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ORIGINAL ARTICLE

Predynastic and Early Dynastic plant economy in the Nile Delta: archaeobotanical evidence from Tell el-Iswid

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Abstract

The large-scale excavation at the prehistoric site of Tell el-Iswid made it possible to undertake a systematic archaeobotanical study of different structures covering the Predynastic and Early Dynastic period (Lower Egyptian Cultures, i.e. Buto II (3500–3300 BC) to Naqada III Culture (3300–2900 BC)). Here we present the results of the analysis of carpological remains preserved mostly in a charred state and coming from 62 samples processed by manual flotation, with total volume of 615 L and containing a total of 9,672 identifiable and quantifiable items. A further ca. 650 wood fragments (or woody vegetative remains) were subject to anthracological analysis. Besides the aim of overall characterisation and exploration of the plant economy of the site, the macrobotanical assemblages were also considered in relation to the structures from which they were uncovered. The study revealed that the agricultural economy of both studied periods relied on emmer, barley, lentils, and pea, but from Early Dynastic times onwards barley and pulses gained more importance, along with flax (*Linum usitatissimum*) and condiments (like *Anethum graveolens* and cf. *Origanum* sp.), which occur first during this period at the site. Together with the cultivated fields, the surrounding wetlands were also an important part of the plant resources utilized at the site. The stems of *Phragmites* are the most common among the anthracological remains, together with a small proportion of *Tamarix* and *Acacia* charcoal fragments. The overall composition of the plant assemblages (charred and mineralised chaff, small weed or wild growing seeds capable of passing herbivore digestion, dung fragments, awns) suggest that the major source of the retrieved plant remains was dung fuel.

Keywords Plant macrofossils · Crop processing · Dung fuel · Land use · Neolithic · Egypt

Introduction

The establishment of Neolithic economy in Egypt, including farming and herding, is a complex process, with certain variations between the different regions of the area and primarily related to the introduction of pottery and animal husbandry (Linseele et al. 2014). The next important element of Neolithic cultural and technological innovations, agriculture, was introduced later in the late fifth to early fourth millennia BC by different Predynastic cultures in the Nile valley (Cappers 2016). Within the Nile valley, the Delta as part of the Lower Egypt (Fig. 1) possesses rather specific environmental settings (i.e. wetland, swampy habitats with incorporated sandy banks or hills affected by seasonal flooding), to which the crops introduced during the Neolithic also had to adapt. Moreover, the geographic position of this region allows the tracing of cultural interactions between Lower and Upper Egypt, as well as the Mediterranean area and Near East. For the Predynastic and Early Dynastic period several archaeobotanical studies have been conducted on

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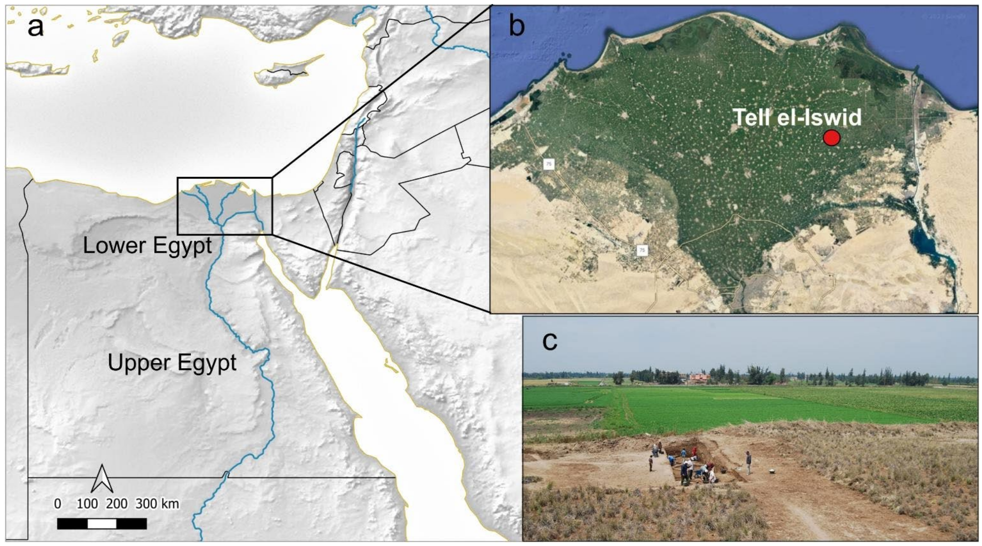


