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Evaluation of Cultivated and Wild Plant Macroremains from a Predynastic Temple in Hierakonpolis - Upper Egypt

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Authors' contributions

This work was carried out in collaboration between all authors. Author MAF identified the samples and write the first version, author AGF designed the work and write the final version and author WMO share the work design and revision. All authors read and approved the final manuscript.

Research Article

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ABSTRACT

Hierakonpolis archaeological site was a Predynastic occupation (3800-3500 B.C.) where the early Egyptian civilization originated. The research aims to discover the cultivated crops in this remote time to recognize life activities of early Egyptians, reconstruct weeds assemblage grow within these crops, also wild plants give us a lot of information about climate and environment prevailed in this time. To reach this aim, soil samples were collected from Predynastic temple area. The samples were sieved and examined under the binocular objective using fine brush and needles and the plant remains were analyzed. Wood and charcoal of native trees were predominant. Cereal refuses, rhizomes, culm fragments, leaves, floral heads were mixed with mud to plaster floor and walls of the temple. Wood of native tall trees like *Acacia nilotica*, *Tamarix aphylla, Tamarix nilotica* and *Balanites aegyptiaca* could have been used for building purposes inside the temple. Comparison and integration of our data with previous archaeobotanical informations from Hierakonpolis, Adaima and El Kab increase our knowledge about habitats and past vegetation of Upper Egypt during Predynastic period. Also agriculture

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practice and food habits of the old Egyptians were recognized. *Triticum dicoccum* and *Hordeum vulgare* were the most important crops. Remains of introduced plant species revealed the relations between inhabitants of Hierakonpolis and their neighbors in the east and south.

Keywords: Archaeobotany; plant macroremains; past vegetation; crops predynastic; Egypt.

1. INTRODUCTION

Archaeobotany deals with the analysis of plants remains (fruits, woods and weed remains) deposited in ancient times to recognize human activities and their reactions with surrounding habitats, also how the man civilization originated and developed, what the crops they cultivated and what they introduced. The present study is based on Predynastic Hierakonpolis archaeological site in the Upper Egypt (25º 06' N, 32º 46'E), it comprises a number of interrelated sites stretching for over 3.5 km on the west bank of the Nile Valley and encompasses several ecozones including the Nubian sandstone formation of the Western Desert of Egypt, low desert palaeo-terraces of the Nile (Sahaba and Masmas Formation) and the floodplain. It locats ca 650 km south of Cairo, and 113 km north of Aswan, between the modern towns of Esna and Idfu. Archaeological excavations at Hierakonpolis provide an excellent opportunity to study well-preserved botanical material from various archaeological features, such as kilns, rubbish mounds, settlement layers and cemeteries from the formative period of Egyptian civilisation, ca. 3800-3100 B.C. [1,2,3].

Since the last century, archaeobotanical studies have been conducted on different localities within the archaeological context of Predynastic Hierakonpolis [4,1,5,6,7,8]. As mentioned above, these localities are different in structure and function. It includes a worker cemetery (HK43), an elite cemetery (HK6), a settlement area (HK11 and 11C), food preparation and brewery areas (HK24A and HK24B) and a Predynastic temple at HK29 and H29A. Discovery of plant macroremains from these different archaeological sites provides us with an exclusive chance to compare and integrate a range of archaeobotanical data sets.

The good level of preservation is attributed to the extremely arid climatic conditions prevailing across southern part of the country now and to a lesser extent in the past. Climatic records of two meteorological stations at Aswan and Qena show that there is an extremely arid climate in this area, with high temperature, low relative humidity, high evaporation rate and a negligible rainfall between 1.4 mm-5.3 mm/year [9]. This area has been described as one of the extremely arid parts of the globe [10], as it is a part of Zonobiome III, the zone of subtropical arid deserts [11].

Archaeobotanical studies increase our knowledge on the conditions of nutrition, economy, agricultural production and environment prevailed in Predynastic Hierakonpolis. The recovery of well-preserved botanical material (charred or desiccated) is a major factor in the success of many archaeobotanical and palaeoethnobotanical research projects in Hierakonpolis. This work focuses on the analysis of all plant macroremains which have been retrieved from locality 29A. Reconstruction of past habitats and vegetation types around the site is another objective of this paper. Locality 29A in Hierakonpolis is located about 250 m S.W of the Nile Valley. A total area ca 600 m^2 of the site were excavated to reveal a large parabolic (oval) shaped courtyard. The oval, which measured over 32 m in length and 13 m in width, was surrounded by fences and mud plastered floor. Initially, this floor appears to have bounded by a mud-covered reed fence which was later replaced by a mud brick wall

[12]. Recent archaeological excavations by Thomas Hikade during the seasons of 2004 – 2007 record presence of four postholes on one side of the oval courtyard. These holes, forming part of the façade of a larger building, once contained wooden poles of more than 12m height. Further rectangular structures were found and interpreted as workshops. Architectural features and the associated artifacts of locality 29A attested that the site was a temple surrounded by workshops. Radiocarbon dates suggests that the site was used in the period between 3636-3351 cal. B.C.

2. MATERIALS AND METHODS

Plant macroremains were gathered by Drs Barbara Adams and Renee Freidman from locality HK29A. Some of the material have been studied by the late Professor M. N. El Hadidi and kept at Cairo University Herbarium. These samples originated from quadrants 140 L 40, 140 L 50, 150 L 50 and 160 L 60. The site in question (Predynastic temple area) was classified into 10 x 10 m^2 quadrants. 31 soil samples (2 liters each) were collected from 8 quadrants for archaeobotanical analysis (Figs. 1 and 2). The age of these materials was confirmed using carbon fourteen.

The samples were sieved through 2 mm sieve to separate stones, large pieces of charcoal and wood. Flotation system was initiated in situ to recover the smaller plant materials. The samples were sorted into components using stereoscopic binocular using magnification between 6x-100x. Each sample was divided into little bits which were examined under the binocular objective using fine brush and needles.

Desiccated and charred wood, branches, grains, chaff and fruits were separated in plastic boxes or in glasses. Desiccated wood and branch fragments were moistened in glycerol/alcohol for 1-24 hour. Thin free hand and/or microtome sections were prepared for every specimen. Sections mounted in Canada balsam or in glycerine-gel. Charcoal fragments were examined under stereo microscope (50x – 100 x) on transverse, tangential and radial sections along fresh hand-made fractures.

Thin sections of desiccated wood, branches, culms, rhizome fragments were identified by comparing them with modern reference slides. References of plant anatomy were used in the identification along with drawings and photographs from archaeobotanical and anatomical studies viz. [13,14,15,16,17,18,19,20].

Seeds, fruits, floral heads and leaves were compared with modern reference collection at the Herbaria of Cairo, Helwan and Beni-Suef Universities. Drawings and photographs from floristic, taxonomic and archaeobotanical publications were used to identify the plant remains under study viz. Boulos [21,22,23,24,25,26,27,28,29,30,31,32]. Nomenclature, citation and arrangement of wild species follows [33]. Nomenclature of cultivated plants is according to [34].

