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Island of the Blessed[1]: 8000 Years of Plant Exploitation in the Dakhleh Oasis, Egypt

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Abstract: *In Northeast Africa, Holocene climate may be characterised as an interplay of arid and humid conditions. After a climatic optimum during the mid-Holocene, the general trend, however, was a shift towards arid conditions. These changes in climate, concomitant with the fluctuation of temperature and the amount and distribution of rain throughout the year, resulted in a change of vegetation. In the Dakhleh Basin the expansion and contraction of the palaeo-oasis with its changing settlement pattern reflects these climatic changes and also finds its expression in subsistence strategies of the local population in prehistoric times. Towards the end of the Old Kingdom, Egyptians from the Nile Valley colonised the oasis and introduced irrigation-based agriculture to the area and until today, the effects of aridification have been compensated by artificial water supply.*

Keywords: *NE-Africa, Western Desert, prehistoric, Pharaonic Egypt, environment, subsistence, adaptive patterns*

Introduction

The Dakhleh Oasis is an isolated place in the centre of the Western Desert of Egypt. It is located some 800 km southwest of Cairo and 320 km west of the Nile River, approximately at the latitude of Luxor (*Fig. 1*). The oasis owes its existence to many millennia of erosion, which carried away up to 400 m of quaternary sediments and thus exposing the Nubian Aquifer, a tertiary formation that holds water in sealed caverns. This water feeds to the surface along natural vents.

The Dakhleh Oasis is composed of several discrete oases, which occupy a north-northwest – east-southeast oriented lowland extending approximately 70 km from west to east and 15–30 km from north to south. The lowland is bounded to the north by a 300–400 m high precipitous escarpment, which marks the southern edge of the Libyan Plateau (Brookes 1983; Kleindienst *et al.* 1999: 1). The palaeo-oasis (*Fig. 2*), however, was much larger and extended at least 15 km to the west, south and east of the present oasis and comprises an area where water supply was more or less reliable in the past (Kleindienst *et al.* 1999: 85).

The area has been inhabited for the last 400,000 years and traces of human presence exist even for the terminal Pleistocene when 'there was nothing and no one in the desert, except wind, sand and stars' (Close & Wendorf 1992: 63; Wiseman 2001). A more continuous occupation commenced in the Holocene and it is this occupation with its changing adaptive patterns, which is of concern here.

Environmental background

In Northeast Africa, the switch from the cold and dry Pleistocene to more humid conditions occurred around 8500 BC and is characterised by an abrupt shift towards substantially wetter conditions, which then persisted during the early and mid-Holocene. These wetter conditions were primarily due to the rapid northward shift of the

1 Island of the Blessed – *Μακάρων νῆσος* – is a quote from Herodotus (III: 26; Feix 1995: 385) where he describes the Libyan Campaign of Kambyses II in 523 BC. The soldiers left Thebes and after seven days of traversing the desert, they reached Oasis – *ὄασις* – known in the Greek world as *Μακάρων νῆσος*. Presumably, they had arrived in the Dakhleh-Kharga Depression and were impressed by its lush vegetation. After their departure from *ὄασις* they were hit by a sandstorm and the army was lost in the Western Desert.

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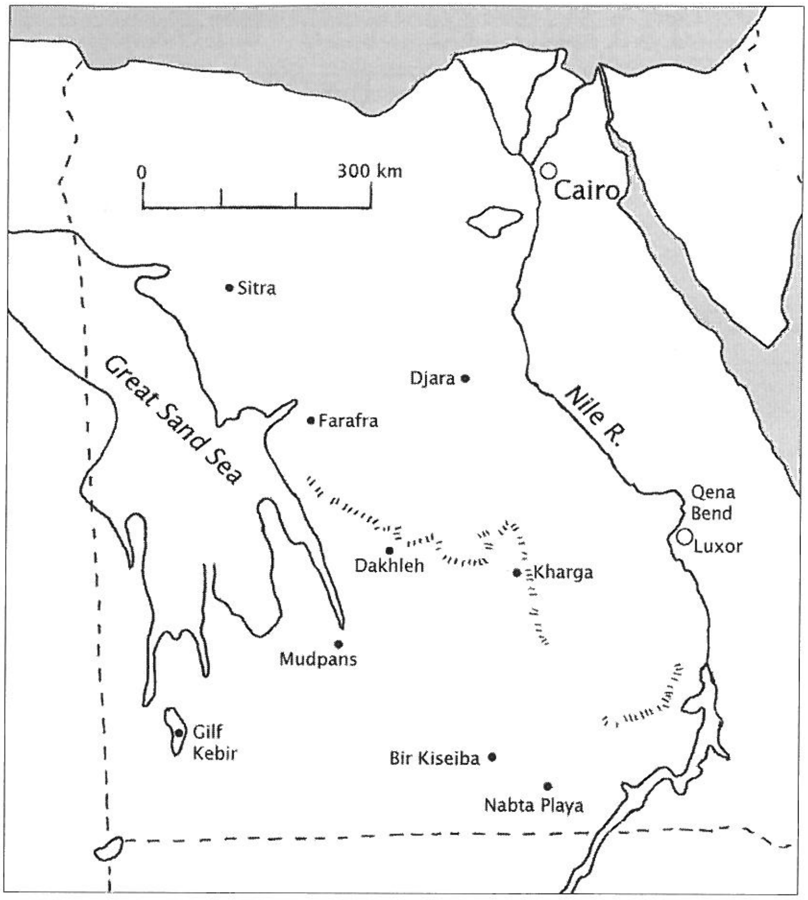

Fig. 1. Sites with archaeobotanical remains in the Western Desert of Egypt (adapted from McDonald 2009: fig. 1).