Fig. 1 (**a**) Map of Egypt indicating the prehistoric division into Lower and Upper Egypt; (**b**) Overview of the Nile Delta (© Google maps) with the location of Tell el-Iswid indicated by a red dot; (**c**) View of the excavation area in the modern landscape

material recovered during excavations of settlement sites in the Nile Delta and Lower Egypt (de Roller 1989; Thanheiser 1991, 1992a, b; van Zeist and de Roller 1993; Thanheiser 1997; Kubiak-Martens 2012; Emery-Barbier 2014). The archaeobotanical studies from these sites provided diverse information on agricultural production and economy, diet and environment in this formative period of Egyptian civilization. At most of the sites the staple cereal crops, during the Predynastic as well as during the subsequent Dynastic periods are emmer (*Triticum turgidum* ssp. *dicoccon* (Schrank) Thell, Syn = *T. dicoccum* Schrank ex Schübl.) and barley (*Hordeum vulgare* L.). The most frequent weeds are *Lolium* (*temulentum* L.) and *Phalaris* (*minor* Retz./*paradoxa* L.), but also numerous finds of *Rumex* (*dentatus* L.) and *Lathyrus hirsutus* L. were present, all typical for the archaeobotanical assemblages in Egypt from the Predynastic period onwards (Fahmy 1997). At most of the sites crop processing by-products are dominant components of the archaeobotanical assemblages and the finds from the site Buto suggest that those by-products were used as fodder (Thanheiser 1991). In Tell el-Farkha and Tell el-Iswid harvesting of tiger nut tubers (*Cyperus esculentus* L.) was also attested (Kubiak-Martens 2012; Emery-Barbier 2014). For the sites from the Nile Delta, with published larger archaeobotanical sets, i.e. Buto (Thanheiser 1992b, 1997), Tell Ibrahim Awad (Thanheiser 1992a) and Tell el-Iswid (de Roller 1989), remarkable homogeneity of the archaeobotanical assemblage from all of the Predynastic layers as well as continuity in the plant economy between Predynastic and Early Dynastic (Thanheiser 1996) layers was observed.

The macro-botanical study from Tell el-Iswid South presented here was conducted in the framework of the archaeological research project of the Institut Français d'Archéologie Orientale (IFAO), which started in 2006 (Midant-Reynes and Buchez 2014) and is still ongoing. The field campaigns involved regular sampling of all structures that promised to provide archaeobotanical information. Thus the study targeted numerous structures over the entire excavated area, aiming to explore the general tendencies and variability over the duration of the long-lasting occupation of the site (covering the entire fourth millennium BC).

The overall design of the current archaeobotanical study is aimed at obtaining a large dataset and anticipates exploring the diachronic development of the plant subsistence of Tell el-Iswid as representative of the Nile Delta region. In the current study we use the opportunity to focus on specific occupation phases, namely Buto II-IIIa (ca. 3500−3300 BC) summarised as Buto II in this paper, and Nagada III A2-B and III C-D (ca. 3300−2900 BC) summarised here as Nagada III. Those two phases are of importance for understanding the genesis of the subsequent Dynastic period (Midant-Reynes 2000) and several societal and technological innovations related to it, including amongst others mud-brick architecture (Midant-Reynes and Buchez 2021). Moreover, by considering the composition of the archaeobotanical assemblages by the different studied context types we aim to explore possible patterns of the deposition of plant remains in these context types, possibly reflecting their function.

