Archaeobotanical Study at the Early Dynastic Cemetery in Helwan (3100–2600 BC), Egypt: Plant Diversity at Early Dynastic Memphis

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Abstract. Recently, several studies have been published dealing with the analysis of plant remains from archaeological sites in the Memphite region. These investigations covered different archaeological periods. However, until now, no research has be completed on plant remains from the Early Dynastic period in this area. This paper will focus on analysis of macro-botanical remains from sealed pots discovered inside ten tombs at the Early Dynastic Cemetery in Helwan, 30 km south of Cairo (3100–2600 BC). The main goal is to study the economy and ecology relating to the site rather than the offering practices of ancient Egypt. In addition, this research will reconstruct agricultural practices, to shed light on plant diversity and to increase our understanding about non-elite lifeways that prevailed during Early Dynastic times in Memphis. Analysis of the plant remains retrieved from Helwan Cemetery has yielded a total of 25,743 fragments of charred plant macroremains. These remains were classified into two major groups: cultivated crops, including cereals, flax and legumes; and wild/weedy plants comprising wild edible fruits, field weeds, plants of moist habitats, plants of dry habitats and other indeterminate taxa. Cereal remains from the studied tombs consisted of chaff and grains. The study revealed that the arable economy of Memphis during this period was based on the cultivation of cereals primarily *Hordeum vulgare* L. subsp. *vulgare* (hulled barley) which was associated with *Triticum turgidum* L. ssp. *dicoccum* (Schrank) Thell. (emmer wheat).

Keywords: Archaeobotany · Cemetery · Early dynastic · Egypt
Helwan · Plant macroremains

Introduction

In Egypt, archaeobotanical studies have greatly contributed to our knowledge of plant diversity, economy, agricultural production and the environment that prevailed in the past with the help of substantial finds of plants within Pharaonic tombs and also by representations of plants, livestock and agriculture-related activities in ancient paintings and reliefs depicted in tombs and temples. In addition, many archaeobotanical

A. M. Mercuri et al. (Eds.): *Plants and People in the African Past*,
https://doi.org/10.1007/978-3-319-89839-1_2

investigations from settlement sites have increased our understanding of human diet and nutrition in the Egyptian past.

Research into Egyptian archaeobotany has a long history. Kunth (1826) identified fruit remains found by the French archaeologist J. Passalacqua in a XIXth dynasty tomb (1570–1070 BC) at Thebes. Unger (1866) drew our attention to the significance of mud bricks as a useful source of archaeobotanical information. He studied plant macro remains preserved in mud bricks from the Pyramids of Dahshur and from the City of Ancient Rameses (Fahmy 2004). Schweinfurth (1882, 1883, 1884, 1887) included brief morphological descriptions of more than 100 plant species represented in archaeological sediments by different types of plant fragments, including grains, seeds, floral heads and leaf fragments.

During the 20th century, considerable advances were made in Egyptian archaeobotanical research by Keimer (1924), Täckholm (1939, 1940, 1951, 1961) and Greiss (1949, 1957). The works of Täckholm et al. (1941), Täckholm and Drar (1950, 1954) provided ample evidence of cultivated and wild plant remains retrieved from different sites across the country. In addition, Murray (2000) provided an extensive summary of earlier archaeobotanical works. Recent studies have increased our knowledge of past relationships between humans and plants in ancient Egypt through different historical periods including Maadi (Kroll 1989; van Zeist and Roller 1993; van Zeist et al. 2003), Hieraknopolis (Fahmy 1995, 2003, 2004; El Hadidi et al. 1996; Fahmy et al. 2011), Adaïma (Newton 2004, 2007) and Giza (Murray and Gendy 2015; Malleson 2016). Nevertheless, at present the only publications dealing with the analysis of plant remains include data from the Neolithic period 'El-Omari' (Barakat 1990), the Predynastic period 'Maadi' (van Zeist et al. 2003) and the Old Kingdom period sites of Abusir and Giza (Murray 2004, 2005, 2007a, b; Gerisch 2007a, b; Pokorný et al. 2009; Pokorná and Pokorný 2010; Beneš 2011a, b; Pokorná 2011; Pokorná and Beneš 2014) in the Memphite region. Accordingly, our analysis and publication of plant remains from the Helwan cemetery as representative of the Early Dynastic period will help to fill a considerable gap in the agricultural and subsistence history of the Memphite region (Fig. 1 shows archaeological sites mentioned in the text).

Archaeological excavations at the cemetery of Helwan (Protodynastic—early Old Kingdom, c. 3200–2700 BC) revealed the presence of sealed pots inside tombs containing ash and soil which included botanical materials (seeds, fruits and charcoal) as well as a variety of plant remains from other contexts (wood associated with burials, coffin wood and organics in stone vessels). Most plant materials were preserved by charring and others, such as wood, were desiccated. Also, a considerable quantity of animal bones have been retrieved from the cemetery. In this regard, the Helwan cemetery is a noteworthy archaeological site because it has not only produced seeds and grains of both cultivated and wild plants, but also considerable quantities of charred and desiccated materials (charcoal, desiccated wood and other organic materials). This paper will focus on the analysis of plant macroremains (seeds, fruits and other vegetative parts) retrieved from sealed pots from 10 tombs excavated in Operation 4 to understand the economic and ecological characteristics of the site in the past. The aim of the present study is to elucidate the agricultural economy that flourished in

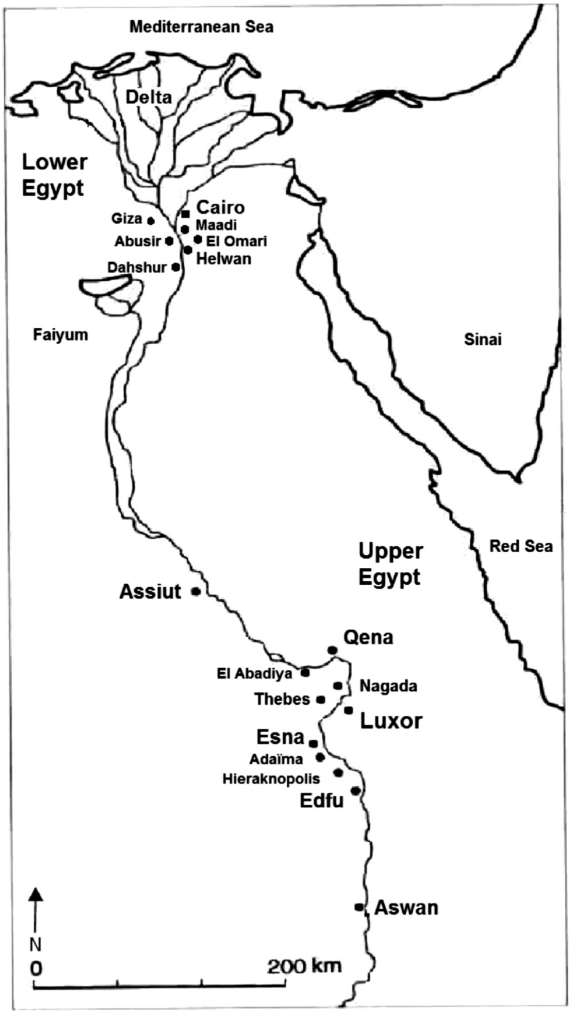

Fig. 1. Map showing archaeological sites mentioned in the text.

the Memphis area during Early Dynastic times and to shed light on past agricultural systems and the main sources of plant foods. It also will examine the weed flora to inform on Early Dynastic agricultural practices, including irrigation and harvesting technique. A detailed study of all botanical materials from Operation 4 at Helwan cemetery including charcoal and wood as well as details of the archaeological contexts will be published at a future date, with archaeobotanical raw data in a separate bioarchaeological volume.

