EGYPTIAN JOURNAL OF AQUATIC RESEARCH ISSN: 1687-4285
VOL. 33 NO. 3, 2007: 122-139

FLORISTIC COMPOSITION AND ENVIRONMENTAL CHARACTERISTICS OF ABU-ZA'ABAL ARTIFICIAL WETLAND, EGYPT

TAREK M. GALAL* AND AHMED A. KHALAFALLAH**

**Botany Department, Faculty of Science, Helwan University.*
***Botany Department, Faculty of Girls, Ain-Shams University*
Ahmed200497@yahoo.com

Keywords: Floristic composition, wetland, lakes, Abu-Za'abal, Egypt.

ABSTRACT

The aim of the present study is to provide a description of the floristic composition and life form spectrum of the recorded species in Abu-Za'abal Wetland (four lakes). It aims also to analyzing the distribution pattern of the plant species and the environmental factors that affect their distribution. Forty stands were selected to represent the apparent variation in the vegetation physiognomy and habitats of these lakes. Sixty four species (38 annuals and 26 perennials) belonging to 56 genera and 28 families were recorded in Abu-Za'abale Wetland. Gramineae (Poaceae) had the highest contribution, followed by Leguminosae (Fabaceae), Amaranthaceae, Chenopodiaceae and Compositae (Asteraceae). Forty-five species (31 annuals and 14 perennials) were terrestrial weeds, 7 species (2 annuals and 5 perennials) natural plants, 6 species (one annual and 5 perennials) aquatic weeds, while other six (5 annuals and one perennial) escaped from cultivations. Life forms of the recorded species indicated the predominance of therophytes, followed by geophytes-helophytes, phanerophytes, hemicryptophytes, chamaephytes and hydrophytes. Pluriregional taxa were dominated over biregional, and monoregional ones. The dendrogram resulting from the agglomerative clustering technique and DCA ordination of the four lakes based on their floristic, soil and water characteristics indicated that three clusters were separated: cluster A includes lake IV, B includes lake I and C includes lakes II and III. Lake I had the highest species diversity, while Lake IV had the lowest.

1- INTRODUCTION

Lakes are microcosms, bound and organized by interdependence and interrelationships. They are bodies of fresh, brackish and saline or hypersaline water. These habitats are highly environmentally structured and they provide a gradient from extremely inundated to relatively mesic. The chemical and hydrophysical characteristics of soils affect also the diversity and structure of the vegetation of these Lakes (El-Bana, 2003). Riemer (1984) classified the lakes according to physical attributes into six types (tectonic, volcanic, glacial, solution, basin formed by stream and human-made lakes and ponds). Abu-Za'abal lakes were considered as human-made lakes (Abd Ellah, 2003).

Abu-Za'abal Wetland (four lakes) was formed during the last century. The first and second lakes were formed during the fifth and eighth decades, respectively, while the third was formed in the ninth decade and the fourth is a small depression still in the filling phase. These lakes were formed probably due to fracture and extraction of basalt rocks and they became gradually filled up by ground water and seepage (Abd Ellah, 2003). The seepage source may be from Ismailliya canal, Bahr El-Baqar drain and cultivated area close the lakes.

Formation of Abu-Za'abal lakes has led to a number of changes in the existing microhabitats that a large number of different species of flora and fauna became re-established in such new ecological settings. The area thus opened several possibilities for various forms of development in tourism and recreational activities, fisheries and limited agricultural or soil reclimatory activities.

Few studies were carried out on lakes Abu-Za'abal; phytoplankton composition, chemical and morphometrical characteristics of Abu-Za'abal lakes' water were studied by Abd Ellah (2003) and Hussian (2005). Rabeh and Azab (2006) studied the bacterial indicators of sewage pollution and trophic status of these lakes.

The aim of the present study is to provide a description of the floristic composition and life form spectrum of the recorded species in Abu-Za'abal Wetland. It aims also to analyzing the distribution pattern of the plant species and the environmental factors that affect their distribution. In addition, this study is considered as the pioneer for further ecological studies.

STUDY AREA

Abu-Za'abal Wetland is located in the north of Qalubiya Governorate between latitude 30º 16.62´ - 30º 17.58´ N and longitude 31º 20.94´ - 31º 21.53´ E with an area of about 627.4 x 10^3 m^2 (Fig. 1). Lake I had the largest area (375.5 x 10^3 m^2), depth (10.2 m) and the maximum storage water (3840.5 x 10^3 m^3). On the other hand, lake IV had the smallest area (19.7 x 10^3 m^2), depth (3.3 m) and the minimum storage water (64.0 x 10^3 m^3) (Table 1). The total water storage was (5234.1 x 10^3 m^3) (Rabeh and Azab, 2006).

Table (1): Morphometry of the four Abu-Za'abal lakes (after Abd Ellah 2003).

Lake	Latitude (N)	Longitude (E)	Area x 10^3 (m^2)	Mean depth (m)	Water storage x 10^3 (m^3)
Lake I	30° 16.84´ - 30° 17.58´	31° 20.94´ -31° 21.53´	<u>375.5</u>	<u>10.2</u>	<u>3840.5</u>
Lake II	30° 16.78´ - 30° 17.15´	31° 20.90´ - 31° 21.22´	151.8	<u>6.1</u>	928.1
Lake III	30° 16.62´ - 30° 16.82´	31° 21.09´ - 31° 21.29´	80.4	5.8	465.5
Lake IV	30° 6.71´ - 30° 16.82´	31° 21.59´ - 31° 21.69´	<u>19.7</u>	<u>3.3</u>	<u>64.0</u>

