbers of seeds be explained? The concentrations of these weed seeds in the samples from the well are many times larger than those in the other waterlogged deposits. It looks as if large quantities of seed-bearing weeds had been thrown in the well which served as a refuse dump. Could it be that the greater part of the abandoned harbour area was covered by vegetation of waste soil, and that regularly patches of ground were cleared of weeds, to be used, for instance, as vegetable garden? At least, it is difficult to imagine that the seed-rich fill of the well was the result of one large clearing operation. It should be emphasised here that most likely not only the species represented by large numbers of seeds formed part of the vegetation that was cleared. Other species of the same vegetation may not or only scarcely be represented because they were not in seed at the time of clearing.

As a matter of fact, not only the refuse of the assumed weed-clearing operations was dumped in the well, but also vegetable waste of other origins must have been disposed of here, as is demonstrated by the salt-marsh species (group 5). Human excrement may have contributed to the food-plant remains preserved in the fill of the well. From the absence of species of maquis and woods it may be concluded that, apart from the food plants, only the local vegetation is represented. Few plant remains may have ended up in the well without the interference of man, for instance, seeds of plants which grew on the rim of the well.

The filling in with refuse suggests that the well no longer functioned as a reservoir of drinking water. Probably the water in the well was salty or had otherwise become undrinkable. The dating of around AD 700 indicates that this filling-in operation must have taken place shortly before or after the capture and destruction of Carthage by the Arab conquerors (see section 1.1). One wonders whether there is any connection between the two events.

8 OTHER SITES

8.1 **Tophet**

The Tophet or Precinct of Tanic was the site where the urns with the charred remains of children sacrificed to the goddess Tanic and god Baal Hammon were buried. Above some of the urn burials stelae, funerary monuments of sandstone or limestone, had been erected. Infant sacrifice was commonly practised in the Levant, the homeland of the Phoenicians. At Carthage, this practice persisted up to the destruction of the Punic city by the Romans. In addition to religious aspects, child sacrifice may have had a socio-economic dimension, namely, that of 'family planning' among the city's elite (Stager 1992).

Through 1976-1979, excavations at the Tophet, conducted by Professor Lawrence E. Stager under the auspices of the American Schools of Oriental Research (ASOR), brought some 400 burial jars to light. The urns contained not only charred bones of the victims and burial offerings but also wood charcoal, presumably from the pyre. A brief report on the examination of charred wood retrieved from (sealed) urns has been published by Stuijts (1991). In addition to the contents of urns, soil from the Tophet was sampled for botanical examination.

The flotation residues of over 160 soil samples were sorted for charred seeds, but only a minority of them yielded a positive result (Table 16). A few samples from which only unidentified remains of seeds or nuts were retrieved are not listed. From Table 16 it appears that numbers of seeds recovered are usually small: from almost half of the samples no more than one identifiable seed was retrieved. It is clear that we are dealing here with so-called settlement noise. The Tophet samples examined for seeds are dated to the fourth century BC (L.E. Stager, personal communication) and correspond in time with the samples from the Punic channel (Tables 3 and 7). The soil volumes of the Tophet samples have not been recorded.

Almost all species represented in Table 16 are food plants. This is somewhat surprising in that a cemetery site like the Tophet is not exactly the place where household activities, such a food preparation, are expected to have been carried out. One would rather expect a predominance of seeds of wild plants that had got carbonised in the pyre. However, the seed evidence suggests that food had indeed been prepared in the Tophet area. Are we dealing here with the remains of funerary meals or had people at work in the Tophet prepared their food there? From a few urns, remains of lentil and olive were retrieved: three urns each yielded one lentil seed and four urns one or a few olive-stone fragments. May these food-plant remains perhaps be regarded as funerary gifts? Otherwise, they could inadvertently have been deposited in the urns, together with the ashes and charred bones from the pyre.

Some of the wheat grains could confidently be attributed to hard wheat or bread wheat (*Triticum durum/aestivum*), but of others a more detailed identification was not possible (*Triticum* spec.) because the grains had seriously been affected by the carbonisation. The *Triticum* spec. grains are probably of *T. durum/aestivum*, but it should not be ruled out that *T. dicoccum* (emmer wheat) is also represented (see discussion in section 4.1). In addition to lentil, which is the most common seed type in the Tophet samples, two other pulse crops are recorded from this site, viz. pea (*Pisum sativum*) and broad bean or faba bean (*Vicia faba*). With seven occurrences, *Pinus pinea* (stone pine) is relatively well represented. In view of the large numbers of fig (*Ficus*) pips found in the waterlogged harbour deposits, this fruit is rather scarcely represented at the Tophet.

8.2 **Site B**

On the north side of the circular harbour, the remains of buildings between *cardines* (north-south streets) XV and XVI were excavated by the British team under the direction of Professor Henry R. Hurst (site B: Fig. 2 no. 10). The buildings consisted of small units in use as workshops (Hurst 1992: 86). In 1976 and 1977, samples were taken for botanical examination. A note on the plant remains, drafted by Professor Hurst on the basis of information provided by W. van Zeist, has been published in the final report on the excavations at site B (Hurst 1994: 325). The results presented in Table 17 differ from those published formerly in that a re-examination resulted in a few corrections of the original identifications. In addition to some grape pips, one wheat grain and one lentil, a considerable number of olive stones were retrieved from this site by Stewart (1976b).

After the fairly detailed discussion in chapter 4, the scarce food-plant remains (wheat, barley, lentil, fig, grape and olive) need no further comment; they formed part of the common food-plant assemblage established for Carthage. Among the wild plant species, *Lolium temulentum* (darnel) is a typical cornfield weed and its seeds may have been brought in as an impurity of the corn destined for consumption. A fair number of darnel seeds were recovered from one of the charred seed samples from the circular harbour (Table 6). The substantial numbers of seeds of *Euphorbia helioscopia*, *Mercurialis annua*, *Chenopodium murale* and *Heliotropium* in the 7th-century sample (context 203) suggest that these weeds were common in the area, which is not exactly to be expected from an urban environment. Could it be that, to some extent, the area had already fallen into decay? After all, by that time the circular harbour may have ceased to function as a busy port. *Thymelaea hirsuta* and the typical salt-marsh species *Suaeda fruticosa*, both forming low shrubs, may have been gathered for fuel. With respect to *Beta* (beet), reference is made to section 4.8, in which this species is discussed.

8.3 **Seaside residential area**

A section of Carthage situated along the coast, some 750 m north-east of the circular harbour, was excavated by a German team under the direction of Professor Friedrich Rakob. From overviews published by Rakob in 1979 and 1992 the following is taken. In early-Punic times, this area was an industrial district with metallurgical workshops and pottery kilns. In the late-fifth century BC, the area became a fashionable residential quarter: spacious, richly decorated houses were built behind the city wall erected along the coast. It remained an elite quarter until the fall and destruction of Carthage in 146 BC. In the second half of the first century BC, when Carthage was rebuilt by the Romans, in the area under consideration a new workshop quarter was established on top of the ruins of the large houses of the Punic period. The character of the area did not change up to the end of the Byzantine period, this in contrast to other parts of the city. After the conquest of Carthage by the Arabs in AD 698, the area was abandoned and was at most used for extracting building material.

In contrast to the detailed information on the occupational history of the site, the botanical evidence obtained is disappointingly meagre. A modest number of samples were secured for the examination of plant remains, but most of them yielded only few or no seeds at all. Sadly, it has not been possible to implement an extensive sampling strategy here, and contexts suitable for archaeobotanical analysis may have been missed. The same applies to more of the sites excavated at Carthage.

A series of fifteen samples were taken from a deposit, more than one metre thick, consisting of a succession of old road-surfaces and sea-sand layers (‘Garten I, E79 Nord’). It

concerns here the raised levels of a Punic east-west street, corresponding with the later Roman *decumanus* 1 north. The sea-sand layers were mixed with pottery, ashes and charcoal. The total numbers of seeds secured from eight of the samples are shown in Table 18:1. Because of the very low density of seeds in the samples only half of them were analysed. A sample from a Punic waterlogged deposit underneath *cardo* XVIII, the Roman north-south street along the coast, was exceptionally rich in seeds but poor in species (Table 18:2). Food plants identified from Punic levels include free-threshing wheat, lentil, olive, fig, grape, hazelnut and stone pine.

Five samples from (probably) Roman contexts, not shown in Table 18, yielded together a small number of fig pips, one olive stone and one wheat grain, in addition to one seed of each *Thymelaea hirsuta* (a common shrub in the Carthage area) and mallow (*Malva*). Among the fig pips recovered from the fill of a Byzantine sewer (Table 18:3), only seventeen were carbonised; the others were mineralised. One may assume that the latter are of the same age as the charred pips. Under particular conditions, various kinds of seeds, among which those of fig, are preserved in a mineralised condition, in which the organic material is replaced by calcium phosphate (Green 1979: 53).

8.4 **Byrsa**

Vestiges of Punic occupation on the south flank of the Byrsa, the central hill of ancient Carthage, were excavated by a French team under the direction of Professor Serge Lancel (Lancel 1981; Lancel & Morel 1992). Levels of Punic occupation are covered here by thick deposits of Punic rubble, originating from the hilltop which was totally destroyed and levelled off by the Romans in rebuilding Carthage. Contrary to what one would expect, it was not until the beginning of the second century BC that the area under consideration became a residential quarter. In the preceding third century the area was (part of) an industrial district with metallurgical workshops. No traces of human activity were found between the third-century level of the workshops and the early-seventh to early-sixth century cemetery at the base of the occupation deposits (the graves were dug into the subsoil). For a period of almost three centuries the area was uninhabited.

The results of the botanical examination have already been published by Professor Lancel under the name of the investigators (Van der Veen & Van Zeist 1982). For the sake of completeness and because a re-examination resulted in a few corrections of the original identifications, the results are presented again (Table 19). The Punic samples (Table 19:1) date to the final stages of Punic Carthage, to the period from just before the fall of the city in 146 BC. They are from refuse layers on streets and from ashy soil on the floor of a house (H IV 4). A few samples from the level of the metallurgical workshops turned out to be barren of seeds. Though the assemblage is very poor, it does fit the picture obtained from other parts of Punic Carthage.

In contrast to the Punic samples, the medieval sample, from a thick layer of ashy soil dated to the 11th-13th centuries AD, was rich in seeds (Table 19:2). In addition to cultivated plants, among which barley (*Hordeum vulgare*) is well represented, a fair number of wild plants have been identified. Most of these wild plants are species of disturbed habitats, such as waste ground and arable fields, listed under group 3 in Tables 3-5 and 7-10. It is clear that the ashy deposit contained waste of crop-cleaning activities.

8.5 **Falbe's site 90**

The designation 'Falbe's site 90' refers to the map prepared by Christian T. Falbe of the ruins of classical Carthage still visible in the field in 1820 (published 1833). At the time, Falbe was

consul general of Denmark at the Court of the Bey of Tunis. Excavations at Falbe's site 90, some 2000 m north-east of the circular harbour, were carried out by a team of the Danish National Museum at Copenhagen, under the direction of Dr. Søren Dietz. During three field campaigns (1975, 1977, 1981) an area of 1000 m^2, on the coast, was uncovered. The Punic period is represented here by deposits, up to 1.5 m thick, without any trace of architecture. Roman occupation of the site, attested by numerous architectural remains, extended from the first to the early-fifth century AD, after which the site was abandoned. The Vandals (AD 439-533) used a few rooms of a large Roman villa from the fourth century for entombing the dead, while in Byzantine times the place was an abode of the poor. The above information is taken from Dietz (1992).

Samples for botanical examination were taken in 1981. Unfortunately, after flotation the samples turned out to be poor in seeds. Some of them did not yield any identifiable seed remains at all. The results, presented in Table 20, fit into the picture obtained from other sites at Carthage: the cereals barley and free-threshing wheat, the pulse crops lentil and bitter vetch, and olive. The scarce representation of food plants does not mean that they did not play an important role in the diet of the inhabitants of the site, but must be due to the fact that no deposits of kitchen refuse and such-like were found, or at least have been sampled.

9 CONCLUSIONS

The goal that the Dutch mission to Carthage had set itself was modest, viz. a reconstruction of the diet of the inhabitants and of the local vegetation of this important ancient urban centre. While there was no doubt that the team could contribute to the furthering of our knowledge about diet and vegetation, a major research question was whether the role of Carthage as an international trading centre would find expression in the archaeobotanical record.

Occupation of Carthage spans some 1500 years, from the 8th century BC Punic levels to c. 700 AD, at the end of the Byzantine rule. While we were able to collect evidence from all three major chronological periods (Punic, Roman, Byzantine), it was not possible to cover each period with equal intensity. The excavations at Carthage were spread all over the town, but there was a marked focus on the monumental rather than the domestic, and excavation techniques varied enormously between trenches and international teams. Moreover, the preservation of archaeobotanical remains varied considerably between the various sites. Plant remains are best preserved in waterlogged deposits and, in dry sediments, in domestic refuse deposits (though charcoal preservation can be excellent in industrial waste deposits). Water-logged deposits were present in both the circular naval harbour and in the rectangular commercial harbour, and the bulk of our analyses were concentrated there. These wet sediments lend themselves also for palynological examination, as is illustrated in the pollen diagrams of Figs. 5-10. As far as was possible dry-land deposits were also sampled, from as many areas of excavation as was practicable.

In terms of our original goal, the reconstruction of diet and local vegetation, much has been achieved, as is evident from the summarising comments made below. An overview of the results (seeds and fruits) is presented in Tables 21-23. The overview tables not only show which plant taxa have been identified, but they also register possible differences between periods with respect to food-plant consumption and vegetation. The sample frequencies of Tables 22 and 23 are based upon the data obtained from the fill of Punic channel and the two harbours, with largely identical conditions of deposition and preservation of plant remains. The compilation of Fig. 21 includes all finds of cereals and pulses, secured from a variety of contexts. Reference is made also to Figs. 3 and 4, in which the frequencies of a selected number of seed types are plotted.

Table 21. Representation (presence/absence) of cereals and pulses (charred remains) in Carthage.