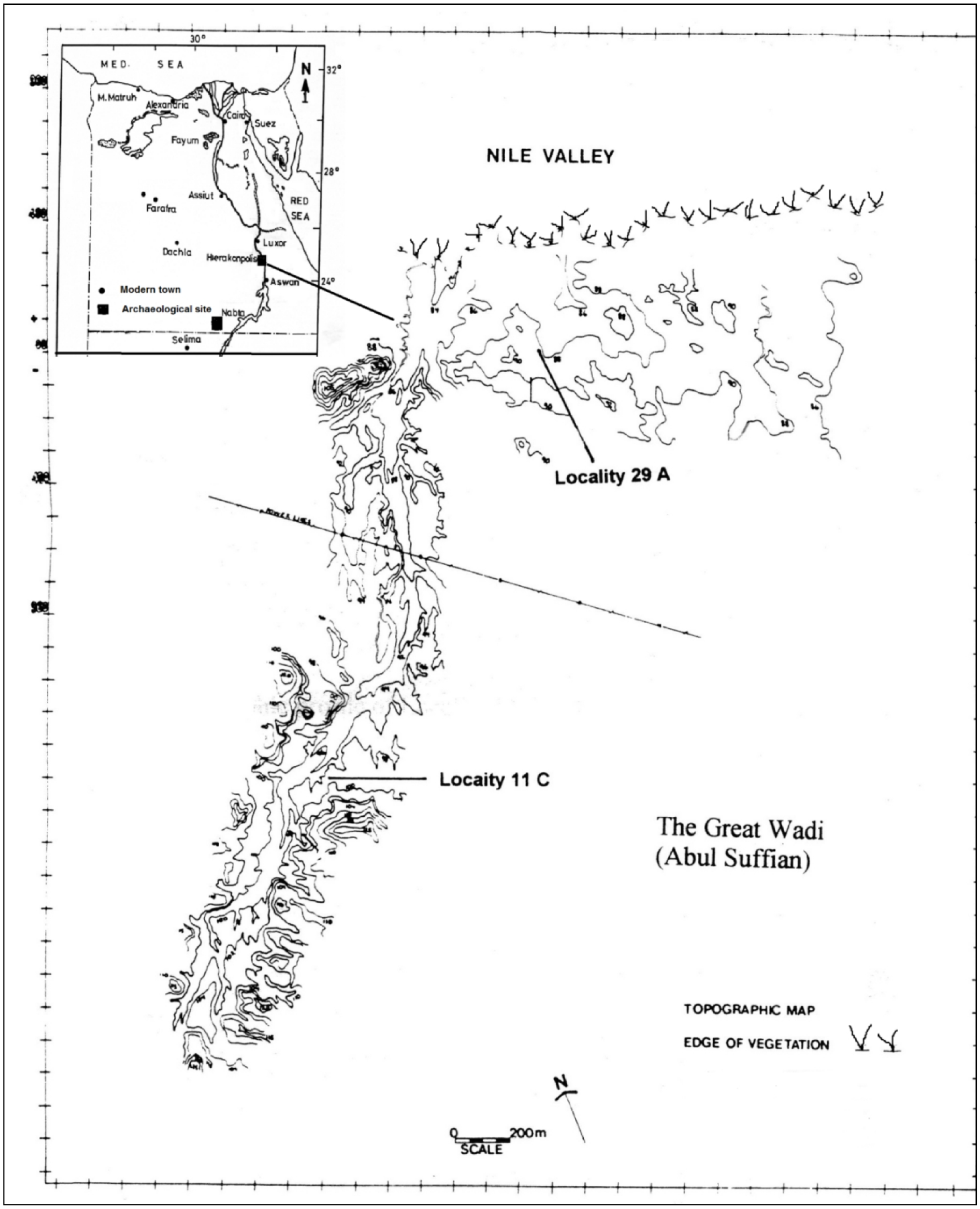

Fig. 1. Map of Hierakonpolis concession shows locations HK 29A, HK 11C; Location map of archaeological sites and modern cities mentioned in text

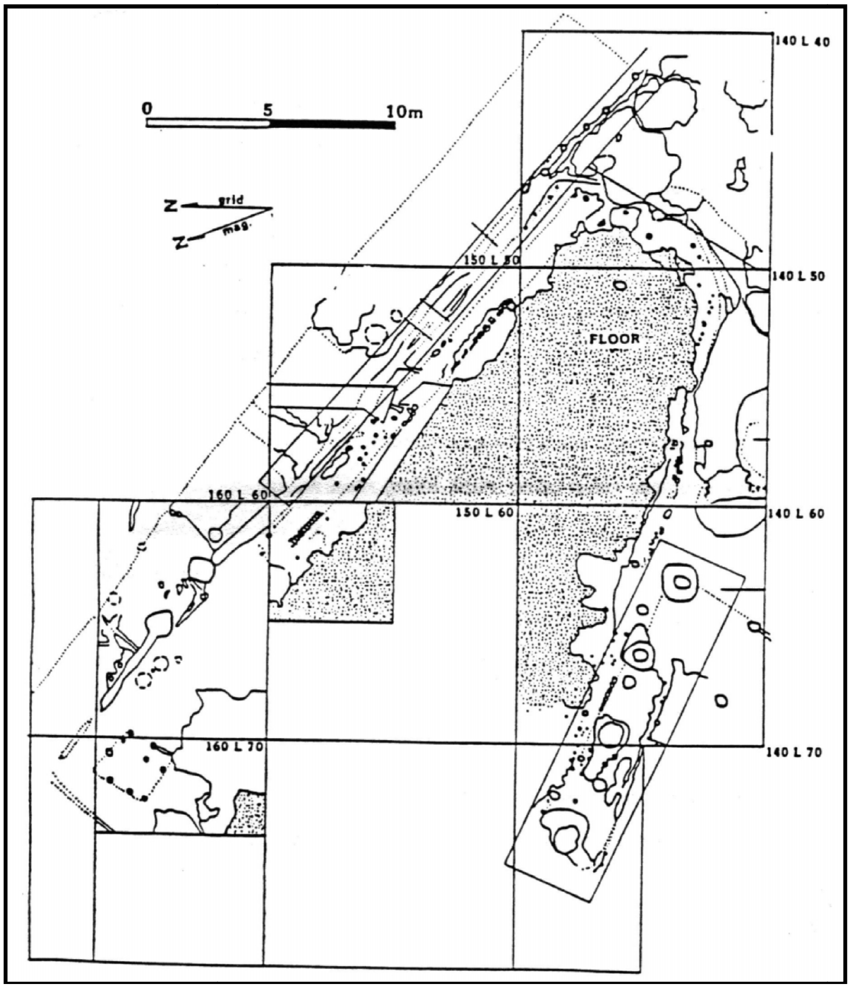

Fig. 2. Plan of the excavated area at locality 29A showing quadrants studied

3. RESULTS AND DISCUSSION

3.1 Results

Analysis of soil samples from locality HK29A revealed presence of well preserved botanical material. A total of 1607 plant macroremains has been separated from all samples. They have been attributed to 39 species. Table 1 showed that desiccated wood and charcoal fragments dominated other forms of plant macroremains in the studied botanical material by 71.6%. Remains of wild species included rhizomes, leaf fragments, floral heads were occurred by 20%. Cereal chaff and vegetables remains were represented by 7.5%. Remains of edible fruits were represented by 1% of the total amount of the plant macroremains.