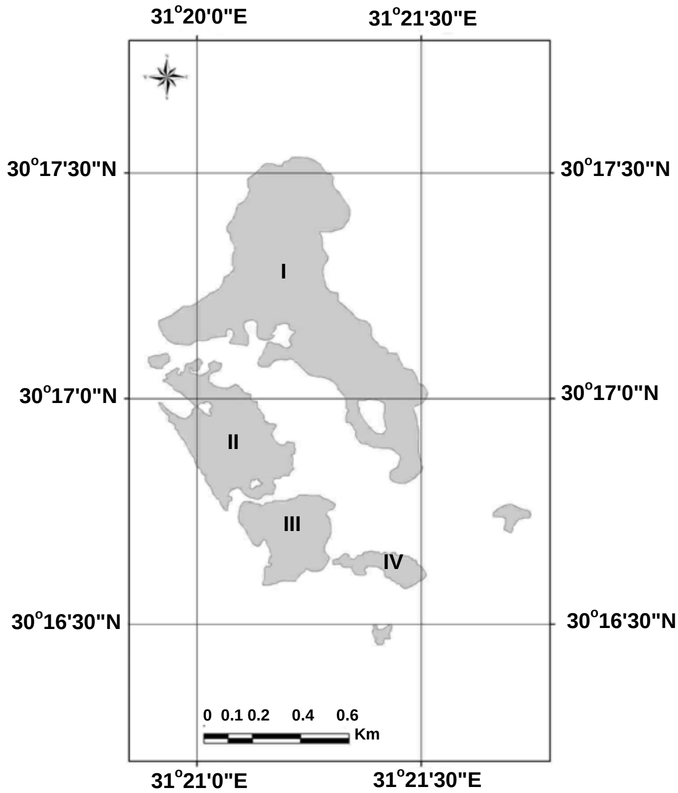

Fig. (1): Location map showing the four lakes of Abu-Za'abal.

2. MATERIALS AND METHODS

2.1. Vegetation analysis

The flora of Abu-Za'abal Wetland was studied seasonally during the period from winter to autumn 2006 (February, April, August and September 2006). Forty stands were selected to represent the apparent variation in the vegetation physiognomy and habitats of these lakes (i.e. the water body, shorelines and wastelands). The stand size was about 10 x 10 m^2 in all habitats, except for the shores where the length and width of each stand varied according to the extension of plant cover and/or nature of the shore. During each season, shoot presence/absence of all vascular plant species within each stand was recorded. Identification and nomenclature were according to Täckholm (1974) and Boulos (1999, 2000, 2002 and 2005). Voucher specimens were deposited in Helwan Faculty of Science Herbarium (HCH).

Life forms of the species were identified following the Raunkiaer scheme (Raunkiaer, 1937). The global geographical distribution of the recorded species in the study lakes were gathered from Täkholm (1974) and Wickens (1977).

The agglomerative clustering techniques were applied to classify the zonal vegetation of the water bodies, based on SØrensen similarity coefficient (Kruscal, 1964). Three techniques were applied to the matrix of 64 species recorded in the four Abu-Za'abal lakes. Detrended Correspondence Analysis (DCA) was applied on the four lakes based on their floristic composition, soil and water characteristics (Hill, 1979).

2.2. Species diversity

Relative evenness or equitability (Shannon-Weavers index) of species was expressed as $\hat{H} = -\Sigma^{s}_{i=1}$ Pi (log Pi), where S is the total number of species and Pi is the relative importance value of the i^{th} species (Pielou, 1975). The relative concentration of dominance is the second group of heterogeniety indices and is expressed by Simpson's index: D= 1/C (C = $\Sigma^{s}_{i=1}$ $(Pi)^2$, where S is the total number of species and Pi is the relative importance value of species) (Magurran, 1988).

2.3. Soil sampling and analysis

Three air-dried soil samples (0-50 cm) were collected from each lake and passed through 2mm sieve to separate gravel and debris. Other three water samples were collected from the stands of the open water during the spring season. Soil texture was determined by Sieve method (Allen *et al.,* 1986). Water and soil water extracts of 1:5 were analyzed for the determination of Electric conductivity (EC) using conductivity meter and soil reactions (pH) using pH meter. Nitrates were determined using sodium salicylate, H_2SO_4 and NaOH as analytical reagents (Allen *et al.,* 1986). Phosphates were estimated by the direct colorimetric molybdenum blue method. Calcium and magnesium were determined by titration against 0.01N versenate solution using meroxide and erichrome black T as indicators (Allen *et al.,* 1986). Total Na, K, Cd, Fe, Mn, Pb, and Zn by using flame photometer and atomic absorption spectrophotometer (Allen *et al.,* 1986).

2.4. Data analysis

The variations in the soil and water variables in relation to the four lakes were assessed using one-way analysis of variance (ANOVA). All statistical analysis was performed with SPSS WIN ver. 10.0 (SPSS 1999).

3. RESULTS

3.1. Physicochemical characteristics

3.1.1. Soil mechanical analysis

Table (2a) appeared that all soil samples showed an alkaline reaction with the range of variation 8.6 in lake I and 7.8 in Lake IV. While EC content fluctuated with the great difference between lakes, where the maximum value (7.36 mS/cm) recorded in Lake III and the minimum (1.76 mS/cm) recorded in lake I. There was a great significant difference in phosphorus content among the four lakes. However, it recorded the highest value in lake I (1353.8 ppm) and the lowest value in Lake III (54.8 ppm). Lake III and Lake IV contained high concentrations of calcium (308.6 and 295.2 ppm, respectively) when compared with lake I and Lake II (52.2 and 95.0 ppm respectively). Great significant difference was recoded in sodium content of lake IV (1250 ppm) than the other three lakes, I, II and III (285, 320 and 350 ppm, respectively). Heavy metals were recorded with low concentrations in the soil of Abu Za'abal lakes. The soil of Lake II had higher concentrations of heavy metals (Fe, Mn, V and Zn) than the other three lakes.