Study area and site

The ancient occupation of Tell el-Iswid (30.871443 N, 31.77695 E, Fig. 1), was established on a "gezira", i.e. a sandy hill formed by the annual flood deposits of the Nile during the Pleistocene. This original landscape has been completely redesigned from the 19th century onwards when dams and the levelling of the land have turned the region into a vast flat area of fields and villages (Tristant and De Dapper 2014). The surface of the tell is covered today with a 20 cm-thick layer of very fine aeolian sediment trapped by grassy (halfa) vegetation, with deep creeping, underground parts. These are usually grasses such as *Cynodon dactylon* (L.) Pers., *Desmostachya bipinnata* (L.) Stapf, *Imperata cylindrica* (L.) P.Beauv., and *Saccharum spontaneum* L. In the surroundings, on the edges of the watercourses *Phragmites australis* (Cav.) Trin. ex Steud., *Salix mucronata* Thunb. and *Tamarix aphylla* (L.), Karst. can also be found (Zahran and Willis 2009).

In this semi-arid climate and low annual rainfall range (29–184 mm), settlements were restricted to a few sandy residual hills, which provide high ground above the floods, and these settlements were threatened not only by water during the annual inundation, but also by the lack of water during the dry periods (Tristant et al. 2008).

The excavations of the site revealed several phases of occupation. The lowest cultural layer belonging to the Lower Egyptian culture (Buto II period) showed traces of fences, shallow pits, and some bricks associated with hearths. During the following phase (Naqada III A-B) social transformations took place and mudbrick architecture, which appeared for the first time toward the end of Buto IIb at Tell al-Iswid (as at Tell el-Farkha), gained importance and was clearly adopted at the site. Towards the end of the Nagada III (C-D) occupation several burials were established at the site. Tell el-Iswid also shows some traces of settlement during the Dynastic times and later periods.

Materials and methods

The studied material comprises charred and mineralised plant macrofossils and charred wood (or woody vegetative remains) coming from soil samples taken in the excavation seasons from 2013 to 2019. The sediment was taken mostly from ovens, but also generally from the cultural layer, post holes, fireplaces, ditches, etc. To extract the plant macro remains the sediment was processed by manual flotation at the site, using sieve meshes of 2, 1 and 0.3 mm. The plant remains extracted by flotation were then studied at the field lab, including sorting and preliminary identification. This work was conducted with the help of a low magnification stereomicroscope (from 10× to 70×). The identification of the plant remains was finalised using the reference collections of IFAO, Cairo. A further important part of the laboratory work was the study and identification of wood, culm- and rhizome/tuber fragments under a reflected light microscope. After the primary identification the archaeobotanical dataset (ESM Table S1) was stored in ArboDat (Kreuz and Schäfer 2002), thus in a format compatible with further analyses and comparisons. The botanical nomenclature follows the one provided by ArboDat and plants not available in the ArboDat-thesaurus follow the Plants of the World Online (POWO 2023) check list. To evaluate the archaeobotanical assemblages basic qualitative and quantitative approaches (like calculations of concentration, diversity, ubiquity of the plant remains) were also applied. The identified plant taxa were grouped in main ecological and economic groups and subsequently the proportions between the sums of the seed/fruit and chaff remains of these groups were calculated; the culms and vegetative parts were excluded from these calculations, as they were considered as anthracological remains. Further, to interpret the studied dataset, the contextual attribution of the different structures from which the plant remains came was used.

Results

Carpological analysis

Overall composition of the macrobotanical assemblages and preservation of the plant remains

Most of the archaeobotanical finds are charred, while mineralised remains play a minor role. However, numerous remains of awn fragments, which are only semi-quantifiable, are also preserved in a mineralised state. Several feature types provided samples containing archaeobotanical remains: oven (n = 25), cultural layer (n = 19), post whole (n = 10), fireplace (n = 3), ditch (n = 2) and silo (n = 2) (Fig. 2). Most of the samples, 46 out of 62, are rich in archaeobotanical finds and contain over 50 identifiable plant remains (seeds/fruits) and comprise over 10 different plant taxa. The samples from both periods show rather high concentrations of plant remains per litre: 15 items for Buto II and 29 for Nagada III (Fig. 2, ESM Table S1). Due to moderate preservation, ca. 25–30% of all seed/fruit remains are identifiable only to a very low taxonomic level (family or an even higher taxonomic group) or unidentifiable (Fig. 3a). Most of the samples, especially those from the Buto II period, contain typically strongly fragmented emmer glume bases, fragmented or not further identifiable “Cerealia” grains (Fig. 3b), potential weed seeds (most numerous of which are *Lolium* and *Phalaris*), often with abraded surfaces and/or fragmented. There is also a high proportion of vegetative parts, mostly stems or culms, including those with nodes, from different grassy plants (Poaceae, Cyperaceae, Monocotyledoneae) as well as other as yet not further identifiable vegetative parts.