Table 1. Total numbers of macroremains separated from locality HK29A

Quadrant type of remains	140L10	140L40	140L50	140L60	140L70	150L50	160L50	160L60	Total
Wood & Charcoa	34	164	102	157	134	433	48	79	1151
Rhizomes, branches	11	45	57	-	7	185	1	16	322
Leaves & floral heads									
Cereal chaff & vegetables	1	7	3	-	1	109	-	-	121
Edible fruits	-	3	-	-	-	10	-	-	13
Total	46	219	162	157	142	737	49	95	1607
%	2.9	13.6	10	9.7	8.8	45.9	3.1	6	100

The highest record of botanical remains (45.9%) was recorded from quadrant 150L50. Smaller amounts of plant macroremains were recorded from quadrants 140 L 40 (13.6%), 140 L 50 (10%), 140 L 60 (9.7%), 140 L 70 (8.8%). Even smaller quantities of botanical remains were observed in quadrants 140 L 10 (2.9%), 160 L 50 (3.1%) and 160 L 60 (6%). Remains of emmer wheat and barley have been separated from five quadrants at locality HK29A. The highest record of cereal remains was recorded from quadrant 150L50. Also, this quadrant is characterized by presence of charred grains of emmer wheat and barley.

Table 2 showed that desiccated cereal chaff of both cereals were recorded in small numbers. The remains of emmer wheat are more common than those of barley.

Table 2. Numbers of identified wild macroremains of cultivated plants, HK29A

Quadrant species	140L10	140L40	140L50	140L70	150L50	Total
Triticum diccocum						
Charred grain	-	-	1	-	23	24
Desiccated spikelet forks	-	-	-	-	30	30
Hordeum vulgare						
Desiccated spikelet	1	-	-	-	1	2
Charred grains	-	-	-	-	10	10
Desiccated rachilla	-	2	2	-	7	11
Cereal						
Desiccated culm fragment	-	5	-	-	22	27
Charred culm fragment.	-	-	-		13	13
Cucumis melo (Desiccated seed)	-	-	-	1	3	4
Total	1	7	3	1	109	121

Amount of desiccated cereal remains in our material is small, however it can be compared with archaeobotanical studies mentioned above on uses of cereals in Predynastic Hierakonpolis. We believe that the cereal chaff had been mixed with soil and used to plaster floor of the courtyard at 29A. Presence of charred grains of wheat and barley together with highest amount of charcoal at quadrant 150L50 is very interesting and required a comment. Association of charcoal and charred grains together may indicate function of quadrant 150L50 which could be linked with food preparation.

Four desiccated seeds of *Cucumis melo* were found in quadrants 140L70 and 150L50. *Cucumis melo* has been recorded in other localities at Hierakonpolis like HK11, HK11C and HK43 [1,5]. Melon fruits (*Cucumis melo*) were introduced into the site as a fresh vegetable. Stones of two edible fruits, balanos (*Balanites aegyptiaca*) and Sidder (*Ziziphus spina-christi*) were discovered among the archaeological sediment of two quadrants. One stone of *Balanites aegyptiaca* and two stones of *Ziziphus spina-christi* were separated from quadrant 140L40, while 10 stones of *Ziziphus spina-christi* were found in quadrant 150L50 (Table 3).

Table 3. Numbers of macroremains of edible fruits of identified Wild species, HK29A.

Species\ quadrant	140L40	150L50	Total
Ziziphus spina-christi			
Desiccated stone	2	10	12
Balanites aegyptiaca			
Desiccated endocarp	1	-	1
Total	3	10	13

Fruits of both trees had played a major role as supplement to human diet in Predynastic Hierakonpolis. Both fruits have been recorded as offerings in tombs dated to Predynastic, Pharaonic and Graeco-Roman periods [35]. This category included remains of wild species which were represented in our samples by leaf fragments, rhizomes, floral heads, seeds and fruits. Desiccated branches and floral heads of *Ceruana pratensis* were found in seven quadrants (Table 4). The highest number of *Ceruana pratensis* remains were found at quadrant 150L50. Until today we do not have any archaeobotanical evidence to confirm that in Predynastic Egypt there were brooms manufactured from *Ceruana pratensis* [35]. The material from Adaima originated from pits which could be silos and the botanical material consists basically of cereal remains and no evidence of cereal grains was found.

However, we should keep in mind that *Ceruana pratensis* grew on canal banks across the fields and it reaches 60 cm height [23] and it has been recorded as a field weed in Upper Egypt [36]. In Predynastic Hierakonpolis, *Ceruana pratensis* was probably gathered with emmer wheat and barley and subjected to the same steps of crop processing and its remains were accumulated at the end with the crop by-product. In a trash mound at locality HK11C in Hierakonpolis, desiccated heads, achenes and branches of *Ceruana pratensis* were found mixed with dense layers of emmer wheat and barley chaff [1]. It represents 16% of the total amount of plant remains. In addition, remains of 25 field weeds were recorded in association with *Ceruana pratensis* from the same material [1]. This record would suggest that *Ceruana pratensis* grew as a field weed in Predynastic Hierakonpolis. Locality HK29A is not linked with any steps of crop processing. This is evident from the very low amount of cereal chaff retrieved from this locality. Hence, twigs and heads of *Ceruana pratensis* here could have been mixed with the soil to support the tempered floor of the temple court. The inhabitants had brought soil from canal bank areas where *Ceruana pratensis* grew. This opinion could be supported by the presence of rhizomes and culm fragments of water loving plants in the material under study like *Phragmites australis*, *Imperata cylindrica* and *Desmostachya bipinnata* which could have been mixed with soil too. Leaf fragments of *Phoenix dactylifera* were retrieved from quadrants 140L40, 140L50 and 150L50. Leaves of date palms were used for making baskets, mats, ropes and for roofing buildings. Various remains of *Desmostachya bipinnata* and *Imperata cylindrica* were isolated from quadrants 140L40, 150L50 and 160L60. Rhizome and culm fragments of *Imperata cylindrica* were identified from quadrant 150L50. Desiccated culm fragments of *Phragmites australis* were recorded in quadrants 140L40 and 150L50. Desiccated rhizome fragments of *Cynodon dactylon* were retrieved from quadrants 140L50 and 160L60. Desiccated culm fragments of Brachiaria sp. were recorded from quadrant 150L50 while that of *Arundo donax* were isolated from quadrant 140L40. Presence of this assemblage of reed and halfa grasses would indicate presence of accessible stands of these plants nearby the site. Growth of halfa grasses (*Desmostachya bipinnata* and *Imperata cylindrica*) was linked with high levels of ground water tables, while the reed vegetation (*Phragmites australis* and *Arundo donax*) grew on canal banks and swampy areas [37].

