

Loutfy Boulos

Flora and Vegetation of the Deserts of Egypt

Abstract

Boulos, L.: Flora and Vegetation of the Deserts of Egypt. — *Fl. Medit.* 18: 341-359. 2008. — ISSN 1120-4052.

Most of the deserts of Egypt lie within the Sahara regional transition zone, with the exception of the western Mediterranean coastal region which lies within the Mediterranean-Sahara regional transition zone and the Gebel Elba region in southeast Egypt which constitutes a part of the Sahel regional transition zone. The vegetation types in the Egyptian deserts and oases are briefly described with mention of their most characteristic elements. Some neighbouring desert regions in Libya, Palestine, the Arabian peninsula and Sudan are compared with those of the Egyptian deserts. The palaeoclimatic conditions in Egypt are briefly discussed in relation to the past climatic changes and their effect on the present-day vegetation.

Key words: Flora, vegetation, Desert, Egypt.

Introduction

Egyptian deserts, the area subject of this study, comprise the desert west of the Nile which will be referred to as the “Western Desert”, the desert east of the Nile which will be referred to as the “Eastern Desert”, and the Sinai peninsula. According to Eig (1931-1932) three floral provinces are represented in Egypt: 1. The Saharo-Sindian province, comprising most of the deserts of Egypt; 2. The Irano-Turanian province, comprising the mountainous region of southern Sinai and the Galala Mountains of the Eastern Desert; 3. The Sudano-Deccanian province, comprising the Gebel Elba region in southeast Egypt. On the other hand, according to White (1993) three phytocaria are represented in Egypt: 1. The Mediterranean-Sahara regional transition zone, comprising the western Mediterranean coastal strip to Port Said; 2. The Sahara regional transition zone, comprising the entire Sinai peninsula, the Western Desert south of the Mediterranean coastal strip and the Eastern Desert excluding the Gebel Elba region; 3. The Sahel regional transition zone comprising the Gebel Elba region (Fig. 1).

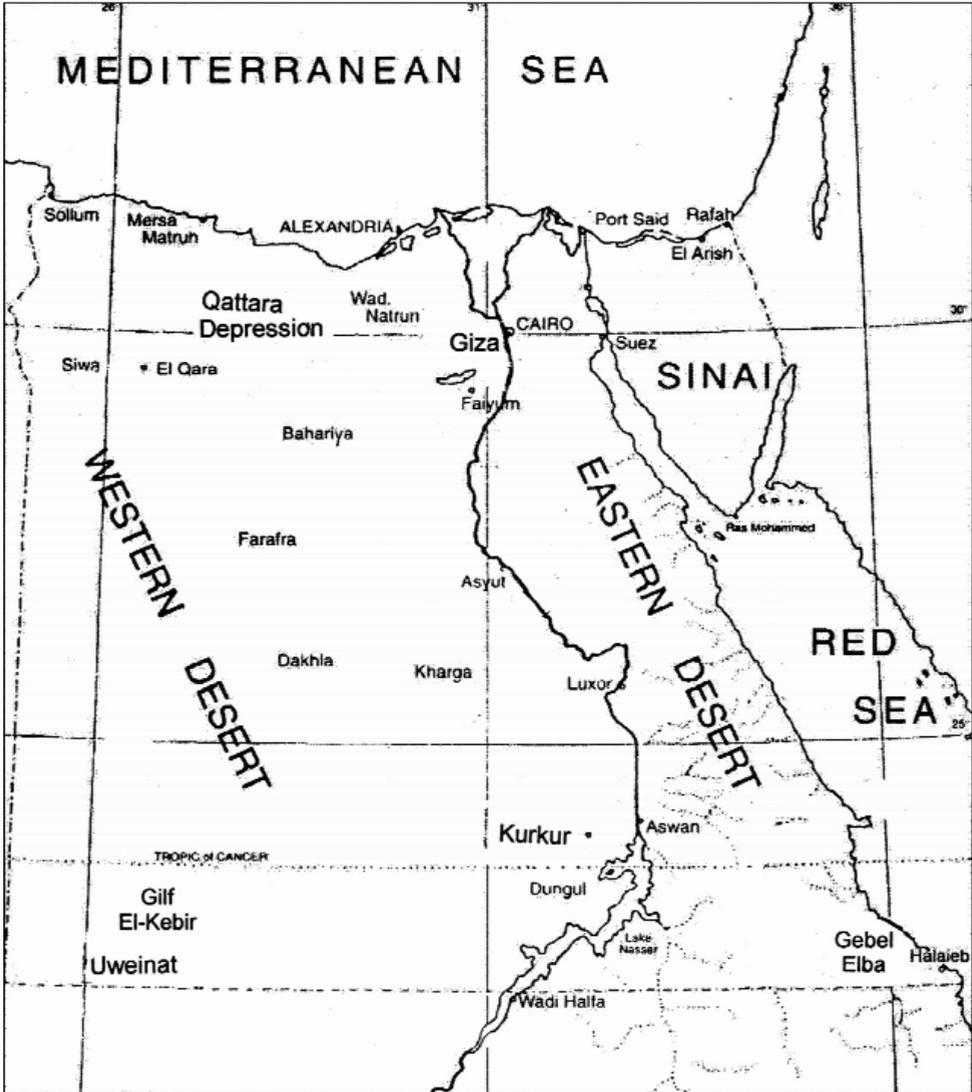


Fig. 1. Map of Egypt, showing different regions.

The Western Desert

Boulos & Barakat (1998) review the palaeoclimatic conditions of the Western Desert. The earliest Holocene wet phase is recorded near the Egyptian-Sudanese border of the Western Desert from Selima buried lake sediments on charcoal during the period 10,300-9,400 B. P. (Haynes & al. 1989). Two other wet phases prevailed during the Early Holocene: El-Beid Wet Phase 9,300-8,000 B. P. and Nabta Playa 8,600-7,100 B. P., both

north of the Selima area (Hassan 1986). During the Middle Holocene 7,000-6,700 B.P., according to Haynes (1980), geological evidence of a moister phase in the Western Desert of Egypt is recorded. According to Hassan (1986), several short pluvial periods during the second part of the Middle Holocene, 6,700-4,500 B. P., with a clear tendency towards aridity are traced. Hassan (1986) assumes that aridity has prevailed and became well established from 4,500 B. P. Boulos & Barakat (1998) compare the present-day plant life in the Western Desert with the vegetation which prevailed during the Early and Middle Holocene, based on the identification of charcoal fragments from different archaeological sites in the Western Desert of Egypt and northwest Sudan. The reconstructed ancient vegetation shows a dry Savanna type with *Acacia tortilis* subsp. *raddiana*, *Acacia ehrenbergiana*, *Maerua crassifolia*, *Capparis decidua*, *Ziziphus spina-christi*. and *Tamarix* spp. (Neumann 1987, 1989a, b; Neumann & Schulz 1987; Barakat 1995). This type of vegetation may be compared with that of the present-day uninhabited oases of the Western Desert of Egypt and Sudan, such as Merga Oasis in northern Sudan (Neumann 1989b) and Uweinat in Egypt, Sudan and Libya (Boulos 1980, 1982a, b). On the other hand, our knowledge on the herbaceous plant cover of the Western Desert is made possible through the discovery of pollen-bearing Holocene lake sediments dated between 9,600 and 6,200 B. P. in the Eastern Sahara (Ritchie & al. 1985; Pachur & Kröpelin 1989). Pollen analyses of these sediments show that Savanna and desert grassland, which dominated these regions during the pluvial phase, is now a hyperarid zone, a part of the present Sahara. The recent archaeobotanical research on the recovered material from the Nabta playa reveals 146 "types" of fruits, seeds and grains (Wasylikowa 1992; Wasylikowa & al. 1993, 2001; Wendorf & al. 1993). Several wild grasses are recorded: *Sorghum bicolor*, *Panicum turgidum*, *Echinochloa* sp., *Setaria* sp., *Digitaria* sp. Among other herbaceous elements are: *Citrullus colocynthis*, *Cyperus rotundus*, *Hyoscyamus muticus*, *Scirpus maritimus*, *Typha* sp., *Boerhavia* sp., *Nymphaea* sp., *Astragalus vogelii*, *Schouwia purpurea*, *Arnebia hispidissima*. Fruits of woody species are also recovered, such as: *Ziziphus spina-christi*, *Capparis decidua*, *Senna alexandrina*, *Maerua crassifolia*, *Salvadora persica*, *Acacia* spp. and *Grewia* sp.