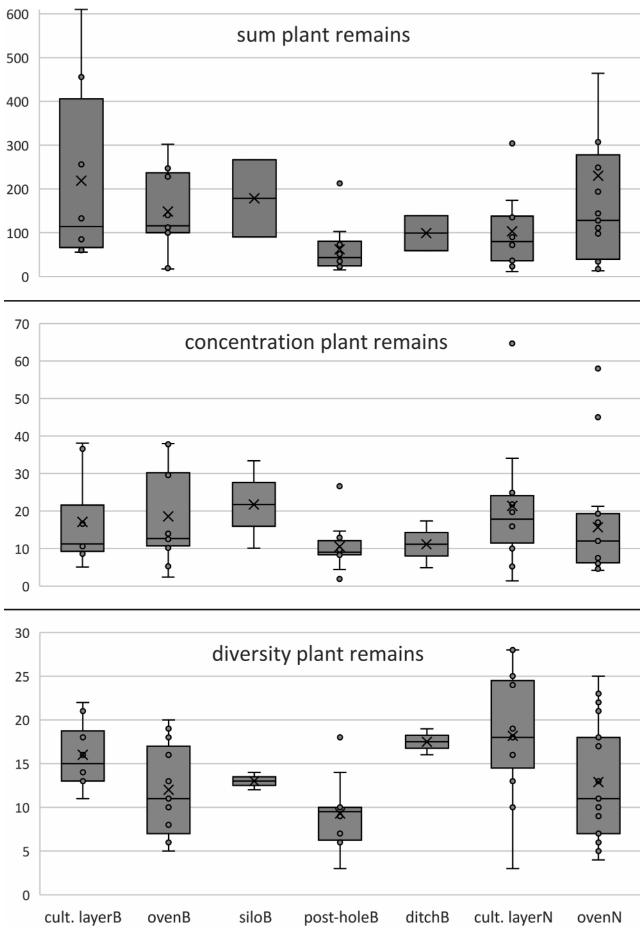


Fig. 2 Trends in sum, concentration and diversity of the archaeobotanical assemblages according to period and feature type (abbreviation after feature type: B = Buto II, N = Nagada III). Buto II: 33 features (2 ditches; 2 silos; 10 post holes, 8 cultural layers; 11 ovens), Nagada III: 29 features (11 cultural layers; 17 ovens)

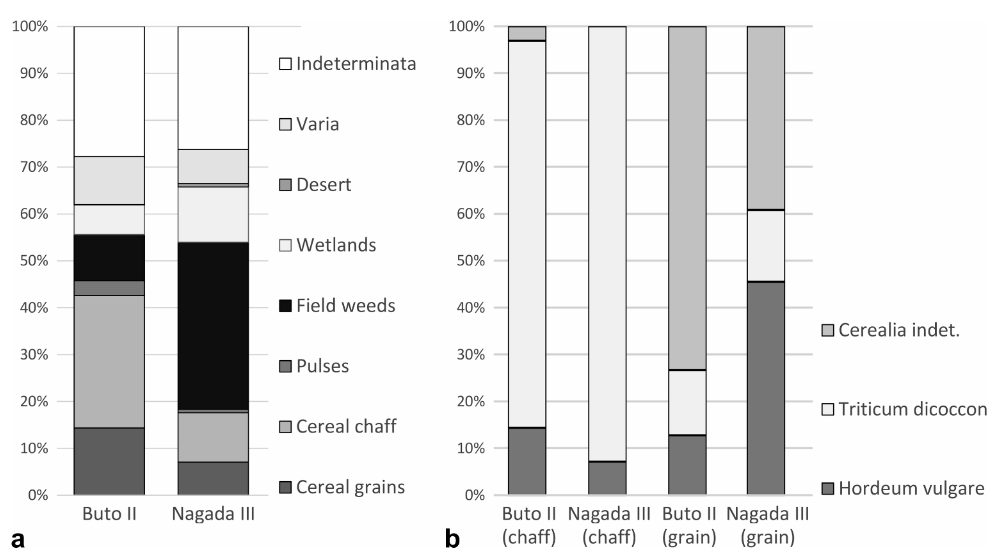
Macrobotanical composition of specific structures