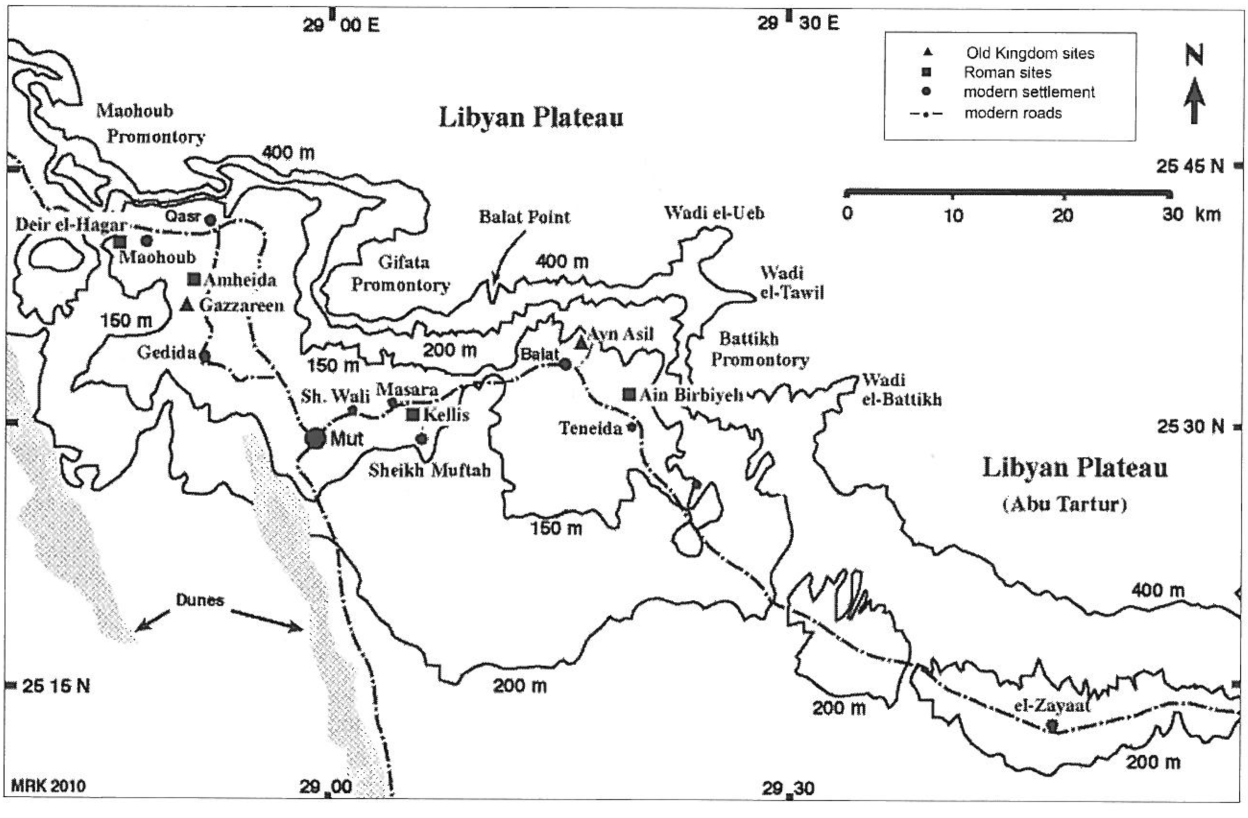

Fig. 2. The Dakhleh Oasis Region (courtesy M.R. Kleindienst 2010, adapted). For the location of prehistoric sites see maps by M.M.A.

		Masara C	Bashendi A	Bashendi B	Sheikh Muftah	'Ain el-Gazzareen	Sum
number of sites		5	6	2	6	1	20
number of samples with charcoal		35	45	8	28	30	116
Arecaceae	Arecaceae		4				4
Calotropis procera	Asclepiadaceae	71	400		15	68	554
Leptadenia pyrotechnica	Asclepiadaceae	80	733			3	816
cf. Brassicaceae	Brassicaceae	9					9
cf. *Malcolmia aegyptiaca*	Brassicaceae	21	15		3		39
Capparis decidua	Capparaceae	7	17				24
Maerua crassifolia	Capparaceae		6				6
Chenopodiaceae	Chenopodiaceae	40	7			2	49
cf. *Salsola* sp.	Chenopodiaceae		3				3
Acacia nilotica	Mimosaceae	74	122		3	165	364
Acacia nilotica type	Mimosaceae	308	726		9		1043
Acacia tortilis ssp. *raddiana* type	Mimosaceae	174	541			2	717
Acacia sp.	Mimosaceae	524	457			122	1103
Faidherbia albida	Mimosaceae	3	15			21	39
Ziziphus spina-christi	Rhamnaceae		3				3
Salvadora persica	Salvadoraceae	31	90		1		122
cf. *Scrophularia saharae*	Scrophulariaceae		15				15
Tamarix sp.	Tamaricaceae	3663	5833	54	506	538	10594
Balanites aegyptiaca	Zygophyllaceae	45	110		1		156
Balanites/*Tamarix* sp.	Zygophyllaceae / Tamaricaceae	15	16				31
Indet. parenchyma		19	21		1		41
Indet. root			3			1	4
Indet. twig		29	72			2	103
Indet.		1975	2381	534	346	497	5733
Totals		**7088**	**11590**	**588**	**885**	**1421**	**21572**

Table 1. Wood charcoal from sites in the Dakhleh Oasis.