The present-day plant life

The flora of the Western Desert has been a subject of study by numerous authors either in the context of the entire flora of the country (Täckholm & Drar 1941-1969; Täckholm 1974; Boulos 1995, 1999, 2000, 2002, 2005), or as ecological and/or floristic works dealing with particular areas within this vast desert.

The present-day plant life in the Western Desert is poor both in diversity and plant cover. The narrow Mediterranean coastal belt (5-25 km), which enjoys a relatively higher rainfall compared with the rest of the Western Desert, lacks many typical circum-Mediterranean elements, especially of trees and shrubs, such as: *Pinus halepensis*, *Juniperus phoenicea*, *Juniperus oxycedrus*, *Ceratonia siliqua*, *Quercus coccifera*, *Quercus ilex*, *Myrtus communis*, *Rosmarinus officinalis*, *Cistus* spp. The diversity in the coastal Mediterranean belt is more pronounced than in the rest of the adjacent desert, where some 1095 species of vascular plants are recorded (Boulos 1975).

The vegetation of the western Mediterranean coastal belt of Egypt, also known by "Mariut" has been a subject of several studies through the pioneer works of Tadros (1953, 1956); Tadros & Atta (1958a, b) and Tadros & Sharkawi (1960). Ayyad (1973, 1976) and his collaborators continued their work on the Western Desert, particularly on the coastal region (Ayyad 1981, 1983; Ayyad & Ammar 1974; Ayyad & El-Ghonemy 1976; Ayyad & El-Bayyoumi 1979; Ayyad & El-Gharib 1982, 1984; Ayyad & Ghabbour, 1993).

The plant life in the Western Desert further south has been subject of numerous studies, among which are those of Léonard (1970a, b; 1971, 1997, 1988-2001); Boulos (1980; 1982a, b; 1989); Ayyad & Ghabbour (1986); Bornkamm (1986); Kehl (1987); Alaily & al. (1987); Bornkamm & Kehl (1989, 1990); Kehl & Bornkamm (1993); Monod (1995); Boulos & Barakat (1997a, b; 1998) and Shaltout (1997).

The aridity of the Western Desert becomes more pronounced towards the hyperarid southern region which holds a few exceptionally green spots: the oases and depressions of Siwa, Moghra, Qara, Bahariya, Farafra, Wadi Natrun, Kharga and Dakhla; these are the inhabited oases. A few others are uninhabited: Qattara depression, Uweinat (in Egypt), Kurkur, Dungul and some other smaller oases. The vegetation of these oases is described by Boulos (1966, 1989); Zahran & Girgis (1970); Zahran (1972); Bornkamm (1986); Zahran & Willis (1992); Abd El-Ghani (1992, 2000).

In general, the major part of the plant cover in the oases is composed of thick groves of date palms and olive trees. In the orchards other fruit trees are cultivated, e.g. pomegranate, guava, orange, citron, sweet lime, apricot, etc., besides vegetables, spices, pulses, fodder plants, medicinal plants and few cereals, especially rice. Apart from rice, other cereals are not highly successful due to soil salinity.

In the main, the natural vegetation of the oases may be recognized into three types:

- a. Swamps: these are common near and around the lakes. *Phragmites australis* and *Typha domingensis* are the most dominant.
- b. Salt marshes : also known as "sabkhas" are usually near the lakes and springs. Several halophytic species grow in the sabkhas such as *Arthrocnemum macrostachyum*, *Sarcocornia fruticosa*, *Suaeda monoica*, *Suaeda vermiculata* and *Cladium mariscus*. The latter species is known only from Siwa Oasis.
- c. Sand formations: these are either in the form of sand flats extending from higher lands and adjoining the salt marshes or sand bars extending along the inner edges of salt marshes. Here, the most dominant species are: *Cornulaca monacantha*, *Zygophyllum album* and *Tamarix nilotica*.

The diversity is not particularly rich in the oases and only two endemic species are known from Kharga Oasis: *Ducrosia ismaelis* and *Pimpinella schweinfurthii*.

The Qattara Depression

Boulos & Barakat (1997a) recognize six vegetation types in the Qattara depression region:

A. TRANSITIONAL AREA

This area lies between the Mediterranean coastal region and the desert south of it to the northern edge of the Qattara depression. The most characteristic shrubs and perennial

species are: *Anabasis articulata*, *Artemisia monosperma*, *Calligonum polygonoides* subsp. *comosum*, *Zygophyllum album*, *Centropodia forsskaolii*, *Moltkiopsis ciliata* and *Polycarpha repens*.

B. SABKHAS

The sabkhas, or salt marshes, in the Qattara depression harbour some halophytes; most typical shrubs are: *Halocnemum strobilaceum*, *Sarcocornia fruticosa*, *Limoniastrum monopetalum*; herbaceous perennials: *Cressa cretica*, *Aeluropus lagopoides*; annuals: *Frankenia pulverulenta* and *Sphenopus divaricatus*.

Salt tolerant species occupy the borders of Sabkhas, such as: *Tamarix nilotica*, *Juncus rigidus*, *Nitraria retusa* and *Alhagi graecorum*.

C. WETLAND HABITATS

The wetland habitat is best demonstrated by Moghra Lake and Ain Kifar in the Qattara depression region. Moghra Lake lies below sea level (-24m) and is 30°15'N, 28°56'E, rather close to the northern Mediterranean coast. The vegetation in the vicinity of Moghra Lake is dominated by vast stands of *Phragmites australis* reed, *Juncus rigidus* rush, *Tamarix nilotica* shrubs and subspontaneous *Phoenix dactylifera* date palm.

The other wetland habitat, yet artificial, located at the “spring” of Ain Kifar, 29°31'N, 26°57'E, is particularly rich in plant species, where underground water was brought to the surface by digging a well. The lush vegetation surrounding the “spring” seems to be in good condition (December 1996); no evidence of grazing nor firewood collecting were observed. Among the species recorded are: *Pluchea dioscoridis*, *Phragmites australis*, *Juncus rigidus*, *Pulicaria crispa*, *Tamarix nilotica*, *Imperata cylindrica* and *Phoenix dactylifera* which constitute the most spectacular part of the vegetation. The fringes are occupied by: *Zygophyllum simplex*, *Astragalus vogelii*, *Cynodon dactylon*, *Cyperus laevigatus*, *Hyoscyamus muticus*, *Launaea nudicaulis* and *Fagonia arabica*. Kehl (1987) adds to the above species *Tamarix passerinoides*, *Typha domingensis*, *Cotula cinerea* and *Setaria viridis* from an earlier visit.

D. ACACIA GROVES WOODLAND

Within the Qattara depression some spots are dominated by *Acacia* groves. A particularly interesting site is that of Talh El-Fawakhir 29°44'N, 26°43'E, where more than 100 trees of *Acacia tortilis* subsp. *raddiana* of different age-sizes grow, accompanied by another herbaceous tropical element: *Schouwia purpurea*.