The oven features for both studied periods are rather rich in plant remains (Fig. 2). This high concentration and diversity of plant remains also points to good preservation. As well as the numerous charred glume bases of emmer, also charred grains of barley, emmer and Cerealia and some mineralised plant remains were found. A large number of caryopses of the field weeds *Lolium temulentum*, *Lathyrus hirsutus/Vicia* (small seeded) and *Phalaris minor/paradoxa* have also been identified. Furthermore, many Cyperaceae and *Rumex crispus/dentatus* (elements of riparian and floodplain vegetation), *Trifolium* sp. seeds (especially in the Nagada III samples) and a lot of charred stem/culm fragments were found. In several of the oven features high concentrations of cereal awns (over 1,000 fragments) were recorded (ESM Table S2), which next to the emmer glume bases suggest the importance of chaff (i.e. threshing by-products) in the archaeobotanical assemblages from the ovens. The samples from the cultural layers do not differ much in their composition from those originating from oven features (Fig. 2). The only slight variation that is visible, at least for some of the cultural layer samples, is that they contain more grains than chaff and show higher diversity of the archaeobotanical finds, especially those belonging to the Nagada III period. From the Buto II period several post holes were also studied and these contain much poorer and less diverse archaeobotanical assemblages compared to the rest of the features.

Anthracological analysis

The material available for anthracological analysis showed that the fragments of culms belonging to reed (*Phragmites*) and to the grass family (Poaceae) are the most numerous. Most of the identified wood charcoal fragments belong to *Tamarix* L.

Fig. 3 **a** Percentage proportions of the main economic and ecological groups of the identifiable plant macrofossils (based on 62 samples with total volume 615 L floated sediment and 9,672 plant remains); **b** percentage proportions of the chaff and grains of *Hordeum vulgare* and *Triticum turgidum* ssp. *dicoccon* during both studied periods



Also, few fragments (n = 22) of *Acacia* Mill were identified in the studied samples from both the considered periods (ESM Table 1). Further, in the Nagada III samples, just five fragments of *Ficus sycomorus* L. recorded in two of the samples from ovens, were identified. In almost all of the samples single fragments of rhizomes and tubers occur (Fig. 4). Some of the rhizomes could belong to the local wetland vegetation (mainly *Imperata/Desmostachya*). A few of the tuber fragments were preserved well enough to be identified as *Cyperus rotundus* L./*esculentus* L.

Discussion

The plant economy of tell el Iswid

Emmer (*Triticum turgidum* ssp. *dicoccon*) and barley (*Hordeum vulgare*) were the major cereal crops that occurred regularly in the studied samples. They are the common cereals at Egyptian sites in Predynastic and Dynastic times, not only in the Nile Delta (Cappers 2016), and as shown by previous botanical studies in Tell el-Iswid, emmer played major role in its Predynastic agricultural economy (de Roller 1989; Emery-Barbier 2014). Emmer, as revealed by gut contents analyses from Predynastic cemeteries, was preferred for human consumption (Fahmy 2003), but also was the main component for Predynastic beer making (Attia et al. 2018). The threshing and husking waste generated by the processing of emmer is more abundant than that of barley. This could be explained not only by taphonomy, but also by the fact that it had a significant economic role, since it could be used as a tempering in mudbricks and pottery, or mixed with animal droppings to obtain slow-burning fuel cakes typical for regions such as the Nile Valley where access to firewood was limited (Newton 2004; Cappers 2005/2006). The other principal cereal crop, barley, has high nutritional values and is less sensitive to drought, bad soil conditions and salinity than emmer. The barley gains importance during the Nagada III period, while the proportion of emmer grains remains constant between the periods (Fig. 3b). The tendency for the increasing importance of barley in the early Dynastic time has already been observed by several studies in Lower and Upper Egypt (for recent discussion see Moustafa et al. 2018) and can be explained by the advantage of this crop over emmer when pressure on the cultivation ground increases.