African monsoon belt and resulted in the establishment of lakes, which are evidenced by palaeo-hydrological records throughout the Sahara and the Sahel (Hoelzmann *et al.* 2004: 228–229; Nicoll 2004; Kuper & Kröpelin 2006). During the humid phase, the average effective rainfall increased. On the basis of charcoal analysis, Neumann estimates that the amount of annual precipitation never exceeded 50–100 mm (Neumann 1993: 167), but gradients of decreasing rainfall existed from west to east and from south to north (Hoelzmann *et al.* 2004: 229). In the mid-Holocene, the southward expansion of Mediterranean climate additionally brought winter rain to much of the Western Desert (Arz *et al.* 2003; Kindermann *et al.* 2006). The mid-Holocene thus experienced a climatic optimum with extensive playas[2] developing in south-eastern Dakhleh and atop the Libyan Plateau. Similar sites with playa deposits occur in Farafra, Kharga, Abu Ballas, and Nabta Playa (McDonald 1998: 136; Hassan *et al.* 2001; McDonald 2001; Schild & Wendorf 2001). The mid-Holocene is the period with the highest population density (Nicoll 2004; Bubenzer & Riemer 2007: 610), and site distribution outside the oases of the Western Desert suggests that there was enough humidity to support a nomadic way of life for at least part of the year (Nicoll 2001; Kindermann *et al.* 2006). However, sedimentological evidence from the southern part of the Western Desert suggests that the period of increased humidity was interrupted by several dry episodes (McDonald 1999: 126; Hassan 2002; Nicoll 2004). The African Humid Period (de Menocal *et al.* 2000) persisted until *ca* 5300 BC and was followed by the mid- to late-Holocene aridification caused by a retreat of the monsoon belt and full desert conditions were reached *ca* 3500 BC (Hoelzmann *et al.* 2004: 230). By this time, the Western Desert is depopulated except for the oases where settlement has continued until today (McDonald 2001; Kuper & Kröpelin 2006).

In the Dakhleh Oasis, environmental reconstruction is based on the analysis of 21,572 pieces of charcoal covering a time-span of 6000 years from the Epipalaeolithic (Masara C) to the Old Kingdom ('Ain el-Gazzareen) (*Tab. 1*)[3]. For all this time only

2 Playas are defined as arid zone basins with a negative water balance, dry for over 75 % of the time (Brierer 2000: 3).

3 See detailed results in Thanheiser (2008). Neither pollen (Ritchie 1999) nor phytoliths are preserved.

minor changes in the assemblage of arboreal taxa can be discerned and they mainly pertain to the number and frequency of Sahelian elements. Ubiquitous as everywhere in the Western Desert (NEUMANN 1989: 109–141; BARAKAT 2001) are *Tamarix* sp. and *Acacia nilotica*. Both are typical elements of contracted desert vegetation of *wadis* and depressions where their deeply penetrating roots can reach water not accessible to other trees. Sahelian elements such as *Capparis decidua*, *Maerua crassifolia*, *Salvadora persica*, *Calotropis procera* and *Leptadenia pyrotechnica* are present throughout, even in the early Holocene when, according to NEUMANN (1989, 2001), it was too cold for them to disperse that far north. It is likely that the Dakhleh Oasis was an ecologically favoured area, sheltered from cold northerly winds by the escarpment and where the effects of dry spells were ameliorated by the special geomorphological situation in the oasis with groundwater close to the surface and a possible accumulation of water due to runoff from the escarpment. In such an environment oscillating climatic conditions would be expressed in an expansion or contraction of the area suitable for human occupation, and the extent and density of tree cover rather than differences in arboreal species composition. From the Old Kingdom onwards, when the continuous drying had already led to arid conditions, agriculturalists with access to irrigation technology provided the necessary water supply for the arboreal flora in the vicinity of settlements and fields.

Early Holocene faunal remains in Dakhleh identified by C. S. Churcher include hartebeest, Dorcas and other gazelles, hare, ostrich and other birds of various sizes, tortoise, lizard and toad. This assemblage is not significantly different from the hunted fauna of the middle Holocene which again includes hartebeest, gazelles, hare, and birds of various sizes (McDONALD 2003: 49).

Holocene settlement history

During the early and middle Holocene, the area witnessed extensive human activity, resulting in some 200 sites (CHURCHER & MILLS 1999). Based on site location, architecture, artefact assemblages, and biological remains, settlement history of this period can be divided into three more or less consecutive cultural units: the Epipalaeolithic Masara, dated *ca* 8300–6500 BC; the Neolithic Bashendi, subdivided into Bashendi A (*ca* 6400–5650 BC) and Bashendi B (*ca* 5400–3800 BC); and the Sheikh Muftah, which may have spanned over 1500 years, extending into Old Kingdom times *ca* 2200 BC (McDONALD 2009: 8–10).

Masara is the earliest of the Holocene cultural units and two contemporaneous subunits can be distinguished, labelled Masara A and C (McDONALD 1991, 2003). While Masara A sites are short-term campsites of mobile hunter-gatherers (McDONALD 2003: 43–45), Masara C sites exhibit signs of "increased sedentism" (McDONALD 2009: 5) such as reoccupation of preferred localities, increased labour input into shelter construction, preferential use of locally available raw material, an expedient tool technology, and the production of luxury goods (McDONALD 1991, 2002, 2003: 45–48, 2009: 8–9). Masara sites are scattered throughout the extant oasis and are present on the Libyan Plateau, but seem to be concentrated on the south-eastern margin of the oasis. Virtually all Masara C sites recorded to date are located in the south-eastern part of the palaeo-oasis where they occupy an area measuring less than 2 km across (McDONALD 1991: fig. 2).