Period	Punic	Roman	Byzantine	
Triticum dicoccum	+	-	-	Emmer wheat
Triticum durum/aestivum	+	+	+	Hard wheat/Bread wheat
Hordeum vulgare	+	+	+	Barley
Lens culinaris	+	+	+	Lentil
Vicia ervilia	+	+	+	Bitter vetch
Pisum sativum	+	-	-	Pea
Vicia faba var. minor	+	-	-	Broad bean
Lathyrus sativus	-	-	+	Grass pea
Cicer arietinum	-	-	+	Chickpea

Table 22. Representation of food plants other than cereals and pulses in channel and harbour deposits (Tables 3,4,7-10). Finds of *Prunus persica* and *Corylus* from the Punic channel are after Stewart (1976a, 1976b).
\+ present in less than 10% of the samples
++ present in 10-50% of the samples
+++ present in more than 50% of the samples

Tables	3,7	8	4,9,10	
Number of samples	17	11	21	
Period	Punic	Roman	Byzantine	
Linum usitatissimum	+	++	++	Linseed
Papaver somniferum	+++	+++	+++	Opium Poppy
Cucumis melo	+	-	+++	Melon
Anethum graveolens	+	+	++	Dill
Coriandrum sativum	++	-	++	Coriander
Foeniculum vulgare	++	+	++	Fennel
Ficus carica	+++	+++	+++	Fig
Morus (nigra)	++	++	+++	Mulberry
Olea europaea	++	+++	+++	Olive
Punica granatum	+++	+++	+++	Pomegranate
Rubus (ulmifolius)	+++	++	++	Blackberry
Vitis vinifera	+++	+++	+++	Grape
Ziziphus lotus	++	++	+	a Jujube species
Amygdalus	++	++	++	Almond
Pinus pinea	++	+	+	Stone Pine
Pyrus	-	+	-	Pear
Crataegus laevigata	-	+	++	Hawthorn
Corylus	[+]	++	+++	Hazelnut
Juglans regia	-	+++	++	Walnut
Prunus domestica	-	-	++	Plum
Prunus persica	[+]	-	++	Peach
Cordia myxa	-	-	+	Egyptian Plum
Carthamus tinctorius	-	++	-	Safflower

- Cereals consumed at Carthage comprised hulled barley (*Hordeum vulgare*), emmer wheat (*Triticum dicoccum*) and hard wheat or bread wheat (*Triticum durum*/*aestivum*). Certainly identified emmer wheat is recorded from Punic levels only (Table 21). The switch from emmer wheat to free-threshing wheat at the end of the first millennium BC in Carthage mirrors that found elsewhere in the Mediterranean and Europe. This switch tends to be associated with an increase in agricultural production, which ties in with the area around Carthage becoming one of the 'granaries' for Rome. Only occasionally were more than a few cereal grains retrieved. In contrast to the grains, Cerealia-type pollen shows (comparatively) high values (Figs. 5-10). It is assumed that the cereal-type pollen in the channel and harbour deposits was derived mainly from human excrement disposed of in the water. The increased production and large-scale shipment of corn in Roman times does not find expression in the archaeobotanical record.
- Six pulse-crop species have been identified: lentil (*Lens culinaris*), pea (*Pisum sativum*), broad bean (*Vicia faba*), bitter vetch (*Vicia ervilia*), chickpea (*Cicer arietinum*) and grass pea (*Lathyrus sativus*). Only lentil has more than occasionally been found. From the generally scarce evidence no conclusions on possible shifts in pulse-crop consumption are justified. Pulses must have been of far greater importance in daily food than is suggested by the numbers of seeds recovered. Pulses are important for human nutrition in that they, in combination with cereals, provide an important source of protein.

- Besides cereals and pulses, olive (*Olea europaea*) must have played a prominent role in the diet of the Carthaginians (oil, salted fruits). In addition, it was a major export item in Roman times: olive oil formed part of the compulsory delivery of agricultural produce to Rome. The waste of olive pressing, consisting of pulp and broken fruitstones, may have been used as fuel.
- From the seeds of opium poppy (*Papaver somniferum*), well represented in the seed record, oil is extracted. However, as (plenty of) olive oil was available, it is more likely that the poppy seeds were consumed as such. It should not be ruled out that opium was extracted from the seed capsules. The importance of opium poppy had declined in the Byzantine period (Figs. 3 and 4), but the species continued to be cultivated in the area.
- A third oil plant, flax or linseed (*Linum usitatissimum*), of which only small numbers of seeds were found, may have been cultivated primarily for its fibres.
- In addition to olive, various other fruit trees were cultivated in the Carthage area: grape (*Vitis vinifera*), fig (*Ficus carica*), pomegranate (*Punica granatum*), mulberry (*Morus* cf. *nigra*), peach (*Prunus persica*), plum (*Prunus domestica*) and almond (*Amygdalus communis*). Punic Carthage was renowned for its high standard of fruit growing, and the archaeobotanical evidence suggests that fruit cultivation continued to be important right into the Byzantine period. Fruits collected from the wild included blackberry (*Rubus*), hawthorn (*Crataegus*) and *Ziziphus lotus*, a jujube species. Only blackberry may have been of more than minor importance, particularly in Punic times. Melon (*Cucumis melo*) was commonly consumed in Byzantine Carthage (Figs. 3 and 4), but we do not know whether sweet melon or a non-sweet form, eaten like cucumber, was concerned here.
- The pollen evidence suggests that manna ash (*Fraxinus ornus*) had been planted, probably for its manna, a sweetish exudation obtained from the bark.
- Evidence of the import of foreign food includes seeds of stone pine (*Pinus pinea*) and shell remains of hazelnut (*Corylus*) and walnut (*Juglans regia*). Stone-pine seeds from Punic levels highlight the contact with the western Mediterranean, where Carthage had colonies. It was not until Roman times that hazelnut and walnut, which could have been imported from temperate Europe and Turkey, were more commonly consumed at Carthage. Egyptian plum (*Cordia myxa*) may have been an import from Egypt or the Levant, reflecting the sphere of influence of the Eastern Roman Empire.
- The wild plant taxa listed in Table 23 are classified according to ecological affinity. By far the largest category is that of species of waste ground, etc. These species may have expanded on the harbour terrain after activities there had (largely) come to a standstill. The tremendous increase of waste-ground taxa in the Byzantine period could point to a larger area of derelict ground, but more likely it illustrates the (unintentional) introduction of new weed species into North Africa.
- Salt-marsh and other salt-tolerant species point to saline conditions in the harbour area. A particular type of vegetation of disturbed saline soil is that made up of *Mesembryanthemum*, *Aizoon hispanicum* and *Apium graveolens* (celery), well represented in the Byzantine harbour deposits, but virtually absent from the Punic channel (Figs. 3 and 4). Some species point to the presence of a sandy sea shore.
- Another clear difference between seed records is made up by freshwater marsh plants, which are almost absent from the Punic period but comparatively well represented in the fill of the Byzantine harbours.
- Mediterranean maquis is equally well represented in all three periods. Maquis vegetation as such was probably not found in and near the harbour area, but a (temporary) local occurrence of some maquis species is suggested by the pollen evidence.
- High herbaceous pollen values (Figs. 5-10) suggest that, apart from orchards, at most only scarce tree growth was found in the Carthage area.

- The seed record obtained from the Byzantine well differs from that of the Byzantine circular harbour by the much higher frequencies of various species of waste ground. This suggests that the island within the circular harbour had become derelict ground by AD 700.

The archaeobotanical examination has provided valuable and detailed information on diet and vegetation at ancient Carthage. A wide range of food plants has been identified and a clear picture has emerged of the vegetation types in and around the harbour, as well as further away from the site. On the other hand, the evidence sheds little light on the trade in foodstuffs and on possible differences in food-plant consumption between town quarters.

Table 23. Representation of wild plant taxa in channel and harbour deposits (Tables 3,4,7-10).
\+ present in less than 10% of the samples
++ present in 10-50% of the samples
+++ present in more than 50% of the samples

Tables	3,7	8	4,9,10
Number of samples	17	11	21
Period	Punic	Roman	Byzantine
Taxa of waste ground, cultivated and fallow fields			
Adonis aestivalis	++	+	++
Amaranthus	++	++	+++
Anagallis (arvensis)	++	++	++
Bifora testiculata	++	-	++
Calendula (arvensis)	++	+	-
Capsella bursa-pastoris	++	-	-
Carduus pteracanthus	++	++	+
Centaurea calcitrapa	++	++	-
Chenopodium album/opulifolium	++	+++	+++
Chenopodium murale	+++	+++	+++
Chrysanthemum coronarium	++	++	++
Chrysanthemum segetum type	++	+	++
Emex spinosa	++	-	+
Euphorbia helioscopia	++	+	+
Fumaria	+++	+++	+++
Heliotropium europaeum	+++	+++	+++
Hyoscyamus (albus)	++	++	+++
Malva nicaeensis	+++	+++	++
Marrubium vulgare	++	+++	++
Mercurialis annua	+	++	-
Oxalis corniculata	++	+++	+
Picris echioides	++	++	+
Polygonum aviculare	+++	+++	++
Portulaca oleracea	+++	+++	++
Raphanus raphanistrum	+++	-	++
Rapistrum rugosum	+++	+++	+++
Reseda alba	++	+	+
Reseda luteola	+	+++	++
Silene cucubalus	+	-	++
Sinapis	++	-	++
Solanum nigrum	++	-	++
Sonchus asper	+	-	+
Stellaria media	+++	+++	++
Urtica membranacea	+++	+++	++
Urtica pilulifera	++	++	++

Table 23 (continued)

Tables	3,7	8	4,9,10
Number of samples	17	11	21
Period	Punic	Roman	Byzantine
Taxa of waste ground, cultivated and fallow fields (continued)			
Urtica urens	+++	+++	+++
Anthemis cotula	-	+	-
Verbena officinalis	-	+	-
Cichorium intybus	-	+	++
Glaucium corniculatum	-	++	+
Poa annua	-	+	+
Sonchus oleraceus	-	++	+
Asphodelus fistulosus	-	-	+++
Ammi visnaga	-	-	++
Bupleurum (lancifolium)	-	-	++
Brassica	-	-	++
Capnopyllum peregrinum	-	-	++
Tordylium apulum	-	-	++
Lolium temulentum	-	-	++
Anthemis arvensis type	-	-	+
Carthamus spec.	-	-	+
Neslia paniculata	-	-	+
Papaver rhoeas type	-	-	+
Ridolphia segetum	-	-	+
Agrostemma githago	-	-	+
Antirrhinum orontium	-	-	+
Polygonum convolvulus	-	-	+
Ranunculus arvensis	-	-	+
Reseda lutea	-	-	+
Sambucus ebulus	-	-	+
Silybum marianum	-	-	+
Thymelaea cf. passerina	-	-	+
Taxa of 'grassy places'			
Euphorbia chamaesyce	++	+	-
Linum spec.	++	++	+++
Lolium perenne type	+	-	-
Medicago	+++	++	++
Ornithopus	-	-	+
Plantago	+	+	-
Stachys hirta type	++	-	-
Valerianella morisonii type	++	++	++
Valerianella vesicaria type	+	-	-
Taxa of saline soil and sandy sea shores			
Arthrocnemum macrostachyum	+++	+++	++
Mesembryanthemum	++	+++	+++
Scirpus lacustris ssp. glaucus	+	+++	+
Scirpus maritimus	++	+	++
Suaeda (fruticosa)	++	+++	+++
Salicornia (fruticosa)	+++	++	++
Coronopus sqamatus	+++	++	-
Ranunculus sardous	++	-	++
Spergularia	+	-	-
Zannichellia	+	-	-

Table 23 (continued)

Tables	3,7	8	4,9,10
Number of samples	17	11	21
Period	Punic	Roman	Byzantine
Taxa of saline soil and sandy sea shores (continued)			
Aizoon (hispanicum)	-	++	+++
Apium (graveolens)	-	++	+++
Atriplex halimus	-	++	-
Ruppia maritima	-	+++	+
Lycium intricatum	-	-	+
Ambrosia maritima	++	+	++
Thymelaea hirsuta	+++	+++	+++
Euphorbia paralias	-	-	+
Glaucium flavum	-	-	++
Marsh and water plants			
Cyperus	++	-	++
Carex otrubae type	-	+	++
Carex vesicaria rype	-	++	-
Cladium mariscus	-	++	-
Ranunculus sect. Batrachium	-	+	-
Alisma plantago-aquatica	-	-	++
Conium maculatum	-	-	++
Eleocharis palustris	-	-	++
Oenanthe aquatica type	-	-	+
Phragmites australis	-	-	+
Solanum dulcamara	-	-	++
Typha angustifolia	-	-	++
Polygonum cf. hydropiper	-	-	+
Ranunculus muricatus	-	-	+
Ranunculus repens type	-	-	+
Taxa of maquis and woods			
Cistus	++	-	-
Erica multiflora	++	++	+++
Juniperus phoenicea	++	++	++
Lavandula stoechas	++	+	+++
Myrtus communis	+	++	++
Pinus (halepensis)	++	++	+
Pistacia lentiscus	++	++	-
Rosmarinus officinalis	+++	+	++
Teucrium	-	-	+
Taxa of uncertain ecological affinity (selection of types)			
Atriplex spec.	+++	+++	++
Beta (vulgaris)	+	-	+
Unident. Cruciferae	++	+	++
Daucus	++	++	+
Unident. Gramineae	++	+++	++
Inula viscosa type	+++	++	+++
Mentha type	+++	+++	+++
Rumex	+++	++	+++
Silene spec.	++	-	+++

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11 APPENDIX

Scientific and English names of cultivated plants and of a great number of wild plant taxa identified from Carthage (pollen and seed records, no wood). With a few exceptions, only plant taxa mentioned in the text are listed. (p) pollen only.