The importance of pulses is difficult to estimate, as many of them are not further identifiable due to fragmentation and abraded surfaces. The few identifiable seeds of leguminous crops belong mostly to pea (*Lathyrus oleraceus* Lam. Syn.=*Pisum sativum* L.) and lentil (*Vicia lens* (L.) Cross & Germ. Syn=*Lens culinaris* Medik.) and also indicate the crops of this group typical for the both periods (see Thanheiser 1992a, b). The microbotanical study (phytolith analysis) of Tell el-Iswid has shown increasing importance of pulses and also fruits during the Nagada III CD period (Emery-Barbier 2014). Our analysis confirms this tendency when considering the ubiquity of pulses between the two studied periods (ESM Table S1). Single finds of melon (*Cucumis melo* L.) suggest that at least during the Buto II period this plant was consumed at the site. Also attested with single finds in the macrobotanical assemblages, figs (*Ficus sycomorus*) and flax (*Linum usitatissimum* L.) seem to be part especially of the Nagadian plant economy, and this was also shown by the microbotanical studies at the site (Emery-Barbier 2014) and for the Nagada period in Upper Egypt (Newton 2004). Also, wood of *F. sycomorus* and *Ficus* sp. was found in two of the ovens studied indicating the use also of the wood of this plant as fuel.