This may suggest a relict of earlier more extensive coverage of the area by dry savanna *Acacia* woodland which is occupied nowadays by a discontinuous belt across the depression which is cut by wadis.

E. WADI VEGETATION

Typical wadi vegetation is encountered in the depression where dry water courses could be traced. The wadi vegetation is dominated by *Tamarix nilotica* forming phytogenic mounds, *Acacia tortilis* subsp. *raddiana*, some desert shrubs and subshrubs such as *Salsola imbricata* subsp. *gaetula*, *Zygophyllum coccineum*, *Zilla spinosa*, *Astragalus spinosus* and *Pergularia tomentosa*, as well as the annual herbs *Anastatica hierochuntica* and *Schouwia purpurea*.

F. UNINHABITED OASES IN THE VICINITY OF SIWA

A few uninhabited oases are located at the southern edge of Qattara depression, those of Arag: 28°52'N, 26°25'E; El Bahrein: 28°40'N, 26°30'E; Nawamis and Sitra: 28°42'45"N, 26°53'45"E. The dominant species in these oases is the date palm, *Phoenix dactylifera* which forms very dense groves. The palms are often covered by mobile sand dunes reaching the crowns and sometimes beyond them. The lowermost part of these oases is occupied by a waterbody and surrounded by reeds of *Phragmites australis*. Further away from the water, the reeds are replaced by other salt tolerant species such as *Tamarix nilotica*, *Nitraria retusa*, *Juncus rigidus*, *Zygodphyllum album* and *Alhagi graecorum*.

Gilf El-Kebir

Little is known about the flora of Gilf El-Kebir mainly because of its remoteness, inaccessibility and erratic rain: visitors may reach the area after a prolonged drought and see very little or only old remnants of the vegetation. The flowering plant species were reported by Bagnold (1931, 1939), Shaw (1936), Léonard (1966), Boulos (1980, 1982a, b), Back (1981) and Monod (1995). Ecological studies on the vegetation were carried out by Alaily & al. (1987). All in all, Some 15 flowering plants were recorded from the entire area of the Gilf by Alaily & al. (1987). However, Monod (1995) Lists 51 species from the Gilf, of which some were recorded only by earlier workers and not observed later on, such as *Phoenix dactylifera* and *Balanites aegyptiaca*. Some others are listed on evidence of their charcoal remains such as *Faidherbia albida* (= *Acacia albida*) and *Ziziphus lotus*.

Although the Gilf region is generally dry, yet a few parts have apparently received some rain about two years before our visit in February 1997, which allowed us to record some green vegetation mainly in Wadi Abd El-Malik. As a result, 22 species were recorded during this field trip.

Alaily & al. (1987) describe the vegetation in the Gilf region as very scarce, being restricted to a small number of favoured sites and poor in species diversity. This has been confirmed during our visit where we have observed in Wadi Abd El-Malik a few young trees of *Acacia tortilis* subsp. *raddiana* and mainly *Zilla spinosa* which occupy channels in the central part of the wadi, leaving almost bare ground on both sides. In some other parts of the wadi, *Acacia tortilis* subsp. *raddiana* trees form an open scrub with some shrubs among the trees such as *Zilla spinosa*, *Fagonia thebachia* being the most common, while *Monsonia nivea*, *Pulicaria incisa*, *Citrullus colocynthis*, *Panicum turgidum* and *Trichodesma africanum* grow here and there in the wadi bed. Few trees of *Maerua crassifolia* grow in the protected parts of the wadi.

On the rocky plateau of the Gilf, dry but recognizable *Anastatica hierochuntica* occupy a vast area. On the sand deposits dry plants of *Centropodia fragilis* were observed.

Apart from the two tree species: *Acacia tortilis* subsp. *raddiana* and *Maerua crassifolia*, and the one shrub: *Acacia ehrenbergiana*, the remaining species may be considered as accidental vegetation which appears after sporadic rains.

Gebel Uweinat

The region of Gebel Uweinat is shared by Egypt, Libya and Sudan. Its flora is rather well documented by several authors since its discovery by the Egyptian geographer Hassanein Bey in 1923. The plant life was studied by Shaw (1931), Shaw & Hutchinson (1931, 1934), Hutchinson (1933), Corti (1938), Léonard (1966, 1970b, 1971, 1997-2001), Osborn & Krombein (1969) and Boulos (1980, 1082a,b). The latter author provided a classification of the vegetation types into four categories: ephemeral, ephemeral and perennial, perennial near wells and perennial in gorges. He has also provided a list of his collections and previous records which comprise 73 species, including 7 cultivated.

Léonard (1997) started a series of six detailed studies on the flora and vegetation of Gebel Uweinat covering the algae, fungi, hepatics, mosses and the monocots. He provides information on the geography, history, scientific explorations to the region, as well as the contributions to our knowledge on its flora by different botanists and plant collectors from 1930 to 1997. For every species he gives its accepted name, synonyms, citations from previous publications, habitat, chorology, biological type, vernacular names and general observations wherever available. In his sixth and last part (2001) he provides a phytosociological and phytochronological analysis of the vegetation.

In Karkur Talh (“Talh” is the local vernacular name of *Acacia tortilis* subsp. *raddiana*, while it is also called “Seyal” in other parts of Egyptian deserts, see Boulos (2005), under vernacular names, p. 486) within the Egyptian territory of Uweinat, the lack of rain for a prolonged period, (probably over one decade, greatly affected the majority of the trees, shrubs and the perennial vegetation, including a complete absence of annuals. Moreover, a very unusual phenomenon was observed: almost all the trees of *Acacia tortilis* subsp. *raddiana* secrete extensive amounts of a gummy fluid covering all parts of the trees in the form of a firm film of substantial thickness, and one could observe the extra dropping gummy fluid forming an obvious crust on the ground matching the size of the crown of the tree. This phenomenon might be explained as a “last device” to protect the trees against drought, in order to retain the water content within the plant tissues for the longest possible time. It has also been observed that the dry dead branches which were used as firewood were burning much slower than those from normal trees elsewhere which may be attributed to the protective gummy film covering the branches. Unless the region will soon receive a substantial amount of rain the entire plant life would reach an irreversible state for most of its elements, which means a very slow recovery, and probably the loss of many genetic resources.

Kurkur, Dungul and Nakhila oases

These are uninhabited oases: Kurkur and Dungul southwest of Aswan and Nakhila west of Aswan. The vegetation of Kurkur was studied by Boulos (1966) and Dungul by Zahran (1966). Shaltout (1997) reviewed the works on the vegetation of southern Egypt. Perhaps the most noticeable element in these oases of the southern part of the Western Desert is *Medemia argun* which was discovered in Dungul and Nakhila (Boulos 1968). *Medemia*, a monotypic genus of fan palms, has its distribution limited to the Nubian Desert in south-

ern Egypt and northern Sudan (Boulos 1968, 1985; Gibbons & Spanner 1996). No endemic genera are known in the flora of Egypt. However, the genus *Medemia* is considered the only near endemic since its distribution in the Nubian Desert is shared between southern Egypt and northern Sudan, not very far from the Egyptian-Sudanese border (Gibbons & Spanner 1996; Boulos 1997).

The Eastern Desert

The plant life of the Eastern Desert has also been a subject of study by numerous authors. Zahran & Willis (1992) reviewed these works and gave a detailed account on the geology, geomorphology, vegetation types and the ecological characteristics of this vast desert.

Two major phytogeographical regions are usually recognized within the Eastern Desert: the Red Sea coastal region and the inland desert.

The Red sea coastal region

Three ecosystems may be recognized within this coastal region, based on the studies of several pioneer workers as well as those by Kassas & Zahran (1962, 1965, 1967, 1971); Zahran (1962, 1964, 1965, 1977) and Zahran & Mashaly (1991).