The Study Area

The materials reported in this study were excavated from the archaeological site of Helwan/Ezbet El Walda, about 30 km south of Cairo, where non-elite inhabitants of early Memphis were buried. This site is considered to be the largest necropolis of the Early Dynastic Period in Egypt (Köhler 2008, 2014) and is located on the east bank of the Nile between the modern villages of Ezbet Kamel Sedqi el-Qebleyah in the north and Ezbet el-Walda in the south. The cemetery stretches over a distance of c. 1.5 km from north to south along the riverbank and rests on a Pleistocene palaeofan of Wadi Hof (Köhler 2008). Figure 2 shows the position of the site in relation to Cairo, the Nile and other sites in Memphite area.

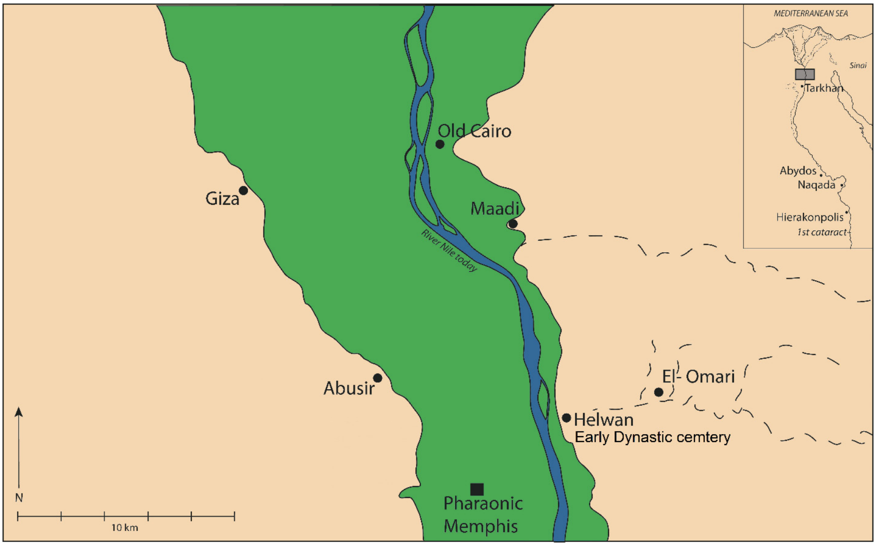

Fig. 2. Map showing relationship of Helwan site to Cairo and the Nile.

Six graves of the cemetery were excavated by Larsen in the 1920s followed by more than 12 years of excavation by Zaki Saad between 1942 and 1954 where more than 10,000 graves were uncovered. This was followed by two more excavation seasons organized by the Egyptian Antiquities Organization in 1966 and 1975 (Köhler 2008). Köhler began fieldwork at the cemetery in 1997 with support of Macquarie University in Sydney. Currently the work has continued as a joint project, led by Köhler for Macquarie University, Sydney and the University of Vienna (Köhler 2008). The excavations have now ceased and the project has entered a phase of analysis and publication.

The period of occupation probably began during Naqada IIIA (c. 3300 BC), continued well beyond Naqada IIIC and IIID (3100–2700 BC), and into the Old Kingdom (after 2700 BC) (Köhler 2015). There is evidence to suggest that certain parts of the site were also occupied throughout much of the Pharaonic period and into the Late Roman and Medieval ages (Köhler 2008). The 218 excavated tombs since 1997 primarily date from Late Naqada IIIC to early Old Kingdom (1st–4th Dynasties) times (Köhler 2015). A series of well-preserved samples of plant macroremains were obtained from ten tombs in the Early Dynastic Cemetery at Helwan/Ezbet El Walda (Operation 4). Table 1 presents the number of samples taken from each tomb, its date, and the age and sex of the occupant. The data reported here should be considered preliminary and pending final analysis. Figure 3 shows the grid plan of the excavated area and illustrates the distribution of the tombs under study.

Table 1 Occupant data and date of the Operation 4 tombs included in this study. Dating is according to Köhler (2014 & in preparation).

Tomb	Number of samples	Cultural dating	Relative chronology	BC dating	Age	Sex
48	1	Late Dynasty 1/early Dynasty 2	Group IIIC3-D1	3100–2900	Adult	Female
68	3	Mid Dynasty 2/Late Dynasty 2	Group IIID2-3	2700	Adolescent	Unknown
71	1	Late Dynasty 2/early Dynasty 3	Group IIID4	2700–2600	Mature Adult	Female
76	4	Dynasty 1-2/Mid Dynasty 2	Group IIID1-2	2700	Adult	Unknown
77	1	Dynasty 1-2/Mid Dynasty 2	Group IIID1-2	2700	Adult	Male?
83	11	Dynasty 1-2/Mid Dynasty 2	Group IIID1-2	2700	Adult	Male
88	4	Mid Dynasty 2	Group IIID2	2700	Mature Adult	Female
91	2	Dynasty 1-2	Group IIID1	3100–2900	Adult	Male?
100	2	Mid Dynasty 2	Group IIID2 (-3?)	2700	Adult	Unknown
104	1	Dynasty 2	–	3100–2900	Adult	Male

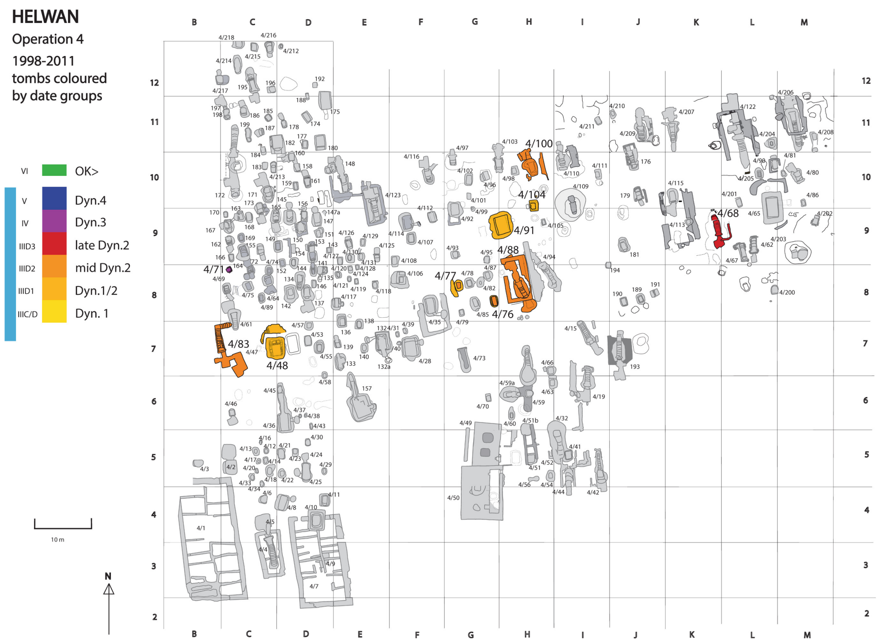

Fig. 3. Grid plan showing the distribution of 10 tombs from Operation 4 mentioned in the text (with kind permission from Prof. Dr. E. Christiana Köhler).

Materials and Methods

Thirty sediment samples were collected during the excavation seasons between 2003 and 2006 from sealed pots inside tombs. The volume of these samples range between 0.3 and 7.1 of ash as well as ash mixed with clay.