The ensuing Bashendi cultural unit covers a time span of *ca* 2600 years, starting *ca* 6400 BC, and the sites are found throughout the modern oasis and beyond (McDONALD 1999: fig. 7.2). Within this time span two distinct cultural groupings can be discerned, termed Bashendi Phase A and Phase B (McDONALD 2001: 33–34). Sites within these two cultural groupings differ substantially in location, artefact assemblages, and adaptive patterns. During Phase A (*ca* 6400–5650 BC) subsistence was based on hunting and gathering and the sites are interpreted as the aggregation camps of mobile hunters and gatherers who also roamed the desert beyond the palaeo-oasis. Later Phase A represents a second period of "increased sedentism" and the sites feature stone-built structures which often show signs of reoccupation. Pottery is present on some sites and grinding equipment is plentiful (McDONALD 2001: 34, 2009: 9–10). The sites of the Bashendi B cultural unit span over a millennium starting *ca* 5400 BC and seem to be the product of mobile herder-hunter-gatherers. They usually consist of groupings of hearth mounds. These are round or oval features with fire cracked rock, sometimes other small slabs, and beneath the surface, occasionally charcoal and a bit of ash, showing that they served as hearths or "combustion features". They appear as mounds today because the rocks provided protection for the deposits underneath while the desert floor all around was lowered through time by erosion. Structures of any sort are rare on Bashendi B sites. The recovered faunal remains attest to the presence of domestic animals, cattle and sheep/goat, but hunting still played an important role as corroborated by the presence of gazelle and probably hartebeest bone as well as arrowheads (McDONALD 2009: 10).

The Sheikh Muftah is the youngest of the prehistoric cultural units. Some 70 localities have been recorded to date in the eastern part of the oasis. The sites are concentrated in the central lowlands within the modern oasis and extend into Camel Thorn Basin to the southeast. While the distribution of sites within the modern oasis suggests sedentism, no structures have been found to date. Most of the sites are surface scatters of chipped stone, some pottery and often an abundance of highly fragmented bone. They are all situated near accessible water sources (McDonald *et al.* 2001). Based on pottery, Sheik Muftah sites appear to run from the Bashendi B cultural unit until the late Old Kingdom (Hope 2002: 45–51; Kaper & Willems 2002: 81).

In the late Old Kingdom, around 2300 BC, Pharaonic Egyptians migrated from the Nile Valley to Dakhleh Oasis where they met the Sheikh Muftah indigenes living there (Kaper & Willems 2002: 80). The two cultures lived side by side for at least a century but then the cultural remains of the Sheikh Muftah disappear. The Egyptians formed a capital at Ayn Asil in eastern Dakhleh, where a large town was built and enormous mud-brick mastaba tombs of the governors were erected[4]. Satellites such as 'Ain el-Gazzareen (Mills 2002a, 2002b: 27–29) were established and the oasis appears to have been densely populated. The Egyptians brought with them the agricultural technology that they had developed during the preceding centuries and the resulting small rectangular field plots still dominate the landscape in the oasis lowland.

Population density seems to have declined after the Old Kingdom, probably due to a lack of water at accessible depths. The number of recorded sites dating to a time span of almost 2000 years from the First Intermediate Period (*ca* 2160–2055 BC) to the conquest of Egypt by Alexander the Great in 332 BC is fewer than in the Old Kingdom (Churcher & Mills 1999; Mills 1999: 176–177). But the area has never been completely deserted and intensification of settlement that set in during Ptolemaic times was probably facilitated by the availability of new effective water lifting devices. By Roman times the oasis appears to have been densely populated. Farms, villages and cemeteries are found throughout the oasis with major centres at Ismant el-Kharab (ancient Kellis)[5], Amheida[6] and 'Ain Birbiyeh, and temples were erected at Deir el-Hagar, Kellis and 'Ain Birbiyeh. Trade routes connected Dakhleh with the other oases of the Western Desert and the Nile Valley and facilitated the exchange of goods. Thus, luxury items found their way from the Nile Valley and beyond to the oasis, which derived its livelihood from agriculture.

4 An extensive bibliography on Ayn Asil has appeared in publications of the Institut Français d'Archéologie Orientale du Caire (IFAO).

5 For publications on Kellis see http://www.arts.monash.edu.au/archaeology/excavations/dakhleh/ismant-el-kharab/publications.php.

6 Additional information on Amheida can be found at http://www.amheida.org/.

Adaptive patterns

In the early Holocene sites of the Masara A cultural unit (*ca* 8300–6500 BC) are thinly scattered throughout the oasis with a few sites atop the Plateau; the Masara C sites are confined to a small area in the south-eastern part of the palaeo-oasis, and judging from the availability of ^{14}C dates, the area outside the palaeo-oasis was scarcely populated. At least part of the Masara cultural unit seems to coincide with a dry spell (Schild & Wendorf 2001). During this time people seem to have sought refuge in the Dakhleh area where groundwater was present close to the surface and where the physiography facilitated the accumulation of water after occasional rain.

Plant remains are rare on Masara A sites and only one sample gave results which are not considered here. Characteristic of the subfossil assemblage of macro-remains from the Masara C cultural unit (*Tab. 2*) is the occurrence of high numbers of small fruits and seeds of only a few taxa. The dominant ones – *Portulaca oleracea*, *Schouwia purpurea*, Vicieae, *Bolboschoenus glaucus*, and unidentified Cyperaceae – have several properties in common: under favourable conditions they occur in massive stands; they produce abundant but small seeds or fruits; there is hardly any ethnographic reference to the utilisation of these seeds or fruits but in contrast to that, other parts of these plants – mainly the leaf but the tuber, the rhizome and the pith as well – are widely used; the taxa are present mainly in the Masara period and are rare or missing in later phases in Dakhleh.