A. THE LITTORAL SALT MARSHES

The Red Sea coastal area in Egypt extends for about 1,100 km from Suez to Halaieb near the Sudanese border, at 22° N, along which the littoral salt marshes form stretches bordering the sea. The vegetation of these salt marshes is sometimes fringed by pure stands of mangroves of *Avicennia marina* or mixed with *Rhizophora mucronata*. Apart from these two mangrove species the salt marsh vegetation is characterized by the following halophytic and salt tolerant species: *Halocnemum strobilaceum*, *Arthrocnemum macrostachyum*, *Halopeplis perfoliata*, *Limonium axillare*, *Aeluropus lagopoides*, *Aeluropus littoralis*, *Sporobolus spicatus*, *Halopyrum mucronatum*, *Nitraria retusa*, *Suaeda monoica*, *Juncus rigidus*, *Tamarix nilotica* and *Zygophyllum album*.

B. THE COASTAL DESERT WADIS

Numerous coastal desert wadis run eastwards and flow into the Gulf of Suez and the Red Sea which greatly vary in length and width. Wadi Araba, about 70 km long, reaches 30 km in width, with many tributaries; it separates North and South Galala and is one of the major drainage systems in the Gulf of Suez region. In the southern coastal region Wadi Hodein, Wadi Di-ib and Wadi Serintai form extensive drainage systems.

C. THE COASTAL MOUNTAINS

An almost continuous range of mountains and hills forms a natural barrier between the above mentioned coastal desert wadis with eastward drainage to the Red Sea and those with westward drainage across the Eastern Desert to the Nile.

The major mountains from north to south are: Gebel Ataq (871 m), North Galala (1274 m), South Galala (1216 m), Gebel Gharib (1751 m), Abu Dukhan (1661 m), Qattar (1963

m), Shayeb El-Banat (2184 m, highest in the Eastern Desert), Nugrus (1504 m), Hamata (1977 m), Elba (1437 m) and Gebel Shindieb (1911 m).

Plant life in coastal desert wadis and mountains

The plant life in the coastal desert wadis and mountains of the Eastern Desert is rather rich and interesting. The area stretches from 30°N at Gebel Ataqa near Suez to 22°N at Gebel Elba and Gebel Shindieb near the Sudanese border.

The Gebel Elba region is the only part of Egypt which belongs to the Sahel regional transition zone, (White 1993). Its plant life is especially rich (458 species according to Zahran & Willis 1992), and the proportion of its tree and shrub species is much higher than in any other region in Egypt. Some Sahelian woody elements are restricted to Gebel Elba and not known elsewhere from Egypt.

Léonard (1988-1989), White & Léonard (1991) suggest that the flora and vegetation of the extreme south of the Arabian Peninsula represent an extension into southwest Asia of the Somalia-Masai regional Centre of endemism, though with some important differences. Among the species they list from the evergreen bushland, thicket and scrub forest, at mid-altitudes which form a transition zone between *Acacia-Commiphora* deciduous bushland and various types of montane forests, are the following species, also known from Gebel Elba: *Euclea schimperi*, *Dodonaea viscosa*, *Grewia tembensis* and *Carissa spinarum*. White & Léonard (1991) shows the distribution of *Euclea schimperi*, with its northernmost locality in Gebel Elba, which represents a northern extension into the Sahel regional transition zone or a satellite of the Somalia-Masai evergreen bushland.

Among the interesting elements in Gebel Elba is *Dracaena ombet*, a high altitude tree, endemic to the Red Sea Hills, with Elba as its northern limit in Egypt extending southwards to Erkwit in Sudan. White and Léonard (1991) comment on the distribution of *Dracaena ombet*: “*Dracaena* also occurs in the mist oases of Erkwit (Kassas 1956) in Sudan and Jebel Elba (SE Egypt); although these localities lie outside the limits of the Somalia-Masai region they support small satellites of Somalia-Masai evergreen bushland.”

Ricinus communis, a widespread element of tropical Africa, has its northern limit of natural distribution in Gebel Elba.

Out of the 10 species of *Acacia* known in Egypt 7 are known from Gebel Elba, of which *Acacia asak* and *Acacia oerfota* var. *oerfota* are restricted to Elba.

The family *Acanthaceae* is represented in Egypt by 8 species, related to 6 genera; all of them are known from Elba, and 4 are restricted to Elba.

The family *Capparaceae* is represented in Egypt by 11 species, related to 5 genera. All except one are known from Elba, of which 9 are trees or shrubs.

Among the genera represented in the flora of Egypt by one tree species the following are restricted to the Gebel Elba region: *Delonix elata*, *Flueggea virosa*, *Maytenus senegalensis*, *Sterculia africana*, *Euclea schimperi* and *Cordia sinensis*.

Some genera are represented in the flora of Egypt by 2, 3 or 4 species, all of which are known from Elba, these are: *Plicosepalus* 2 species, *Trianthema* 2, *Zaleya* 2, *Cadaba* 3, *Boscia* 2, *Maerua* 2, *Commiphora* 2, *Grewia* 3, *Triumfetta* 2, *Kedrostis* 2, *Coccinia* 2,

Cucumis 4, *Jasminum* 2, *Pergularia* 2, *Merremia* 2, *Evolvulus* 2, *Seddera* 2, *Trichodesma* 2, *Lindenbergia* 2, *Barleria* 2, *Commelina* 4, *Enneapogon* 4, *Aristida* 3 and *Tragus* 2 species.

The only endemic taxon known from Gebel Elba is *Biscutella didyma* var. *elbensis*.

The links between the plant life in the northern mountains and wadis of the Eastern Desert (west of the Gulf of Suez) and Sinai (east of the Gulf of Suez) are obvious. Three species, endemic to Egypt, have their distribution restricted to the Galala mountains and Sinai; these are: *Dianthus guessfeldtianus*, *Colchicum cornigerum* and *Colchicum gussfeldtianum*. On the other hand, some species are restricted to the Galala mountains and not known elsewhere from Egypt, e.g. *Tulipa stylosa*. One is endemic to the Galala mountains: *Bellevia flexuosa* Boiss. var. *galalensis*, while *Helianthemum schweinfurthii* is endemic to Gebel Shalufa, north of Suez.

The list here presented comprises 40 species known from both sides of the Gulf of Suez: the northern mountains and wadis of the Eastern Desert (west of the Gulf of Suez) and Sinai (east of the Gulf of Suez). These are not known elsewhere in Egypt. The largest families represented in this group of species are *Compositae* (11 species) and *Labiatae* (8 species).

The inland Desert

The inland part of the Eastern Desert, an area of about 223,000 km², constitutes a rocky plateau dissected by numerous wadis and their tributaries, between the Red Sea coastal mountains and the Nile, and may be divided according to Zahran & Willis (1992) into 4 main ecological regions:

- a. Cairo-Suez Desert
- b. Limestone Desert
- c. Sandstone Desert
- d. Nubian Desert

Kassas & Girgis (1970, 1972) presented a study on the plant life in the Nubian Desert east of the Nile, and the region between lat. 27°30' and 25°30' N of the Eastern Desert of Egypt.

El-Sharkawi & Fayed (1975); El-Sharkawi, Fayed & Salama (1982a, b, 1984, 1988); El-Sharkawi & Ramadan (1983, 1986) presented a series of papers entitled "Vegetation of inland desert wadis in Egypt" in which they have described numerous communities from several wadis in the Eastern Desert draining into the Nile.