Water flotation processing was used for the separation of plant macroremains from the archaeological sediments found inside the pots. The volume of each sample was measured and samples were processed using bucket flotation. Floating macro-botanical remains were skimmed from the surface using a tea strainer (0.5 mm) and placed onto fine cheesecloth. This process was repeated until no more floating charred remains were observed. The cheesecloth was carefully folded over and set aside to dry while the heavy fraction was processed. After drying, each sample was stored in a small plastic box. The volume of plant macroremains was recorded in ml. Only charred materials were retrieved from these thirty samples and they appeared to be in a homogenous state of preservation.

All charred remains of cultivated and wild plants were sorted into categories using a binocular microscope (magnification: 10x–20x) and counted. Only nine samples were sub-sampled because of their large size, where 50% by volume of each sample was analyzed.

For Scanning Electron Microscope (SEM) studies, seeds and grains were coated with gold and examined by a JEOL JXA-840 SEM. It operated at an accelerating voltage of 15 kV at the Electron Microscope Unit, National Research Center, Dokki, Egypt.

Identification of cereal remains was based on Jacomet (2006) and Zohary et al. (2012). Remains of wild plants were identified using morphological descriptions and illustrations in the Flora of Egypt (Täckholm 1974; Boulos 1999, 2000, 2002, 2005), in addition to Willcox et al. (2002), Cappers et al. (2006) and online data bases and websites including those at the United States Department of Agriculture (USDA 2016). Specimens were identified according to their gross morphological features and compared to a modern reference collection of seeds and fruits held at the Helwan University Herbarium. The nomenclature of the wild taxa is according to Boulos (2009), while that of cultivated plants follows Zohary et al. (2012).

Results

Analysis of Helwan samples has yielded a total of 25,743 fragments of charred plant macroremains including grains, seeds, achenes, nutlets, capsules, pods and vegetative parts of cultivated and wild plants. Table 2 and Fig. 4 summarize the plant macro remains which were classified into two major groups: cultivated crops including 10,303 remains of cereals (40.02%), 6 flax (0.02%) and 2530 pulses (9.83%); and wild plants including 2 remains of wild edible fruits (0.01%), 11,480 field weeds (44.59%), 644 plants of moist habitats (2.50%), 10 plants of dry habitats (0.04%) and 768 indeterminate records (2.98%) (Fig. 4). Cereals and field weeds together dominate plant remains with a combined percentage of 84.61%, which are attributed to 40 species, 47 genera and 18 families.

Table 2 Plant macroremains separated from the Operation 4 tombs in Helwan Early Dynastic cemetery. (A) Number of plant macroremains, (F) Number of samples in which a taxon occurs.

Types/Families	Taxa	Plant element	A	F
1. Crops				
1.1 Cereals				
Poaceae	*Hordeum vulgare* L. subsp. *distichum*	Grain	37	9
		Rachis internode	62	16
	Hordeum vulgare L. subsp.*vulgare* (hulled)	Grain	706	29
		Rachis internode	6299	29
	Hordeum vulgare L. subsp. *vulgare* (naked)	Grain	9	6
	Hordeum sp.	Grain	144	16
		Spikelet	3	2
	Triticum turgidum L. ssp. *dicoccum* (Schrank) Thell.	Grain	75	20
		Glume base	697	23
		Fork	75	11
		Rachis internode	92	14
		Spikelet	3	3
	cf. *Triticum durum* Desf./*aestivum* L.	Rachis internode	2	2

(*continued*)

Table 2 (*continued*)

Types/Families	Taxa	Plant element	A	F
	Triticum sp.	Grain	19	12
	Cereal indeterminate	Grain	9	2
		Glume base	4	1
		Culm	1233	24
		Grain fragment	825	27
		Internodes unknown	9	2
		Cereal total	**10303**	
1.2 Flax				
Linaceae	*Linum usitatissimum* L.	Seed	3	2
		Capsule	3	3
		Flax total	**6**	
1.3 Pulses				
Fabaceae	*Lens culinaris* Medik.	Seed	5	3
	Trifolium alexandrinum L.	Seed	2460	26
		Fruit	65	7
		Pulse total	**2530**	
2. Wild plants				
2.1 Wild edible fruit				
Rhamnaceae	*Ziziphus spina-christi* (L.) Desf.	Fruit	2	2
		Wild plant total	**2**	
2.2 Field weeds				
Asteraceae	*Anthemis retusa* Delile, Descr.	Fruit	7	2
	Senecio aegyptius L.	Capitula	34	4
	Centaurea sp.	Capitula	1	1
	Pulicaria sp.	Fruit	2	2
Brassicaceae	cf. *Camelina* type	Seed	1	1
	Lepidium sativum L.	Fruit	4	2
Chenopodiaceae	*Chenopodium murale* L.	Seed	8	5
Fabaceae	*Lathyrus hirsutus* L.	Seed	12	6
	Lathyrus aphaca L.	Seed	1	1
	Lens sp.	Seed	4	3
	Lupinus type	Seed	4	3
	Medicago polymorpha L.	Seed	151	18
		Fruit	32	7
	Medicago lupulina L.	Seed	1245	25
	Melilotus type	Seed	25	7
	Pisum sp.	Seed	60	12
	Scorpiurus muricatus L.	Fruit	1	1
	Trifolium type 1	Seed	54	6

(*continued*)

Table 2 (*continued*)

Types/Families	Taxa	Plant element	A	F
	Trifolium type 2	Seed	24	5
	Trifolium type 3	Seed	7	3
	Vicia sativa L.	Seed	184	22
	Vicia ervilia (L.) Willd.	Seed	55	18
	Vicia type	Seed	7	5
	Vicia type 2	Seed	13	6
Malvaceae	*Malva* cf *parviflora* L.	Mericarp	1	1
	Malvaceae type1	Seed	11	8
	Malvaceae type2	Seed	13	5
Poaceae	*Agropyron* type	Grain	4	2
	Avena sp.	Grain	1	1
		Rachilla	7	6
	Bromus sp.	Grain	296	26
	Digitaria sanguinalis (L.) Scop.	Grain	2	2
	Lolium temulentum L.	Florets	1984	19
		Grain	870	10
		Internode	57	8
	Phalaris minor Retz.	Spikelet	45	10
		Grain	2981	30
	Phragmites type	Leaves	26	1
	Setaria type	Grain	2	2
	Grasses indeterminate	Grain	319	18
		Rhizome	47	13
		Fragments	871	23
		Culm fragment	75	6
		Internode	3	1
		Glume base	219	12
		Small branch	2	1
		Branches	721	21
Polygonaceae	*Persicaria senegalensis* (Meisn.)	Seed	2	2
	Polygonum equisetiform Sm.	Seed	12	8
	Polygonum sp.	Seed	4	3
	Polygonaceae type	Seed	6	4
	Rumex dentatus L.	Seed	692	25
		Fruiting bodies	183	13
	Rumex sp.	Seed	3	3
Portulacaceae	*Portulaca oleracea* L.	Seed	15	5
Solanaceae	*Solanum nigrum* L.	Seed	3	1
		Field weed total	**11480**	

(*continued*)

Table 2 (*continued*)