Heads and desiccated achenes of *Senecio aegyptius* were isolated from quadrants 140L10 and 140L40. This plant has been recorded by [1] from locality HK11C. It is an annual herb grows on silty canal banks along the Nile valley. Desiccated seeds of *Citrullus colocynthis*, a plant that flourished in desert wadis, were identified from quadrants 140L50 and 150L50. Three desiccated seeds of *Acacia sp*. were recorded in quadrant 140L40.

Three desiccated seeds of *Calotropis procera* and two desiccated pods of *Trigonella glabra* were recorded in quadrant 150L50. One desiccated pod fragment of *Acacia nilotica* and another desiccated spikelet of *Stipagrostis* were identified from quadrants 140L40 and 140L50 respectively.

Charcoal and desiccated wood of native trees have been recorded in almost all samples from HK29A (Table 5). The highest numbers and percentages of wood and charcoal have been recorded *for Acacia nilotica, Tamarix aphylla, Tamarix nilotica, cf Ficus sp., Balanites aegyptiaca* and *Faidherbia alba* (Fig. 3).

These taxa were recorded in previous archaeobotanical studies on other localities at Hierakonpolis, like HK6, HK11, HK11C and HK43 [1,7]. Desiccated and charred wood fragments of *Acacia nilotica* were recorded from all quadrants studied at HK29A. Wood of this tree was the most common in HK29A. Wood fragments of *Tamarix aphylla* were retrieved from quadrants 140L40, 140L50, 140L60, 140L70, 150L50 and 160L60. Remains of *Tamarix nilotica* were identified from quadrants 140L40, 140L50, 140L60, 140L70 and 160L60. This would indicate that wood of *Acacia* and *Tamarix* was of common use as fuel and timber resources. Desiccated and charred wood fragments of cf *Ficus sp*. were separated from quadrants 140L10, 140L40, 140L50, 140L60, 140L70, 150L50 and 160L60. *Balanites aegyptiaca* were recorded from quadrants 140L40, 140L50, 140L60, 140L70, 150L50 and 160L60 mostly as charred wood. Wood of *Faidherbia albida* was occurred in quadrants 140L60, 150L50, 160L50 and 160L60 mainly as charred wood.

Desiccated wood of five woody perennials were represented in lower quantities (Table 5), namely: *Capparis decidua, Hammada elegans*, *Zygophyllum coccineum, Fagonia bruguieri* and *Agathophora alopecuroides.* Charcoal and wood of *Hyphaene thebaica*, *Salix tetrasperma, Tamarix tetragyna* and *Phoenix dactylifera* were very rare in our material. A few wood fragments are attributed to introduced conifer wood; they are *Cupressus semperiverense, Juniperus phoenecia* and *Cedrus libani*. Wood of *Cupressus semprivirense* (15 fragment) have been identified from quadrant 150L50, while three fragments of *Juniperus phoenicea* were reported from quadrants 140L40 and 140L50. *Cedrus libani* was represented by two wood fragments separated from quadrant 140L50.

Table 4. Numbers of identified woody plant macroremains of wild species, 29A, Hierakonpolis. d: desiccated, c: charred

Quadrant species	140L10	140L40	140L50	140L70	150L50	160L50	160L60	Total
Ceruana pratensis								
Branch (d)	1	16	42	4	105	1	11	246
Head (d)	-	14	8	3	41	-	-	
Phoenix dactylifera								
Leaflet fragment (d)	-	-	3	-	10	-	-	14
Midrib fragment (d)	-	1	-	-	-	-	-	
Desmostachya bipinnata								
Rhizome (c)	-	2	-	-	-	-	-	
Culm (c)	-	-	-	-	3	-	-	12
Culm (d)	-	3	-	-	-	-	4	
Senecio aegyptius								
Head (d)	1	-	-	-	-	-	-	
Head (c)	-	1	-	-	-	-	-	11
Achene (d)	9	-	-	-	-	-	-	
Imperata cylindrica								
Rhizome (c)	-	-	-	-	3	-	-	
Rhizome (d)	-	-	-	-	2	-	-	8
Culm (d)	-	-	-	-	3	-	-	
Imperata/Desmostachya (Leaf, d)	-	-	-	-	5	-	-	5
Citrullus colocynthis (Seed, d)	-	-	2	-	4	-	-	6
Acacia sp. (Seed, d)	-	3	-	-	-	-	-	3
Calotropis procera (Seed, d)	-	-	-	-	3	-	-	3
Phragmites australis Culm fragment (d)	-	2	-	-	1	-	-	3
Cynodon dactylon Rhizome fragment (d)	-	-	1	-	-	-	1	2
Trigonella glabra (Fruit, d)	-	-	-	-	2	-	-	2
Hibiscus sp.								
Fruit (d)	-	1	-	-	-	-	-	2
Seed (d)	-	1	-	-	-	-	-	
Brachiaria sp. (Culm, d)	-	-	-	-	2	-	-	2
Acacia nilotica								
Pod fragment (d)	-	-	-	-	1	-	-	1
Stipagrostis (Spikelet, d)	-	-	1	-	-	-	-	1
Arundo donax (Culm, d)	-	1	-	-	-	-	-	1
Number of fragments	11	45	57	7	185	1	16	322

Table 5. Numbers of wood and charcoal fragments/species from Locality 29A in Predynastic Hierakonpolis, d : Desiccated wood

Quadrant species	140L10	140L40	140L50	140L60	140L70	150L50	160L50	160L60	Total
Acacia nilotica									
Wood (d)	6	11	23	-	-	40	10	-	331
Charcoal	10	14	16	49	46	87	11	8	
Tamarix aphylla									
Wood (d)	-	11	12	-	3	44	-	-	220
Charcoal	-	30	3	18	30	50	-	19	
Tamarix nilotica									
Wood (d)	-	20	3	-	-	26	-	1	190
Charcoal	15	21	7	30	22	30	-	15	
Cf Ficus sp									
Wood (d)	-	-	-	-	-	11	-	-	181
Charcoal	-	15	15	36	29	48	15	12	
Balanites aegyptiaca									
Wood (d)	-	-	-	-	-	2	-	-	102
Charcoal	-	24	12	10	4	41	-	9	
Faidherbia albida									
Desiccated wood	-	-	-	-	-	1	-	-	51
Charcoal	-	-	-	9	-	22	12	7	
Capparis decidua (d)	-	11	2	-	-	2	-	2	17
Cupressus sempervirens (d)	-	-	-	-	-	15	-	-	15
Hammada elegans(d)	-	2	5	-	-	-	-	-	7
Zygophyllum coccineum (d)	-	-	-	-	-	5	-	-	5
Palmae (Charcoal)	3	-	1	-	-	-	-	-	4
Juniperus phoenicea (d)	-	2	1	-	-	-	-	-	3
Cedrus libani (d)	-	-	2	-	-	-	-	-	2
Salix tetrasperma (d)	-	1	-	-	-	1	-	-	2
Fagoni bruguieri (d)	-	1	-	-	-	-	-	1	2
Tamarix tetragyna (d)	-	-	-	-	-	1	-	-	1
Agathophora alopecuroides (d)	-	-	1	-	-	-	-	-	1
Number of fragments	34	164	102	157	134	433	48	79	1151