The occurrence of high numbers of subfossil seeds of questionable use (*Tab. 3*) is a matter of conjecture. Taking into consideration the small size of the propagules and the absence of ethnographic parallels referring to their utilisation, it seems unlikely that they were the target of collecting strategies. Alternatively, the diaspores may have arrived at the sites as by-products of the collection of other parts of the plants such as leaves or tubers. However, leaves destined for human consumption are often collected before the plant sets flowers. Seeds would then appear in archaeological deposits in small numbers only (Wasylikowa 2001: 557). As mentioned by Wasylikowa a possible alternative source for the seeds in the subfossil record would be the burning of the withered plant itself or of animal dung (Miller 1984; Hillman *et al.* 1997; Butler 2001: 602; Wasylikowa 2001: 557). Easily collected, dung provides fuel of high calorific value and is used even in areas where fuel-wood is abundant (Charles 1998). What role the collecting of dung might have played in prehistoric times in Dakhleh, is a matter of speculation. So far, no dung fragments have been recovered from Epipalaeolithic sites.

		Masara C	Bashendi A	Bashendi B	Sheikh Muftah	'Ain el-Gazzareen	Sum
number of sites		5	7	3	3	1	19
number of samples with macro-remains		29	48	4	9	38	128
Amaranthaceae	Amaranthaceae	11					11
Amaranthus sp.	Amaranthaceae		7				7
Asphodelus tenuifolius	Asphodelaceae					264	264
Asteraceae	Asteraceae	46	14				60
Calendula arvensis	Asteraceae					286	286
Arnebia hispidissima/tinctoria	Boraginaceae	143	3		4		150
Boraginaceae/Lamiaceae	Boraginaceae/Lamiaceae	1	21				22
Brassicaceae	Brassicaceae	4	22			21	47
Brassica nigra	Brassicaceae	1				2	3
Eruca sp.	Brassicaceae		2				2
Schouwia purpurea	Brassicaceae	1540	883				2423
Caryophyllaceae type	Caryophyllaceae	68	56				124
Chenopodium murale	Chenopodiaceae					74	74
Cornulaca monacantha	Chenopodiaceae	63	9				72
Salsola imbricata type embryo	Chenopodiaceae	136	3			4	143
Salsola imbricata type flower	Chenopodiaceae	22					22
Suaeda cf. *aegyptiaca*	Chenopodiaceae					2	2
Suaeda cf. *monoica*	Chenopodiaceae					2	2
Citrullus colocynthis	Cucurbitaceae		32			1	33
Cucurbitaceae	Cucurbitaceae		96				96
Bolboschoenus glaucus	Cyperaceae	509	295			644	1448
Cyperaceae	Cyperaceae	555	692	60		387	1694
Fimbristylis bisumbellata	Cyperaceae					2	2
Schoenoplectus litoralis	Cyperaceae					152	152
Alhagi graecorum	Fabaceae					4	4
Astragalus cf. *vogelii*	Fabaceae	177	9				186
Astragalus type	Fabaceae	12	12		16	42	82
Fabaceae	Fabaceae	8	113		8	72	201
Fabaceae flower	Fabaceae					346	346
Scorpiurus muricatus	Fabaceae	2					2
Trifolieae type A	Fabaceae	10	90		195	518	813
cf. *Vicia ervilia*	Fabaceae		8				8
Vicieae	Fabaceae	386	1				387
Vigna type	Fabaceae		1				1
Cocculus pendulus	Menispermaceae				1		1
Acacia nilotica	Mimosaceae					38	38
Acacia nilotica pod	Mimosaceae					35	35
Acacia nilotica type	Mimosaceae					2508	2508
Acacia nilotica type pod	Mimosaceae					748	748
Acacia type	Mimosaceae				18	9	27
Acacia type flower	Mimosaceae		13			318	331
Acacia type inflorescence	Mimosaceae	20				914	934
Acacia type juvenile leaf	Mimosaceae					173	173
Acacia type leaflet	Mimosaceae		2				2
Acacia type stipular spine	Mimosaceae					704	704
Acacia type twig	Mimosaceae					47	47
Boerhavia cf. *coccinea*	Nyctaginaceae		6				6
Boerhavia sp.	Nyctaginaceae	267	665				932
Avena cf. *fatua*	Poaceae					43	43
Brachiaria cf. *eruciformis*	Poaceae		1				1
Brachiaria sp.	Poaceae		20			2	22
Digitaria type	Poaceae		27			2	29
Echinochloa cf. *colona*	Poaceae		15				15
Hordeum vulgare	Poaceae					993	993
Hordeum vulgare basal rachis	Poaceae					106	106
Hordeum vulgare rachis fragment	Poaceae					19102	19102
Hordeum/Triticum sp.	Poaceae					3513	3513
Hordeum/Triticum sp. basal rachis	Poaceae					127	127
Hordeum/Triticum sp. rachis fragment	Poaceae					4	4

Table 2 *(continued on next page)*. Macro-remains from sites in the Dakhleh Oasis (where not stated otherwise, the recovered items are fruits or seeds).