Scientific name	English name
Adonis aestivalis	Summer Pheasant's-Eye
Aizoon (hispanicum)	Aizoon
Alisma plantago-aquatica	Common Water-Plantain
Alnus (p)	Alder
Amygdalus communis	Almond
Amaranthus	Amaranth
Ambrosia maritima	Ragweed
Ammi visnaga	Bishop's Weed
Anagallis (arvensis)	Scarlet Pimpernel
Anethum graveolens	Dill
Apium (graveolens)	Celery
Arbutus (p)	Strawberry Tree
Artemisia herba-alba (p)	White Wormwood
Arthrocnemum macrostachyum	
Asphodelus fistulosus	Asphodel
Atriplex halimus	Shrubby Orache
Atriplex spec.	Orache
Beta (vulgaris)	Beet
Bifora testiculata	Small Coriander
Brassica	Cabbage, Mustard
Bupleurum (lancifolium)	Hare's Ear
Calendula (arvensis)	Field Marigold
Calligonum (p)	
Capnophyllum peregrinum	
Capsella bursa-pastoris	Shepherd's Purse
Carduus pteracanthus	Thistle
Carex	Sedge
Carthamus spec.	
Carthamus tinctorius	Safflower
Centaurea (p)	Knapweed/Star Thistle
Chenopodiaceae	Goosefoot Family
Chenopodium album/opulifolium	Fat Hen
Chenopodium murale	Nettle-leaved Goosefoot
Chrysanthemum coronarium	Crown Daisy
Chrysanthemum segetum-type	Corn Marigold
Cicer arietinum	Chickpea
Cichorium intybus	Chicory
Cistus	Rock Rose
Citrullus (p)	Watermelon/Colocynth
Citrus (p)	Citron
Cladium mariscus	Great Fen-Sedge
Compositae (Asteraceae)	Daisy Family
Conium maculatum	Hemlock
Cordia myxa	Egyptian Plum
Coriandrum sativum	Coriander
Coronopus squamatus	Swinecress
Corylus	Hazel, Filbert
Crataegus laevigata	Midland Hawthorn

Scientific name	English name
Cruciferae (Brassicaceae)	Cabbage Family
Cucumis melo	Melon
Cyperaceae	Sedge Family
Cyperus	Galingale
Daucus	Carrot
Eleocharis palustris	Common Spike-Rush
Emex spinosa	
Erica multiflora	Heath
Euphorbia chamaecyse	Spurge
Euphorbia helioscopia	Sun Spurge
Euphorbia paralias	Sea Spurge
Ficus carica	Fig
Foeniculum vulgare	Fennel
Fraxinus ornus	Manna Ash
Fumaria	Fumitory
Glaucium corniculatum	Red Horned-Poppy
Glaucium flavum	Yellow Horned-Poppy
Gramineae (Poaceae)	Grass Family
Heliotropium (europaeum)	Heliotrope
Hordeum (vulgare)	Barley
Humulus/Cannabis (p)	Hop/Hemp
Hyoscyamus (albus)	Henbane
Inula viscosa-type	Fleabane
Juglans regia	Walnut
Juniperus phoenicea	Phoenician Juniper
Lathyrus sativus	Grass Pea
Lavandula stoechas	French Lavender
Lens culinaris	Lentil
Linum usitatissimum	Flax, Linseed
Linum spec.	Flax (wild)
Lolium perenne-type	Perennial Ray-Grass
Lolium temulentum	Darnel
Lycium (intricatum)	Boxthorn
Lythrum (p)	Loosestrife
Malva nicaeensis	Mallow
Marrubium vulgare	White Horehound
Medicago	Melilot
Mentha-type	Mint
Mercurialis annua	Annual Mercury
Mesembryanthemum	
Morus (nigra)	Black Mulberry
Myrtus communis	Myrtle
Noaea (p)	
Olea europaea	Olive
Oenanthe aquatica-type	Water Dropwort
Oxalis corniculata	Yellow Oxalis
Papaver somniferum	Opium Poppy
Phalaris	Canary Grass
Phillyrea (p)	
Phragmites australis	Reed
Pinus halepensis	Aleppo Pine
Pinus pinaster (P. maritima)	Maritime Pine
Pinus pinea	Stone Pine (Umbrella Pine)
Pistacia lentiscus	Mastic Tree
Pisum sativum	Pea
Plantago	Plantain
Poa annua	Annual Meadow-Grass
Polygonum aviculare	Knotgrass

Scientific name	English name
Portulaca oleracea	Purslane
Poterium/Sanguisorba (p)	Burnet
Prunus domestica	Plum
Prunus persica	Peach
Punica granatum	Pomegranate
Quercus coccifera-type (p)	Kermes Oak
Quercus deciduous (p)	Deciduous Oak
Ranunculus arvensis	Corn Buttercup
Ranunculus muricatus	Buttercup
Ranunculus repens	Creeping Buttercup
Ranunculus sardous	Hairy Buttercup
Raphanus raphanistrum	Wild Radish
Rapistrum rugosum	Bastard Cabbage
Reseda alba	White Mignonette
Reseda lutea	Wild Mignonette
Reseda luteola	Weld
Ricinus (p)	Castor
Rosmarinus officinalis	Rosemary
Rubus (ulmifolius)	Bramble
Rumex	Dock, Sorrel
Ruppia maritima	Beaked Tasselweed
Salicornia (fruticosa)	Glasswort
Scirpus lacustris subsp. glaucus	Glaucus Club-Rush
Scirpus maritimus	Sea Club-Rush
Sesamum (p)	Sesame
Silene cucubalus	Bladder Campion
Silene spec.	Catchfly
Silybum marianum	Milk Thistle
Sinapis	Mustard
Solanum dulcamara	Bittersweet
Solanum nigrum	Black Nightshade
Stellaria media	Common Chickweed
Suaeda (fruticosa)	Seablite
Thymelaea hirsuta	Shaggy Sparrow-Wort
Tordylium apulum	
Tribulus terrestris (p)	Maltese Cross
Triticum dicoccum	Emmer Wheat
Triticum durum/aestivum	Hard Wheat/Bread Wheat
Typha angustifolia	Lesser Reedmace
Ulmus (p)	Elm
Umbelliferae (Apiaceae)	Carrot Family
Urtica membranacea	Nettle
Urtica pilulifera	Roman Nettle
Urtica urens	Annual Nettle
Valerianella morisonii-type	Cornsalad
Valerianella vesicaria-type	Bladder-Fruited Cornsalad
Vicia ervilia	Bitter Vetch
Vicia faba	Broad Bean
Vitis vinifera	Grape Vine
Zannichellia palustris	Horned Pondweed
Ziziphus lotus	Lotus Thorn

TABLES 1-13, 16-20

Table 1. Circular harbour. Pollen and seed samples examined. Depth of samples is in metres below sea level. The location of the sampling sites is indicated in Fig. 2.

Seed samples	Depth below sea level	Pollen samples	
Punic channel *(Table 3, Fig. 5)*			
A78 IV I	0.20 m	-	
A77 IV 38	c. 0.40	A78 IV 4	(spectrum 6)
A78 IV III	0.60	A78 IV 6	(spectrum 5)
A78 IV IV	0.80	-	
A77 IV 40	c. 0.80	A77 IV 40	(spectrum 4)
A78 IV V	1.00	A78 IV 10	(spectrum 3)
A78 IV VI	1.20	A78 IV 12	(spectrum 2)
A78 IV VII	1.40	A78 IV 14	(spectrum 1)
Byzantine harbour *(Table 4, Fig. 6)*			
A77 VII 262	c. 0.00 m	A77 VII 262	(spectrum 6)
A77 VII 263	c. 0.30	A77 VII 263	(spectrum 5)
A77 VII 263A	c. 0.55	A77 VII 263A	(spectrum 4)
A77 VII 263B	c. 0.85	A77 VII 263B	(spectrum 3)
A78 VII IV	1.20	-	
-	1.55	A78 VII 15	(spectrum 2)
A78 VII V	1.75	A78 VII 17	(spectrum 1)

Byzantine well *(Table 5)*

360
385/100
385/101
385 1.75 m below well-offset
390/116
391/117
392/118
392/126
393

Samples 360, 385 (1.75 m below well-offset) and 393 (bottom of well) are from the fill of the well, the others from the contents of jars.

Table 2. Rectangular harbour. Pollen and seed samples examined. Depth of samples is in metres above base of sediment. The location of the sampling sites is indicated in Fig. 2.

***Punic channel**: E1.070 (Table 7, Fig. 7). Base of sediment is at c. 1.40 m below sea level.*

Seed samples		Pollen samples	
		33	1.60 m (spectrum 13)
		32	1.55 m (spectrum 12)
B	1.36-1.53 m	30	1.45 m (spectrum 11)
		29	1.40 m (spectrum 10)
		28	1.35 m (spectrum 9)
C	1.19-1.36 m		
D	1.02-1.19 m	23	1.10 m (spectrum 8)
E	0.85-1.02 m	19	0.90 m (spectrum 7)
F	0.68-0.85 m		
G	0.51-0.68 m		
		14	0.65 m (spectrum 6)
H	0.34-0.51 m		
		8	0.35 m (spectrum 5)
J	0.17-0.34 m	7	0.30 m (spectrum 4)
		5	0.20 m (spectrum 3
K	0.00-0.17 m	3	0.10 m (spectrum 2)
		1	0.01 m (spectrum 1)

Roman deposit: II.2 (Table 8, Fig. 8). Base of sediment is at 1.05 m below sea level.

Seed samples		Pollen samples	
A	1.30-1.50 m		
B	1.10-1.30 m		
C	1.00-1.10 m	10	1.00 m (spectrum 5)
D	0.90-1.00 m		
E	0.80-0.90 m	8	0.80 m (spectrum 4)
F	0.70-0.80 m	7	0.70 m (spectrum 3)
G	0.60-0.70 m		
H	0.50-0.60 m		
J	0.40-0.50 m		
K	0.30-0.40 m	3	0.30 m (spectrum 2)
L	0.20-0.30 m		
M	0.10-0.20 m	1	0.10 m (spectrum 1)
N	0.00-0.10 m		

Byzantine harbour: G1.060 (Table 9, Fig. 10). Base of sediment is at 2.40 m below sea level.

Seed samples		Pollen samples	
		22	1.05 m (spectrum 5)
A	0.88-1.10 m		
B	0.66-0.88 m	16	0.75 m (spectrum 4)
C	0.44-0.66 m		
		9	0.40 m (spectrum 3)
D	0.22-0.44 m	8	0.35 m (spectrum 2)
E	0.00-0.22 m	4	0.15 m (spectrum 1)

Table 2 (continued)

Byzantine harbour: KL12.053 (Table 9, Fig. 9). Base of sediment is at 2.00 m below sea level.

Seed samples		Pollen samples	
		12	1.10 m (spectrum 4)
D	0.80-1.00 m		
		8	0.70 m (spectrum 3)
C	0.50-0.70 m		
B	0.30-0.40 m	4	0.30 m (spectrum 2)
A	0.00-0.20 m		
		1	0.01 m (spectrum 1)

Byzantine harbour: GH2.072 (Table 10). Base of sediment is at 2.35 m below sea level.

Seed samples

II	0.52-0.62 m
IV	0.38-0.45 m
VI	0.29-0.34 m
VIII	0.20-0.25 m
X	0.10-0.15 m
XII	0.00-0.05 m

Table 3. Circular harbour. Numbers of seeds etc. in samples from the fill of the Punic channel, calculated per 5 litres of sediment. Presence of leaves etc. is indicated by a plus-sign (+).

Sample designation A77 IV/A78 IV	78/ I	77/ 38	78/ III	78/ IV	77/ 40	78/ V	78/ VI	78/ VII
Centimetres below sea level	20	c.40	60	80	c.80	100	120	140
1. **Annual crop plants**								
Hordeum (vulgare)	-	1	-	1	1	-	-	-
Triticum dicoccum	-	1	-	-	-	-	-	-
Triticum durum/aestivum	-	-	-	-	1	-	-	-
Linum usitatissimum	-	-	-	-	1	-	-	-
Papaver somniferum	-	4	17	474	38	24	17	11
Cucumis melo	-	-	1	-	-	-	-	-
Coriandrum sativum	-	-	-	1	1	-	-	-
Foeniculum vulgare	-	-	-	1	-	-	-	-
2. **Cultivated and wild fruits and nuts**								
Ficus carica	940	1610	4480	5140	409	540	104	543
Morus (nigra)	-	1	-	-	-	-	-	-
Olea europaea	-	1	1	2	-	1	-	-
Punica granatum	-	19	112	101	9	5	2	12
Rubus (ulmifolius)	2	7	40	19	1	1	-	1
Vitis vinifera	5	59	104	20	11	3	2	4
Ziziphus lotus	-	2	1	-	-	-	-	-
Amygdalus communis	-	1	1	-	1	-	-	-
Pinus pinea	-	1	-	-	-	-	-	-
3. **Taxa of waste ground, cultivated and fallow fields**								
Adonis aestivalis	-	-	-	2	1	-	1	-
Amaranthus	-	-	-	-	-	1	-	-
Anagallis (arvensis)	-	-	-	-	-	2	-	1
Bifora testiculata	-	4	-	3	1	1	1	1
Calendula (arvensis)	-	-	-	10	-	-	1	2
Capsella bursa-pastoris	-	-	-	5	-	-	2	-
Carduus pteracanthus	-	1	-	15	-	-	-	-
Chenopodium album/opulifolium	-	1	-	11	-	-	2	-
Chenopodium murale	-	9	82	96	3	1	5	9
Chrysanthemum coronarium	-	-	-	9	-	-	1	1
Chrysanthemum segetum type	-	2	15	19	2	-	-	2
Emex spinosa	-	2	-	11	-	-	-	-
Euphorbia helioscopia	-	2	-	-	1	-	-	2
Fumaria	-	2	6	1	1	1	-	2
Heliotropium (europaeum)	-	3	3	9	1	1	-	3
Hyoscyamus (albus)	-	1	17	9	1	-	-	-
Malva nicaeensis	6	8	122	1	2	1	6	11
Marrubium vulgare	-	-	6	9	-	-	-	2
Mercurialis annua	-	-	-	-	-	1	-	-
Oxalis corniculata	-	-	-	11	-	16	-	1
Picris echioides	-	-	-	9	1	2	-	2
Polygonum aviculare	-	3	24	9	1	-	1	6
Portulaca oleracea	2	-	-	21	1	4	1	-
Raphanus raphanistrum	-	2	5	1	3	1	-	-
Rapistrum rugosum	5	19	46	7	5	3	2	1
Reseda alba	2	1	-	-	-	-	-	1
Reseda luteola	2	-	-	-	-	-	-	-
Sinapis	-	-	-	-	1	-	-	2
Solanum nigrum	-	1	-	-	-	1	1	-
Sonchus asper	-	-	-	-	-	-	-	1
Stellaria media	-	-	-	5	1	-	1	-

Table 3 (continued)