Types/Families	Taxa	Plant element	A	F
2.3 Plants of moist habitats				
Asteraceae	*Ceruana pratensis* Forssk.	Capitula	11	5
Brassicaceae	*Coronopus niloticus* (Delile) Spreng.	Fruit	1	1
Cyperaceae	*Carex divisa* Huds.	Fruit	1	1
		Seed	3	2
	Cyperus articulatus L.	Seed	3	3
	Cyperaceae type 1	Seed	225	23
	Cyperaceae type 2	Seed	3	1
	Eleocharis palustris (L.) Roem. & Schult.	Seed	63	11
	Fimbristylis bisumbellata (Forssk.)	Seed	1	1
	Scirpus type 1	Seed	29	1
	Scirpus type 2	Seed	4	1
Juncaceae	*Juncus rigidus* Desf.	Seed	1	1
Rosaceae	*Potentilla supina* L.	Seed	299	9
		Plants of moist places total	**644**	
2.4 Plants of dry habitats				
Asphodelaceae	*Asphodelus fistulosus* L.	Seed	1	1
Asteraceae	*Nauplius graveolens* (Forssk.)	Capitula	5	5
Boraginaceae	*Echium* sp.	Seed	3	3
Brassicaceae	*Zilla spinosa* (L.) Prantl	Fruit	1	1
		Plants of dry places total	**10**	
2.5 Indeterminate taxa				
Boraginaceae	Boraginaceae type	Seed	16	1
Brassicaceae	Cruciferae type	Seed	4	4
Euphorbiaceae	*Euphorbia* type	Seed	2	2
Fabaceae	Fabaceae 1 (*Vicia* type 1)	Seed	1	1
	Fabaceae 2	Seed	44	12
	Fabaceae 4 (*Vicia* type 3)	Seed	20	7
	Fabaceae 5 (*Vicia* type 4)	Seed	2	1
	Fabaceae unidentified	Seed	332	18
	Fabaceae fragments	Seed	149	7
	Fabaceae broken seed	Seed	194	19
Lamiaceae	Labiatae type 1	Fruit	2	2
	cf. Labiatae type 2	Seed	1	1
Poaceae	Poaceae type	Spikelet	1	1
		Indeterminate total	**768**	
		Total remains	25,743	

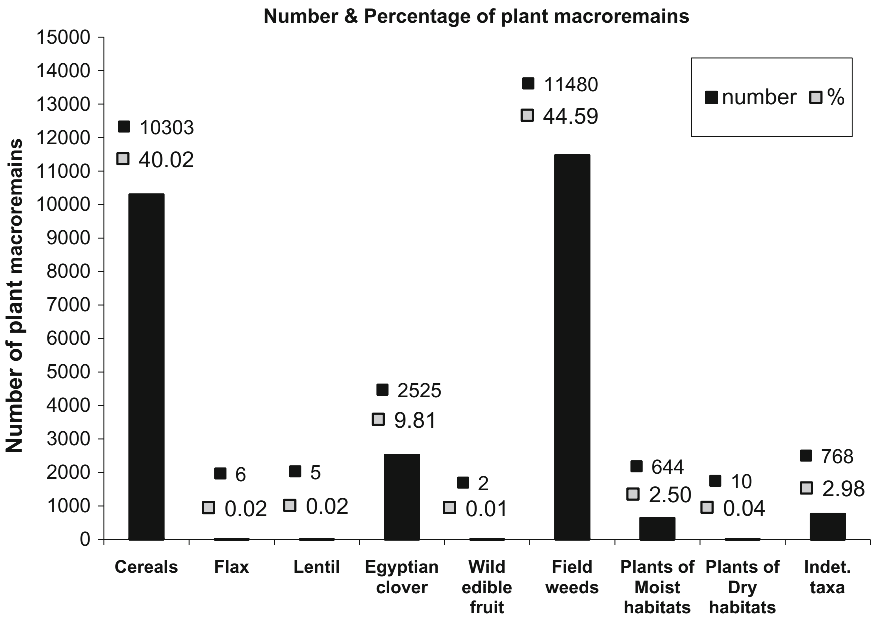

Fig. 4. Frequencies and percentages of plant macroremains from 10 tombs of Operation 4 at the Helwan Early Dynastic cemetery.

Crop Plants

Crops represent 49.87% of the total number of plant macroremains (Fig. 4), which are mostly of cereals, 40.02%, while 0.02% comprises flax and 9.83% are legumes.

Cereals

Cereal remains appeared in all studied samples and included grains, rachis fragments, glume bases, and spikelet forks. These elements consist of 90.3% chaff and 9.7% of grains. Remains of five cereals have been identified: *Hordeum vulgare* L. ssp. *vulgare* (hulled barley), *Hordeum vulgare* L. ssp. *distichum* (two-row barley), *Hordeum vulgare* L. ssp. *vulgare* (naked barley), *Triticum turgidum* ssp. *dicoccum* (Schrank) Thell. (emmer wheat), *Triticum aestivum/durum* (free threshing bread/macaroni wheat). The latter category was represented only by articulated rachis segments. As shown in Fig. 5, the remains of hulled barley dominate the macro-botanical assemblage with 70.7% of the total number of cereal grains and 67.7% of the total number of chaff elements. On the other hand, emmer, free threshing wheats, two-rowed and naked barley are represented by comparatively lower percentages.

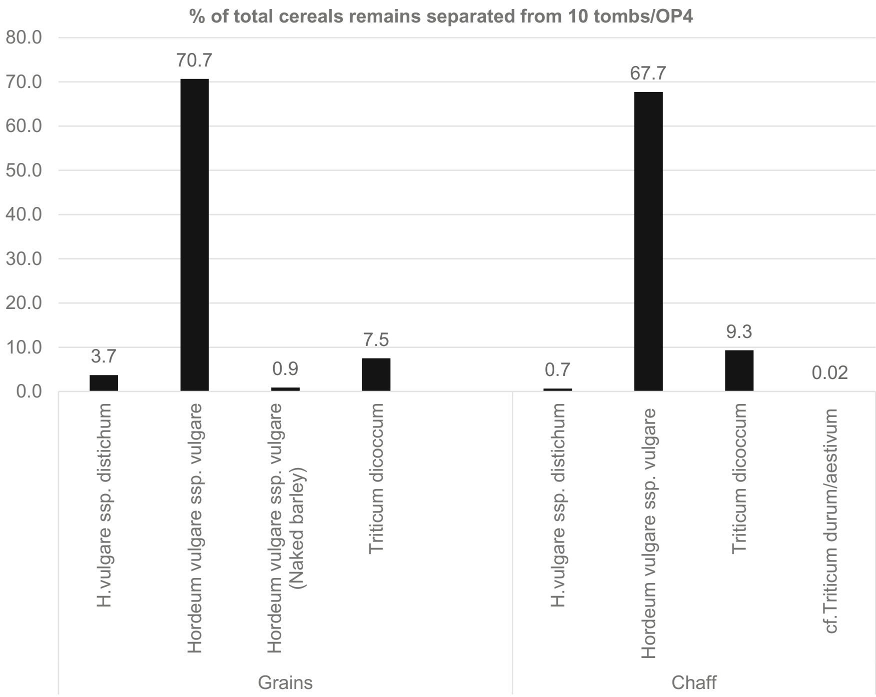

Fig. 5. Percentages of total cereal remains (grain and chaff) separated from 10 tombs of Operation 4 in the Helwan Early Dynastic cemetery.