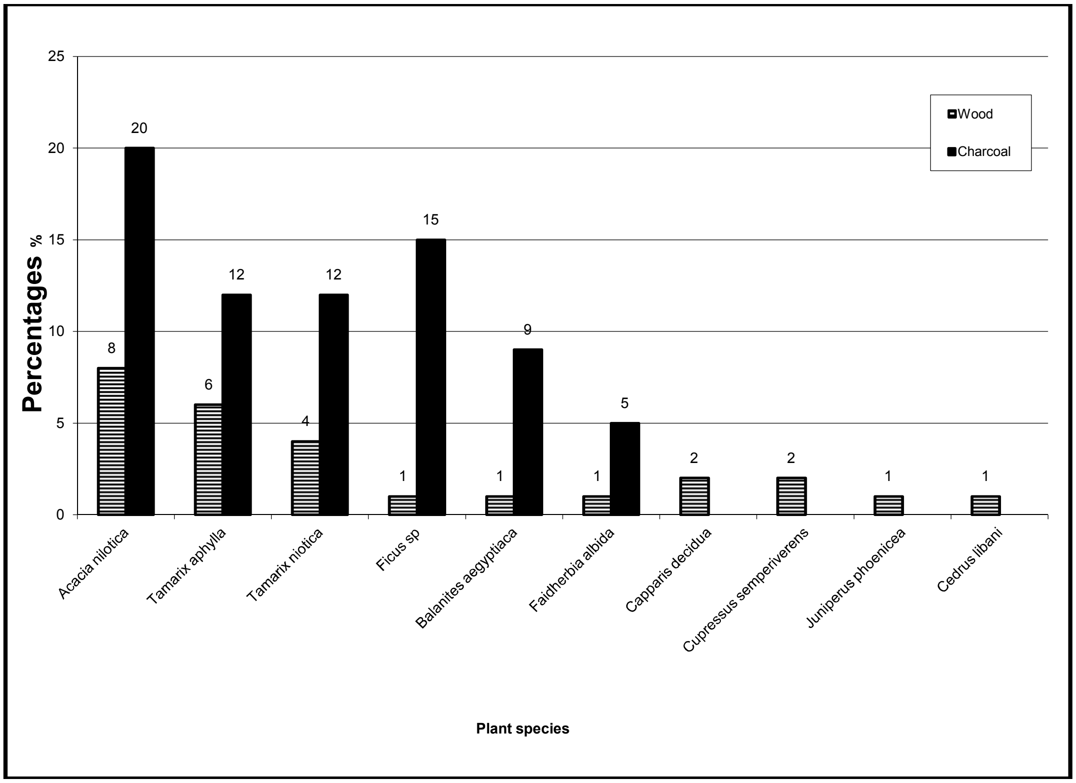

Fig 3. Wood and charcoal separated from locality HK 29A. (nb=1151)

4. DISCUSSION

The present study provides an opportunity to discuss and evaluate plant exploitation in Predynastic Hierakonpolis. The total number of plant macroremains separated from locality HK 29A is small (n=1607) compared to other localities at Hierakonpolis like HK11C (n=6996[(1]) and HK 43 (n= 2841 [5]).

Tall posts of native wood have been used for construction purposes inside the temple at HK29A. Excavations by Thomas Hikade during the seasons of 2006-2007 reveals the presence of a building once contained wooden poles of more than 12 m height. Trunks of *Acacia nilotica* and *Faidherbia albida* trees can grow more than 15 m tall [21], *while Balanites aegyptiaca* reach 10 m tall [22]. It is clear that there is a remarkable high record of wood and charcoal characterizes structure of the botanical material from HK29A (Fig. 4).

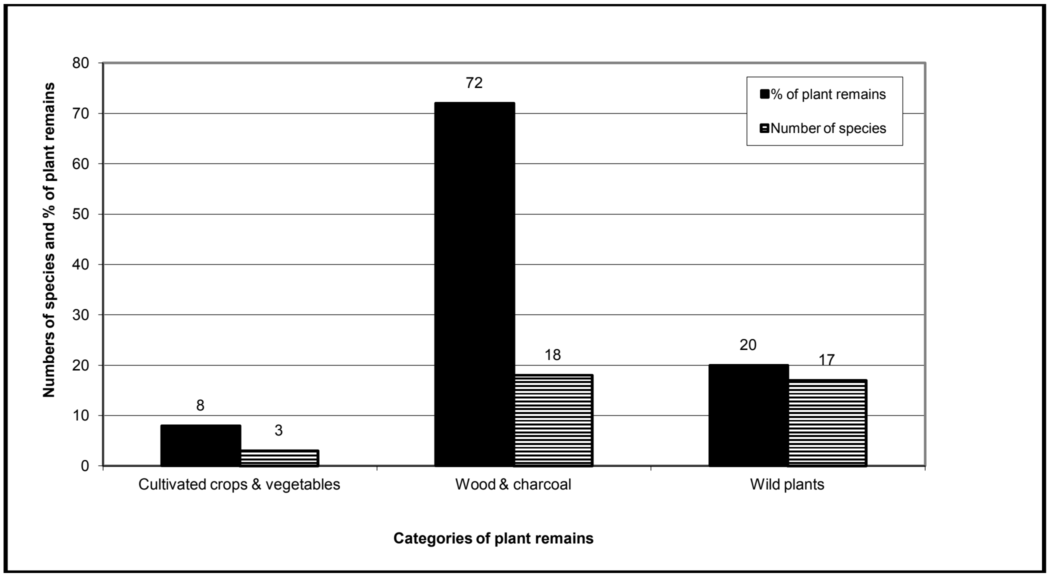

Fig. 4. Botanical structure of locality 29 A. (nb = 1607)

Presence of charcoal fragments could be linked with ceremonies which had been held inside the temple during the Predynastic period. *Acacia nilotica, Tamarix aphylla, Tamarix nilotica* and *cf. Ficus sp*. were major sources of charcoal and wood. Also, considerable amounts of wood and charcoal fragments were attributed to *Balanites aegyptiaca* and *Faidherbia albida*. It is interesting to notice that desiccated wood only of perennial herbs (xerophytes) were found in very low numbers: *Agathophora alopecuroides, Capparis decidua, Fagonia brugieri, Hammada elegans* and *Zygophyllum coccineum*. Desiccated and charred remains of cereals were represented by 8% only of the total amount of plant macroremains. 20% of the botanical material have been attributed to rhizomes and culms of wild plants. It seems that mud had been mixed with parts of wild plants including rhizomes and culms as well as cereal chaff to plaster floor of the temple (Fig. 4).