3.1.2. Water characteristics

Table (2b) showed that water of lake I was more transparence than the other three lakes. The maximum Secchi depth was recorded in lake I (95 cm) and the minimum Secchi depth in Lake IV (85 cm). Water electric conductivity of Abu Za'abal lakes increased gradually from lake I (5.95 mS/cm) to Lake IV (11.65 mS/cm). Lake I and III had high concentrations of silicates, while Lake II contained the highest concentration of nitrates. Lake IV contained the highest concentrations of calcium (171 ppm) and sodium (2250 pmm) in proportional to the other three lakes. On the other hand lake I contained the lowest concentrations of cations. Water heavy metals concentrations did not show significant variation among the four lakes.

Table (2): Soil (a) and water (b) characteristics of the four Abu Za'abal lakes (Mean ±SD).

(a)

Soil variable		Lake I	Lake II	Lake III	Lake IV
Sand	**%**	84.8 ± 5.45a	92.75 ± 3.87a	81.76 ± 4.19ab	84.22 ± 3.75c
Silt		6.4 ± 0.42a	5.6 ± 0.34b	7.88 ± 0.55b	1.71 ± 0.23c
Clay		1.9 ± 0.09a	0.9 ± 0.03b	1.21 ± 0.10ab	6.2 ± 0.71c
pH		8.6 ± 0.15a	8.2 ± 0.20a	7.9 ± 0.31ab	7.8 ± 0.15ab
EC mS/cm		1.76 ± 0.03a	2.42 ± 0.08b	7.36 ± 0.09c	3.15 ± 0.06d
PO_4^{---}	**ppm**	1353.8 ± 59.25a	258.7 ± 24.39b	54.8 ± 12.61c	725.6 ± 27.96d
SiO_2^{--}		13.3 ± 0.45a	7.9 ± 0.35b	13.4 ± 0.35a	10.5 ± 0.5c
NO_3^-		3.6 ± 0.25a	4.2 ± 0.25b	4.1 ± 0.3b	6.4 ± 0.15c
Ca^{++}		52.2 ± 3.1a	95 ± 4.55b	308.6 ± 7.41c	295.2 ± 8.91d
Mg^{++}		8.2 ± 0.20a	23 ± 1.42b	31.6 ± 2.30c	29.4 ± 1.67c
Na^+		285 ± 13.2a	320 ± 12.4b	350 ± 18.6c	1250 ± 36.2d
K^+		5 ± 0.21a	6 ± 0.24ab	7 ± 0.19b	9 ± 0.22c
Cu		0.19 ± 0.02a	0.21 ± 0.04a	0.1 ± 0.01b	0.39 ± 0.04c
Fe		0.17 ± 0.03a	0.32 ± 0.02b	0.14 ± 0.01a	0.17 ± 0.02a
Mn		0.09 ± 0.007a	0.12 ± 0.006a	0.09 ± 0.004a	0.11 ± 0.004a
V		0.06 ± 0.001a	0.08 ± 0.001b	0.07 ± 0.001ab	0.06 ± 0.001a
Zn		0.09 ±0.001a	0.15 ± 0.002b	0.11 ± 0.001a	0.10 ± 0.001a

(b)

Water variable		Lake I	Lake II	Lake III	Lake IV
Transparency (cm)		95 ± 6.47a	90 ± 4.57b	92.5 ± 4.98b	85 ± 3.44c
pH		8.5 ± 0.72a	8.3 ± 0.80a	8.5 ± 0.49a	8.5 ± 0.54a
EC mS/cm		5.95 ± 0.25a	7.3 ± 0.30b	8.54 ± 0.28b	11.65 ± 0.54c
SiO_2^{--}	**ppm**	26.9 ± 1.17a	21.5 ± 1.52b	27.9 ± 1.57a	21.5 ± 0.98b
NO_3^-		0.26 ± 0.012a	0.69 ± 0.020b	0.34 ± 0.017a	0.28 ± 0.011a
Ca^{++}		113.5 ± 6.54a	127.5 ± 5.88b	132.8 ± 7.42b	171.0 ± 6.87c
Mg^{++}		61.3 ± 4.32a	95.2 ± 6.50b	102 ± 5.48c	94.9 ± 4.55b
Na^+		1040 ± 55.4a	1100 ± 59.8a	1450 ± 80.92b	2250 ± 10.37c
K^+		7 ± 0.24a	13 ± 0.43b	14 ± 0.38b	9 ± 0.65a
Cu		0.09 ± 0.001a	0.05 ± 0.001b	0.08 ± 0.002a	0.05 ± 0.001b
Fe		0.15 ± 0.011a	0.24 ± 0.042b	0.17 ± 0.019a	0.15 ± 0.041a
Mn		0.07 ± 0.001a	0.05 ± 0.001a	0.06 ± 0.001a	0.08 ± 0.001a
V		0.15 ± 0.016a	0.19 ± 0.024b	0.21 ± 0.027b	0.17 ± 0.019ab
Zn		0.05 ± 0.001a	0.04 ± 0.001a	0.03 ± 0.001a	0.04 ± 0.001a

Values with the same letters in the rows are not significant.

Table (2) Cont.