Hulled barley remains vary in percentage among the 10 tombs, where chaff ranges 23.0–90.3% and grains range 0.2–23.2% of the total number of cereals remains retrieved from each tomb. Rachis internodes (Fig. 6) of barley were found in all studied tombs. The dominance of barley in all samples may suggest its significant role as a symbol of resurrection. Also, short and plump grains of naked barley which are characterised by the presence of transverse ridges on their dorsal side (Fig. 7) were recorded in low numbers, which may reflect the minor role of this crop in the Early Dynastic agricultural economy at Memphis. It also may represent a contaminant in fields of hulled barley. Van Zeist and Roller (1993) reported that all barley grains from the site of Maadi were of the hulled type. A total of 37 grains of *Hordeum distichum* were recorded from 9 samples with average dimensions of 3.1 × 1.5 × 1.05 mm (length x breadth x thickness). Rachis internodes of this variety (Fig. 8) were recorded in 16 samples. Although it can be difficult to distinguish between two and six-row barley (*Horedum vulgare* ssp. *hexastichum* L.), based on grain shape and the presence of associated rachis internodes, we conclude these grains are the two-rowed form (Table 2).

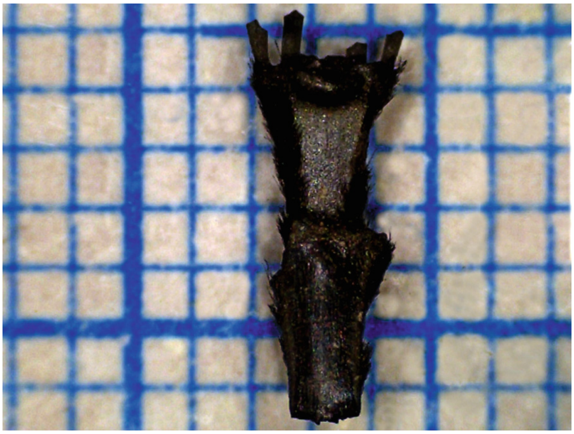

Fig. 6. Rachis internode of hulled barley. Each unit = 1 mm.

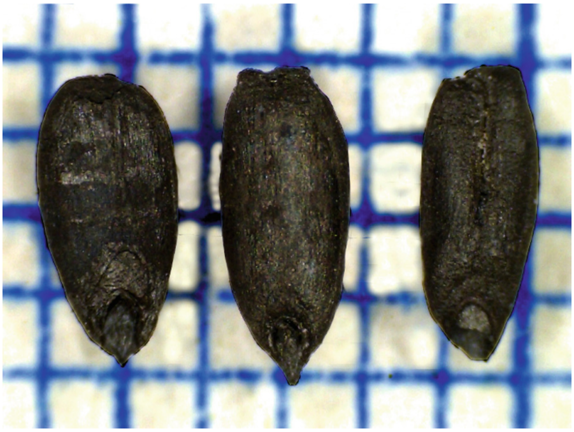

Fig. 7. Grains of naked barley. Each unit = 1 mm.

Emmer wheat remains were not abundant in the Helwan samples. They represent only 7.5% of the total number of cereals grains and 9.3% of the total number of chaff elements (Fig. 5). In addition, emmer grains were recorded in low numbers with percentages ranging 0.3–2.3% of the total number of cereals remains in each tomb while emmer chaff occurred in very small percentages ranging 0.2–26.1% of the total number of cereals remains retrieved from each tomb. Emmer chaff included glume bases, spikelet forks (Fig. 9), rachis segments and whole spikelets.

Rachis internodes of free threshing wheat were represented by 2 elements. This demonstrates that it was likely a contaminant of emmer/barley fields. As reported by van Zeist and Roller (1993), van Zeist et al. (2003) and Cappers et al. (2004), free-threshing wheat was not cultivated in Predynastic and Pharaonic Egypt.

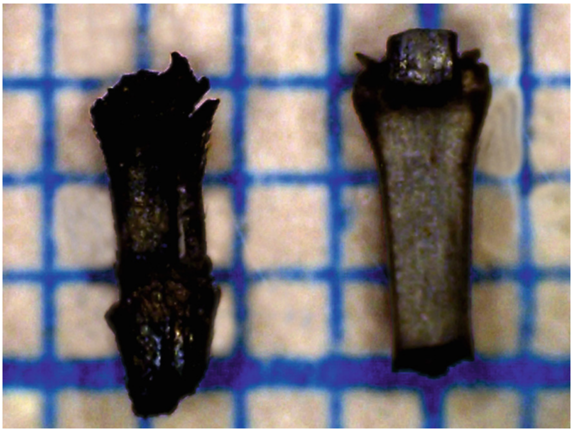

Fig. 8. Rachis internodes of *Hordeum distichum.* Each unit = 1 mm.

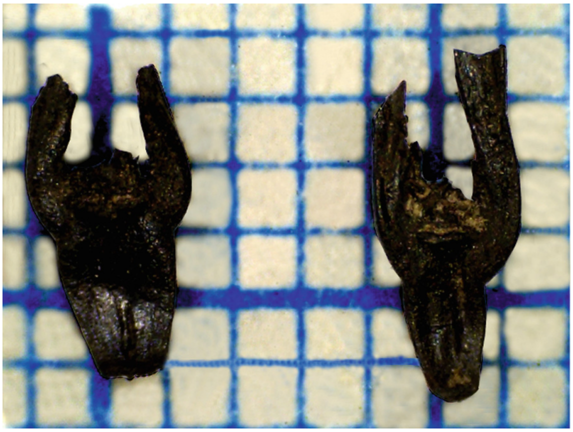

Fig. 9. Spikelet forks of emmer wheat. Each unit = 1 mm.

Flax

Very few seeds and capsules of *Linum usitatissimum* L. (Fig. 10) were recorded from the tombs, representing 0.02% of the total number of the plant macroremains. Flax has been cultivated in Egypt as both a fiber and oil crop.

Pulses

Pulses represent 9.83% of the total number of plant remains and include seeds of lentil which comprise only 0.02% of the total number of plant remains. In contrast, large numbers of *Trifolium alexandrinum* L. seeds and fruits were recorded, which represent 9.81% of the total number of plant remains (Fig. 4). Clover remains appeared in most examined samples (Table 2) and are in an excellent state of preservation (Fig. 11).

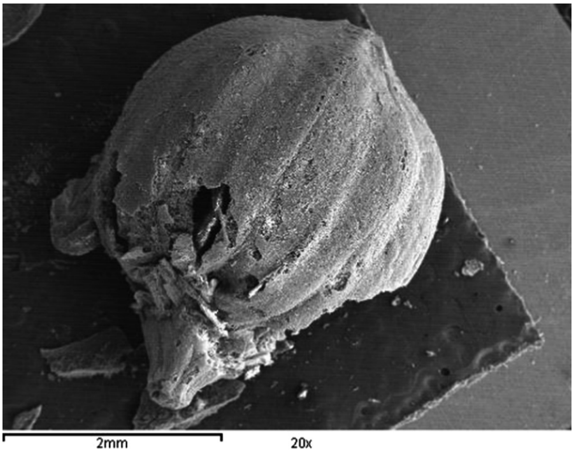

Fig. 10. SEM micrograph of a capsule of *Linum usitatissimum*.

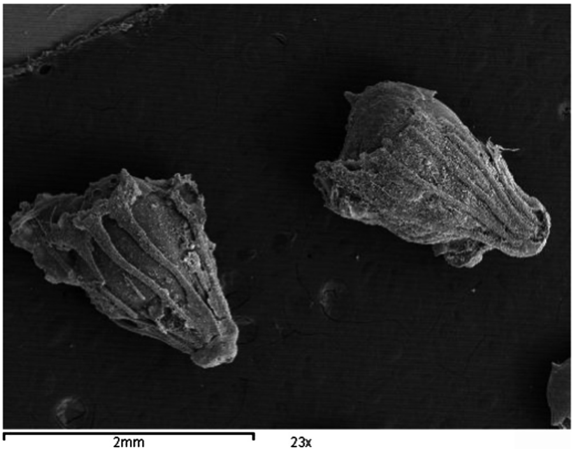

Fig. 11. SEM micrograph of *Trifolium alexandrinum*.