Figs. 5 and 6 show that the botanical structure of locality HK11C and HK43 consists of four categories: cultivated crops and vegetables, field weeds, wood and charcoal as well as wild plants. Cereal chaff remains was the dominant category of the botanical material retrieved from the trash mound at locality HK11C. On the other hand, the cemetery of locality HK43 was dominated by offerings of wild plants. Available archaeobotanical evidence from Predynastic Adaima, 25 km north of Hierakonpolis showed that soil had been mixed with different cereal remains and other botanical material for lining walls and floors of pits which could have been used as silos [35]. A similar record has been found in Ahmar at Mureybet, Northern Syria [38]. The botanical structure of the temple at locality HK29A contained three categories: cultivated crops and vegetables, field weeds, wood and charcoal as well as wild plants. We notice that locality HK29A is characterized by dominance of wood and charcoal fragments as well as absence of field weeds. This would confirm that the botanical material retrieved from archaeological sites could be used as indicators on function of archaeological sites.

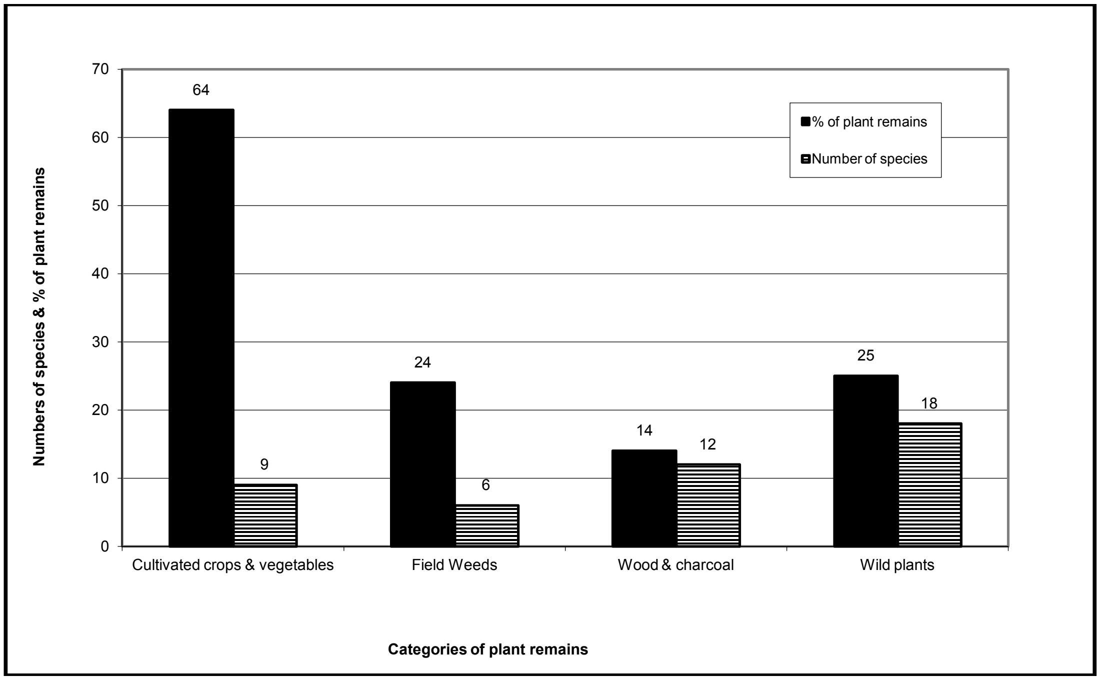

Fig. 5. Botanical structure of locality HK 11C

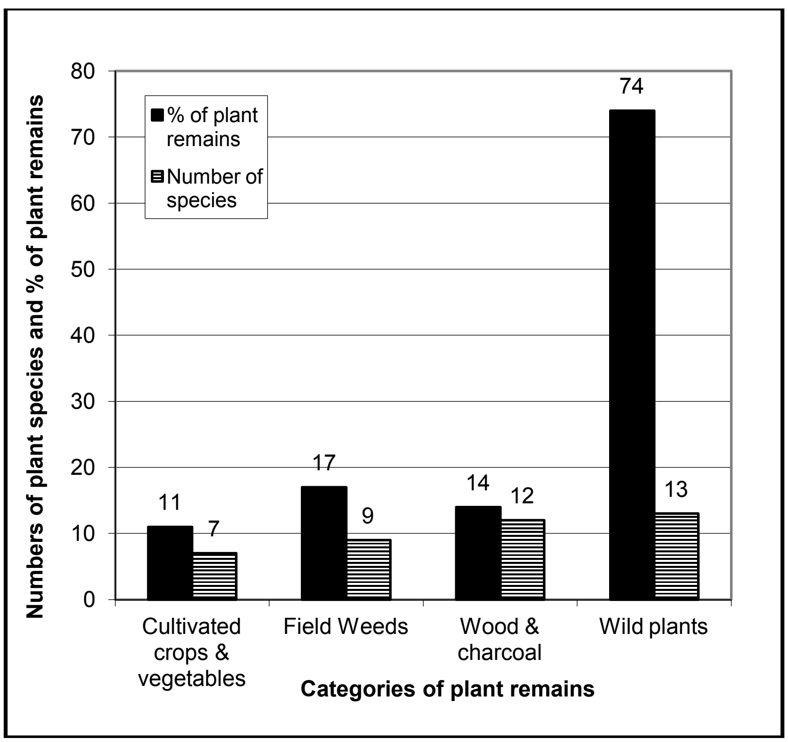

Fig. 6. Botanical structure of locality HK 43

Wood and charcoal of some native trees and shrubs occur frequently in high numbers from at least 4 samples of the 8 samples from locality HK29A (Table 5). This group included remains of *Acacia nilotica, Tamarix aphylla, Tamarix nilotica, Ficus sp., Balanites aegyptiaca* and *Faidherbia alba*. High abundance of wood and charcoal of native trees and shrubs would indicate their dominance in the plant communities flourished around the site. On the other hand, rest of the taxa in Table 5 are represented by small number of wood fragments and occur in less samples. This group includes remains of xerophytes like *Agathophora alopecuroides, Capparis decidua, Fagonia bruguieri, Hammada elegans, and Zygophyllum coccineum as well as remains of introduced foreign wood Cupressus semperivirens, Juniperus phoenicea* and *Cedrus libani.*

In this study we have been able to identify specimens until species level like *Acacia nilotica, Tamarix nilotica* and *Tamarix aphylla.* We should keep in mind that many species have a large ecological amplitude which means that these taxa can grow in different types of habitats. In case of most frequent taxa *like Acacia nilotica, Tamarix aphylla* and *T. nilotica*, their abundance and large ecological amplitude could be attributed to the fact that these taxa can grow in a variety of plant communities existed in different habitats around the site.

4.1 Plant Life in Predynastic Hierakonpolis

This section discusses aspects of plant life in Predynastic Hierakonpolis including plant habitats and plant communities. It interprets archaeobotanical data from this work as well as integrates data from other localities like HK11C and HK43. Also, we will consider archaeobotanical results obtained from Predynastic Adaima and El Kab [39,40].