Sample designation A77 IV/A78 IV	78/ I	77/ 38	78/ III	78/ IV	77/ 40	78/ V	78/ VI	78/ VII
Taxa of waste ground, cultivated and fallow fields (continued)								
Urtica membranacea	-	-	35	11	-	-	-	-
Urtica pilulifera	4	-	-	-	-	-	-	1
Urtica urens	2	1	6	29	2	2	-	1
4. **Taxa of 'grassy places'**								
Linum spec.	-	-	-	11	-	-	-	-
Lolium perenne type	2	-	-	-	-	-	-	-
Medicago	-	2	2	1	1	1	-	-
Stachys hirta type	-	-	-	-	-	2	-	-
Valerianella morisonii type	-	1	-	5	-	-	-	-
5. **Salt-marsh and other salt-tolerant taxa**								
Arthrocnemum macrostachyum	2	1	17	-	1	2	-	1
Coronopus squamatus	-	2	12	-	1	-	-	1
Mesembryanthmum	-	-	-	-	1	-	1	-
Ranunculus sardous	-	2	-	1	1	1	-	-
Salicornia (fruticosa)	-	1	-	-	1	-	-	-
Scirpus lacustris subsp. glaucus	-	-	6	-	-	-	-	-
Scirpus maritimus	-	4	15	-	1	-	1	-
Suaeda (fruticosa)	-	-	6	5	3	-	-	-
5a. **Taxa of sandy sea shores**								
Ambrosia maritima	-	-	-	1	-	-	-	-
Thymelaea hirsuta	6	32	62	66	27	21	1	7
6. **Marsh and water plants**								
7. **Taxa of maquis and woods**								
Erica multiflora (leaves)	-	+	-	+	+	-	-	-
Juniperus phoenicea	-	+	+	+	+	+	+	+
Lavandula stoechas	-	2	12	9	1	-	-	1
Myrtus communis	-	-	-	1	-	-	-	-
Pinus halepensis	-	-	1	1	-	-	-	-
Pinus, scales	-	1	-	-	-	-	-	-
Pistacia lentiscus	-	-	-	-	2	-	-	-
Rosmarinus officinalis	-	-	17	28	5	9	1	2
8. **Taxa of uncertain ecological affinity**								
Atriplex spec.	2	3	17	-	-	-	1	4
Beta (vulgaris)	-	-	-	-	1	-	-	-
Unident. Caryophyllaceae	-	-	-	-	1	-	-	-
Unident. Compositae	-	-	-	-	1	-	-	-
Unident. Cruciferae	-	-	-	-	-	4	-	-
Daucus	-	1	-	-	-	-	-	-
Euphorbia spec.	-	-	-	-	-	-	-	1
Unident. Gramineae	-	-	-	-	-	-	-	2
Inula viscosa type	-	3	-	21	-	-	-	1
Juncus	-	-	17	5	1	-	-	-
Mentha type	2	5	-	75	11	2	2	2
Rumex	-	1	17	20	1	-	-	-
Silene spec.	-	-	-	11	1	3	1	1
Unident. Umbelliferae	-	-	-	19	1	-	-	-

Table 4. Circular harbour. Numbers of seeds etc. in samples from the Byzantine harbour fill, calculated per 5 litres of sediment. Presence of leaves etc. is indicated by a plus-sign (+). In brackets: recovered from wood sample.

Sample designation A77 VII/A78 VII	77/ 262	77/ 263	77/ 263A	77/ 263B	78/ IV	78/ V
Centimetres below sea level	c.0	c.30	c.55	c.85	155	175
1. **Annual crop plants**						
Hordeum (vulgare)	1	7	-	-	1	-
Triticum durum/aestivum	-	-	-	-	1	-
Papaver somniferum	2	-	2	1	6	5
Cucumis melo	[2]	39	30	48	29	9
Anethum graveolens	-	-	6	-	4	-
Coriandrum sativum	-	-	-	-	1	1
2. **Cultivated and wild fruits and nuts**						
Crataegus laevigata	-	4	[2]	-	1	-
Ficus carica	695	11065	5175	2910	7820	6550
Morus (nigra)	-	-	-	-	5	2
Olea europaea	6	91	44	16	11	6
Prunus domestica	1	4	2	-	-	-
Prunus persica	1	4	5	2	1	2
Punica granatum	1	14	2	-	7	3
Rubus (ulmifolius)	-	-	-	-	2	2
Vitis vinifera	8	158	126	116	58	42
Ziziphus lotus	-	-	[1]	-	-	-
Amygdalus communis	-	-	1	-	1	1
Corylus	1	4	4	1	3	1
Juglans regia	[1]	2	1	1	1	1
Pinus pinea	1	-	-	-	-	-
3. **Taxa of waste ground, cultivated and fallow fields**						
Adonis aestivalis	-	-	-	2	2	-
Amaranthus	-	-	-	-	14	14
Ammi visnaga	1	5	-	1	6	8
Anagallis (arvensis)	-	-	2	-	-	3
Anthemis arvensis type	-	-	-	-	2	-
Asphodelus fistulosus	-	4	4	2	6	6
Bifora testiculata	-	4	2	-	1	-
Brassica	-	-	-	-	6	3
Bupleurum (lancifolium)	-	-	-	-	1	2
Capnophyllum peregrinum	1	11	-	-	-	1
Chenopodium album/opulifolium	5	-	-	-	12	-
Chenopodium murale	1	25	2	1	6	-
Chrysanthemum coronarium	-	-	-	-	4	-
Cichorium intybus	-	-	-	-	8	-
Emex spinosa	-	4	-	-	-	-
Euphorbia helioscopia	-	-	-	-	4	-
Fumaria	1	-	2	2	-	-
Heliotropium (europaeum)	1	-	5	1	6	-
Hyoscyamus (albus)	408	5	5	3	-	30
Malva nicaeensis	-	-	-	-	4	-
Marrubium vulgare	2	-	-	11	12	1
Polygonum aviculare	-	-	-	-	2	3
Portulaca oleracea	-	5	-	1	-	-
Raphanus raphanistrum	-	-	-	-	1	1
Rapistrum rugosum	1	4	1	2	8	1
Reseda luteola	-	-	-	-	-	5
Silene cucubalus	-	-	-	-	-	1

Table 4 (continued)

Sample designation A77 VII/A78 VII	77/ 262	77/ 263	77/ 263A	77/ 263B	78/ IV	78/ V
Taxa of waste ground, cultivated and fallow fields (continued)						
Solanum nigrum	-	-	-	-	2	2
Sonchus asper	-	-	-	-	2	-
Stellaria media	-	-	-	-	2	-
Tordylium apulum	-	4	-	-	-	-
Urtica membranacea	2	9	-	1	6	-
Urtica urens	-	4	2	-	2	-
4. **Taxa of 'grassy places'**						
Linum spec.	-	-	2	1	6	5
Medicago	[1]	-	1	1	4	-
Ornithopus	-	-	-	-	1	-
Valerianella morisonii type	1	-	-	-	-	-
5. **Salt-marsh and other salt-tolerant species**						
Aizoon (hispanicum)	2	20	20	16	30	40
Apium (graveolens)	6	25	58	63	30	47
Arthrocnemum macrostachyum	2	-	-	1	6	-
Lycium (intricatum)	-	-	-	-	-	1
Mesembryanthemum	27	660	670	825	2820	1900
Ranunculus sardous	-	-	-	-	2	2
Ruppia maritima	1	-	-	1	-	-
Salicornia (fruticosa)	1	-	-	3	6	-
Scirpus maritimus	1	4	2	1	6	-
Suaeda (fruticosa)	9	20	8	8	438	25
5a. **Taxa of sandy sea shores**						
Ambrosia maritima	-	7	4	8	12	7
Thymelaea hirsuta	2	38	6	1	20	8
6. **Marsh and water plants**						
Alisma plantago-aquatica	-	14	-	-	6	5
Carex otrubae-type	-	-	-	-	2	-
Conium maculatum	-	-	-	-	-	8
Cyperus	-	-	2	-	-	-
Eleocharis palustris	-	5	-	-	6	-
Oenanthe aquatica type	-	-	-	-	-	2
Phragmites australis	-	-	-	-	-	5
Solanum dulcamara	-	-	-	-	2	2
Typha angustifolia	-	-	-	-	6	15
7. **Taxa of maquis and woods**						
Erica multiflora (seeds)	-	15	-	-	42	5
Erica multiflora (leaves, flowers)	+	-	-	-	+	+
Juniperus phoenicea	+	-	-	-	+	-
Lavandula stoechas	1	7	2	-	18	2
Myrtus communis	-	4	-	-	1	1
Pinus, scales	[2]	-	-	-	-	-
Rosmarinus officinalis	-	4	-	-	2	-

Table 4 (continued)

Sample designation A77 VII/A78 VII	77/ 262	77/ 263	77/ 263A	77/ 263B	78/ IV	78/ V
8. **Taxa of uncertain ecological affinity**						
Atriplex spec.	-	-	-	-	8	-
Beta (vulgaris)	-	-	-	-	1	-
Unident. Chenopodiaceae	3	-	-	-	-	2
Unident. Compositae	-	-	-	-	6	2
Unident. Cruciferae	1	-	-	-	-	-
Daucus	-	-	-	-	-	3
Inula viscosa type	-	18	-	1	174	15
Juncus	-	-	-	1	-	-
Unident. Malvaceae	1	-	-	-	-	-
Mentha type	-	-	5	3	-	5
Rumex	-	7	2	2	10	6
Scirpus spec.	-	-	-	-	6	-
Silene spec.	-	5	-	3	24	5
Unident. Umbelliferae	-	-	-	1	-	2

Table 5. Circular harbour. Numbers of seeds etc. in samples from the fill of the Byzantine well. Presence of leaves etc. is indicated by a plus sign (+).

Sample designation A78 III	360	385/ 100	385/ 101	385	390/ 116	391/ 117	392/ 118	392/ 126	393
Part of sample on which numbers are calculated	1/6	1/3	1/4	1/4	1/4	1/1	1/1	1/1	1/4
1. **Annual crop plants**									
Hordeum (vulgare)	-	-	-	-	-	1	2	-	-
Triticum durum/aestivum	-	-	-	-	1	1	-	-	1
Papaver somniferum	4	9	25	2	20	25	3	6	30
Cucumis melo	-	-	-	-	-	-	4	-	2
Anethum graveolens	-	-	-	-	-	-	6	-	-
Coriandrum sativum	-	-	-	-	-	-	1	-	-
2. **Cultivated and wild fruits and nuts**									
Ficus carica	7	35	70	128	28	41	1280	293	689
Morus (nigra)	-	-	6	-	19	3	3	-	10
Olea europaea	-	-	-	-	-	-	1	-	2
Punica granatum	-	-	-	-	-	-	-	-	1
Vitis vinifera	-	-	15	2	1	8	1	9	13
Amygdalus communis	-	-	-	-	-	-	-	-	1
Corylus	-	-	-	-	-	1	-	1	1
Pinus pinea	-	-	-	-	-	-	1	-	-
3. **Taxa of waste ground, cultivated and fallow fields**									
Amaranthus	-	3	-	-	-	-	3	-	-
Anagallis (arvensis)	-	3	-	-	8	6	-	-	-
Asphodelus fistulosus	46	1	-	42	8	11	-	-	1
Brassica	-	2	-	-	-	-	-	-	-
Bupleurum (lancifolium)	-	2	1	-	-	-	-	-	-
Calendula (arvensis)	3	26	29	210	2	-	-	-	-
Capnophyllum peregrinum	-	-	-	-	-	-	3	-	1
Carduus pteracanthus	-	-	-	-	-	-	-	-	6
Chenopodium album/opulifolium	18	1125	5985	292	298	3160	261	25	3130
Chenopodium murale	12	107	360	120	142	44	96	-	72
Chrysanthemum coronarium	202	962	4355	14340	1020	2	6	-	61
Chrysanthemum segetum type	-	-	-	-	-	12	6	-	-
Cichorium intybus	-	-	-	-	-	-	3	-	-
Emex spinosa	1	3	5	17	18	4	-	-	1
Euphorbia helioscopia	-	-	-	-	-	-	-	2	-
Fumaria	73	24	10	164	37	77	6	6	26
Glaucium corniculatum	-	-	-	-	-	-	6	-	2
Heliotropium (europaeum)	70	305	863	544	582	270	275	30	618
Hyoscyamus (albus)	4	46	400	348	61	117	24	6	87
Malva nicaeensis	2	218	3870	357	396	17	737	29	1175
Marrubium vulgare	62	131	725	272	236	284	321	63	395
Mercurialis annua	2550	952	3340	4490	4155	1815	45	38	1550
Onopordum	-	-	-	1	1	-	-	-	-
Polygonum aviculare	-	2	-	-	-	-	-	-	-
Portulaca oleracea	-	3	5	-	4	4	12	-	18
Raphanus raphanistrum	-	-	-	-	-	-	-	1	-
Rapistrum rugosum	1	-	1	-	-	-	6	1	-
Reseda lutea	-	-	-	-	-	-	-	-	6
Silybum marianum	341	16	-	95	38	3	2	-	11
Sinapis	-	-	-	-	-	-	3	-	-
Solanum nigrum	4	21	101	8	158	17	6	1	12
Sonchus asper	-	-	10	-	-	-	-	-	-
Sonchus oleraceus	-	6	-	-	-	-	-	-	-

Table 5 (continued)

Sample designation A78 III	360	385/ 100	385/ 101	385	390/ 116	391/ 117	392/ 118	392/ 126	393
Taxa of waste ground, cultivated and fallow fields (continued)									
Stellaria media	4	9	20	-	3	7	12	9	6
Urtica membranacea	-	42	240	96	67	35	30	3	48
Urtica pilulifera	1	10	40	60	-	-	24	-	-
Urtica urens	5	140	436	336	134	77	80	12	94
4. **Taxa of 'grassy places'**									
Lolium perenne type	-	-	-	-	-	-	-	1	-
Medicago	-	-	-	-	-	-	1	-	1
5. **Salt-marsh and other salt-tolerant taxa**									
Aizoon (hispanicum)	-	-	5	-	-	-	-	-	66
Apium (graveolens)	-	-	-	-	-	-	39	6	6
Arthrocnemum macrostachyum	-	-	-	-	-	4	-	3	-
Atriplex cf. rosea (fruiting bracts)	-	-	+	-	-	-	+	+	-
Mesembryanthemum	-	9	-	8	-	-	279	6	-
Suaeda (fruticosa)	173	10	20	28	12	21	-	-	12
5a. **Taxa of sandy sea shores**									
Thymelaea hirsuta	-	-	-	8	4	1	15	6	6
6. **Marsh and water plants**									
7. **Taxa of maquis and woods**									
8. **Taxa of uncertain ecological affinity**									
Atriplex spec.	-	2	42	-	-	1	23	1	12
Beta (vulgaris)	1	-	1	-	1	-	1	-	-
Unident. Chenopodiaceae.	-	-	10	-	-	4	9	-	-
Unident. Compositae	-	1	-	-	-	1	-	-	-
Inula viscosa type	-	-	10	-	-	-	-	-	-
Unident. Malvaceae	-	-	-	-	-	-	-	1	-
Mentha type	-	-	-	-	-	-	21	-	-
Polygonum spec.	-	5	-	-	-	-	-	-	
Rumex	-	2	-	18	-	-	3	1	-
Silene spec.	-	15	45	-	9	-	6	3	6
Unident. Umbelliferae	-	-	-	-	-	-	8	-	-

Table 6. Circular harbour. Numbers of carbonised seeds in dry-land (non-waterlogged) samples. c century.