Wild/Weedy Plants

A total of 32 species of wild and weedy plants were retrieved from Early Dynastic flotation samples from the Helwan tombs. These include one species of wild fruit, 20 species of field weeds, eight species of moist habitats and three species occupying dry habitats.

Wild Fruits

The fruit of *Ziziphus spina-christi* (L.) Desf. (sidder) was recorded in the Early Dynastic Helwan cemetery. The fruit remains of sidder appear repeatedly in the

Egyptian archaeological contexts from Predynastic times onwards (Zohary and Hopf 1993; Fahmy 1995). These fruits were often recorded among offering dishes in tombs (Täckholm 1976; Wetterstrom 1984; Fahmy 1995). In addition, there is an interesting record of desiccated sidder fruits in the annex of the tomb of Tutankhamun, which was probably part of a royal meal and stored in a separate container (Vartavan 2002). Moreover, the sidder tree itself was considered sacred by ancient Egyptians (Täckholm 1976; Fahmy 2003).

Field Weeds

Twenty species of field weeds were recorded in the botanical assemblage from the Early Dynastic cemetery at Helwan with percentage value of 44.59%. Well-preserved specimens of *Scorpiurus muricatus* L. and *Lepidium sativum* L. are illustrated in Figs. 12 and 13, respectively. We noted that most of the weed species were represented by seeds, grains, fruit fragments or vegetative parts and consist of 10 winter weeds, two summer weeds and eight all year round weeds. As shown in Table 2, eight species dominate the weeds and were recorded in over 50% of the examined samples, namely, *Medicago polymorpha* L., *M. lupulina* L., *Vicia sativa* L., *V. ervilia* (L.) Willd., *Bromus* sp, *Lolium temulentum* L., *Phalaris minor* Retz., and *Rumex dentatus* L. In addition, among the 20 species are *Malva parviflora* L., *Medicago polymorpha*, *Solanum nigrum* L., *Portulaca oleracea* L. (Fig. 14), *Chenopodium murale* L., *Rumex dentatus*, *Senecio aegyptius* L., *Polygonum equisetiforme* Sm., which are still found as field weed assemblages associated with wheat and clover cultivation in modern Egypt (El Hadidi et al. 1999: Table 1). *Phalaris minor* and *V. sativa* are common species in modern wheat fields while *R. dentatus* and *M. polymorpha* are indicator species of clover (*T. alexandrinum*) (El Hadidi et al. 1999). The greater number of *P. minor*

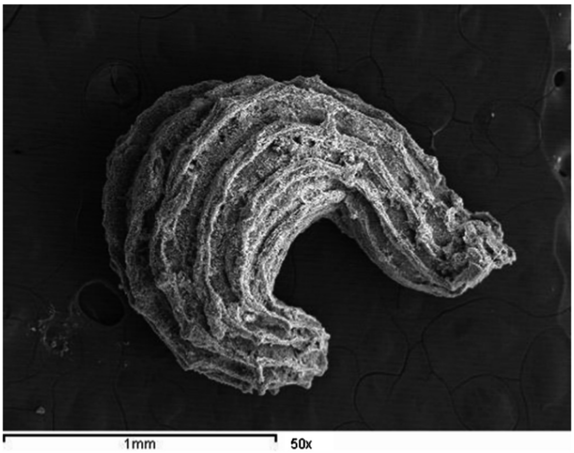

Fig. 12. SEM micrograph of *Scorpiurus muricatus*.

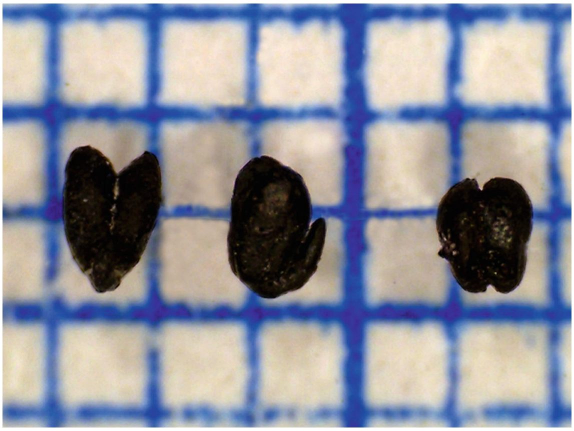

Fig. 13. Fruits of *Lepidium sativum.* Each unit = 1 mm.

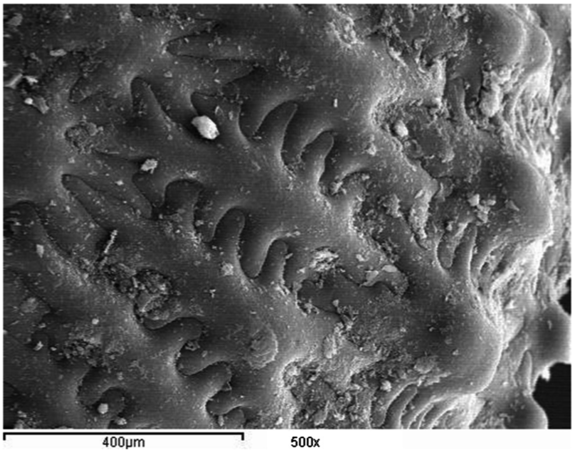

Fig. 14. SEM micrograph of the seed surface of *Portulaca oleracea* subsp. *nitida*.

(Fig. 15) and *L. temulentum* remains could suggest that both species were common field weeds in Early Dynastic wheat fields near the site. They may be considered as an indication that farming activities were practised during the winter months in contrast with the low number of summer weeds such as *P. oleracea* and *Digitaria sanguinalis* (L.) Scop., which sprout during late summer and continue during winter.

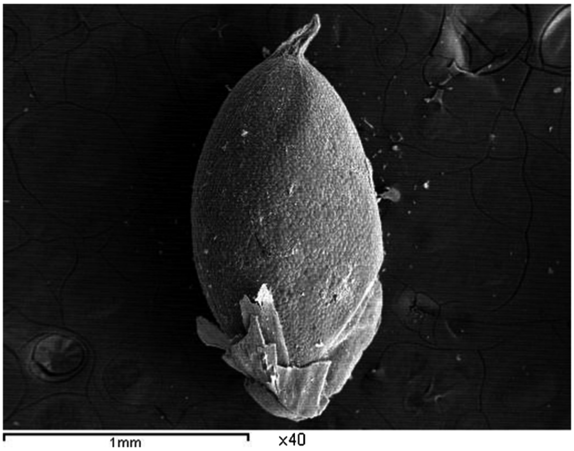

Fig. 15. SEM micrograph of the grain of *Phalaris minor* (lateral view).