Available archaeological and geological data prove that in Hierakonpolis, the cultivated fields were stretched along the Nile and surrounded by desert wadis and plains from the western side. Archaeobotanical evidences confirm that flood plain of the Nile river was cultivated with cereals and vegetables [1;5,6]. Seeds of *Cucumis melo* have been recorded in Ma'adi of lower Egypt [41,42]. [43] reported the presence of two melons depicted on the wall of grave number 17 in Saqqara (5th Dynasty). The trash mound at locality HK 11C includes remains of five cereals: emmer wheat, two rowed barley, six rowed barley, free threshing wheat and barley. Also, remains of cultivated melons were discovered from the same locality. Both *Cucumis melo* and *Phoenix dactylifera* are cultivated, the first is not recorded in the Egyptian flora and the second needs artificial pollination to produce good fruits. The remains of cereals were mixed with seeds and fruits of 24 species of field weeds. Such high number of field weeds would indicate a large scale of cereals cultivation on the flood plain as a major counterpart of the agricultural economy of Predynastic Hierakonpolis (3800-3500 cal BC).

Wood and charcoal fragments of riparian species were frequently recorded in most of the samples. This type of vegetation included trees of *Acacia nilotica, Faidherbia alba, Ficus sp., Salix tetrasperma* and *Tamarix nilotica*. Possible areas where these taxa grew could be between cultivated fields, canal banks and fallow land along the Nile flood plain. A similar assemblage of taxa has been identified in charcoal fragments separated from the archaeological sites in Adaima and El Kab, 25-35 Km to the north of Hierakonpolis [43]. Charcoal fragments of *Tamarix* were frequently recorded in the samples of Adaima, while *Acacia sp*. were dominant in the samples from El-Kab. Fig. 3 shows that the botanical material of HK29A was dominated by charcoal and wood of *Acacia nilotica*. Today Acacia nilotica flourishes on canal banks and moist ground habitats [21]. We believe that *Acacia nilotica* grew during the Predynastic period in similar habitats along the Nile. Associated species belonged to this riparian vegetation included trees, shrubs and herbs of *Ceruana* *pratensis, Ficus sp., Salix tetrasperma, Ziziphus spina-christi, Desmostachya bipinnata* and *Imperata cylinderica*. [37] reported that these taxa are characterized by intricate root system forming inter-wining network that hold the soil together, being effective because the dense clumps prevent the surface soil being disturbed.

Swampy areas could have occurred as patches in and around the Nile flood plain as well as fallow land of high underground water table. Today, in swampy parts along the Nile, reeds grow near water usually with their root and lower parts of their shoot system below the water level [37]. Available archaeobotanical evidence from localities HK6, HK11C, HK29A and HK43 suggest that swamps existed in Predynastic Hierakonpolis [1,5]. *Phragmites australis* and *Typha* grew in dense stands on waterlogged soil on margins of the swamps. The identified plant remains of Hierakonpolis comprise most of the species of the modern reed swamp vegetation form. Some water loving taxa were expected to grow in Hierakonpolis on wet edges close to the flood plain like *Crypsis alopecuroides, C. schoenoides, C. rotundus, Fimbrystylis bisumbellata, Rumex dentatus* and *Senecio aegyptius.*

The landscape west of the Nile flood plain of Hierakonpolis lies within the western desert of Egypt which belongs to Eastern Sahara. Topography of this area is irregular and includes three major wadis (Tarifa, Khamasini and Abu Suffian), many depressions, small runnels, plateaus and plains. This desert landform existed during the Predynastic period.

During the period 7000 – 5000 BP, [44] assumed a mean annual rainfall between 50 mm and 100 mm for the western desert between the cities of Esna and Idfu (80 km north and 30 km south of Hierakonpolis, respectively). [45] has concluded that during this period the subtropical vegetation zones were extended towards the north about 500 -600 km more than today. Irregular topography of the desert resulted in forming relatively dense and contracted vegetation in depressions, wadis and runnels [46]. This is due to the fact that lower areas may receive a considerable supply of water, while at higher elevations most of the rain that is received runs down to the lower region. However, a diffuse type of vegetation could evenly distributed in areas with rainfall above 100 mm per annum [46]. These facts on relationship between topography and rainfall in the desert should be considered when we reconstruct the past vegetation of Predynastic Hierakonpolis.

An open vegetation grew on sandy plains around the site, especially on margins of the floodplain where underground water table was high. This plant cover could have been dominated by shrubs of *Tamarix nilotica* and trees of *Tamarix aphylla.* Associated taxa includes woody plants of *Agathophora alopecuroides, Calotropis procera, Citrullus colocynthis, Fagonia bruguieri, Hammada elegans,* and *Zygophyllum coccineum. Tamarix nilotica* is an important species in many plant communities described from the western desert. The wide distribution of this tree could be related to its wide ecological amplitude. It grows on sand dunes and parts of salt marshes with the deepest sand deposits. The shrubs of *T. nilotica* are more vigorous on the sand dunes than in the salt marshes [37]. Some of the xerophytes reported from Hierakonpolis are still growing as associates in many phytocoenosis of *Tamarix nilotica* in the western desert [10;37].

A contracted desert vegetation grew in wadis, small runnels and depressions around the site. This type of plant cover was dominated by trees of *Balanites aegyptiaca* and *Faidherbia albida.* Associated species included woody perennials of *Capparis decidua, Fagonia bruguieri* and *Zygophyllum coccineum.*

The inhabitants of Hierakonpolis had exploited all habitats around the site. They had established a strong agricultural economy based on intensive cultivation of cereals on the Nile flood plain. Emmer wheat and barley were major crops as well as melons (*Cucumis melo*). They have gathered wild fruits of Christ's thorn (*Balanites aegyptiaca*) from trees grew along the riverine vegetation while the fruits of *Balanites aegyptiaca* were collected from stands in desert wadis around the site. The tall trunks of *Acacia nilotica*, *Balanites aegyptiaca* and *Faidherbia albida* could have been used in construction purposes inside the temple. Branches of *Tamarix nilotica* were a good source for fuel while its wood for making fences.

Few numbers of wood fragments have been attributed to three coniferous taxa: *Cupressus semprivirense, Juniperus phoenicea* and *Cedrus libani*. None of these trees is native to the flora of Egypt, except few shrubs of *Juniperus phoenicea* which are growing in limited areas in North Sinai (Gebel Halal and Gebel El Maghara). There is no evidence in the archaeobotanical record to suggest that these taxa were grown in ancient Egypt. These taxa were brought from Syria and Palastine in the east.

5. CONCLUSION

Integration of archaeobotanical results from localities HK29A, HK11C at Hierakonpolis with those obtained from Adaima and El Kab [40] provides an excellent opportunity to reconstruct the Predynastic vegetation in Upper Egypt. During the period between 3600-3000 cal BC, the vegetation around Hierakonpolis, Adaima and El Kab was similar. It was highly diversified when we compare it with the current plant cover. The following types of vegetation could be reconstructed in Upper Egypt during the Predynastic period:

1. A riverine plant cover along the Nile
2. An arable vegetation including fields of cereal cultivation along the Nile flood plains
3. A ruderal vegetation in the flood plain including swamps of reeds.
4. A desert plant cover stretches westward and eastward of the Nile valley. An open vegetation could cover the desert plains while a contracted one characterized mouths of wadis
5. A salt marsh vegetation dominated by halophytes on sabkhas (areas with bad drainage and high salt contents).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Boulos L. Flora of the Nile Region in Egyptian Nubia. Feddes Repert. 1966;83(3):183-215.
2. Fahmy AG. Evaluation of the Weed Flora of Egypt from Predynastic to Graeco-Roman Times, J. Veget. Hist. and Archaeobot. 1997;6(4):241-247.
3. Friedman R, Watrall E, Jones J, Fahmy AG, Van Neer W, Linseel V. Excavations at Hierakonpolis. Archeo-Nil. 2002;12:55-68.
4. El-Hadidi MN. The Predynastic Flora of Hierakonpolis region. In The Predynastic of Hierakonpolis - an interim report. Edited by M.A. Hoffman (ed.). Egyptian Studies Association. 1982;102-115.