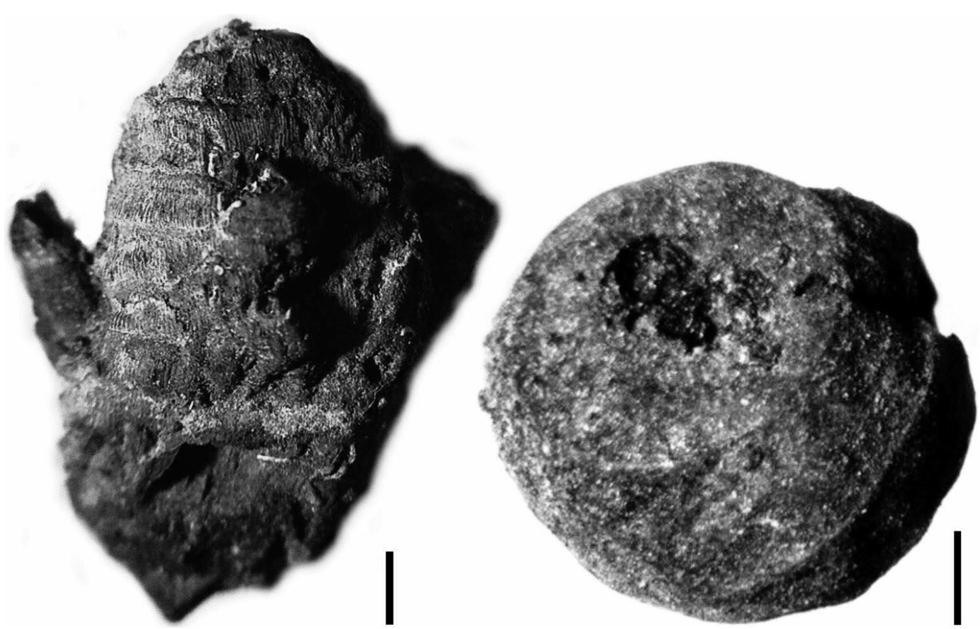


Fig. 4 Rhizome fragment (left) and possible *Cyperus*-tuber (right), scale 1 mm

Two plants which were used as spices and were well established in the Dynastic food practice in the region (Murray 2000) were also attested in the samples from Nagada III – dill (*Anethum graveolens* L.) and possibly oregano (cf. *Origanum* sp. L.). The seeds of cf. *Origanum* sp. could originate from the Syrian oregano (*O. syriacum* L.), but as there are only two such finds, they must be considered with caution and more material is needed to allow definite conclusions on this hypothesis. However, both plant taxa, dill and oregano, are of interest as they both have their natural distribution in the Near and Middle East and together with the annual crops clearly indicate the connections with the Levantine area.

Together with the crop remains, there are numerous finds of field weeds, especially *Lolium* cf. *temulentum* and *Phalaris minor/paradoxa*, but also leguminous weeds with small seeds like *Lathyrus hirsutus* (occurring overall in 50% of the samples from the Nagada III) are quite common. All of them are typical for the Predynastic and subsequent Dynastic period and belong to the most common weeds in the Egyptian archaeobotanical assemblages (Fahmy 1997). Also quite common in the Nagada III samples are the remains of *Trifolium* sp. (occurring in 50% of the samples, ESM Table S1). Analyses of Old Kingdom plant assemblages from Giza suggest that *Trifolium* sp. and other 'weeds' may well have been viewed as integral plants within ancient Egyptian cereal fields and were intentionally favoured for different useful purposes related to soil fertility, fodder etc. (Malleson 2016). The increasing importance of *Trifolium* sp., *Lathyrus hirsutus* and other potential weeds belonging to the Fabaceae family (see Fig. 3a) at Tell el-Iswid could thus represent an initial stage of the later established subsistence practices involving more strongly this ecological group.

Wetlands played an important role in the plant economy of the site (ESM Table S1), which is also attested by the phytolith analyses (Emery-Barbier 2014). This fact could be explained by both the dominance of those plant habitats in the surroundings of the site (Tristant and De Dapper 2014) and the various uses of their resources.

How the plant remains became incorporated in the cultural layer

The carpological analysis revealed the dominance of plant remains coming from cereal crops (emmer and barley), weeds or ruderal plants like *Lathyrus* sp., *Lolium* sp., *Phalaris* sp., *Trifolium* sp., *Vicia* sp. (small) and numerous representatives of the wetland vegetation like Cyperaceae, *Eleocharis* R.Br., *Phragmites*, *Persicaria lapatifolia* (L.) Delarbre, *Rumex crispus* L./*dentatus* L. Many of the cereal grains ("Cerealia indet.") could not be identified due to the bad preservation. But they should belong either to emmer or barley – the main cereal crops found on regular basis at the site. Their strong fragmentation and abrasion of the surfaces suggests either redeposition, or that they were abraded prior to charring and deposited as part of food processing activities.

The Monocotyledon rhizomes and the *Cyperus*-tubers could also represent remains of food preparation, for example by roasting. Such wild food resources were used for human consumption in Predynastic times and this has also been suggested for the contemporary site Tell el-Farkha (Kubiak-Martens 2012). However, the underground parts of the grasses like *Imperata/Desmostachya* or *Phragmites*, might represent by-products of craft activities that had been discarded in the fire, Both the leaves and culms of these grasses could be used for mats, ropes and basketry (Gale and Cutler 2000). Mattings were largely used in the Predynastic sites as also attested by the studies at Tell el-Farkla (Kubiak-Martens 2012) and at Tell el-Iswid (Emery-Barbier 2014).