Species	State	Habit	Life form	Floristic category	Lakes			
					I	II	III	IV
Malvaceae								
Malva parviflora L.	TW	Annual	TH	ME+IR-TR	+	+		
Tamaricaceae								
Tamarix nilotica (Ehrenb.) Bunge	NP	Perennial	PH	SA-AR+S-Z	+	+	+	
Umbelliferae (Apiaceae)								
Ammi majus L.	TW	Annual	TH	ME+IR-TR	+			
Asclepiadaceae								
Cynanchum acutum L.	TW	Perennial	PH	ME+IR-TR	+	+		
Convolvulaceae								
Convolvulus arvensis L.	TW	Annual	HE	Trop	+			
Solanaceae								
Lycopersicum esculentum	EP	Annual	TH	Cultivated	+			
Solanum nigrum L.	TW	Perennial	CH	ME+ER-SR+IR-TR	+			
Scrophulariaceae								
Veronica anagallis-aquatica L.	AW	Perennial	GH	Borealo-Tropical		+		
Plantaginaceae								
Plantago major L.	TW	Perennial	HE	COSM		+		
Compositae (Asteraceae)								
Launaea nudicaulis (L.) Hook. F.	NP	Perennial	HE	SA-AR+IR-TR+S-Z	+			
Pluchea dioscoridis (L.) DC.	TW	Perennial	PH	SA-AR+S-Z	+	+	+	
Senecio glaucus subsp. *coronopifolius* (Maire) C. Alexander	TW	Annual	TH	ME+SA-AR+IR-TR				+
Soncuhs oleraceous L.	TW	Annual	TH	COSM	+			
Najadaceae								
Najas marina subsp. *Armata* (H. Lindb.) Horn	AW	Annual	HH	COSM	+	+	+	+
Alliaceae								
Allium cepa L.	EP	Perennial	GH	Cultivated	+			
Juncaceae								
Juncus acutus L.	TW	Perennial	GH	ME+ER-SR+IR-TR	+	+	+	
Juncus bufonius L.	TW	Annual	TH	COSM	+		+	
Juncus rigidus Desf.	TW	Perennial	GH	ME+SA-AR+IR-TR	+			
Gramineae (poaceae)								
Avena fatua L.	TW	Annual	TH	COSM	+	+		
Bromus catharticus Vahl	TW	Annual	TH	ME+ER-SR+IR-TR +MA	+			
Cynodon dactylon (L.) Pers.	TW	Perennial	GH	COSM	+		+	
Digitaria sanguinalis (L.) Scop.	TW	Annual	TH	PAL	+			
Desmostachya bipinnata (L.) Stapf	NP	Perennial	HE	SA-AR+S-Z	+			
Echinocloa colona (L.) Link	TW	Annual	TH	ME+IR-TR+Trop	+			
Parapholis marginata Runemark	TW	Annual	TH	ME+ER-SR+IR-TR	+			
Paspalidium geminatum (Forssk.) Stapf	AW	Perennial	GH	Trop	+			
Phalaris minor Retz.	TW	Annual	TH	ME+IR-TR	+			

Table (2) Cont.

Species	State	Habit	Life form	Floristic category	Lakes			
					I	II	III	IV
Phragmites australis (Cav.) Trin.ex Steud	AW	Perennial	GH	COSM	+	+	+	+
Poa annua L.	TW	Annual	TH	ME+ER-SR+IR-TR	+	+		
Polypogon monspeliensis (L.) Desf.	TW	Annual	TH	COSM	+	+		
Triticum aestivum L.	EP	Annual	TH	Cultivated	+			
Zea mays L.	EP	Annual	TH	Cultivated	+			
Palmae								
Phoenix dactylifera L.	NP	Perennial	PH	SA-AR+S-Z	+			
Lemnaceae								
Lemna gibba L.	AW	Perennial	HH	COSM		+		
Typhaceae								
Typha domingensis (Pers.) Poir.ex Steud	AW	Perennial	GH	ME+IR-TR	+	+		
Cyperaceae								
Cyperus alopecuroides Rottb.	TW	Perennial	GH	Trop			+	
Cyperus articulatus L.	TW	Perennial	GH	Trop		+		
Cyperus rotundus L.	TW	Perennial	GH	ME+IR-TR+Trop	+			
Total					**56**	**27**	**11**	**4**
Relative evenness					**4.0**	**3.3**	**2.4**	**1.4**
Relative concentration of dominance					**56**	**27**	**11**	**4**

3.2. Floristic features

Sixty four species (38 annuals and 26 perennials) belonging to 56 genera and 28 families were recorded in Abu-Za'abal Wetland (Table 3). Gramineae (Poaceae) had the highest contribution (25 % of the total recorded species), followed by Leguminosae (Fabaceae) (7.8%) and Amaranthaceae, Chenopodiacea and Compositae (Asteraceae) (6.3%). Lake I contributed the highest number of species (87.5% of the total recorded species) followed by lakes II, III and IV (42, 17 and 6%, respectively). Forty-five species (70.3% of the total recorded species) were terrestrial weeds, 31 of them are annuals (*Melilotus indicus, Soncuhs oleraceous* and *Polypogon monspeliensis*) and 14 species are perennials (*Cynanchum acutum, Juncus acutus* and *Spergularia marina*) (Table 3). On the other hand, seven species (10.9% of the total species) were desert plants; two of them are annuals (*Tribulus bimucronatus* var. *inermis* and *Zygophyllum simplex*) and 5 perennials (*Desmostachya bipinnata, Launaea nudicaulis* and *Tamarix nilotica*). Six species (9.4% of the total species) were aquatic weeds (one annual and 5 perennials), while other six are escaped from cultivations (5 annuals and one perennial).

The total number of the recorded species varies between 56 species in lake I and four in Lake IV. Lake I had the highest species diversity (Table 3), it had the highest values of relative evenness (4.0) and relative concentration of dominance (56). On the other hand, Lake IV had the lowest of relative evenness (1.4) and relative concentration of dominance (4).

Life forms of the recorded species indicated that therophytes have the highest contribution (57% of the total recorded species), followed by geophytes-helophytes (19%), phanerophytes (8%), hemicrypto-phytes (8%), chamaephytes (5%) and hydrophytes (3%) (Fig. 2). Lake I contributed the highest numbers of therophytes, (34 species) phanerophytes, geophytes-helophytes, chamaephytes and hemicryptophytes (34, 9, 5, 3 and 4 species, respectively). Hydrophytes had its highest contribution in Lake II. The global distribution of the recorded species indicated that 42.2% of the recorded species were pluriregionals pluriregional taxa (*Alhagi graecorum, Bromus catharticus* and *Launaea nudicaulis*), 23.4% biregionals (*Bassia indica, Sporopolus pungens* and *Urtica urens*), 23.4% cosmopolitans (*Chenopodium album, Plantago major* and *Phragmites australis*) and 9.4% escaped cultivated plants (*Faba sativa, Triticum aestivum* and *Zea mays*). On the other hand, monoregional taxa (1.6%) were represented by only one Sudano-Zabezian species (*Sesbania sesban*) recorded in lake I (Fig. 3).