5. Fahmy AG. Palaeoethnobotanical studies of the Egyptian Predynastic cemeteries. New dimensions and contributions. In 3rd International Workshop on African Archaeobotany, Frankfurt, Germany. Heinrich Barth Institute, Köln; 2003.
6. Fahmy AG. Missing plant macro remains as indicators of plant exploitation in Predynastic Egypt. J.Veget. Hist. and Archaeobot. 2005;14:287-294.
7. Fahmy A, Barakat H. Plant macro remains from tomb 11. In Excavations in the locality 6 cemetery at Hierakonpolis 1979 – 1985, Barbara Adams. British Archaeological Reports (BAR), Oxford; 2000.
8. Fahmy AG, Khodary S, Fadl M, ElGarf I. Plant macroremains from an elite cemetery at Predynastic Hierakonpolis, Upper Egypt. International Journal of Botany. 2008;4(2):2005-2012.
9. Anonymous. Climatic Normals of Egypt. Ministry of Military Production. Meteorological Department. Cairo; 1960.
10. Bornkam R, Kehl H. Landscape ecology of the Western Desert of Egypt. J. Arid Environ. 1990;17:271-277.
11. Walter H. Vegetation und Klimazonen. UTB. Ulmer, Stuttgart; 1984.
12. Hoffman MA. The Predynastic of Hierakonpolis, an interim report. Egyptian Studies Association, Cairo; 1982
13. El-Hadidi MN, Waly NM. Wood anatomy of some Egyptian woody perennials and its adaptation to environmental conditions. Taeckholmia. 1991;16:31-44.
14. Fahn A. Plant anatomy. 3rd edition. Pergamon Press. Oxford; 1982.
15. Fahn A, Werker E, Baas P. Wood anatomy and identification of trees and shrubs of Israel and adjacent regions. Israel Academy of Sciences and Humanities, Jerusalem; 1986.
16. Greiss EI. Anatomical Identification of some ancient Egyptian materials. Mem. Inst. Egypt. 1957;55.
17. Neumann K, Schoch W, Détienne P, Schweingruber FH, Richter HG. Woods of the Sahara and the Sahel, Haupt, Berlin; 2001.
18. Waly NM. Identified Wood Specimens from Tutankhamun Funerary Furniture. Taeckholmia. 1996;16:61-74.
19. Waly NM. Wood anatomical characters of the Egyptian *Tamarix* L. species and its taxonomic significance. Taeckholmia. 1999;19(2):115-126.
20. Wheeler EA, Baas P, Gasson PE. IAWA list of microscopic features for hard wood identification. IAWA Bull. 1989;10(3):219-332.
21. Boulos L. Flora of Egypt. Al Hadara. Cairo. Egypt; 1999.
22. Boulos L. Flora of Egypt. Al-Hadara. Cairo. Egypt; 2000.
23. Boulos L. Flora of Egypt. Al-Hadara. Cairo. Egypt; 2002.
24. Boulos L. Flora of Egypt. Al-Hadara. Cairo. Egypt; 2005.
25. CopeTA, Hosni HA. A key to the Egyptian Grasses. Royal Botanic Gardens, Kew and Cairo University Herbarium; 1991.
26. Cope TA, Hosni HA. A key to the Egyptian Grasses. Royal Botanic Gardens. Kew and Cairo University Herbarium; 1991.
27. El-Hadidi MN. The genus *Fagonia* L.in Egypt. Candollea. 1966;21(1):13-54.
28. El-Hadidi MN, Hosny H. Flora Egyptiaca. The Palm Press. Cairo. 2002;11:151.
29. Fayed A, Zareh M. Systematic revision of *Compositae* in Egypt. 2. Tribe *Senecioneae* Cass. Taeckholmia. 1987;10:67-75.
30. Täckholm V. Student Flora of Egypt. 2nd ed. Cairo Univ; 1974.
31. Zohary M. Flora Palaestina. The Israel Academy of Sciences and Humanities. Jerusalem; 1966.
32. Zohary M. Flora Palaestina. The Israel Academy of Sciences and Humanities, Jerusalem; 1972.

33. Boulos L. Flora of Egypt Checklist. Al-Hadara. Cairo. Egypt; 1995.
34. Schultze-Motel J. Rudolf Manfsfield verzeichnis landwirtschaftlicher und grätnerischer Kulturpflanzen (ohne Ziepflanzen). 4 bände. Springer- Verlag, Berlin; 1986.
35. Vartavan C, Asensi Amoros V. Codex of Ancient Egyptian Plant Remains. London: Triade Exploration; 1997.
36. Boulos L, El-Hadid MN. The weed flora of Egypt. American University of Cairo, Cairo. Egypt; 1984.
37. Zahran MA, Willis AJ. The Vegetation of Egypt. Chapman and Hall. London; 2009.
38. Willcox GH, Fornte S. Impressions of wild cereal chaff in pise from the tenth millennium at Jerf el Ahmar at Mureybet, Northern Syria. J. Veget. Hist. and Archaeobot. 1999;11:21-24.
39. Newton C. Plant tempering of Predynastic pise at Adamïa in Upper Egypt: Bulding material and taphonomy. Veget. Hist. Archaeobot. 2004;13:55-64.
40. Newton C. Upper Egypt: vegetation at the beginning of the third millennium BC inferred from charcoal analysis at Adaima and ElKab. J. Arch. Sci. 2005;32:355-367.
41. Kroll H. Die pflanzenpfunde von Ma'adi. Ma'adi III. The non lithic small finds and the structural remains of the Predynastic settlement, Edited by: I. Rizkana and J. Seeher. Verlag Philip Von Zabern. 1989;129-136.
42. Van Zeist W, de Roller GJ. Plant remains from Ma'adi, a Predynastic site in Lower Egypt. Veget. Hist. Archaeobot. 1993;2:1-4.
43. Woenig F. Die Pflanzen im alten Ägypten. Wilhelm Friedrich, Leipzig; 1886.
44. Butzer KW. Environment and human ecology in Egypt during Predynastic and early Dynastic times. Bull. Soc. Geog. Egypt. 1959;32:43-87.
45. Neumann K. In search for the green Sahara: palynology and botanical macro remains. Palaeoeco. Afr. 1991;22:203-212.
46. Batanouny KH. Plants in the deserts of the Middle East. Springer Verlag. Berlin; 2001. Livingstone; 2003.

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