The majority of the studied archaeobotanical samples come from combustion structures (n = 28) and their composition should at least partly reflect the fuel used in these structures. Most probably the wood identified by the anthracological analysis originates from burning of fuel, considering the abundance of *Tamarix* wood, mostly of local origin. The high proportion of emmer chaff in the oven structures could be explained by the fact that the by-products of de-husking were further used and became incorporated in the fuel either as part of dung (Valamoti 2013) or directly as waste mixed with the dung to form dung cakes (Valamoti and Charles 2005). The strong fragmentation and abrasion of most glume bases could be related precisely to the fact that many of them had passed through herbivore digestion (Valamoti 2013). The rather similar trend of the amount, concentration and diversity between the ovens and the cultural layers suggests a serious contribution of the fuel remains to the "settlement noise" (sensu Cappers 2016). It seems also that those two structure types provide here the most representative information on the overall economy of the site. Compared to them the post-holes contain archaeobotanical assemblages with a greatly limited amount and diversity (Fig. 2).

Apart from the few wood fragments and vegetative parts of grasses or other Monocotyledons, possible dung fragments and mineralised plant matter were also recorded. The presence of high amounts of small seeds, which can pass through herbivore digestion (Wallace and Charles 2013), is an additional argument for dung fuel comprising an important contribution to the archaeobotanical assemblages of both the Buto II and Nagada III periods. The common use of dung fuel was suggested from macrobotanical assemblages in the Nile Delta region with similar composition, but belonging to the Old Kingdom period (Moens and Wetterstrom 1988; Crawford 2003; Malleson 2016), and would also be quite plausible for the Predynastic period (Cappers 2005/2006).

Conclusions

The archaeobotanical study of the Buto II and Nagada III macrobotanical assemblages has shown that the main annual crops used in the period between 3500–2900 BC were emmer and barley, known to be already principal crops in the study area from the beginning of the Neolithic. Pulses (pea and lentil) are of less importance, but it seems that their significance increases from the Buto II to Naganda III period. Further elements of the plant economy were melon, flax, fig and eventually some condiments like dill. The most common weeds typical in the Predynastic period such as *Lolium* cf. *temulentum* and *Phalaris minor/paradoxa* also dominate the weed assemblages from Tell el-Iswid showing that the site´s agricultural practices fit well with those from the rest of the region. Apart from the cultivated fields, the wetlands also played a significant role in the plant economy of the site providing fodder, fuel, construction/raw materials and further food resources.

The quantitative evaluation shows that the archaeobotanical assemblages from the Buto II period are dominated by emmer chaff, followed by cereal grains; barley and emmer grains are in the proportion 1:1. In contrast, during the Nagada III period the potential field weeds, followed by wetland plants, are the most numerous find categories and barley played a much more important role in the economy of the site (barley to emmer grains in the proportion 3:1) – both tendencies are also observed in several other Early Dynastic sites in Egypt. Thus, although the overall composition of the main elements of the plant economy remain the same, there is a clear change in the emphasis of the economic activities between the two considered periods and also a shift in dominance of barley as a main cereal crop, a tendency observed later on in the region in Early Dynastic times. Most probably the explanation is that already during the Nagada III period, the growing intensity of occupation and pressure on cultivated areas to be more productive lead to an increase of barley, more resistant to stress and salinity and capable of growing on poorer soils than the emmer. Moreover, during the Nagada III period also *Trifolium* sp. and *Lathyrus hirsutus* gain importance in the archaeobotanical assemblages, possibly as an element of animal fodder. Along with the growing importance of cultivated pulses, this can be seen in the light of the need to increase the soil fertility and thus productivity of the agricultural economy and can be considered as some first hint of emerging "informal intercropping of legumes with cereals" (sensu Malleson 2016), observed later on in Old Kingdom Lower Egypt.

During both study periods, the types of contexts richest in plant remains and containing the most diverse assemblages are the ovens and cultural layers. The overall composition of the studied archaeobotanical assemblages suggests strongly that dung fuel was the main source of the macro botanical remains deposited in the studied structures, and most probably the main portion of plant remains in the ovens and cultural layer came from its plant components. The slightly higher diversity of the plant assemblages from cultural layer contexts, rather than those from the ovens, post-holes and silo, could be explained by the broader range of activities, i.e. sources of plant material, which could be deposited in the cultural layer, rather than in the structures with narrower functions (silo, post-hole).

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Declarations

Competing interests The authors have no competing interests to declare that are relevant to the content of this article.

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