Trench/layer A77	IV/241[1]	IV/262[2]	XI/135	XI/138	XI/91	XIV/26B[3]	XIV/29[3]
Date (BC)	4th/3rd c	4th/3rd c	4th/3rd c	4th/3rd c	3rd c	146	146
Hordeum vulgare	1	63	1	-	1	-	-
Triticum durum/aestivum	-	6	-	-	-	-	1
Lens culinaris	-	26	3	-	-	-	2
Linum usitatissimum	-	-	1	-	-	-	-
Ficus carica	26	3880	2	-	1	1	3
Vitis vinifera	-	1020	1	-	-	-	-
Punica granatum	-	15	-	-	-	-	-
Rubus (ulmifolius)	-	23	-	-	-	-	-
Pinus pinaster	-	1	-	-	-	-	-
Lolium temulentum	-	27	-	-	-	-	-
Phalaris	1	-	-	-	-	-	-
Unident. Gramineae	-	-	-	1	-	-	-
Vicia spec.	-	2	-	-	-	-	-
Malva spec.	1	-	42	2	-	-	-
Atriplex spec	-	-	1	-	-	-	-
Chenopodium murale	-	-	-	1	-	-	-
Polygonum aviculare	-	-	1	-	-	-	-
Thymelaea hirsuta	2	3	-	-	-	-	1

[1] sum of 2 samples
[2] part of sample examined
[3] sum of 4 samples

Table 7. Rectangular harbour. Numbers of seeds etc. in samples from the fill of the Punic channel, calculated per 5 litres of sediment. Presence of leaves etc. is indicated by a plus-sign (+).

Sample designation E1.070	B	C	D	E	F	G	H	J	K
Centimetres above base of sediment	136-153	119-136	102-119	85-102	68-85	51-68	34-51	17-34	0-17
1. **Annual crop plants**									
Hordeum (vulgare)	-	1	1	-	1	1	-	-	1
Triticum durum/aestivum	-	-	-	-	1	2	-	-	1
Triticum dicoccum	1	-	-	-	-	-	1	-	-
Lens culinaris	-	-	-	-	-	-	-	-	1
Papaver somniferum	4	5	10	3	14	11	2	3	7
Anethum graveolens	-	-	-	-	-	-	1	-	-
Coriandrum sativum	-	-	-	-	-	-	1	-	-
Foeniculum vulgare	-	-	1	-	-	1	1	-	-
2. **Cultivated and wild fruits and nuts**									
Ficus carica	119	130	530	425	890	2150	1345	153	260
Morus (nigra)	-	-	1	-	-	1	-	-	-
Olea europaea	-	-	-	-	-	1	-	-	1
Punica granatum	-	-	13	5	4	47	10	1	1
Rubus (ulmifolius)	1	-	1	2	7	5	3	-	1
Vitis vinifera	1	3	25	10	38	96	45	9	7
Ziziphus lotus	-	-	-	-	1	1	-	-	-
Pinus pinea	-	-	1	-	-	-	1	-	-
3. **Taxa of waste ground, cultivated and fallow fields**									
Adonis aestivalis	-	-	1	-	-	-	-	-	-
Amaranthus	-	-	1	-	-	1	-	1	1
Anagallis arvensis	1	-	1	1	-	1	-	-	-
Bifora testiculata	-	1	-	-	-	-	1	-	-
Carduus pteracanthus	-	-	1	-	-	-	-	-	-
Centaurea calcitrapa	-	-	-	-	-	-	-	1	1
Chenopodium album/opulifolium	-	-	-	-	-	2	2	2	3
Chenopodium murale	2	4	3	4	4	6	8	10	9
Euphorbia helioscopia	1	1	1	1	-	-	1	-	-
Fumaria	1	5	4	1	3	2	1	1	1
Heliotropium (europaeum)	1	-	1	3	4	5	1	-	2
Hyoscyamus (albus)	-	-	-	-	-	1	-	-	-
Malva nicaeensis	2	1	3	1	1	2	1	2	3
Marrubium vulgare	-	-	-	-	1	1	-	-	-
Picris echioides	-	-	-	-	-	2	1	-	-
Polygonum aviculare	-	1	-	2	1	1	6	2	1
Portulaca oleracea	-	1	2	1	1	1	1	-	3
Raphanus raphanistrum	-	-	1	-	1	2	1	-	-
Rapistrum rugosum	-	1	1	1	1	3	5	1	1
Reseda alba	1	1	-	-	1	1	-	-	-
Silene cucubalus	-	-	1	-	-	-	-	-	-
Stellaria media	5	8	4	1	-	1	1	-	3
Urtica membranacea	-	1	4	1	1	-	2	5	3
Urtica pilulifera	1	-	-	-	-	-	-	1	-
Urtica urens	7	8	3	2	3	2	1	2	1

Table 7 (continued)

Sample designation E1.070	B	C	D	E	F	G	H	J	K
4. **Taxa of 'grassy places'**									
Euphorbia chamaesyce	6	5	2	1	2	1	1	1	-
Linum spec.	-	-	-	-	-	-	-	1	-
Medicago	1	1	1	-	1	-	1	-	1
Plantago	-	-	-	-	-	1	-	-	-
Stachys hirta-type	-	1	-	-	1	-	-	-	-
Valerianella morisonii type	1	1	1	-	-	-	-	1	1
Valerianella vesicaria type	1	-	-	-	-	-	-	-	-
5. **Salt-marsh and other salt-tolerant taxa**									
Arthrocnemum macrostachyum	2	2	3	4	3	3	6	6	11
Coronopus squamatus	1	2	1	1	1	3	2	-	1
Mesembryanthemum	1	-	-	1	-	1	-	-	1
Ranunculus sardous	-	1	1	-	-	-	1	-	1
Salicornia (fruticosa)	1	1	2	1	3	-	2	-	1
Spergularia	-	-	1	-	-	-	-	-	-
Suaeda (fruticosa)	-	-	-	-	1	1	-	-	1
Zannichellia	-	-	-	1	-	-	-	-	-
5a. **Taxa of sandy sea shores**									
Ambrosia maritima	-	1	-	-	-	-	-	-	-
Thymelaea hirsuta	15	17	20	10	15	17	25	1	2
6. **Marsh and water plants**									
Cyperus	-	1	-	-	-	-	-	-	1
7. **Taxa of maquis and woods**									
Cistus	-	-	1	-	-	-	3	-	-
Erica multiflora (seeds)	1	-	-	-	-	1	-	-	-
Erica multiflora (leaves)	-	-	-	-	-	-	-	+	-
Juniperus phoenicea	+	-	-	-	-	-	-	-	-
Lavandula stoechas	-	-	-	-	1	-	1	-	-
Pinus halepensis	-	-	-	-	-	1	2	-	-
Pistacia lentiscus	-	-	1	1	1	5	3	1	-
Rosmarinus officinalis	1	-	1	1	1	1	1	1	-
8. **Taxa of uncertain ecological affinity**									
Atriplex spec.	1	7	9	9	21	24	29	31	31
Carex spec.	-	-	-	-	-	-	1	-	-
Unident. Caryophyllaceae	-	-	-	-	2	-	-	-	-
Chenopodium spec.	-	-	-	2	-	-	-	-	-
Unident. Compositae	-	-	-	-	-	1	2	2	1
Unident. Cruciferae	-	-	-	-	-	1	-	-	-
Daucus	-	-	-	1	-	-	-	-	-
Unident. Gramineae	-	-	1	-	-	-	-	1	-
Inula viscosa type	1	-	1	-	1	1	3	1	-
Unident. Labiatae	-	-	-	-	-	-	-	-	1
Lolium spec.	1	-	-	-	-	-	-	-	-
Mentha type	-	2	4	-	3	1	4	-	2
Phalaris	-	1	-	-	-	-	-	-	-
Polygonum spec.	1	-	-	-	-	-	-	-	-
Reseda spec.	-	-	-	-	-	1	-	-	-
Rumex	1	2	1	1	-	-	1	1	-
Scirpus spec.	-	-	1	-	-	1	1	-	1
Silene spec.	2	-	-	-	-	-	-	-	-
Unident. Umbelliferae	-	-	1	-	-	-	2	-	-

Table 8. Rectangular harbour. Numbers of seeds etc. in samples from the Roman deposit, calculated per 10 litres of sediment (supposed to correspond to 5 litres of sediment of other sections: see text). The results of samples A-C are combined. Presence of leaves etc. is indicated by a plus-sign (+).

Sample designation II.2	A-C	D	E	F	G	H	J	K	L	M	N
Centimetres above base of sediment	100-130	90-100	80-90	70-80	60-70	50-60	40-50	30-40	20-30	10-20	0-10
1. **Annual crop plants**											
Hordeum (vulgare)	-	-	-	-	-	1	-	-	-	-	-
Triticum durum/aestivum	-	-	-	-	-	-	1	-	-	-	-
Vicia ervilia	2	-	-	-	-	-	-	-	-	-	-
Linum usitatissimum	-	-	-	-	-	1	-	-	1	-	-
Papaver somniferum	-	2	5	5	4	5	12	6	9	8	2
Anethum graveolens	-	-	-	-	-	-	1	-	-	-	-
Foeniculum vulgare	-	-	-	-	-	-	1	-	-	-	-
Carthamus tinctorius	-	-	1	-	-	-	-	-	-	-	1
2. **Cultivated and wild fruits and nuts**											
Crataegus laevigata	-	-	-	-	-	-	-	-	-	1	-
Ficus carica	93	265	355	458	685	585	660	1505	755	472	585
Morus (nigra)	-	-	1	-	2	-	-	-	-	1	-
Olea europaea	60	-	-	1	2	2	3	4	2	1	1
Punica granatum	2	-	1	-	1	2	3	4	2	1	1
Pyrus	-	-	-	-	-	-	-	1	-	-	-
Rubus (ulmifolius)	-	-	-	-	-	-	-	1	-	-	1
Vitis vinifera	3	1	1	6	3	5	9	24	15	7	10
Ziziphus lotus	-	-	1	-	-	-	1	-	-	-	-
Amygdalus	-	-	1	-	-	-	1	-	-	-	-
Corylus	-	-	1	-	-	1	-	1	1	-	-
Juglans regia	-	-	1	-	1	-	1	1	1	1	1
Pinus pinea	1	-	-	-	-	-	-	-	-	-	-
3. **Taxa of waste ground, cultivated and fallow fields**											
Adonis aestivalis	-	-	-	-	-	-	-	-	1	-	-
Amaranthus	-	2	-	-	-	-	2	-	-	-	2
Anagallis arvensis	-	-	-	-	-	-	1	-	1	-	-
Anthemis cotula	-	-	-	-	-	-	1	-	-	-	-
Calendula (arvensis)	-	-	1	-	-	-	-	-	-	-	-
Carduus pteracanthus	-	-	-	-	-	1	-	-	-	1	-
Centaurea calcitrapa	-	1	-	-	1	-	4	-	1	-	-
Chenopodium album/opulifolium	1	4	6	3	4	-	6	19	9	6	11
Chenopodium murale	1	3	6	4	17	21	22	37	21	14	14
Chrysanthemum coronarium	-	-	-	-	-	-	2	1	-	-	-
Chrysanthemum segetum type	-	1	-	-	-	-	-	-	-	-	-
Cichorium intybus	-	-	-	-	-	-	-	-	1	-	-
Euphorbia helioscopia	-	-	-	-	-	-	1	-	-	-	-
Fumaria	-	-	1	1	1	1	1	-	1	1	1
Glaucium corniculatum	-	-	-	-	-	-	-	-	1	-	1
Heliotropium (europaeum)	-	4	3	2	4	10	7	21	20	10	15
Hyoscyamus (albus)	-	-	-	1	-	-	-	-	-	1	2
Malva nicaeensis	-	-	1	1	2	3	12	6	11	4	8
Marrubium vulgare	-	-	-	-	1	2	1	-	1	2	2
Mercurialis annua	-	-	1	-	1	-	-	1	-	-	-
Oxalis corniculata	1	2	1	-	1	2	3	-	-	-	1
Picris echioides	-	-	-	1	1	-	-	-	-	-	1
Poa annua	-	-	-	-	-	-	-	-	-	-	1
Polygonum aviculare	-	-	1	-	1	-	2	1	4	1	1
Portulaca oleracea	-	-	-	1	6	6	6	-	8	2	1
Rapistrum rugosum	-	-	1	1	-	3	1	4	4	-	1

Table 8 (continued)

Sample designation II.2	A-C	D	E	F	G	H	J	K	L	M	N
Taxa of waste ground, cultivated and fallow fields (continued)											
Reseda alba	-	1	-	-	-	-	-	-	-	-	-
Reseda luteola	1	1	4	3	11	4	9	9	8	5	9
Sonchus oleraceus	-	-	-	-	-	-	1	-	-	-	1
Stellaria media	-	-	1	2	4	4	7	9	4	-	2
Urtica membranacea	-	-	1	1	3	2	3	6	4	-	4
Urtica pilulifera	-	-	-	-	-	-	-	-	-	2	1
Urtica urens	-	-	2	2	5	14	24	6	18	12	3
Verbena officinalis	-	-	-	1	-	-	-	-	-	-	-
4. **Taxa of 'grassy places'**											
Euphorbia chamaesyce	-	-	-	-	-	-	-	-	1	-	-
Linum spec.	-	-	-	-	-	-	1	-	1	-	1
Medicago	-	-	-	-	-	-	1	1	1	1	1
Plantago	-	-	-	-	-	2	-	-	-	-	-
Valerianella morisonii type	-	-	1	-	-	2	-	-	-	-	-
5. **Salt-marsh and other salt-tolerant taxa**											
Aizoon (hispanicum)	-	-	1	1	-	-	1	-	-	-	-
Apium (graveolens)	-	-	-	1	1	-	-	-	-	-	-
Arthrocnemum macrostachyum	5	2	2	1	7	12	11	3	19	10	22
Atriplex halimus (fruiting bracts)	-	-	-	-	+	+	+	-	-	+	-
Coronopus squamatus	-	-	-	-	-	1	-	1	1	-	-
Mesembryanthemum	-	25	331	146	503	342	446	264	407	280	187
Ruppia maritima	-	-	-	-	1	1	-	2	2	1	4
Salicornia (fruticosa)	-	-	2	1	-	2	-	-	-	-	-
Scirpus lacustris ssp. glaucus	-	-	-	-	2	3	1	-	1	3	4
Scirpus maritimus	-	-	-	1	-	-	-	-	-	-	-
Suaeda (fruticosa)	-	-	5	2	12	10	22	6	20	6	5
5a. **Taxa of sandy sea shores**											
Ambrosia maritima	-	-	-	-	-	-	1	-	-	-	-
Thymelaea hirsuta	-	-	-	-	3	1	2	2	1	1	3
6. **Marsh and water plants**											
Carex otrubae type	-	-	-	1	-	-	-	-	-	-	-
Carex vesicaria type	-	-	-	-	1	-	-	-	1	-	1
Cladium mariscus	-	-	-	-	-	-	-	1	-	1	-
Ranunculus sect. Batrachium	-	-	1	-	-	-	-	-	-	-	-
7. **Taxa of maquis and woods**											
Erica multiflora	-	-	-	-	-	-	-	3	-	-	1
Juniperus phoenicea	-	-	-	-	-	+	+	-	-	-	-
Lavandula stoechas	-	-	-	-	-	-	-	-	-	2	-
Myrtus communis	-	-	-	-	-	1	2	-	2	1	-
Pinus halepensis	-	-	-	-	1	-	-	-	-	-	-
Pinus spec. (scale)	-	-	-	-	-	-	-	-	-	1	-
Pistacia lentiscus	-	-	-	-	-	1	-	-	1	1	-
Rosmarinus officinalis	-	-	-	-	1	-	-	-	-	-	-