The diversity in the inland part of the Eastern Desert is less pronounced than that of the coastal wadis and mountains. As an example, Belal & al. (1997) have recorded 127 species of higher plants from the Wadi Allaqi basin (Lat. 23°-22°N), the longest and widest in the Eastern Desert of Egypt. No endemic species are recorded, but large undisturbed populations of *Salvadora persica* and *Balanites aegyptiaca* occur in the upstream of Wadi Allaqi, while these are threatened elsewhere in Egypt. They add: the vegetation of the main channel is an open scrubland of sparse and scattered *Acacia* trees and a few perennial species during the rainless period. However, after rain annuals appear on the floor of the wadi. Numerous fossil hillocks with dead remnants of *Tamarix* and *Salvadora* in the midstream part of the wadi are obviously relicts of extensive thickets which were growing in the past.

In a recent study by Fossati, (1998) on the northern sector of the Eastern Desert between Cairo, Suez and Qena, with special reference to the inland wadis draining into the Nile between lat. 30°N and 26°30'N, 124 perennial species are recorded of which *Zilla spinosa* and *Zygophyllum coccineum* were observed in more than half of the 237 studied relevés. *Iphiona mucronata*, *Deverra tortuosa*, *Nauplius graveolens*, *Pulicaria undulata*, *Pulicaria incisa* and *Achillea fragrantissima* were present in more than 48 relevés. *Launaea nudicaulis* and *Citrullus colocynthis* have a large distribution too and are encountered in all described communities.

In conclusion, it is obvious that the coastal desert wadis and the Red Sea mountains receive more rain and enjoy a natural protection through the high Red Sea chain of mountains against the severe dry and often hot winds from the Sahara. These conditions probably resulted in more isolated habitats with richer plant life, including a few endemic species, in contrast to a poorer flora and hardly any endemics in the inland Eastern Desert (223,000 km²) despite its much greater surface.

The Sinai peninsula

The plant life of the Sinai peninsula has been a subject of interest which attracted many botanists and explorers (Batanouny 1985). The Sinai peninsula, which occupies an area of 61,000 km² or 6.1% of the surface of Egypt, is rich both in the number of species and the high percentage of endemics. Boulos (1995) lists 1,262 taxa of vascular plants known from Sinai, or 56.2% of the flora of Egypt is represented in Sinai; the number of native and naturalized taxa known from Egypt is 2,247 (2094 species and 153 infraspecific taxa). On the other hand, the endemic taxa known from Sinai are 36 out of 70, or 51.4% of those known from Egypt (Boulos 1997).

The phytogeographical concept of Eig (1932-1933), which was basically adopted by most workers for several decades, identifies four regions represented in the Sinai Peninsula: the Mediterranean region, the Saharo-Sindian, the Irano-Turanian and the Sudano-Deccanian.

Täckholm (1974) recognizes three phytogeographical regions in Sinai: the Mediterranean coastal region, the Isthmic desert (El-Tih and the region north of Wadi Tumilat) and Sinai proper (the mountainous plateau south of El-Tih). However, according to White (1993), the Sinai peninsula totally lies within the Sahara regional transition zone. Boulos (1995) treats the entire Sinai peninsula, including the coastal Mediterranean strip and El-Tih Desert east of Suez Canal, as one unit.

Three regions may be distinguished in the Sinai peninsula according to their geomorphological features (Zahran & Willis, 1992 and several others):

1. NORTHERN SINAI

This region is bordered by the Mediterranean Sea. Lake Bardawil and a wide plain of sand dunes constitute its major features.

2. CENTRAL SINAI

This region includes El-Tih plateau, Wadi El-Arish basin and three mountains: Gebel El-Halal (892 m), Gebel El-Maghara (735 m) and Gebel Yallaq (1094 m).

3. SOUTHERN SINAI

The main bulk of southern Sinai is a high plateau of igneous and metamorphic rocks. The highest peak is St. Katherine (2641 m). The western coastal region of southern Sinai, which is bordered by the Gulf of Suez, the Qaa plain is much broader (average breadth 30 km) than that bordering the Gulf of Aqaba.

Although the entire Sinai peninsula is treated here as a part of the Sahara regional transition zone, its variable geomorphology and environment produce different habitat types, often of great contrast. Consequently, 8 vegetation types may be recognized in Sinai (Boulos 1982c).

1. Coniferous woodland of *Juniperus phoenicea* are restricted to Gebels El-Maghara, Halal and Yallaq of the northern part of Central Sinai. Although the rainfall in this region is below 100 mm (Danin 1983) this woodland is regenerating as many seedlings were recorded.

2. High altitude dwarf vegetation, restricted to southern Sinai and is characterized by the presence of many endemics such as: *Bufonia multiceps*, *Silene leucophylla*, *Silene oreosinaica*, *Silene schimperiana*, *Rosa arabica*, *Astragalus fresenii*, *Primula boveana*, *Ballota kaiseri*, *Phlomis aurea*, *Anarrhinum pubescens*, and *Veronica kaiseri*.

It may be worthwhile to mention here that a species which was considered to be endemic in Sinai such as *Hypericum sinaicum* was later recorded from Dahna, southern Jordan, and Saudi Arabia. Likewise *Polygala sinaica* var. *glabrescens* and *Pterocephalus sanctus* were later recorded from Palestine and northwest Saudi Arabia.

3. Arid vegetation with infiltration of Mediterranean elements, such as: *Capparis spinosa*, *Teucrium polium*, *Ballota undulata*, *Phagnalon rupestre*, *Centaurea eryngioides* and *Verbascum sinuatum*. The region which represents this vegetation type is the southern region of Central Sinai, adjacent to the southern mountainous plateau.

4. Hyperarid vegetation with elements such as *Cornulaca monacantha*, *Anabasis articulata*, *Astragalus spinosus*, *Zilla spinosa* and *Gymocarpus decandrus*. This vegetation type occurs north of the previous region, or in the central part of Central Sinai.

5. The coastal sand dunes with some typical elements such as *Ammophila arenaria*, *Cakile maritima*, *Euphorbia paralias*, *Silene succulenta* and *Pancratium maritimum*. This area is interrupted by patches of salt marshes where halophytic vegetation dominates, e.g. *Halocnemum strobilaceum*, *Arthrocnemum macrostachyum*, *Limoniastrum monopetalum* and *Frankenia hirsuta*.

6. The sandy desert south of the coastal sand dune area which is characterized by its perennial grasses such as *Stipagrostis plumosa* and the dominance of *Artemisia monosperma* and its associates.

7. The hot deserts facing the southern coasts of Sinai are characterized by the following elements: *Acacia tortilis* subsp. *tortilis* and *A. tortilis* subsp. *raddiana*, *Ziziphus spina-christi*, *Haloxylon salicornicum*, *Capparis decidua*, *Retama raetam*, *Ochradenus baccatus*, *Aerva javanica*, *Calotropis procera* and *Senna italica*. In the swampy areas *Phragmites australis*, *Typha domingensis* and *Juncus rigidus* dominate. Often oasis-like patches are dominated with *Phoenix dactylifera* and *Tamarix nilotica*. According to Täckholm & Drar (1950), groves of *Hyphaene thebaica* grow at El-Tor (Gulf of Suez) and Taba (Gulf of Aqaba). They also refer to 4 places along the seashore forming dense growth at Aqaba, but this most probably refers to Aqaba Port in Jordan.

8. The mangrove vegetation is represented by *Avicennia marina* in the form of shore-line swamps at Ras Mohammad and Nabq, some 50 km North of Ras Mohammad. The occurrence of *Avicennia marina* as far north as Nabq is probably the northern most known locality of mangrove vegetation worldwide.

The plant life in Sinai, apart from being rich both in the number of species and endemics compared to its relatively small area (6.1% of Egypt), has some unusual elements with discontinuous distribution. Perhaps the most striking is *Lasiospermum brachyglossum* which was known from Sinai and the Cape of Good Hope (Boulos 1995), was recently recorded from Jordan and Saudi Arabia (Boulos 2002).