		Masara C	Bashendi A	Bashendi B	Sheikh Muftah	'Ain el-Gazzareen	Sum
Paniceae	Poaceae	25	223			8	256
Paniceae rachis fragment	Poaceae	134	1705	4			
Panicum cf. *coloratum*	Poaceae		54				54
Panicum turgidum	Poaceae		3				3
Panicum turgidum glume	Poaceae		3				3
Panicum cf. *turgidum*	Poaceae		7				7
Panicum type	Poaceae	21	32				53
Paspalum sp.	Poaceae	4	19				23
Pennisetum type	Poaceae		6				6
Phalaris sp.	Poaceae	4				1046	1050
Poaceae	Poaceae	33	1138	4		210	
Poaceae awn	Poaceae	55	828				883
Poaceae basal rachis	Poaceae					8	8
Poaceae culm	Poaceae		34		7	180	221
Poaceae glume base	Poaceae	10	2022	32			2064
Poaceae leaf	Poaceae	215	3291	3			3509
Sorghum bicolor ssp. *arundinaceum*	Poaceae	10	460				470
Sorghum bicolor ssp. *arundinaceum* immature spikelet	Poaceae	6	98				104
Sporobolus sp.	Poaceae		8				8
Triticum dicoccum	Poaceae					75	75
Triticum dicoccum spikelet fork	Poaceae					3463	3463
Triticum durum rachis fragment	Poaceae					15	15
Triticum durum/aestivum	Poaceae					4	4
Triticum sp.	Poaceae					86	86
Triticum sp. basal rachis	Poaceae					8	8
Triticum sp. rachis fragment	Poaceae					1	1
Urochloa sp.	Poaceae		24				24
Portulaca oleracea	Portulacaceae	6915	267				7182
cf. *Portulaca oleracea* embryo	Portulacaceae	737	38				775
Portulaca oleracea ssp. *oleracea*	Portulacaceae					4	4
Ziziphus spina-christi	Rhamnaceae				1		1
Hyoscyamus cf. *muticus*	Solanaceae		10			1	11
Tamarix aphylla vegetative	Tamaricaceae	11700	2040	4	158	29	13931
Tamarix cf. *nilotica* vegetative	Tamaricaceae	34	302				336
Tamarix sp. flower	Tamaricaceae	49	3			21	73
Tamarix sp. inflorescence axis	Tamaricaceae					33	33
Tamarix sp. vegetative	Tamaricaceae	555	222	73	4	727	1581
Vitis vinifera ssp. *vinifera*	Vitaceae					14	14
Zygophyllum cf. *coccineum*	Zygophyllaceae		2				2
type 22		2322	28				2350
type 40			62				62
type 41			54	8			62
type 42			2				2
type 46			33				33
Totals		**28003**	**18019**	**201**	**537**	**42980**	**89740**

(end of Table 2)

For whatever purpose the plants arrived at the sites, they indicate various ecological habitats, differing in the amount of water and soluble salts present in the soil. Pools of (periodically) standing (brackish) water, swamps or wet soils would support the growth of *Bolboschoenus glaucus* and other Cyperaceae, probably together with *Tamarix* species. Open, moist habitats are required by *Portulaca oleracea*, and desert annuals such as *Boerhavia* sp., *Schouwia purpurea*, *Astragalus vogelii* and *Arnebia hispidissima* could have developed abundantly after (seasonal) rains. Some species are salt tolerant (*e.g.*, *Cornulaca monacantha*, *Salvadora persica*, *Tamarix* spp., *Bolboschoenus glaucus*) and can grow in halophytic communities.

The southeastern part of the palaeo-oasis which is the focus of settlement for the Masara C cultural unit is structured on a small scale and with its diverse micro-habitats seems to have offered dependable resources in an otherwise hostile environment leading to repeated occupation of the same localities and thus to "increased sedentism".

The ensuing Bashendi A period (*ca* 6400–5650 BC) coincides with a climatic optimum when increased humidity and higher temperatures resulted in the spread of savanna vegetation throughout the Western Desert and when a nomadic way of life beyond the palaeo-oasis was possible for at least part of the year. As for macro-remains recovered from the sites (*Tab. 2*), a shift in the floral composition can be observed. The traditional Masara plants *Schouwia purpurea* and *Portulaca oleracea* are still present but their overall importance has declined. Instead, various taxa of Poaceae are present as grains, glumes, rachis and leaf fragments and the various parts of grass plants constitute *ca* 55.5 % of the macro-remains for the Bashendi A period.

Wild grasses often occur in dense stands in open habitats and offer respectable – and in some circumstances dependable – yields of high-quality food. Hunter-gatherers of the world highly appreciate wild-grass grains. Besides roots and tubers they are an important source of carbohydrates. They are easily collected by rubbing with the hands or beating into a container, using a swinging receptacle, sweeping or raking off the floor, collecting from ants′ nests, cutting with a sickle or knife, *etc.* Harlan, who has undertaken experiments in wild-grass grain harvesting in the Sahara and in sub-Saharan Africa has demonstrated that the return per labour input can be considerable (HARLAN 1989). Once completely dry, storing for future use is possible without much effort. For Africa, about 60 species are reported to be harvested in the wild. Prominent among these are *Aristida pungens, Cenchrus biflorus, Panicum laetum, P. turgidum, Oryza barthii, Paspalum scrobiculatum, Echinochloa stagnina* and several species of *Eragrostis, Dactyloctenium* and *Brachiaria* (JARDIN 1967; PORTÈRES 1976; HARLAN 1989). In Dakhleh, wild sorghum (*Sorghum bicolor* ssp. *arundinaceum*) and various millets dominate the spectrum. The grains, however, need some preparation prior to consumption and seed processing can be a time consuming and arduous task. It often requires dehusking and cleaning prior to grinding or roasting and the remains of the equipment employed, such as grinding slabs and hand-stones, are sometimes the only indication that grass fruits may have been processed at a site[7].

The presence of minute grass leaf fragments is unusual at sites with exclusively charred plant remains and to the best of our knowledge the Bashendi A sites of the Dakhleh Oasis are the only ones where they occur in abundance. They may indicate that the grains were harvested by beating into a container, a method well documented by ethnographic records from North Africa. Leaf fragments are then regular by-products of the harvest and are removed in a first cleaning operation together with undesirable fruits, seeds and insects (Kahlheber pers. comm. 2010). Another source for the leaf fragments could have been the harvesting of whole plants by uprooting or by cutting low on the culm. After the extraction of the grains by whatever method, the stalks and other vegetative parts could have served as bedding or fuel. This would imply, however, a harvesting of grain, which is not quite ripe, as wild-growing grass would shatter its grain at maturity. Alternatively, the grass leaf fragments may derive from dung used as fuel. Direct evidence for the burning of dung, however, is missing.