Table 8 (continued)

Sample designation II.2	A-C	D	E	F	G	H	J	K	L	M	N
8. **Taxa of uncertain ecological affinity**											
Atriplex spec.	-	1	4	-	23	23	33	16	4	23	19
Bromus	-	-	-	-	-	-	-	-	1	-	-
Carex spec.	-	-	-	1	3	2	-	-	-	-	-
Unident. Caryophyllaceae	-	-	-	-	-	-	-	3	-	-	-
Chenopodium spec.	-	-	-	3	4	6	-	-	1	-	-
Unident. Compositae	-	-	1	-	-	1	2	-	-	1	-
Unident. Cruciferae	-	-	-	-	1	-	-	-	-	-	-
Daucus	-	-	-	-	-	2	1	-	-	-	-
Unident. Gramineae	1	1	4	3	5	12	27	7	10	38	58
Inula viscosa type	-	-	1	1	1	-	2	-	-	-	-
Juncus	-	-	-	-	-	-	-	3	1	-	-
Mentha type	-	1	2	-	6	2	2	15	4	-	5
Phalaris	1	-	-	-	-	-	-	-	-	-	-
Rumex	-	-	1	-	-	-	-	-	-	1	-
Scirpus spec.	1	-	1	-	-	-	-	-	-	1	1
Solanum spec.	-	-	-	-	1	-	-	-	-	-	-

Table 9. Rectangular harbour. Numbers of seeds etc. in samples from two exposed sections of the Byzantine harbour fill, calculated per 5 litres of sediment. Presence of leaves etc. is indicated by a plus-sign (+).

Sample designation G1.060	A	B	C	D	E	KL12.053 D	C	B	A
Centimetres above base of sediment	88-110	66-88	44-66	22-44	0-22	80-100	50-70	30-40	0-20
1. **Annual crop plants**									
Hordeum (vulgare)	-	-	1	3	-	-	-	-	-
Hordeum (rachis internodes)	-	-	-	-	2	-	-	-	-
Triticum durum/aestivum	1	-	1	1	-	-	-	1	-
Linum usitatissimum	-	-	-	1	1	-	-	-	-
Papaver somniferum	-	-	-	2	2	18	18	11	-
Cucumus melo	35	29	10	4	30	2	24	29	16
Anethum graveolens	2	1	-	-	7	-	-	3	-
Coriandrum sativum	-	-	-	-	-	3	-	-	-
Foeniculum vulgare	1	1	-	-	-	-	-	-	-
2. **Cultivated and wild fruits and nuts**									
Cordia myxa	-	-	1	-	-	-	-	-	-
Crataegus laevigata	-	-	-	1	-	2	-	2	-
Ficus carica	2120	2220	535	1665	5115	565	2175	2830	1720
Morus (nigra)	1	1	2	1	5	-	3	1	2
Olea europaea	10	2	4	10	21	84	8	17	-
Prunus domestica	1	-	-	-	-	-	-	-	-
Punica granatum	-	-	1	1	23	4	5	1	16
Rubus (ulmifolius)	-	-	1	-	-	3	2	-	-
Vitis vinifera	53	29	24	15	39	8	13	12	14
Amygdalus	-	1	-	-	1	1	1	1	-
Corylus	1	1	1	1	5	1	1	2	-
Juglans regia	1	1	-	1	-	1	-	-	-
Pinus pinea	-	-	-	-	-	1	-	-	-
3. **Taxa of waste ground, cultivated and fallow fields**									
Adonis aestivalis	-	-	-	-	-	-	-	3	-
Amaranthus	2	-	1	4	2	-	2	-	2
Ammi visnaga	-	-	-	-	-	2	-	-	-
Anagallis arvensis	-	-	-	-	2	6	-	-	-
Asphodelus fistulosus	-	-	-	4	-	-	5	-	-
Bifora testiculata	-	-	-	-	-	-	1	-	-
Brassica	-	-	-	2	-	94	2	3	-
Bupleurum (lancifolium)	-	-	-	-	15	15	8	8	-
Capnophyllum peregrinum	-	-	-	2	3	5	-	2	-
Carthamus spec.	-	-	-	1	2	-	-	-	-
Chenopodium album/opulifolium	4	-	1	4	8	-	-	3	-
Chenopodium murale	15	-	2	8	6	18	14	43	24
Chrysanthemum coronarium	-	-	-	-	-	2	2	1	-
Chrysanthemum segetum type	-	1	-	-	1	-	2	8	3
Cichorium intybus	-	-	-	-	-	2	-	-	-
Fumaria	1	-	-	-	2	1	-	2	1
Heliotropium (europaeum)	3	1	-	1	2	2	4	6	-
Hyoscyamus (albus)	-	5	1	33	27	12	3	20	9
Lolium temulentum	-	1	-	3	2	-	-	-	-
Malva nicaeensis	-	-	-	-	11	-	-	-	-
Marrubium vulgare	-	-	-	-	5	-	-	-	3
Neslia paniculata	-	1	-	-	2	-	-	-	-
Papaver rhoeas type	-	-	-	-	-	4	-	-	-
Picris echioides	-	-	-	2	-	-	-	-	-
Poa annua	2	-	-	-	-	-	-	-	-
Polygonum aviculare	-	-	-	1	-	2	2	-	-

Table 9 (continued)

Sample designation	G1.060	A	B	C	D	E	KL12	D	C	B	A
Taxa of waste ground, cultivated and fallow fields (continued)											
Portulaca oleracea		2	-	-	-	-		4	-	-	6
Ranunculus arvensis		1	-	-	-	-		-	-	-	-
Raphanus raphanistrum		1	1	-	-	-		-	-	-	-
Rapistrum rugosum		2	1	1	1	11		12	11	-	1
Reseda luteola		-	-	-	-	-		24	-	-	-
Ridolfia segetum		-	-	-	-	-		-	4	3	-
Silene cucubalus		-	-	-	1	9		7	2	-	2
Silybum marianum		1	-	-	-	-		-	-	-	-
Sinapis		-	-	1	-	6		6	2	9	3
Sonchus oleraceus		-	-	-	-	-		-	2	-	-
Stellaria media		-	-	1	-	2		-	2	-	-
Tordylium apulum		-	-	-	-	3		-	-	1	-
Urtica membranacea		2	-	-	-	-		-	-	-	-
Urtica pilulifera		1	-	-	-	-		-	-	-	3
Urtica urens		1	1	1	-	-		4	-	-	6
4. **Taxa of 'grassy places'**											
Linum spec.		-	-	1	-	2		12	4	4	-
Medicago		1	1	-	-	-		-	-	1	-
Ornithopus		-	-	-	-	-		-	1	-	-
Valerianella morisonii type		-	-	-	1	-		4	2	-	-
5. **Salt-marsh and other salt-tolerant taxa**											
Aizoon (hispanicum)		50	10	2	6	6		138	61	80	-
Apium (graveolens)		32	28	1	2	20		108	25	10	-
Arthrocnemum macrostachyum		-	-	-	-	12		-	-	-	-
Mesembryanthemum		870	1200	318	855	1705		2125	1720	1765	645
Ranunculus sardous		-	-	-	-	3		-	-	-	-
Salicornia (fruticosa)		-	-	-	-	2		-	-	-	-
Scirpus maritimus		1	-	-	-	-		-	-	-	-
Suaeda (fruticosa)		18	-	1	10	30		-	6	10	3
5a. **Taxa of sandy sea shores**											
Ambrosia maritima		-	-	1	-	5		2	-	-	-
Euphorbia paralias		-	-	1	-	-		-	-	-	-
Glaucium flavum		-	-	-	-	2		2	-	-	-
Thymelaea hirsuta		3	3	-	4	11		2	11	-	1
6. **Marsh and water plants**											
Carex otrubae type		-	-	-	-	-		-	-	3	-
Cladium mariscus		-	-	-	-	-		-	2	-	-
Cyperus		2	-	-	-	-		-	-	-	-
Eleocharis palustris		2	-	-	-	-		2	-	-	-
Polygonum cf. hydropiper		1	-	-	-	-		-	-	-	-
Ranunculus muricatus		-	-	-	-	2		-	-	-	-
Ranunculus repens type		-	1	-	-	-		-	-	-	-
Sambucus ebulus		-	-	-	-	2		-	-	-	-
Solanum dulcamara		-	-	-	-	-		-	2	-	-

Table 9 (continued)

Sample designation	G1.060	A	B	C	D	E	KL12	D	C	B	A
7. **Taxa of maquis and woods**											
Erica multiflora (seeds)		-	-	-	-	6		4	-	-	6
Erica multiflora (leaves)		-	+	-	-	-		+	+	+	+
Juniperus phoenicea		+	-	+	-	-		+	+	+	-
Lavandula stoechas		4	-	2	-	8		12	2	-	3
Myrtus communis		-	1	-	-	-		2	-	1	4
Pinus spec. (scales)		-	-	-	-	2		-	1	-	-
Rosmarinus officinalis		-	-	1	-	2		2	-	-	3
Teucrium		-	-	-	-	-		2	-	-	-
8. **Taxa of uncertain ecological affinity**											
Alopecurus		-	-	-	-	-		-	-	3	-
Althaea rosea type		1	-	-	-	-		-	-	-	-
Atriplex spec.		-	-	-	-	2		-	-	-	-
Avena		-	-	-	-	2		-	-	-	-
Bromus		-	-	-	-	2		-	-	-	-
Unident. Caryophyllaceae		-	-	-	2	2		-	-	-	-
Cerastium		-	3	-	-	-		-	-	-	-
Unident. Chenopodiaceae		-	-	-	-	6		-	-	-	-
Cirsium		-	-	-	-	-		-	1	-	-
Unident. Compositae		-	-	-	-	-		-	3	-	-
Unident. Cruciferae		-	-	-	-	-		-	-	-	6
Unident. Cyperaceae		-	-	-	-	-		4	-	-	-
Euphorbia spec.		-	-	-	-	-		-	-	3	-
Galium		-	-	-	-	-		-	-	1	-
Unident. Gramineae		1	-	-	-	-		-	-	-	-
Inula viscosa type		4	-	-	-	10		6	-	10	-
Juncus		-	-	-	-	-		-	3	-	-
Mentha type		4	-	1	-	2		34	17	14	-
Phalaris		-	-	1	2	2		-	-	-	-
Rumex		-	-	1	2	20		2	3	4	-
Scirpus spec.		1	1	-	-	-		-	-	-	-
Silene spec.		4	-	-	-	-		-	5	10	9
Solanum spec.		1	-	-	-	-		-	-	-	-
Unident. Umbelliferae		2	-	-	-	-		-	-	-	-

Table 10. Rectangular harbour. Numbers of seeds etc. in samples from a third exposed section of the Byzantine harbour fill, calculated per 5 litres of sediment. Presence of leaves etc. is indicated by a plus-sign (+).

Sample designation GH2.072	II	IV	VI	VIII	X	XII
Centimetres above base of sediment	52-62	38-45	29-34	20-25	10-15	0-5
1. **Annual crop plants**						
Hordeum (vulgare)	-	1	1	-	-	-
Triticum durum/aestivum	-	3	-	-	-	-
Linum usitatissimum (capsule remains)	-	-	+	-	-	-
Papaver somniferum	7	-	-	8	-	-
Cucumis melo	24	29	14	20	20	16
Anethum graveolens	-	3	-	4	3	-
Foeniculum vulgare	-	1	-	-	-	-
2. **Cultivated and wild fruits and nuts**						
Cordia myxa	-	-	-	-	-	4
Ficus carica	4285	4120	2555	2480	2135	2875
Morus (nigra)	-	7	1	-	-	2
Olea europaea	3	4	6	-	1	4
Punica granatum	2	8	3	10	1	6
Rubus (ulmifolius)	-	2	-	-	-	-
Vitis vinifera	26	19	22	24	12	18
Amygdalus communis	-	1	-	-	-	-
Corylus	1	1	-	-	1	1
3. **Taxa of waste ground, cultivated and fallow fields**						
Adonis aestivalis	-	-	-	-	-	2
Agrostemma githago	-	-	-	2	-	-
Amaranthus	-	1	4	10	8	-
Ammi visnaga	-	5	-	4	-	-
Anagallis arvensis	2	10	-	2	2	-
Antirrhinum orontium	-	-	-	-	-	15
Asphodelus fistulosus	2	1	1	-	1	-
Brassica	-	1	-	-	-	-
Bupleurum (lancifolium)	-	1	1	-	-	-
Carduus pteracanthus	-	-	-	2	-	-
Chenopodium album/opulifolium	2	5	5	-	13	-
Chenopodium murale	3	11	2	34	2	8
Chrysanthemum coronarium	-	-	4	-	-	-
Chrysanthemum segetum type	-	-	5	-	-	-
Cichorium intybus	-	4	-	-	-	-
Fumaria	-	1	1	2	-	-
Glaucium corniculatum	-	-	1	-	-	-
Hyoscyamus (albus)	85	85	52	10	32	5
Lolium temulentum	2	-	-	-	-	-
Malva nicaeenis	2	2	1	2	1	2
Marrubium vulgare	3	1	-	-	-	-
Oxalis corniculata	-	-	-	-	2	-
Papaver rhoeas type	-	5	-	-	-	-
Polygonum aviculare	-	2	-	-	2	-
Polygonum convolvulus	-	-	1	-	-	-
Portulaca oleracea	5	-	-	2	-	-
Raphanus raphanistrum	-	2	-	-	-	2
Rapistrum rugosum	1	2	4	11	-	-
Reseda alba	-	-	-	-	3	-
Reseda lutea	-	-	-	2	-	-
Reseda luteola	-	5	-	-	2	-
Ridolfia segetum	-	1	-	-	2	-
Silene cucubalus	-	-	1	-	-	-