Plants of Moist Habitats

Remains of eight species commonly found in moist habitats (marshes and muddy banks of water bodies) were recovered in the Helwan tomb samples with percentage 2.23% of the total number of the plant macroremains (Fig. 4). As examples, Figs. 16 and 17 are SEM micrographs of *Carex divisa* Huds. and *Eleocharis palustris* (L.) Roem. & Schult., respectively. Today, these species typically grow on wet soil near irrigation canals and water bodies. It is interesting to note that one of the earliest examples of pictorial evidence for irrigation canals in ancient Egypt is found on the Scorpion King mace-head showing the king ceremonially holding a hoe and digging a canal (Late Predynastic, c. 3100 BC), indicating that irrigation canals were present by at least the

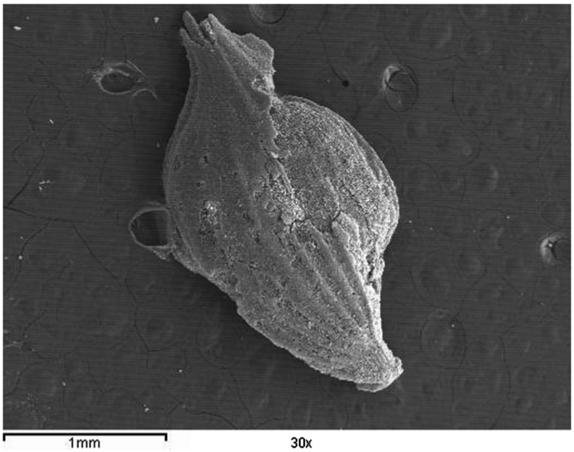

Fig. 16. SEM micrograph of a *Carex divisa* utricle.

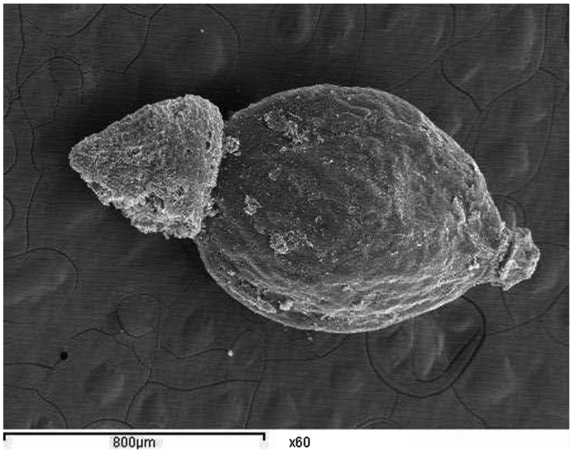

Fig. 17. SEM micrograph of a nutlet of *Eleocharis palustris*.

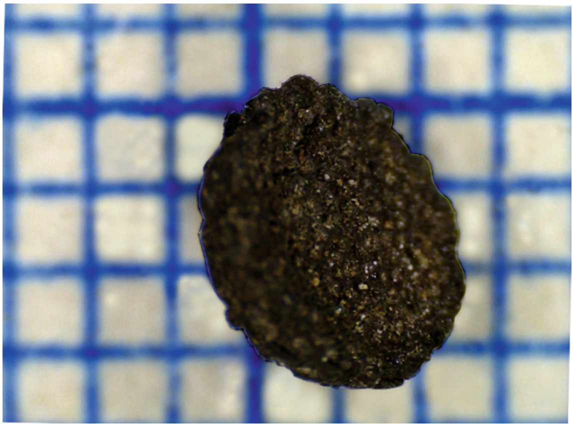

Fig. 18. Capitula of *Ceruana pratensis.* Each unit = 1 mm.

Late Predynastic period. These moist conditions are a suitable habitat for the growth of pasture plants of moist habitat including *Fimbristylis bisumbellata* (Forssk.), *Ceruana pratensis* Forssk. (Fig. 18), and *Juncus rigidus* Desf. The latter two species are also important material in the manufacture of baskets and mats (El Hadidi et al. 1996).

Plants of Dry Habitats

Remains of 3 species which are adapted to dry conditions were identified from the 10 tomb samples. The following taxa have been attributed to this desert vegetation: *Zilla spinosa* (L.) Prantl, *Nauplius graveolens* (Forssk.) and *Asphodelus fistulosus* L. (Fig. 19).

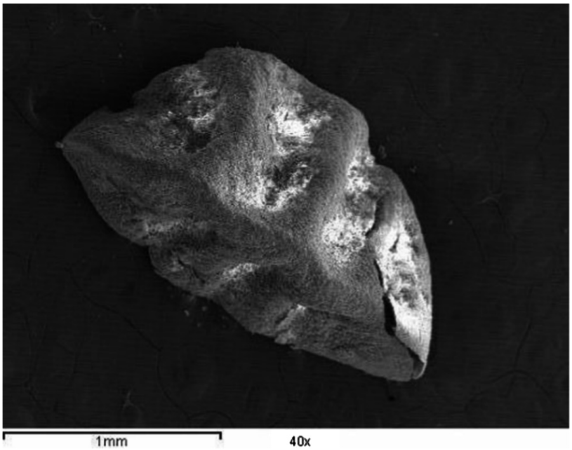

Fig. 19. SEM micrograph of a seed of *Asphodelus fistulosus*.

Indeterminate Taxa

The category indeterminate taxa includes plant macroremains which have been identified only to the family level. As such, it was not possible to deduce specific information about the significance of these specimens in the economic or ecological reconstructions. This category makes up only 2.86% of the total number of the plant macroremains (Fig. 4). It includes the plant macroremains of the following families: Boraginaceae, Brassicaceae, Fabaceae, Lamiaceae and Poaceae types.

Discussion

The overall analysis of the Helwan tomb samples suggests that this botanical assemblage is comprised of cereal chaff refuse with associated field weeds which were transported from the area where crop processing activities took place. This is similar to many rural settlements across the Near East and Europe where the processing remains of cereals and other crops have been recovered. But in the case of the Helwan tomb samples, it is difficult to determine if the cereal chaff refuse was transported to the settlement, directly to the cemetery or transported to the settlement then to the cemetery to serve as a fuel for fires made during funerary rites.

It is generally agreed that crop processing usually took place either at or near the point of deposition and their by-products were brought in for specific purposes such as fodder, bedding, fuel, or as building materials (van der Veen 2007). In addition, cereal crop by-products are used in rural Egypt today as kindling in hearths, kilns and furnaces in villages and nomadic settlements. Similar practices may have occurred in Early Dynastic Memphis, namely kindling the fire with chaff placed between branches of acacia and tamarisk wood possibly during burial ceremonies.

In addition, the analysis suggests that samples also represent accumulations of debris during food preparation. This debris was transferred from ovens used in cooking into pots which were later sealed by mud stoppers and placed beside the dead as a part of ritual ceremonies. However, it is not clear if these debris were put into jars at the settlement and then transferred to the cemetery and deposited into tombs or if they were placed into pots at the cemetery. The issue of funerary practices, deposition of these material and their significance will be the subject of future research on the Helwan tomb samples.

The results from this study demonstrate that the two major cereals retrieved from the Helwan botanical assemblage were hulled barley and emmer wheat. However, the remains of hulled barley, including grains and chaff elements, overwhelmingly dominate the botanical assemblage which suggests a significant role of barley in Memphis during Early Dynastic times (Late Naqada IIIC-early Old Kingdom). Similar results have been recorded from Adaïma, end Naqada II (Predynastic) to Naqada IIIB/C (Protodynastic, I and II dynasties) in Upper Egypt where Newton (2007) made a quantitative comparison between emmer wheat and barley remains and concluded that barley remains are 2.5 times more abundant than emmer.