Grasses exhibit a wide ecological range reaching from sandy desert soils to halophytic communities and swamps (*cf.* BOULOS 2005: 124-349; for more details see THANHEISER 2008). Taxa such as *Brachiaria, Digitaria, Echinochloa colona* and *Sorghum bicolor* ssp. *arundinaceum* race *virgatum* are usually associated with moist or damp places. *Sporobolus spicatus* preferentially grows on seasonally inundated desert sands and *Echinochloa colona* forms dense stands on floodplains. The southeastern part of the basin and its surroundings is dotted with pockets of playa silts which may be the result of run-off from the escarpment or rain being trapped in low-lying areas, offering ideal conditions for these grasses. After (seasonal) rains they could have developed abundantly along with *Schouwia purpurea, Boerhavia* sp., *Arnebia hispidissima, Astragalus vogelii* and *Hyoscyamus muticus*. Whether a rich harvest was ascertained by methods of *décrue* cultivation is a matter of speculation. HARLAN & PASQUEREAU (1969) describe this method for the inland delta of the Niger River, where after rain, when the water had receded, seeds are sown into the moist soil. They can then be left unattended to grow and ripen, and the signs of reoccupation of some Bashendi A sites may indicate a return of people for the harvest. Extensive utilisation of grass is not a unique phenomenon in Dakhleh but also characterises roughly contemporaneous sites in Nabta Playa (WASYLIKOWA 2001) and Farafra (FAHMY 2001). However, unlike in the Fertile Crescent this extensive use did not lead to domestication in Northeast Africa.

After a hiatus coinciding with another dry spell, the representatives of the Bashendi B cultural unit seem to have reverted to a more mobile way of life. The elaborate stone structures of previous occupations are no longer present but are replaced by scatters of hearth mounds. The archaeobotanical assemblage – both charcoal and macro-remains – is very poor. Only *Tamarix* species, Poaceae, Cyperaceae and an unidentified Type 41 (*cf.* THANHEISER 2008: 42) are present. This points to contracted desert vegetation where only few taxa survived in favoured locales. The general trend towards desertification and diminishing groundwater supply will already have lead to the disappearance of plants needing significant amounts of water. The possible purpose of some sites as camps of mobile herders with little emphasis on plant processing may also have contributed to the lack of charred plant remains.

7 However, the conclusion that the presence of grinding equipment at a site is proof of the processing of grass grains is not compelling. The same equipment could have been used for grinding roots and tubers or ochre (see, *e.g.*, HILLMAN 1989: 227).

		flowers	fruits and seeds	wild cereals	green parts	tubers and rhizomes	gum and sap	salt	manna	dyes	tannin	medicine	fuel	animal feed
		use for human consumption					*plant products*							
Amaranthus sp.	Amaranthaceae				■									■
Arecaceae	Arecaceae		■		■		■						■	■
Calotropis procera	Asclepiadaceae											■		■
Leptadenia pyrotechnica	Asclepiadaceae		■		■							■	■	■
Asteraceae	Asteraceae	■	■		■	■	■					■		
Arnebia hispidissima/tinctoria	Boraginaceae									■				
Boraginaceae/Lamiaceae	Boraginaceae/Lamiaceae											■		
Brassica nigra	Brassicaceae		■									■		
Eruca sp.	Brassicaceae				■									
Malcolmia aegyptiaca	Brassicaceae				■								■	■
Moricandia arvensis	Brassicaceae				■									□
Schouwia purpurea	Brassicaceae		?		■								?	□
Capparis decidua	Capparaceae		■					■				■	■	■
Maerua crassifolia	Capparaceae		■		■					■		■		■
Caryophyllaceae	Caryophyllaceae											□		□
Cornulaca monacantha	Chenopodiaceae												■	□
Salsola imbricata	Chenopodiaceae							■	■			■	■	□
Chenopodiaceae	Chenopodiaceae		□		□								■	
Citrullus colocynthis	Cucurbitaceae		□									■		■
Cucurbitaceae	Cucurbitaceae		■									■		■
Bolboschoenus glaucus	Cyperaceae			■		■								■
Cyperaceae	Cyperaceae		■		■	■								■
Astragalus vogelii	Fabaceae		■		■									■
Trifolieae	Fabaceae	□	□			□						■		□
Vicia ervilia	Fabaceae		■											
Vicieae	Fabaceae		■											
Vigna sp.	Fabaceae		□		□	□								?
Cocculus pendulus	Menispermaceae	□										■		■
Acacia nilotica	Mimosaceae	□	■				■				■	■	■	■
Acacia tortilis ssp. *raddiana*	Mimosaceae										■	■	■	■
Faidherbia albida	Mimosaceae										■	■	■	■
Boerhavia sp.	Nyctaginaceae		■		■	■						■		■
Brachiaria eruciformis	Poaceae			■										
Brachiaria sp.	Poaceae			■										
Digitaria sp.	Poaceae			■										
Echinochloa colona	Poaceae			■										
Paniceae	Poaceae			■									?	■
Panicum coloratum	Poaceae													■
Panicum turgidum	Poaceae			■								■	■	■
Paspalum sp.	Poaceae			■										■
Pennisetum sp.	Poaceae			■										
Poaceae	Poaceae			■		■							?	■
Sorghum bicolor ssp. *arundinaceum*	Poaceae			■										
Sporobolus sp.	Poaceae			■										
Urochloa sp.	Poaceae			■										
Portulaca oleracea	Portulacaceae		□		■							■		■
Ziziphus spina-christi	Rhamnaceae		■									■	■	
Salvadora persica	Salvadoraceae		□					■				■	■	■
Hyoscyamus muticus	Solanaceae											■		
Tamarix aphylla	Tamaricaceae							■	■			■	■	
Tamarix nilotica	Tamaricaceae											■	■	
Tamarix sp.	Tamaricaceae												■	
Balanites aegyptiaca	Zygophyllaceae		■		■		■					■	■	■