3.3. Multivariate analysis

The dendrogram resulting from the agglomerative clustering technique (Fig. 4) of four lakes of Abu-Za'abal Wetland based on their floristic composition showed that three clusters were separated at-similarity coefficient: cluster A includes Lake IV, B includes lake I and C includes lakes II and III. The application of DCA ordination on the 4 lakes based on their floristic composition (Fig. 5a), soil (Fig. 5b) and water (Fig. 5c) characteristics confirmed the separation of these clusters.

Table (3): Floristic categories and life forms of the species recorded in the four Abu-Za'abal lakes. AW: Aquatic weed, TW: terrestrial weed, EP: Escaped from cultivation, NP: desert plants, CH: chamaephytes, HE: hemicryptophytes, GH: geophytes-helophytes, HH: hydrophytes, PH: phanerophytes, TH: therophytes, ME: Mediterranean, COSM: Cosmopolitan, SA-SR: Saharo-Arabian, Trop: Tropical, S-Z: Sudano-Zambezian, MA: Malysian, ER-SR: Euro-Siberian, IR-TR: Irano-Turanian, PAL: Palaeotropical, PAN: Pantropical and Temp: Temperate.

Species	State	Habit	Life form	Floristic category	Lakes			
					I	II	III	IV
Urticaceae								
Urtica urens L.	TW	Annual	TH	ME+ER-SR	+	+		
Polygonaceae								
Emex spinosa (L.) Cambd.	TW	Annual	TH	ME+SA-AR	+			
Rumex dentatus L.	TW	Annual	TH	ME+ER-SR+IR-TR	+	+		
Aizoaceae								
Trianthema portulacastrum L.	TW	Annual	TH	PAL	+	+		
Portulacaceae								
Portulaca oleracea L.	TW	Annual	TH	COSM	+	+		
Caryophyllaceae								
Spergularia marina (L.) Bessler	TW	Perennial	HE	ME+ER-SR+IR-TR	+	+		
Chenopodiaceae								
Bassia indica (Wieght) A. J. Scott	TW	Annual	TH	IR-TR+S-Z	+	+		+
Beta vulgaris L.	TW	Annual	TH	ME+ER-SR+IR-TR	+			
Chenopodium album L.	TW	Annual	TH	COSM	+			
Chenopodium murale L.	TW	Annual	TH	COSM	+	+		
Amaranthaceae								
Amaranthus albus L.	TW	Annual	TH	Temp	+			
Amaranthus graecizans subsp. *graecizans* L.	TW	Annual	TH	PAL	+			
Amaranthus hybridus L.	TW	Annual	TH	COSM	+	+		
Amaranthus viridis L.	TW	Annual	TH	COSM	+			
Cruciferae (Brassicaceae)								
Raphanus sativus L.	EP	Annual	TH	Cultivated	+			
Leguminosae (Fabaceae)								
Alhagi graecorum Boiss.	TW	Perennial	CH	ME+IR-TR+SA-AR +S-Z	+	+	+	
Faba sativa	EP	Annual	TH	Cultivated	+			
Medicago polymorpha L.	TW	Annual	TH	COSM	+			
Melilotus indicus (L.) All.	TW	Annual	TH	ME+SA-AR+IR-TR	+			
Sesbania sesban (L.) Merr.	NP	Perennial	CH	S-Z	+			
Zygophyllaceae								
Tribulus bimucronatus var. *inermis* (Kralik) Hosni	NP	Annual	TH	SA-AR+S-Z		+	+	
Zygophyllum simplex L.	NP	Annual	TH	SA-AR+S-Z		+	+	
Euphorbiaceae								
Euophorbia peplus L.	TW	Annual	TH	ME+ER-SR+IR-TR	+	+		
Ricinus communis L.	TW	Perennial	PH	PAN	+			

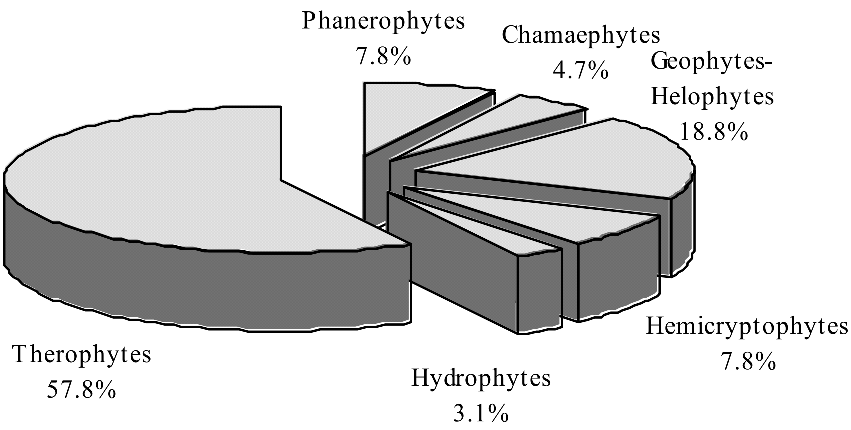

Fig. (2): Life form spectra of the recorded species in lakes Abu-Za'abal.

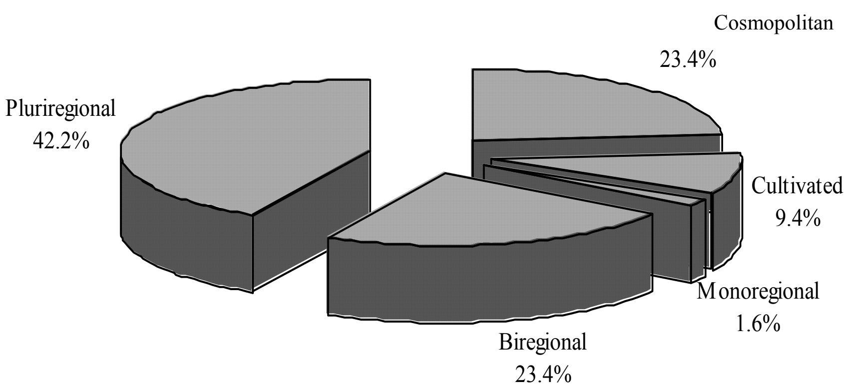

Fig. (3): Global distribution of the total recorded species in Lakes Abu-Za'abal.