Conclusions

Apart from the western coastal Mediterranean narrow belt which enjoys a relatively higher rainfall than the inner desert, the present-day plant life in the Western Desert of Egypt constitutes a part of the vegetation of the Sahara with a few endemic species known from Kharga Oasis and one near endemic genus from Dungul and Nakhila oases. As a result of the climatic changes, the ancient vegetation of the Western Desert which was a Savanna type during the Early and Middle Holocene degraded into a hyperarid zone, poor in diversity and plant cover. The recent prolonged periods of drought, especially in Gilf El-Kebir and Gebel Uweinat, which often last for more than one decade, brought drastic losses to the vegetation and probably resulted in the extinction of some species.

The plant life in the Eastern Desert is much richer than that of the Western Desert. The flora of the northern wadis and mountains of the Eastern Desert west of the Gulf of Suez has strong relations with that of the Sinai peninsula.

The southern region of Gebel Elba, the only part of Egypt which lies within the Sahel regional transition zone, has a rich plant life including some Sahelian woody elements which are not known elsewhere from Egypt.

The Sinai peninsula, although occupying only 6.1% of the area of Egypt, has 56.2% of the taxa of vascular plants of the entire flora, and 51.4% of the endemics of Egypt.

List of taxa known in Egypt only from the study area

Species known from both sides of the Gulf of Suez: the northern mountains and wadis of the Eastern Desert (west of the Gulf of Suez) and Sinai (east of the Gulf of Suez), and not known elsewhere from Egypt.

POLYGONACEAE

Atraphaxis spinosa var. *sinaica* (Jaub. & Spach) Boiss.

CARYOPHYLLACEAE

Minuartia picta (Sibth. & Sm.) Bornm.

Paronychia sinaica Fresen.

CLEOMACEAE

Cleome arabica L.

CHENOPODIACEAE

Seidlitzia rosmarinus Bunge ex Boiss.

Haloxylon persicum Bunge

ZYGOPHYLLACEAE

Zygophyllum dumosum Boiss.

Fagonia tristis Sickenb.

UMBELLIFERAE

Deverra triradiata Hochst. ex Boiss.

Zosima absinthifolia (Vent.) Link

RUBIACEAE

Callipeltis cucullaris (L.) Steven

LABIATAE

Thymus bovei Benth.

Satureja sinaica (Benth.) Briq.

Salvia deserti Decne.

Salvia palaestina Benth.

Ballota undulata (Fresen.) Benth.

Leucas inflata Benth.

Teucrium leuocladum Boiss.

Teucrium decaisnei C. Presl

SOLANACEAE

Solanum elaeagnifolium Cav.

SCROPHULARIACEAE

Kickxia floribunda (Boiss.) Täckh. & Boulos

Scrophularia hypercifolia Wydler

DIPSACACEAE

Scabiosa palaestina L.

CAMPANULACEAE

Campanula sulphurea Boiss.

COMPOSITAE

Echinops glaberrimus DC.

Atractylis mernephtae Asch., Schweinf. & Letourn.

Atractylis serratuloides Sieber ex Cass.

Onopordum ambiguum Fresen.
Zoegea purpurea Fresen.
Centaurea eryngioides Lam.
Phagnalon nitidum Fresen.
Iphiona mucronata (Forssk.) Asch. & Schweinf.
Chiliadenus montanus (Vahl) Brullo
Crepis sancta (L.) Bornm.
Lactuca orientalis (Boiss.) Boiss.

LILIACEAE

Tulipa biflora Pall.

COLCHICACEAE

Androcymbium palaestinum Baker

ASPHODELACEAE

Asphodelus aestivus Brot.

GRAMINEAE

Poa sinaica Steud.

Pennisetum orientale Rich.

Acknowledgment

I wish to thank Professor S. I. Ghabbour, Cairo University, for reading the manuscript and for useful comments.

References

- Abd El-Ghani, M. M. 1992: Flora and vegetation of Qara Oasis, Egypt. – *Phytocoenologia* **21**: 1-14.
 — 2000: Floristic and environmental relations in two extreme desert zones of western Egypt. – *Global Ecol. Biogeogr.* **9**: 499-516.
 Alaily, F., Bornkamm, R., Blume, H.-P. Kehl, H. & Zielinski, H. 1987: Ecological investigations in the Gilf Kebir (SW-Egypt). – *Phytocoenologia* **15**: 1-120.
 Ayyad, M. A. 1973: Vegetation and environment of the Western Mediterranean coastal land of Egypt. I. The habitat of dunes. – *J. Ecol.* **61**: 509-523.
 — 1976: Vegetation and environment of the Western Mediterranean coastal land of Egypt. IV. The habitat of non-saline depressions. – *J. Ecol.* **64**: 713-722.
 — 1981: Soil vegetation-atmosphere interactions. – Pp 9-81. In: O. W. Goodall O. W. & Perry R. A. (eds) *Arid Land Ecosystems: Structure, Functioning and Management* Vol. 2. – *Int. Biol. Programme*, **17**. – Cambridge.
 — 1983: Some aspects of land transformation in the Western Mediterranean Desert of Egypt. – *Adv. Space. Res.* **2(8)**: 19-29.
 — & Ammar, M. Y. 1974: Vegetation and environment of the Western Mediterranean coastal land of Egypt. II. The habitat of inland ridges. – *J. Ecol.* **62**: 439-456.

- & El-Bayyumi, M. A. 1979: On the phytosociology of sand dunes of the Western Desert of Egypt. – Pp. 219-237 in Prof. R. Misra commemoration volume. – Glimpses of Ecology. – Jaipur, India.
- & El-Ghareeb, R. E. M. 1982: Salt marsh vegetation of the Western Mediterranean desert of Egypt. – *Vegetatio* **49**: 3-19.
- & — 1984: Habitats and plant Communities of the NE Desert of Egypt. – *Comm. Agrisci. Develop. Res. Coll. Agric. Univ. Alexandria*, **7(6)**: 1-34.
- & El-Ghonemy, A. A. 1976: Phytosociological and environmental gradients in a sector of the Western Desert of Egypt. – *Vegetatio* **31(2)**: 93-102.
- & Ghabbour, S. I. 1986: Hot deserts of Egypt and the Sudan. – Pp 149-202. in Evenari & al. (eds) *Ecosystems of the World, 12B, Hot Deserts and Arid shrublands*. – Amsterdam.
- & — 1993: Dry coastal ecosystems of Eastern North Africa. – Pp 1-16 in van der Maarel E. (ed.) *Ecosystems of the World 2B, Dry Coastal Ecosystems*. – Amsterdam.
- Back, H.-E. 1981: Beitrag zur Faunistik und Zoogeographie der Lepidopteren in der östlichen Sahara. – *Nota Lepid.* **4(4)**: 111-124.
- Bagnold, R. A. 1931: Journey in the Libyan desert 1929 and 1930. – *Geogr. J.* **78**: 13-39.
- 1939: An expedition to the Gifl Kebir and Uweinat, 1938. 1. Narrative of the journey. – *Geogr. J.* **93**: 281-287.
- Barakat, H. N. 1995: Contribution archeobotanique à l'histoire de la végétation dans le Sahara oriental et dans le Soudan central. – Thèse, Fac. Sci. Techn. Saint-Jerome, Univ. Aix-Marseille III.
- Batanouny, K. H. 1985: Botanical exploration of Sinai. – *Qatar Univ. Sci. Bull.* **5**: 187-211.
- Belal, A. E., Springuel, I. Ghabbour, S., Mursy, A., Paris, F., Ali, D. & Faraldi, C. 1997: Wadi Allaqi Biosphere Reserve. – Cairo.
- Bornkamm, R. 1986: Flora and vegetation of some small oases in S-Egypt. – *Phytocoenologia* **14(2)**: 275-284.
- & Kehl, H. 1989: Landscape ecology of the western desert of Egypt. – *J. Arid Environm.* **17**: 271-277.
- & — 1990: The plant communities of the Western Desert in Egypt. – *Phytocoenologia* **19(2)**: 149-231.
- Boulos, L. 1966: A natural history study of Kurkur Oasis, Libyan Desert, Egypt. IV. The vegetation. – *Postilla* **100**: 1-22.
- 1968: The discovery of Medemia Palm in the Nubian Desert of Egypt. – *Bot. Not.* **121**: 117-120.
- 1975: The Mediterranean element in the flora of Egypt and Libya. – *Colloques Internat. CNRS* 235. *La flore du Bassin Méditerranéen: essai de systématique synthétique*: 119-124.
- 1980: Journey to the Gifl Kebir and Uweinat, southwest Egypt, 1978. IV. Botanical results of the expedition. Pp. 68-71 in El-Baz & al. *Journey to the Gifl Kebir and Uweinat, southwest Egypt, 1978* – *Geogr. J.* 146: 51-93.
- 1982a: Flora of Gebel Uweinat and some neighbouring regions of southwestern Egypt. – *Candollea* **37**: 257-276.
- 1982b: The flora of Gebel Uweinat and neighbouring regions, southwest Egypt. In: *Desert Landforms of Southwest Egypt: a basis for comparison with Mars*. in El-Baz, F. & Maxwell, T. A. NASA CR-3611, Washington, D. C., pp. 341-347
- 1982c: Flora of Sinai. – Pp 45-57 in EDITOR *Environment of Sinai, World Environment Day*. – Cairo. (in Arabic).
- 1985: The arid eastern and south-eastern Mediterranean area. Pp. 123-140 in: Gomez-Campo, C. (ed.) *Plant Conservation in the Mediterranean area*. – Dordrecht.
- 1989: The Flora. – Pp. 85-106 in Kassas, M. (ed.) *Encyclopaedia of the Western Desert, 1*. – Acad. Sci. Res. Techn. Cairo, 1 (in Arabic).
- 1995: *Flora of Egypt Checklist*. – Cairo.
- 1997: Endemic flora of the Middle East and North Africa. – Pp 229-260 in: Barakat, H. N. & A. K. Hegazy (eds.) *Reviews in Ecology: Desert Conservation and Development*. – Cairo.