Table 10 (continued)

Sample designation GH2	II	IV	VI	VIII	X	XII
Taxa of waste ground, cultivated and fallow fields (continued)						
Sinapis	-	3	-	2	2	-
Solanum nigrum	2	-	-	-	-	-
Sonchus oleraceus	-	-	-	-	2	-
Stellaria media	-	-	-	-	-	3
Thymelaea cf. passerina	-	5	-	-	-	-
Tordylium apulum	-	1	-	-	2	-
Urtica membranacea	-	5	-	8	-	-
Urtica pilulifera	-	-	1	-	-	-
Urtica urens	2	-	3	2	9	-
4. **Taxa of 'grassy places'**						
Linum spec.	9	2	1	-	2	-
Medicago	-	1	1	-	3	-
Valerianella morisonii type	-	1	-	-	-	-
5. **Salt-marsh and other salt-tolerant taxa**						
Aizoon (hispanicum)	70	33	23	32	20	23
Apium (graveolens)	28	20	10	44	7	13
Arthrocnemum macrostachyum	2	10	-	-	-	3
Mesembryanthemum	665	2985	3110	5875	2560	600
Ranunculus sardous	-	1	-	2	-	-
Salicornia (fruticosa)	-	5	-	4	3	-
Scrirpus lacustris ssp. glaucus	2	-	-	-	-	-
Scirpus maritimus	-	-	1	-	-	-
Suaeda (fruticosa)	22	50	55	12	13	-
5a**. Taxa of coastal sands**						
Ambrosia maritima	3	3	-	-	-	-
Glaucium flavum	-	-	2	-	-	-
Thymelaea hirsuta	3	7	15	6	3	2
6. **Marsh and water plants**						
Alisma plantago-aquatica	-	-	22	-	-	-
Carex otrubae type	-	1	-	-	-	-
Conium maculatum	-	1	1	-	-	-
Cyperus	-	-	5	2	-	-
Eleocharis palustris	-	5	5	-	-	-
Oenanthe aquatica type	-	-	1	-	-	-
Ranunculus repens type	-	-	-	2	-	-
Typha angustifolia	-	15	-	-	-	-
7. **Taxa of maquis and woods**						
Erica multiflora (seeds)	2	55	10	12	3	-
Erica multiflora (leaves, flowers)	+	+	+	+	-	+
Lavandula stoechas	-	6	3	4	-	-
Myrtus communis	-	1	-	-	-	-
Rosmarinus officinalis	-	1	1	6	-	-

Table 10 (continued)

Sample designation GH2	II	IV	VI	VIII	X	XII
8. **Taxa of uncertain ecological affinity**						
Atriplex spec.	2	-	-	12	-	-
Carex spec.	-	1	-	-	-	-
Unident. Caryophyllaceae	-	-	-	-	-	2
Unident. Cruciferae	-	10	10	4	-	-
Unident. Gramineae	2	-	-	4	-	-
Inula viscosa type	-	30	20	8	-	3
Mentha type	2	25	-	24	3	-
Phalaris	3	1	1	-	-	-
Rumex	2	2	3	4	-	3
Scirpus spec.	2	-	4	-	2	-
Silene spec.	2	30	15	6	7	-

Table 11. Rectangular harbour. Numbers of seeds and nuts hand-picked in the field by the excavators. The minimum value given is 1 (one).

Year	C79	C77	C77	C77	C77	C77	C77	C77	C77	C77
General registry number	A492	A198	A217	A227	A146	A246	A270	A219	A258	A259
Area	CE2	CD1	CD1	CD1	D2	G1	G1	GH2	GH2	GH2
Locus	103	041	050	052	008	066B	070	016	024	026
Olea	4	4	1	1	1	1	1	1	1	1
Prunus persica	-	-	-	-	-	-	-	-	-	-
Prunus domestica	-	-	-	-	-	-	-	-	-	-
Corylus	-	-	-	-	-	-	-	-	-	-
Vitis	-	-	-	-	-	-	-	-	-	-
Pinus pinea	-	-	-	-	-	-	-	-	-	-
Juglans	-	-	-	-	-	-	-	-	-	-
Crataegus laevigata	-	-	-	-	-	-	-	-	-	-
Ziziphus lotus	-	-	-	-	-	-	-	-	-	-

Year	C77	C77	C77	C77	C77	C77	C77	C77	C78	C78
General registry number	A269	A276	A285	A295	A327	A309	A317	A236	A387	A394
Area	GH2	GH2	GH2	GH2	GH2	GH2	GH2	KL12	KL12	KL12
Locus	026B	026B	026B	026B	026B	026E	026B	006	047	051
Olea	9	-	5	-	-	-	4	2	5	1
Prunus persica	3	2	5	1	-	-	-	-	5	3
Prunus domestica	-	-	-	-	-	-	-	-	-	-
Corylus	-	-	2	-	1	-	-	-	1	1
Vitis	1	-	1	-	-	-	-	-	-	-
Pinus pinea	1	-	1	-	1	-	-	-	-	-
Juglans	-	-	-	-	-	1	-	-	-	-
Crataegus laevigata	-	-	-	-	-	-	-	-	-	-
Ziziphus lotus	-	-	-	-	-	-	-	-	-	1

Year	C78	C78	C78	C78	C78	C78	C78	Sample
General registry number	A459	A415	A428	A378	A410	A461	A462	frequency
Area	KL12	KL12	KL12	SU	SU	SU	SU	
Locus	051	053	053	014	015	015	015	
Olea	-	-	-	3	-	9	3	19
Prunus persica	4	-	2	-	1	3	-	10
Prunus domestica	-	-	-	-	2	-	-	1
Corylus	-	1	-	-	-	-	1	6
Vitis	-	-	-	-	-	-	-	2
Pinus pinea	-	-	-	-	-	-	-	3
Juglans	-	-	-	-	-	-	-	1
Crataegus laevigata	-	-	-	-	-	-	1	1
Ziziphus lotus	-	-	-	-	-	-	-	1

Dating:
CE2: 4th cent. BC
CD1: 3rd/2nd cent. BC
D2: ?
G1, GH2, KL12: about AD 600
SU: ?

Table 12. Circular harbour. Pollen types identified from the fill of the Punic channel and the Byzantine harbour. An asterisk (*) indicates that most likely the species was not found in the wide surroundings of Carthage (long-distance transport); some taxa, followed by 'p.p.', are listed under more than one category. Families listed in this table may include two or more pollen types.

Punic channel	Byzantine harbour
1. **Annual crop plants**	
Cerealia type	Cerealia type
	Cucurbitaceae
Humulus/Cannabis	Humulus/Cannabis
2. **Cultivated and wild fruits and nuts**	
Citrus	
Olea	Olea
Punica	Punica
Vitis	Vitis
Corylus*	Corylus*
Fraxinus ornus	Fraxinus ornus
3. **Taxa of waste ground, cultivated and fallow fields**	
Androsace	Androsace
Asphodelus	
Calendula type	Calendula type
Carduus type	Carduus type
	Carthamus
Caryophyllaceae p.p.	
Centurea solstitialis type	
Chenopodiaceae p.p.	Chenopodiaceae p.p.
Compositae Liguliflorae p.p.	Compositae Liguliflorae p.p.
Cruciferae p.p.	Cruciferae p.p.
	Emex
Euphorbia	
Malva	Malva
Matricaria type	Matricaria type
Mercurialis annua type	Mercurialis annua type
Nigella	Nigella
Polygonum aviculare type	Polygonum aviculare type
Solanum nigrum	Solanum nigrum
Tribulus terrestris	
	Urtica pilulifera
	Xanthium
4. **Taxa of 'grassy places'**	
	Filipendula
Gramineae p.p.	Gramineae p.p.
	Linum
Plantago p.p. (various types)	Plantago p.p. (various types)
Poterium/Sanguisorba	Poterium/Sanguisorba
Valerianella	
4a. **Steppe plants**	
Artemisia p.p.	Artemisia p.p.
Calligonum*	
Gramineae p.p	Gramineae p.p.
Noaea type*	

Table 12 (continued)

Punic channel	Byzantine harbour
5. **Salt-marsh and other salt-tolerant taxa**	
	Apium type
Chenopodiaceae p.p.	Chenopodiaceae p.p.
Cyperaceae p.p.	Cyperaceae p.p.
Eryngium type	Eryngium type
Mesembryanthemum type	Mesembryanthemum type
Ranunculus sceleratus type	
	Spergularia type
5a. **Taxa of sandy sea shores**	
Thymelaea	Thymelaea
6. **Marsh and water plants**	
Cyperaceae p.p.	Cyperaceae p.p.
	Lythrum
Polygonum persicaria type	
	Solanum dulcamara
Sparganium type	Sparganium type
7. **Taxa of maquis and woods**	
Alnus	Alnus
Arbutus	
Betula*	Betula*
	Bryonia type
Buxus*	
Cedrus*	Cedrus*
Cistus	Cistus
	Cytisus
Ericaceae	Ericaceae
Fagus*	
	Myrtus
Ostrya type*	Ostrya type*
Phillyrea	
Pinus	Pinus
Pistacia	Pistacia
Quercus coccifera type	Quercus coccifera type
Quercus deciduous*	Quercus deciduous*
	Sambucus/Viburnum
Tilia*	
8. **Taxa of uncertain ecological affinity**	
	Acanthus
Aquilegia-type	Aquilegia type
Artemisia p.p.	Artemisia p.p.
	Asphodeline
	Campanula type
Caryophyllaceae p.p.	
Centaurea jacea type	
	Cirsium type
Compositae Liguliflorae p.p.	Compositae Liguliflorae p.p.
Compositae Tubuliflorae	Compositae Tubuliflorae
Cruciferae p.p.	Cruciferae p.p.
Cynocrambe (Theligonum)	Cynocrambe (Theligonum)
	Datisca type
	Filago type
Galium type	

Table 12 (continued)

Punic channel	Byzantine harbour
Taxa of uncertain ecological affinity (continued)	
	Gentianaceae
	Geranium
Gramineae p.p.	Gramineae p.p.
Haplophyllum	
	Helianthemum
Helleborus type	Helleborus type
	Labiatae
Leguminosae	Leguminosae
Liliaceae	Liliaceae
	Lotus type
Matricaria type	Matricaria type
Mentha/Thymus type	Mentha/Thymus type
Paronychia type	
Plantago p.p. (various types)	Plantago p.p. (various types)
Ranunculaceae	Ranunculaceae
	Ranunculus acer type
Rosaceae	Rosaceae
Rumex	Rumex
Scrophulariaceae	Scrophulariaceae
Senecio type	Senecio type
Umbelliferae	Umbelliferae

Table 13. Rectangular harbour. Pollen types identified from waterlogged sediments. An asterisk (*) indicates that most likely the species was not found in the wide surroundings of Carthage (long-distance transport); some taxa, followed by 'p.p.', are listed under more than one category. Families listed in this table may include two or more pollen types distinguished.

Punic channel (E1)	Roman sediment (II.2)	Byzantine harbour (G1 & KL12)
1. **Annual crop plants**		
Cerealia type	Cerealia type	Cerealia type
Sesamum		
Ricinus	Ricinus	
Citrullus		Citrullus
		Cucumis
		Cucurbitaceae
Humulus/Cannabis	Humulus/Cannabis	Humulus/Cannabis
2. **Cultivated and wild fruits and nuts**		
Olea	Olea	Olea
Punica	Punica	Punica
Vitis	Vitis	Vitis
Castanea*	Castanea*	Castanea*
Corylus*	Corylus*	Corylus*
		Juglans*
Fraxinus ornus	Fraxinus ornus	Fraxinus ornus
3. **Taxa of waste ground, cultivated and fallow fields**		
Arctiumtype		
Asphodelus	Asphodelus	Asphodelus
Bunium type	Bunium type	Bunium type
Bupleurum type	Bupleurum type	Bupleurum type
Carduus type	Carduus type	Carduus type
Carthamus	Carthamus	
Caryophyllaceae p.p.	Caryophyllaceae p.p.	Caryophyllaceae p.p.
Centaurea solstitialis type	Centaurea solstitialis type	Centaurea solstitialis type
Chenopodiaceae p.p.	Chenopodiaceae p.p.	Chenopodiaceae p.p.
Chrozophora		
Compositae Liguliflorae p.p.	Compositae Liguliflorae p.p.	Compositae Liguliflorae p.p.
Convolvulus	Convolvulus	Convolvulus
Cruciferae p.p.	Cruciferae p.p.	Cruciferae p.p.
Echinops		Echinops
Echium type		Echium type
Emex	Emex	Emex
Euphorbia	Euphorbia	
		Fumaria
	Glaucium	
Heliotropium type		
Hyoscyamus		Hyoscyamus
Malva	Malva	Malva
Matricaria type	Matricaria type	Matricaria type
Mercurialis annua type	Mercurialis annua type	Mercurialis annua type
Nigella	Nigella	Nigella
Polygonum aviculare type	Polygonum aviculare type	Polygonum aviculare type
Spergula		
Tribulus terrestris		
		Urtica dioica type
Urtica pilulifera type	Urtica pilulifera type	Urtica pilulifera type
		Verbena
Xanthium		Xanthium

Table 13 (continued)