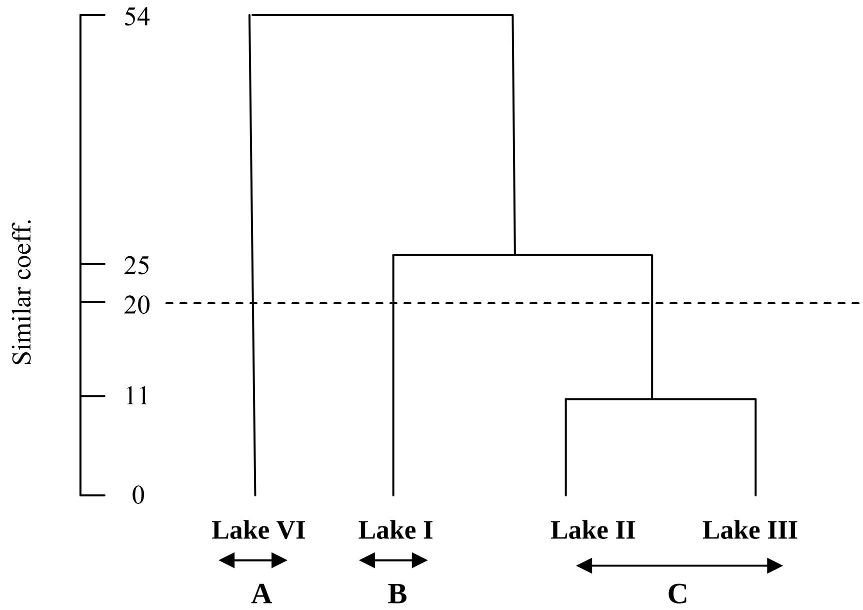

Fig. (4): The dendrogram resulting from the application of the agglomerative clustering technique on the floristic composition of the four lakes of Abu Za'abal Wetland.

a)

b)

c)

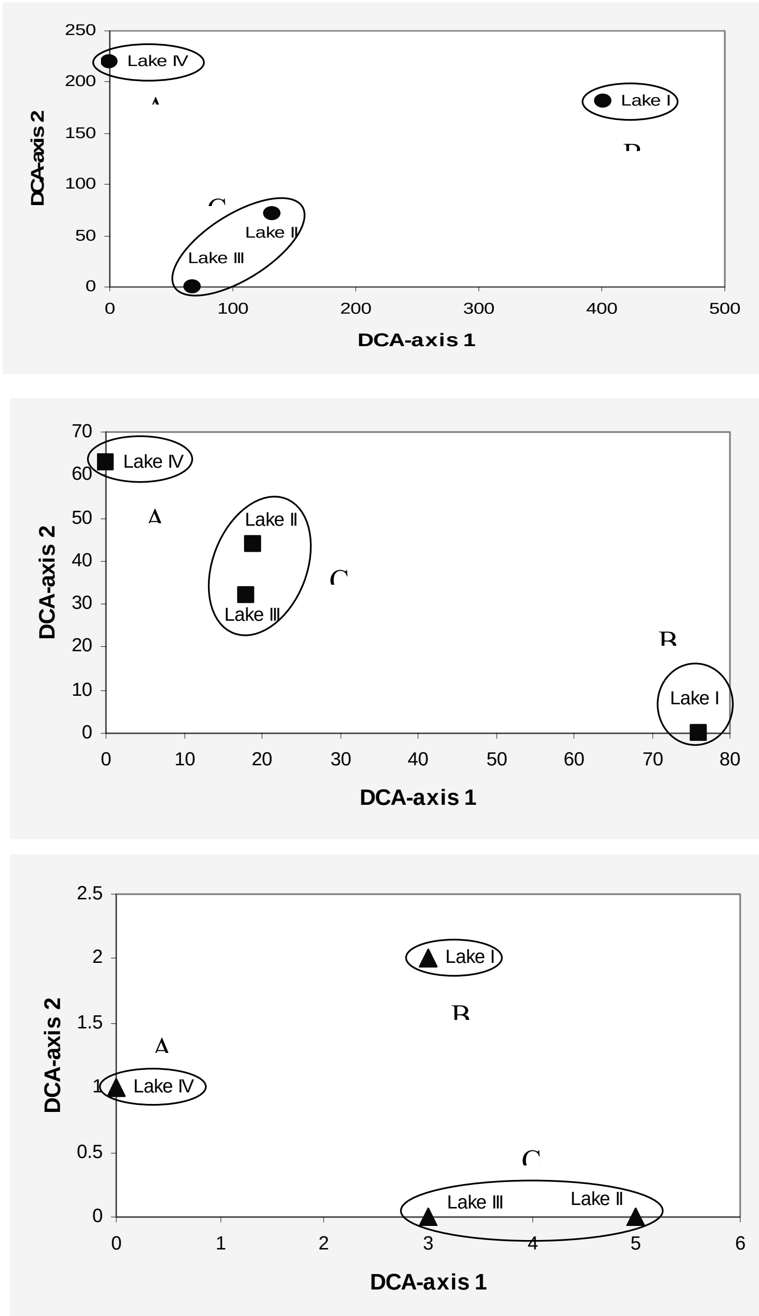

Fig. (5): DCA ordination of the four lakes of Abu Za'abal Wetland based on their floristic composition (a), soil characteristics (b) and water characteristics (c).