Table 3. Possible utilisation of plants recovered from prehistoric sites in the Dakhleh Oasis based on ethnographic reports (full symbols: use ethnographically well documented, empty symbols: ethnographic reports scanty and/or not from the region). Main sources: BUSSON 1965; BURKILL 1985–2000; PETERS *et al.* 1992; NEUWINGER 2000. For more details see THANHEISER 2008.

The remains of the youngest prehistoric cultural unit, the Sheikh Muftah, are concentrated in the oasis lowlands, in and around present day areas of cultivation. This site distribution may indicate that the palaeo-oasis had already shrunk to its present size and that life outside the oasis was no longer possible. General living conditions must have been harsh as the few burials recovered to date all exhibit signs of heavy labour or physical stress (Thompson & Madden 2003). Plants, which were most likely collected for human food (*Tab. 2, 3*), are very rare on Sheikh Muftah sites. This lack of plant remains – if not caused by bad preservation – is combined with a scarcity of tools usually associated with the processing of plants: sickles, knives, grinding stones. It is therefore likely that plant food procurement was not a major activity at the sites. An abundance of heavily fragmented animal bone rather points to the processing of meat both of domestic as well as hunted origin.

Egyptians from the Nile valley reached the oasis towards the end of the Old Kingdom, around 2300 BC. They brought with them a subsistence strategy hitherto unknown in the area: agriculture. However, the oasis environment with its lack of annual Nile floods was challenging. The climate had more or less reached its present state of hyperaridity and only very little rain fell at irregular intervals rendering rain fed agriculture impossible. The surrounding area had already lost most of its plant cover and feeding life-stock by grazing outside the oasis was no longer possible. Therefore all life depended on groundwater reaching the surface along natural vents or as springs. At the time no effective water lifting devices were available and therefore wells only served to meet the personal needs of the inhabitants and possibly to water small garden plots. Agriculture depended entirely on careful management of springs. The easiest way to provide sufficient water for irrigation would have been to build dams around spring eyes and this way raise the point of discharge and create the necessary gradient for gravity propelled irrigation. The whole spectrum of cultivated plants known from Old Kingdom sites in the Nile Valley is present in Dakhleh, but barley (*Hordeum vulgare*) is dominant (Pettman *et al.* forthcoming). Barley needs less water than emmer wheat (*Triticum dicoccum*), has lower demands concerning soil quality and can even grow on slightly saline ground. It is therefore often the cereal of choice on newly reclaimed agricultural land. That agriculture was a very successful subsistence strategy during the later Old Kingdom in the Dakhleh Oasis is expressed in population density, and the enormous mastaba tombs erected for the governors near Ayn Asil. Although indigenous Sheikh Muftah and Egyptians lived side by side for about a century, none of the typical Old Kingdom cultigens present in 'Ain el-Gazzareen were recovered in its neighbour Loc. 404 or any other Sheikh Muftah site although some sort of exchange of goods is attested by the occurrence of Old Kingdom pottery in Sheikh Muftah sites and vice versa.

After a period of *ca* 2000 years which seems to have experienced a decline in population density, an agriculture boom recurs during Roman times. Ptolemaic technical innovations in water lifting such as the *sakkiyeh* and the *tanbur* made water from deeper wells accessible and Roman period Kellis and Amheida feature a wide variety cereals, oil and fibre plants, condiments, spices and fruits and virtually all cultivated plants present in the Nile Valley are also found in Dakhleh (Thanheiser *et al.* 2002). The cultivation of olive trees seems to have been of particular importance and finds of olive stones, leaves and small branches are present throughout habitation areas. Although no oil presses have been recovered to date, it seems possible that in the Dakhleh Oasis olive oil was produced for export to the Nile Valley where it was an esteemed commodity. Bagnall (2008) claims that the affluence visible in the decoration of houses and the presence of luxury items is based on the income from trade in olive oil.

A profound change in the traditional Egyptian agricultural system, which only knew one winter crop per year, was initiated with the introduction of summer crops such as pearl millet (*Pennisetum glaucum* ssp. *glaucum*) and cotton (*Gossypium* sp.). The advanced irrigation techniques allowed the summer cropping of heat resistant crops thus valorising a period of the year previously not used for farming activities and increased the food production. Pearl millet became an important source of carbohydrates for the local population and a mash prepared from its grains seems to have been an important food component in infant weaning (Dupras & Tocheri 2007; Thanheiser *et al.* forthcoming).

Conclusions

For the first half of the Holocene life in the Dakhleh Oasis and its environs depended on precipitation and local groundwater sources, and settlement patterns reflect the waxing and waning of the palaeo-oasis. The oasis was an Island of the Blessed with a sustained water supply even at times when low rainfall rendered life in the wider area difficult if not impossible. It also served as a refuge in times when people were driven out of the desert. From the Old Kingdom onwards new skills in irrigation and in retrieving underground water brought some independence from local precipitation, a situation which has continued until today, when commercial deep-coring for water has opened new and hitherto unused areas for agriculture.

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