- 1999, 2000, 2002, 2005: Flora of Egypt, **1, 2, 3, 4**. – Cairo.
- , & Barakat, H. N. 1997a: Report on the vegetation in the surveyed area of Qattara depression. (unpublished).
- & — 1997b: Report on the flora of Gilf El-Kebir and Gebel Uweinat: assessment, threats and protection (unpublished).
- & — 1998: Some aspects of the plant life in the Western Desert of Egypt. – *J. Union Arab Biol. Cairo* **5 (B)**: 79-94.
- Corti, R. 1938: Le raccolte botaniche del Sud Cirenaico del Prof. L. Di Caporiacco (1933- Spediz. Marchesi) e del Prof. U. Monterin (1934-R. Soc. Geogr. Italiana) e la Florula delle Oasi di Cufra e del Gebel Auenát. Nuovo – *Giorn. Bot. Ital.*, n. s., **54**: 202-240.
- Danin, A. 1983: Desert vegetation of Israel and Sinai. – Jerusalem.
- Eig, A. 1931-1932: Les éléments et les groupes phytogéographiques auxiliaires dans la flore palestinienne. – *Beih. Repert. Spec. Nov. Regni. Veg.* 63 (1, texte): 1-201 (1931) & (2, Tabl. analyt.), 1-120 (1932).
- El-Sharkawi, M.M. & Fayed, A.A. 1975: Vegetation of inland desert wadis in Egypt, 1. Wadi Bir El-Ain. – *Feddes Repert.* **86**: 589-594.
- , — & F. M. Salama 1982a: Vegetation of inland desert wadis in Egypt, 2. Wadi El-Matuli and Wadi Qarn. – *Feddes Repert.* **93**: 125-133.
- , — & — 1982b: Vegetation of inland desert wadis in Egypt, 3. Wadi Gimal and Wadi El-Minyah. – *Feddes Repert.* **93**: 145-153.
- , — & — 1984: Vegetation of inland desert wadis in Egypt, 6. Wadi Qassab. – *Feddes Repert.* **95**: 561-570.
- , — & — 1988: Vegetation of inland desert wadis in Egypt, 9. Eastern tributaries of lower wadi Qena. – *Feddes Repert.* **99**: 489-495.
- & Ramadan, A.A. 1983: Vegetation of inland desert wadis in Egypt, 4. Phytosociology and wadi systems east of Minya Province. – *Feddes Repert.* **94**: 335-346.
- & — 1986: Vegetation of inland desert wadis in Egypt, 7. Ecophysiological characteristics of plant communities in wadi system East of Minya Province. – *Feddes Repert.* **97**: 373-383.
- Fossati, J., Pautou, G. & Peltier, J. P. 1998: Wadi vegetation of the North-Eastern Desert of Egypt. – *Feddes Repert.* **109**: 313-327.
- Gibbons, M. & Spanner, T. W. 1996: *Medemia argun* lives. – *Principes* **40(2)**: 65-74.
- Hassan, F. A. 1986: Desert environment and origins of agriculture in Egypt. – *Norw. Arch. Rev.* **19 (2)**: 63-76.
- Haynes, C. V. 1980: Geological evidence of pluvial climates in the Nabta area of the western desert, Egypt. – Pp. 353-371 in Wendorf, F. & Schild, R. *Prehistory of the Eastern Sahara*. – New York.
- , Eyles, C. H., Pavlish, L., A. Ritchie, J. C. & Rybak, M. 1989: Holocene palaeoecology of the eastern Sahara: Selima Oasis. – *Quaternary Sci. Rev.* **8**: 109-136.
- Hutchinson, J. 1933: Botany of Bagnold's expedition in the desert. – *Geogr. J.* **82**: 226.
- Kassas, M. 1956: The mist oasis of Erkwit, Sudan. – *J. Ecol.* **44**: 180-194.
- & Zahran, M. A. 1962: Studies on the ecology of the Red sea coastal land, I. The district of Gebel Ataqa and El-Galala El-Bahariya. – *Bull. Soc. Géogr. Egypte*, **35**: 129-175.
- & — 1965: Studies on the ecology of the Red Sea coastal land, II. The district from El-Galala El-Qibliya to Hurghada. – *Bull. Soc. Géogr. Egypte* **38**: 155-193.
- & — 1967: On the ecology of the Red Sea littoral salt marsh, Egypt. – *Ecol. Monogr.* **37(4)**: 297-315.
- & — 1971: Plant life on the coastal mountains of the Red Sea, Egypt. – *J. Ind. Bot. Soc.* **50A**: 571-589.
- Kehl, H. 1987: Zonation and establishment of vegetation in selected uninhabited Egyptian and Sudanese oases. – *Catena* **14**: 275-290.