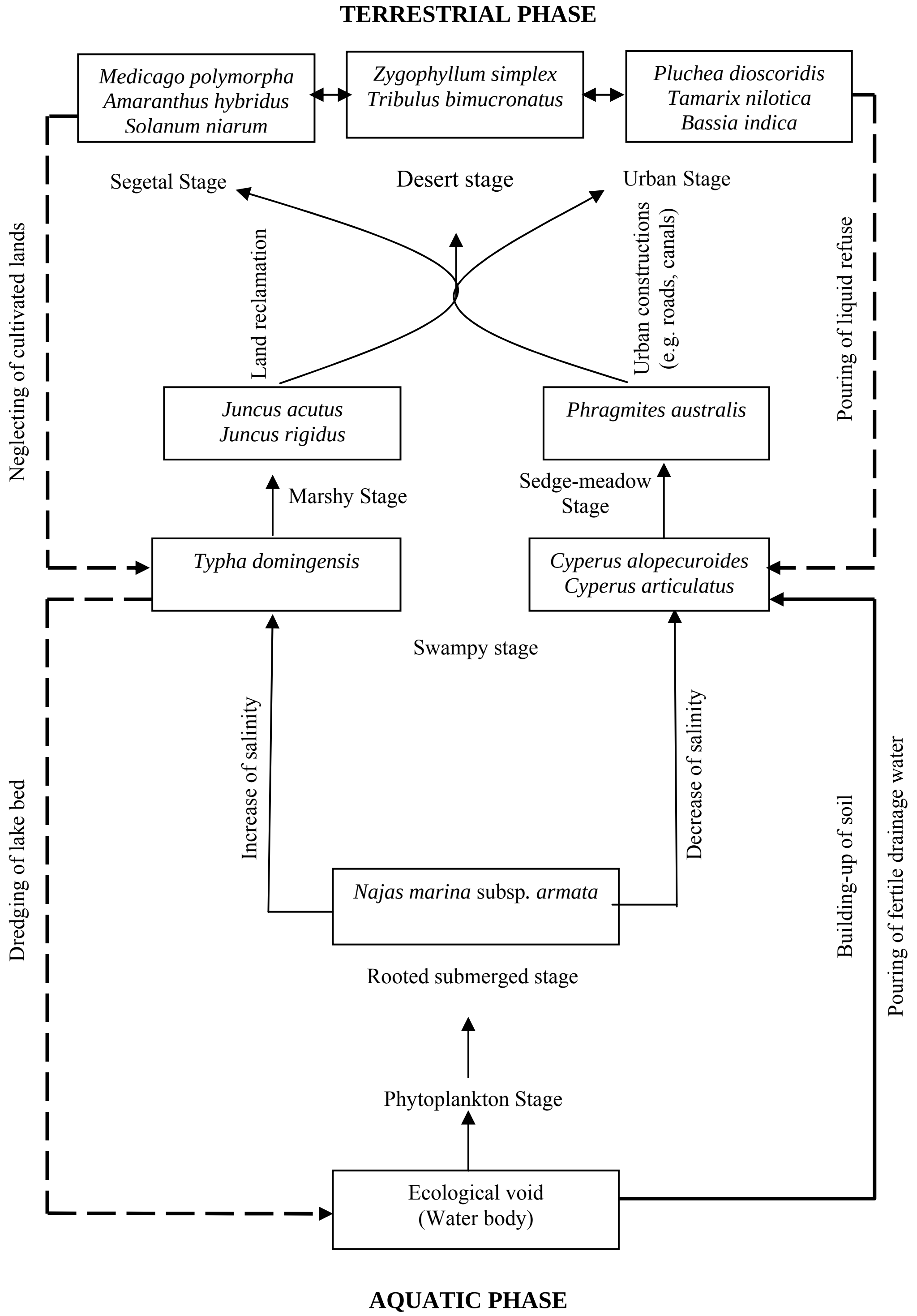

Fig. (6): Schematic representation of the presumed successional relationship between the species dominating the different habitats in Abu-Za'abal Wetland.

4. DISCUSSION

Lakes are extremely complex ecosystem. The unique inter-relationships of their physical, chemical and biological properties give each lake its own characters (Rabeh and Azab, 2006). Abu Za'abal Wetland comprises four newly artificial lakes in north of Qalubiya Governorate (Nile Delta). Sixty four species (15.9% of the total flora of the northern lakes) belonging to 56 genera and 28 families were recorded in Abu Za'abal Wetland. Poaceae had the highest contribution, followed by Fabaceae, Amaranthaceae, Chenopodiacea and Asteraceae. These results were coincided with that of Galal (2005) in the northern lakes of Egypt and Al-Sodany (1998) along the watercourses in north Nile Delta. Although Lake Nasser (an artificial lake in the south of Egypt) has a large area compared to that of Abu Za'abal, it has a smaller number of species, which represents 89% of the recorded species in Abu-Za'abal wetland (Ali, 1992).

Zohary (1973) reported that a striking feature in Egyptian flora is the large number of genera in proportion to that of the species (about 2.1 species per genus). This is a very low figure compared with the global average which amounts to 13.6 (Good, 1947). The present study indicated that the flora of Abu-Za'abal Wetland goes below the average level of the Egyptian flora where the number of species per genus was 1.14, which is a close figure to 1.9 and 1.6 recorded for the Nile Delta (Ahmed, 2003) and the northern lakes of Egypt (Galal, 2005), respectively. This means that the flora of Abu Za'abal Wetland is relatively rich as the region that has a certain number of species, each of which belongs to a different genus, is relatively more diverse than a region has the same number of species but belongs to a few number of genera (Hawksworth, 1995).