Van Zeist and Roller (1993) have concluded that the arable economy of Predynastic Maadi (Naqada IIC/D) was largely based upon the cultivation of wheat, probably emmer, and hulled barley (two and six-rowed forms). Fahmy et al. (2011) reported that emmer wheat represented 56% of the total number of retrieved plant remains while barley represented only 6.1% of the botanical assemblage from Hierakonpolis (Naqada IIC/D). They concluded that the economy of Predynastic Hierakonpolis was based on the cultivation of cereals: emmer wheat and barley which were consumed by humans as well as animal populations. In addition, Wetterstrom (unpublished report) concluded that barley production was increasing during Predynastic times and the larger portion of the harvest was probably used as fodder and the rest for making beer. She recorded a displacement of emmer wheat by barley over time at Naqada KH3 and Naqada South Town (3800–3400 BC).

It seems that there is a marked reduction in the use of emmer wheat which was replaced by barley moving from Predynastic times to the early Old Kingdom. This trend may reflect the growing significance of barley, which may be attributed to beer making, the extensive use of barley as animal fodder and/or the success of barley cultivation under basin irrigation (Murray 2000). This observation was also made by Murray (2000) where textual and linguistic evidence suggested that barley was the predominant cereal during the Old and Middle Kingdom with emmer wheat rising to become the most important cereal during the New Kingdom to Ptolemaic period. This observation requires further research, including more archaeobotanical sampling at other archaeological sites dating to the later Pharaonic period, which should examine the relative abundance of barley and emmer wheat over time.

The role of flax and lentil in the economy of Memphis remain obscure. The samples from the Helwan tombs could have been contaminants from earlier processing episodes. Similar low quantities of flax and lentil were observed by Kroll (1989) and van Zeist and Roller (1993) at Maadi.

One interesting finding is the remarkably high numbers of *Trifolium alexandrinum* seeds and fruits, which may suggest that clover was a cultivated crop in Early Dynastic Memphis. Moreover, weeds of *R. dentatus* and *M. polymorpha* present in the same sample are indicator species for clover cultivation (El Hadidi et al. 1999). The large quantity of

Trifolium in the Helwan tomb samples may be the result of informal intercropping of legumes with cereals crops (Malleson 2016). Also the absence of dung remains coupled with an abundance of well preserved charcoal suggests that the botanical assemblage resulted from a field to fire pathway, with legumes and weeds derived from using cereal processing by-products directly as fuel and tinder. This assemblage did not arise from a fodder-dung-fuel pathway, and given the exceptional preservation, it is unlikely to have undergone mastication and digestion by livestock (Malleson 2016). Furthermore, Malleson (2016) suggested that *Trifolium* sp. and other weeds may have been an integral part of cereal fields, because farmers were likely aware of the benefits that they added to the crop. The findings of this study suggest that the remains of clover retrieved from the Early Dynastic cemetery at Helwan constitutes an interesting earlier example of what was suggested by Malleson (2016) at Old Kingdom site of Giza.

Sidder fruit was probably part of the diet on a regular basis: the fleshy mesocarp is slightly acidic, and may be consumed fresh, dried, as a drink or as a sweet cake. Their importance in the diet is also evidenced by their presence in tombs as food offerings and they could be interpreted as a bread-like food ingredient (Newton 2007). The presence of sidder fruit in the plant macroremains within ashy deposits at Helwan may be attributed to food preparation or bread making.

Another interesting finding is the exceedingly large number of weeds in the Helwan tomb assemblage. This could be attributed to the practice of informal intercropping by ancient farmers where they allowed clover and other weeds to grow amongst the cereals because they would increase the value of the harvest by improving the quality and quantity of valuable by-products (Malleson 2016). Moreover, this may indicate that Early Dynastic farmers did not remove weeds from their fields.

The large number of recorded winter weeds retrieved from the Helwan sample could be the result of the classic basin irrigation system which was applied in ancient Egypt. This practice involved the complete inundation of fields during the summer, and consequently the crop rotation was simple and confined to the winter season (Fahmy 1997). The 10 species of winter weeds are typically found in temperate regions of the Old world consisting of Mediterranean and Irano-Turanian elements. These field weeds were introduced to Egypt along with cereal crops from the Near East (El Hadidi 1993; Fahmy 1997) during the Predynastic period. The presence of summer weeds in this assemblage may simply be the result of their occurrence in near-by tropical ecosystems (Kosinová 1975).

The majority arable weeds retrieved from the Early Dynastic cemetery at Helwan grew to over 40 cm, however the presence of low growing weeds such as *Portulaca oleracea*, suggests that cereal crops and possible clover fields were harvested by cutting the cereals culms just above the soil. Thanheiser (1996) reported that the cereals were harvested by the same method in Pre and Early Dynastic periods by using sickles and the culms were cut just above the soil.

The occurrence of plants of moist habitats could reflect the presence of herbaceous species on the Nile floodplain near Memphis. Furthermore, the presence of such an assemblage of taxa demonstrates the existence of wet soils along water courses that would have penetrated cultivated fields especially during the winter. A similar observation was made in archaeobotanical analyses at Predynastic Maadi (Van Zeist and Roller 1993) and Hierakonpolis (El Hadidi et al. 1996). Among the recorded plants of moist habitats were and still today include taxa of the palaeotropical kingdom and comprise 6 species which are mainly Sudano–Zambezian (African elements). These are principally riverine species and are part of the natural vegetation of Egypt.

The plants of dry habitats derive from the desert vegetation near Helwan which is comprised of perennials and complementary assemblages of therophytes. Also, *Asphodelus fistulosus,* one of the co-dominant species of irrigated winter crop vegetation, typically invades uncultivated dry lands and areas under fallow. The presence of such an assemblage among cereal chaff remains could indicate that ruderal vegetation grew in the vicinity within cultivated fields near the site. Similar situations have been recorded at Predynastic Hierakonpolis (Fahmy 1995) and Adaïma (Newton 2007). The present vegetation around the site is sparse and dominated by a few stands of *Alhagi graecorum* Boiss. and scarce individuals of *Tamarix nilotica* Bunge and *Zygophyllum coccineum* L.

Conclusions

The assemblage of plant macroremains retrieved from the Early Dynastic cemetery at Helwan has shed some light on the agricultural history and relationships between humans and diverse plants that grew during this period. This was possible partly because of the excellent preservation plant macroremains in the tombs. The purpose of this study was to determine the plant diversity and agriculture practices that prevailed during Early Dynastic times in Memphis, in addition, to assess food consumed by inhabitants. The results indicate that the Early Dynastic inhabitants of Memphis cultivated cereals including hulled barley and emmer wheat as major sources of food. In addition they applied different agriculture practices such as intercropping legumes with cereal crops, basin irrigation, and specific harvesting techniques during the Early Dynastic period. The study also suggested the occurrence of different vegetation types and habitats of xerophytes and swampy stands in the general vicinity of the site resulting from a high water table.

This study represents a preliminary analysis of macro-botanical remains from 10 tombs in the Helwan Cemetery. The sample represents a fraction of the total botanical assemblage available from Helwan which includes more than 200 tombs already sampled for macroremains and awaiting analysis. Further study will certainly add to the emerging picture of the Early Dynastic agricultural economy of the Memphis region. Additional research will focus on the type, significance and importance of archaeological contexts as well as funerary practices to consider why these plant remains were kept in jars and placed in tombs, and the significance of these activities. Study of the entire botanical assemblage also will elucidate changes in the botanical assemblage during the long time span of the site occupation.

Acknowledgements. We wish to express our deepest gratitude and appreciation to Prof. Dr. Christiana Köhler, Institute for Egyptology, University of Vienna, for giving the opportunity to work with her excavation team at Helwan and for using this material. Many thanks are due to the Academy of Scientific Research and Technology (ASRT), Egypt for the grant (June 2007–June 2011) which has helped in the accomplishment of this study.

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