- & Bornkamm, R. 1993: Landscape ecology and vegetation units of the Western Desert of Egypt. – *Catena Suppl.* **26**: 155-178.
- Léonard, J. 1966: The 1964-1965 Belgian Trans - Saharan expedition. – *Nature* **209**: 126-128.
- 1970a: Expédition scientifique belge dans le Désert de Libye, Jebel Uweinat 1968-1969. I. Préface. – *Africa-Tervuren* **15**: 102-104.
- 1970b: Expédition scientifique belge dans le Désert de Libye, Jebel Uweinat 1968-1969. IV. La flore. – *Africa-Tervuren* **15**: 110-116.
- 1971: Aperçu de la flore et de la végétation du Jebel Uweinat (Désert de Libye), Résumé. – *Mitt. Bot. Staatssamml. München* **10**: 476-477.
- 1988-1989: Contribution à l'étude de la flora et de la végétation des déserts d'Iran, fasc. 8 (Etude des aires de distribution. Les phytochories. Les chorotypes); fasc. 9 (Considérations phytogéographiques sur les phytochories irano-touranienne, saharo-sindienne et de la Somalie-pays Masai). – *Jard. Bot. Nat. Belgique* **8**: 1-190; **9**: 1-123.
- 1997-2001: Flore et végétation du Jebel Uweinat (Désert de Libye: Libye, Egypte, Sudan). – *Bull. Jard. Bot. Nat. Belg.* **66**: 223-340 (1997); **67**: 123-216 (1999); *Syst. Geogr. Pl.* **69**: 215-264 (1999); **70**: 3-73 (2000); **70**: 75-135 (2000); *Scripta Botanica Belgica* **21**: 1-139 (2001).
- Monod, Th. 1995: Contribution à l'établissement d'une florule du Gilf Kebir (S.- O. Egypte). – *Bull. Mus. natl. Hist. nat. Paris, sér. 4, sect. B, Adansonia* **17**: 259-269.
- Neumann, K. 1987: Middle Holocene vegetation of Gilf Kebir, SW Egypt: a reconstruction. – *Palaeocol. Africa* **18**: 179-188.
- 1989a: Vegetationsgeschichte der Ostsahara im Holozän: Holzkohlen aus prähistorischen Fundstellen (mit einem Exkurs über die Holzkohlen von Fachi-Dogouboulo/Niger). – *Africa prehistorica* **2**: 1-341
- 1989b: Holocene vegetation of the Eastern Sahara: charcoal from prehistoric sites. – *African Archaeological Rev.* **7**: 97-116.
- & Schulz, E. 1987: Middle Holocene savanna vegetation in Central Sahara. Preliminary report. – *Palaeocol. Africa* **18**: 163-166.
- Osborn, D. J. & Krombein, K. V. 1969: Habitats, flora, mammals and wasps of Gebel Uweinat, Libyan Desert. – *Smithsonian Contr. Zool.* **11**: 1-18.
- Pachur, H. J. & Kröpelin, S. 1989: L'aridification du Sahara oriental à l'Holocène moyen et supérieur. – *Bull. Soc. Géol. France* **8**: 99-107.
- Ritchie, J. C., Eyles, C. H. & Haynes, C. V. 1985: Sediments and pollen evidence for a middle Holocene humid period in the Eastern Sahara. – *Nature* **314**: 352-355.
- & Haynes, C. V. 1987: Holocene vegetation zonation in the eastern Sahara. – *Nature* **330**: 645-647.
- Shaltout, K. H. 1997: Current situation of flora and vegetation of south-west Egypt. – Pp. 199-241 in Abdel-Ghaffar & al. (eds.) *Integrated land development of Southern Egypt: available resources and alternative options.* – Cairo.
- Shaw, W. B. K. 1931: Botanical results of the expedition.. – Pp. 13-39 in: Bagnold, R. A., *Journey in the Libyan Desert, 1929 and 1930.* – *Geogr. J.* **78**: 13-39, 524-535.
- 1936: An expedition in the southern Libyan Desert. – *Geogr. J.* **87**: 193-221.
- & Hutchinson, J. 1931: XXV. The flora of the Libyan desert. – *Bull. Misc. Inf. Royal Bot. Gardens Kew* 1931:161-166.
- & — 1934: XXXVI. - The flora of the Libyan desert. – *Bull. Misc. Inf. Royal Bot. Gardens Kew.* 1934: 281-289.
- Täckholm, V. 1974: *Students' Flora of Egypt*, 2nd ed. – Beirut.
- & Drar, M. 1941, 1950, 1954, 1969: *Flora of Egypt*, 1, 2, 3, 4. – *Bull. Fac. Sci. Cairo Univ.* **17**, **28**, **30**, **36**, (vol. 1 with G. Täckholm).
- Tadros, T. M. 1953: A phytosociological study of halophilous communities from Mareotis (Egypt). – *Vegetatio* **4**: 102-124.

- 1956: An ecological survey of the semi-arid coastal strip of the western desert of Egypt. – Bull. Inst. Désert Egypte **6(2)**: 28-56.
- , & Atta, B. A. M. 1958a: Further contribution to the study of the sociology and ecology of the halophilous plant communities of Mareotis (Egypt). – Vegetatio **8**: 137-160.
- & — 1958b: The plant communities of barley fields and uncultivated desert areas of Mareotis (Egypt). – Vegetatio **8**: 161-175.
- & El-Sharkawi, H. M. 1960: Phytosociological and ecological studies on the vegetation of Ras El-Hikma area. II. Consistency and homogeneity of the open desert communities. – Bull. Inst. Désert Egypte **10(1)**: 16-63.
- Wasylikowa, K. 1992: Exploitation of wild plants by prehistoric peoples in the Sahara. – Würzb. Geogr. Arb. **84**: 247-262.
- , Harlan, J. R.; Evans, J.; Wendorf, F.; Schild, R. Close, A. E. Królik, H. & Housley, R. A. 1993: Examination of botanical remains from early neolithic houses at Nabta Playa, Western Desert, Egypt, with special reference to Sorghum grains. – Pp. 154-164. in Shaw, T. & al.: The Archaeology of Africa, Food, metals and towns. – New York.
- Wasylikowa, K., Barakat, H. N., Boulos, L., Butler, A., Dahlberg, J. A., Hather, J. & Mitka, J. 2001: Site E-75-6: Vegetation and subsistence of the Early Neolithic and Nabta Playa, Egypt, reconstructed from charred plant remains. – Pp. 544-591 in F. Wendorf, F. & al. (eds.): Holocene Settlement of the Egyptian Sahara, 1– New York.
- Wendorf, F., Close, A. E., Schild, R., Wasylikowa, K., Housley, R. A., Harlan, J. R. & Królik, H. 1993: Saharan exploitation of plants 8,000 years BP. – Nature **359**: 721-724.
- White, F. 1993: The AETFAT chorological classification of Africa: history, methods and applications. – Bull. Jard. Bot. Nat. Belg. **62**: 225-281.
- & Léonard, J. 1991: Phyogeographical links between Africa and Southwest Asia. – Flora Vegetatio Mundi **9**: 229-246.
- Zahran, M. A. 1962: Studies on the ecology of the Red Sea coastal land. – M. Sc. Thesis, Fac. Sci., Cairo Univ.
- 1964: Contributions to the study on the ecology of the Red Sea coast. – Ph. D. Thesis, Fac. Sci., Cairo Univ.
- 1965: Distribution of mangrove vegetation in Egypt. – Bull. Inst. Désert Egypte **15(2)**: 7-12.
- 1966: Ecological study of wadi Dungul. – Bull. Inst. Désert Egypte **16**: 127-143.
- 1972: On the ecology of Siwa Oasis. – Egypt. J. Bot. **15**: 223-242.
- 1977: Africa. A. Wet formations of the African Red Sea coast. – Pp 215-231 in: Chapman V. J. (ed.) Wet Coastal Ecosystems – Amsterdam.
- & Girgis, W. A. 1970: On the ecology of wadi El-Natrun. – Bull. Inst. Désert Egypte **20**: 229-267.
- & Mashaly, I. A. 1991: Ecological notes on the flora of the Red Sea coastal land of Egypt. – Bull. Fac. Sci. Mansoura Univ. **18(2)**: 251-292.
- & Willis, A. J. 1992: The vegetation of Egypt. – London.

Address of the author:

Loutfy Boulos,

Faculty of Science, Alexandria University, Egypt.

E-mail: hadara@idsc.net.eg