Punic channel (E1)	Roman sediment (II.2)	Byzantine harbour (G1 & KL12)
4. **Taxa of 'grassy places'**		
Filipendula		Filipendula
Gramineae p.p.	Gramineae p.p.	Gramineae p.p.
Linum		
Plantago p.p. (various types)	Plantagop.p. (various types)	Plantago p.p. (various types)
Poterium/Sanguisorba	Poterium/Sanguisorba	Poterium/Sanguisorba
Valerianella		
4a. **Steppe plants**		
Artemisia herba-alba type*	Artemisia herba-alba type*	Artemisia herba-alba type*
Calligonum*	Calligonum*	Calligonum*
Gramineae p.p.	Gramineae p.p.	Gramineae p.p.
Noaea type*	Noaea type*	Noaea type*
5. **Salt-marsh and other salt-tolerant taxa**		
Apium type	Apium type	Apium type
Chenopodiaceae p.p.	Chenopodiaceae p.p.	Chenopopdiaceae p.p.
Cyperaceae p.p.	Cyperaceae p.p.	Cyperaceae p.p.
Eryngium type	Eryngium-type	Eryngium type
Mesembryanthemum type	Mesembryanthemum type	Mesembryanthemum type
Ranunculus sceleratus type		Ranunculus sceleratus type
Spergularia type	Spergularia type	
5a. **Taxa of sandy sea shores**		
Ephedra fragilis type	Ephedra fragilis type	Ephedra fragilis type
Thymelaea	Thymelaea	Thymelaea
6. **Marsh and water plants**		
Cyperaceae p.p.	Cyperaceae p.p.	Cyperaceae p.p.
		Hydrocotyle
	Lythrum	Lythrum
	Polygonum amphibium	
		Polygonum persicaria type
Ranunculus repens type	Ranunculus repens type	
		Rumex hydrolapathum
Sparganium type	Sparganium type	Sparganium type
7. **Taxa of maquis and woods**		
	Abies*	Abies*
Alnus	Alnus	Alnus
	Arbutus	Arbutus
Betula*	Betula*	Betula*
Bryonia type		Bryonia type
	Carpinus betulus*	Carpinus betulus*
	Cedrus*	Cedrus*
		Ceratonia
Cistus	Cistus	Cistus
	Clematis type	Clematis type
Cupressaceae		Cupressaceae
Ericaceae	Ericaceae	Ericaceae
Fagus*	Fagus*	Fagus*
Genista-type		
Juniperus	Juniperus	Juniperus
Myrtus	Myrtus	Myrtus
Ostrya type*	Ostrya type*	Ostrya type*
Paliurus	Paliurus	Paliurus

Table 13 (continued)

Punic channel (E1)	Roman sediment (II.2)	Byzantine harbour (G1 & KL12)
Taxa of maquis and woods (continued)		
Phillyrea	Phillyrea	Phillyrea
Pinus	Pinus	Pinus
Pistacia	Pistacia	Pistacia
Quercus coccifera type	Quercus coccifera type	Quercus coccifera type
Quercus deciduous*	Quercus deciduous*	Quercus deciduous*
	Fraxinus excelsior type	
Rhamnaceae		Rhamnaceae
Salix	Salix	Salix
Sambucus/Viburnum	Sambucus/Viburnum	Sambucus/Viburnum
Tamarix	Tamarix	Tamarix
	Tilia*	Tilia*
	Ulmus	Ulmus
8. **Taxa of uncertain ecological affinity**		
Actaea spicata type		
Anemone		Anemone
		Aquilegia type
Artemisia vulgaris type	Artemisia vulgaris type	
		Asperula type
Asphodeline		
		Atraphaxis
Beta type		
		Campanula type
Caryophyllaceae p.p.	Caryophyllaceae p.p.	Caryophyllaceae p.p.
Compositae Liguliflorae p.p.	Compositae Liguliflorae p.p.	Compositae Liguliflorae p.p.
Compositae Tubuliflorae	Compositae Tubuliflorae	Compositae Tubuliflorae
Cruciferae p.p.	Cruciferae p.p.	Cruciferae p.p.
Delphinium type		
Dipsacaceae	Dipsacaceae	Dipsacaceae
Ephedra distachya type		Ephedra distachya type
Euphorbiaceae		
Erodium	Erodium	
	Fagopyrum	
Galium type	Galium type	Galium type
Gentianaceae		Gentianaceae
Geranium	Geranium	Geranium
Gramineae p.p.	Gramineae p.p.	Gramineae p.p.
Helianthemum		Helianthemum
Hypericum		
	Jasione type	Jasione type
Labiatae	Labiatae	Labiatae
Leguminosae	Leguminosae	Leguminosae
Liliaceae	Liliaceae	Liliaceae
Mentha/Thymus type	Mentha/Thymus type	Mentha/Thymus type
		Myrica
Plantago p.p. (various types)	Plantago p.p. (various types)	Plantago p.p. (various types)
Polygonaceae		
Primulaceae		Primulaceae
Ranunculaceae		
Rhus	Rhus	
Rosaceae	Rosaceae	Rosaceae
Rumex acetosa type	Rumex acetosa type	Rumex acetosa type

Table 13 (continued)

Punic channel (E1)	Roman sediment (II.2)	Byzantine harbour (G1 & KL12)
Taxa of uncertain ecological affinity (continued)		
Scrophulariaceae	Scrophulariaceae	Scrophulariaceae
Senecio type	Senecio type	Senecio type
Thalictrum		
Theligonum (Cynocrambe)	Theligonum	Theligonum
Umbelliferae	Umbelliferae	Umbelliferae
		Valeriana
Valerianaceae		
		Viola

Table 16. Tophet. Charred seeds and nuts in samples from 4th century BC deposits (no urn contents). The minimum value given is 1 (one). In particular nut remains may consist of one or a few fragments only.

General registry number	A195	A198	A199	A202	A206	A208	A212	A213	A217	A218	A222	A224	A225
Area	2	2	2	1	3	2	2	3	2	2	2	2	2
Locus	041	046	041	034	047	046	046	049	046	046	046	052	051
Triticum durum/aestivum	-	-	-	-	-	-	-	-	-	-	-	-	-
Triticum spec.	-	1	-	-	-	-	-	-	-	-	-	-	-
Hordeum	-	-	-	-	-	-	-	-	-	-	-	-	-
Lens	-	1	-	-	-	-	-	-	-	-	1	-	-
Pisum	-	-	-	-	-	-	-	-	-	-	-	-	-
Vicia faba	-	-	-	-	-	-	-	-	-	-	-	-	1
Ficus	-	5	-	1	-	-	-	1	1	-	-	-	-
Olea	1	-	-	-	-	-	-	-	1	-	-	-	-
Vitis	-	-	-	-	-	-	1	-	-	-	-	-	-
Punica	-	-	-	-	1	-	-	-	-	1	-	-	-
Ziziphus lotus	-	-	-	-	-	-	-	-	-	-	-	-	-
Amygdalus	-	-	-	-	-	1	1	-	-	-	-	-	-
Pinus pinea	-	-	-	-	-	-	-	-	-	-	-	1	-
Lolium temulentum	-	-	-	-	-	-	-	-	-	-	-	-	-
Malva	-	2	1	-	-	-	-	-	-	-	-	-	-
Thymelaea hirsuta	-	-	-	-	-	-	-	-	-	-	-	-	-

General registry number	A229	A231	A232	A233	A234	A235	A241	A245	A246	A254	A255	A258	A263
Area	2	2	1	2	2	1	2	2	1	2	2	2	2
Locus	052	054	035	054	054	034	054	047	035	054	061	061	064
Triticum durum/aestivum	-	-	-	2	1	-	-	-	-	-	-	-	-
Triticum spec.	-	-	-	-	1	-	-	-	-	-	3	-	1
Hordeum	-	-	-	1	-	-	-	-	-	-	1	-	-
Lens	-	-	-	3	2	1	-	1	-	3	7	-	1
Pisum	-	-	-	3	-	-	-	-	-	-	1	-	-
Vicia faba	-	-	-	-	-	-	-	-	-	-	-	-	-
Ficus	2	1	-	-	-	-	-	-	-	-	-	-	-
Olea	-	-	-	1	-	-	1	-	-	-	1	-	1
Vitis	-	-	-	2	1	-	-	-	1	-	1	-	-
Punica	-	-	-	-	-	-	-	-	-	-	-	1	-
Ziziphus lotus	-	-	-	-	-	-	-	-	-	1	-	-	-
Amygdalus	-	-	-	-	-	-	-	-	-	-	1	-	-
Pinus pinea	-	-	1	-	-	-	-	-	-	-	1	-	-
Lolium temulentum	-	-	-	1	-	-	-	-	-	-	-	-	-
Malva	1	-	-	-	-	-	-	-	-	-	-	-	-
Thymelaea hirsuta	1	-	-	-	-	-	-	-	-	-	-	-	-

Table 16 (continued)

General registry number	A270	A274	A282	A288	A294	A295	A301	A303	A314	A316	A339	A348	Sum
Area	1	2	2	2	3	2	2	2	2	3	2	2	
Locus	037	061	061	074	067	057	078	074	085	068	090	090	
Triticum durum/aestivum	-	1	-	-	-	-	2	-	-	-	-	1	7
Triticum spec.	-	1	-	-	-	1	-	-	-	-	-	-	8
Hordeum	-	-	-	2	1	-	-	-	-	-	-	-	5
Lens	-	1	4	16	-	-	1	4	-	1	-	1	48
Pisum	-	-	-	-	-	-	-	-	-	-	-	-	4
Vicia faba	-	-	-	-	-	-	-	-	-	-	-	-	1
Ficus	-	-	-	-	-	-	-	-	-	-	-	-	11
Olea	-	-	1	-	-	-	1	-	-	-	-	-	8
Vitis	-	-	-	-	-	-	-	-	-	-	-	-	6
Punica	-	-	-	-	-	-	-	-	-	-	-	-	3
Ziziphus lotus	1	-	-	-	-	-	-	-	-	-	-	-	2
Amygdalus	-	1	-	-	-	-	-	-	-	-	-	-	4
Pinus pinea	-	1	1	-	-	-	-	-	1	-	1	-	7
Lolium temulentum	-	-	-	-	-	-	-	-	-	-	-	-	1
Malva	-	-	-	-	-	-	-	-	-	-	-	-	4
Thymelaea hirsuta	-	-	-	-	-	-	-	-	-	-	-	-	1

Table 17. Seeds from site B, on the north side of the circular harbour (B76/77: trench VIII).

Context	203[1]	671[2]	672[2]	442[3]	443[3]	444[3]	445[3]
Triticum durum/aestivum	4	1	-	-	-	-	-
Hordeum (vulgare)	10	-	-	-	-	-	-
Lens culinaris	1	-	-	-	-	-	-
Ficus carica	14	7	1	4	3	4	-
Vitis vinifera	1	-	-	-	3	-	-
Olea europaea	1	2	-	1	1	3	1
Lolium temulentum	7	-	-	-	-	-	-
Phalaris	2	5	5	-	-	-	-
Unidentified Gramineae	5	-	-	-	-	-	-
Euphorbia helioscopia	131	-	-	-	-	-	-
Mercurialis annua	84	-	-	-	-	-	-
Chenopodium murale	29	-	-	-	-	-	-
Suaeda (fruticosa)	5	-	2	-	-	-	-
Heliotropium (europaeum)	20	-	-	-	-	-	-
Thymelaea hirsuta	-	-	1	-	-	-	-
Beta (lid of compound fruit)	1	-	-	-	-	-	-
Crozophora tinctoria	1	-	-	-	-	-	-
Fumaria	1	-	-	-	-	-	-
Rapistrum rugosum	1	1	-	-	-	-	-
Carex	10	-	-	-	-	-	-
Scirpus maritimus	1	-	-	-	-	-	-

[1] From 7th-century AD silting of drain
[2] From fill of culvert, 4th(/6th?) century
[3] From 3rd-century use of Room 3

Table 18. Seaside residential area. In this table the main results of the archaeobotanical examination are presented.

Punic levels

1. Eight samples taken at intervals from a deposit of successive road-surfaces and intermediate sea-sand layers yielded together:

Triticum durum/aestivum	4
Lens culinaris	1
Olea europaea	1
Ficus carica	29
Thymelaea hirsuta	1
Chenopodium album	1

2. From 1/6 of a sample from waterlogged occupational soil under Cardo XVIII, dated to the 4th century BC, were recovered:

Vitis vinifera	c.185
Ficus carica	c.4300
Corylus	1
Pinus pinea	1
Glaucium corniculatum	2

Sixth/seventh century AD

3. Seeds in sample from fill of a sewer (‘Kanal 1’)

Vitis vinifera	2
Ficus carica	c.300
Olea europaea	1
Thymelaea hirsuta	4
Phalaris	1

Table 19. Byrsa. Numbers of seeds recovered from late-Punic (end of first half of 2nd century BC) and medieval (11th-13th century AD) contexts.

1. ***Punic contexts****:*

Square (‘carré’)	G III 7[1]	G III 7	G III 5	F II 15	H IV 4
Level (‘couche’)	13	15	13		
Triticum cf. dicoccum	2	-	-	-	-
Lens culinaris	-	-	1	-	-
Vicia ervilia	1	-	-	-	-
Olea europaea	1	-	-	-	-
Vitis vinifera	1	-	-	-	-
Ficus carica	38	1	60	2	1
Hyoscyamus	1	-	-	-	-
Chenopodium murale	-	-	1	-	-
Unidentified Gramineae	1	-	-	-	-
Scirpus spec.	-	-	6	-	-

[1] sum of 3 samples

2. ***Medieval context****: square I IV 7, level 6*

Hordeum vulgare	200	Heliotropium	4
Hordeum, rachis internodes	16	Hyoscyamus	1
Triticum durum/aestivum	5	Unidentified Leguminosae	4
Triticum, rachis internodes	2	Lithospermum arvense	35
Pisum sativum	1	Unidentified Malvaceae	7
Ficus carica	3	Medicago	5
Coriandrum sativum	1	Mercurialis annua	1
Amygdalus (nut fragment)	1	Phalaris	3
		Plantago	2
Asphodelus	14	Raphanus raphanistrum	1
Carex	2	Rapistrum rugosum	3
Chenopodium album	3	Reseda alba	2
Chenopodium murale	19	Rumex pulcher type	2
Chrysanthemum coronarium	8	Sherardia	4
Emex spinosa	3	Suaeda (fruticosa)	32
Fumaria	11	Thymelaea hirsuta	7
Unidentified Gramineae	18	Valerianella vesicaria type	2
Helianthemum	1		

Table 20. Falbe's site 90. Numbers of charred seeds in samples from occupation deposits.

	Hordeum	Triticum durum/aest.	Vicia ervilia	Lens	Olea	Phalaris	Myrtus
1. 25/30, 3d E. section	2	1	-	-	-	-	-
2. 25/30, 3d N. section I	1	1	3	-	-	1	-
3. 25/30, 3d N. section II	2	1	-	-	-	-	-
4. 35/35, 1d, 2	-	-	-	-	2	-	-
5. 30/50, 4a	-	-	-	-	1	-	1
6. CO	-	-	-	2	-	-	-
7. CL 6, 4b	-	-	-	-	1	-	-
8. CL 6, 6c	-	-	-	-	1	-	-
9. CL 6, 6d	-	-	-	-	1	-	-

1-3 Punic levels
4,5 Roman levels
6 ca. AD 400: fill of drain (Dietz & Trolle 1979: 24)
7-9 5th century AD: arched structure (Dietz & Trolle 1979: 44)