The low contribution of aquatic weeds in Abu-Za'abal Wetland (only 6 species) may be attributed to the large depth of these lakes (mean depth: 3.3-10.2 m). Lakes with the majority of their bottom exceeding 2-3 times the Secchi depth (0.85-0.95 m secchi depth of Abu-Za'abal Lakes) have fewer aquatic macrophytes. Even shallow lakes, if they are turbid enough, will have sparse aquatic plant growth (Canfield *et al.,* 1985 and Engel and Nichols, 1994). The manipulation of lake depth and slope are both powerful tools when encouraging or discouraging the growth of aquatic plants in specific areas of a lake. With some exceptions, a depth ranges between 9 and 14 m is the limit for most aquatic plants. Emergent and floating-leaved plants seldom grow in water exceeding 3 m, so deep lakes also have limited emergent communities (Hoyer and Canfield, 1997). The relatively high number of aquatic weeds in Lakes I and II compared with Lakes III and IV may be attributed to the large amounts of nutrients transported to these lakes through the direct sewage drainage.

Al-Sodany (1998) reported that these conditions favor the growth of floating and emergent hydrophytes.

Najas marina subsp. *armata* is the only submerged macrophyte in Abu-Za'abal lakes. It occurs in the Nile system including Nile Valley, Nile Delta, Nile Fayium, Lake Nasser and the northern lakes (Täckholm, 1974 and Khedr, 1989). In Nile Delta, the community dominated by *N. marina* subsp. *armata* appears only in late autumn and winter (El-Fiky, 1974). The plant spreads as a mat along the bottom of the shallow water of the northern lakes (e.g. Lakes Burullus and Manzala) as well as Abu-Za'abal Wetland. In Lake Manzala, the rich growth of this community usually occurs in the brackish water of the lake (Khedr, 1989).

The life form spectra provide information, which may help in assessing the response of vegetation to variations in environmental factors (Ayyad and El-Ghareeb, 1982). Therophytes had the highest contribution, followed by geophytes-helophytes, phanerophytes, hemicryptophytes, chamaephytes and hydrophytes. The main advantage of being annual or geophyte is to have high degree of plasticity in growth rate, size and phenology and to remain dormant in years of climatic extremes (Khedr, 1999). The high percentage of therophytes in the present study may be related to the seasonal rainfall. This trend is similar to that of the whole Egyptian flora (Hassib, 1951). Heneidy and Bidak (2001) pointed out that the dominance of therophytes over the other life forms seems to be a response to the hot-dry climate, topographic variation and biotic influence. El-Ghareeb and Rezk (1989) provided evidence that therophytes acquire dominance in less saline and more sandy habitats, while cryptophytes and chamaephytes in more saline habitats in the coastal area of Egypt. The floristic categories of the recorded species showed that pluriregional taxa had the highest contribution, followed by bi-regional, cosmopolitan and monoregional. Zohary (1973) referred the dominance of interregional species (bi, tri and pluriregionals) over monoregional ones to the presence of interzonal habitats, such as anthropogenic or hydro-, halo- and psammophilous sites.

The biodiversity of fresh water bodies is among the most poorly known on the earth (WRI, UNEP, FAO, and UNESCO: 1992) that is seriously threatened today. In Abu-Za'abal Wetland, Lake I had the highest diversity, while Lake IV had the lowest. The high diversity of Lake I may be associated with the increase in annuals during spring. El-Kady *et al.* (2000) has described similar results in other vegetation types in the northwestern part of the Nile Delta.

The dendrogram resulting from the agglomerative clustering technique of the four lakes of Abu-Za'abal Wetland based on their floristic composition indicated that three clusters were separated: cluster A includes lake IV, B includes lake I and C includes lakes II and III. These results were confirmed by the DCA ordination technique depending on floristic composition, soil and water characteristics of these lakes. These results may be attributed to the fact that lake I is the oldest and largest one, while lake IV is the newest and smallest. On the other hand, lakes II and III originated in the eighth and ninth decades of the last century, respectively. However the group B is characterized by highest floristic composition in contrast with the group A, while group C is indicated by *Zygophyllum simplex* and *Tribulus bimucronatus* (not recorded in other clusters). This study provides evidence that the vegetation shows discernible zonation.

Depending on the regional and local conditions of topography and landforms, moisture, Electric conductivity and sedimentation are the main operative factors in the successional process on the vegetation of Abu-Za'abal Wetland. Building-up of soil as well as continuous discharging of fertile drainage water into the lake increase the organic matter, which favor the growth of swampy communities passing through the rooted submerged (*Najas marina* subsp. *armata*). Retrogression may occur as a result of mechanical dredging of the lakebed (Fig. 6). Decrease of salinity may lead to the formation of emergent communities (*Phragmites australis*). The urban stage characterized by ruderal communities (*Tamarix nilotica* and *Bassia indica*) may be developed as a result of urban constructions (roads, canals). On the other hand, the segetal stage characterized by segetal weeds (*Cynodon dactylon* and *Medicago polymorpha*) may also be produced as a result of land reclamation. Furthermore, increase of aridity enhances the formation of the desert scrubland dominated by *Zygophyllum simplex* and *Tribulus bimucronatus*.

ACKNOWLEDGMENT

The authors wish to thank Prof. Dr. Kamal. H. Shaltout for kindly support, encouragement and reviewing the manuscript.

REFERENCES

Abd E1lah, R.G.: 2003, 'On physical limnology of Abu Za'abal lakes, Egypt', *Bull. Nat. Inst. Ocean. Fish., ARE.,* **29:** 46 1-471.

Ahmed, D.A.: 2003, 'Current status of the flora and vegetation of Nile Delta region', *M.Sc. Thesis, Fac. Sci., Tanta Univ., Tanta,* 321 pp.

Ali, M.M.: 1992, 'Ecological Studies on Fresh Water Macrophytes in Regulated Water Bodies in Egypt and UK', *Ph.D. Thesis, Fac. Sci., Assiut Univ., Assiut,* 253 pp.

Allen, S.E., Grimshaw, H.M., Parkinson, J.A., Quamby, C. and Roberts, J.D.: 1986, 'Methods in Plant Ecology', 2nd Edition *(Ed. by Moore, P.D. and Chapman, S.B.). Blackwell Scientific Publications, Oxford:* 411-466.

Al-Sodany, Y.M.: 1998, 'Vegetation analysis of the canals, drains and lakes of the northern part of Nile Delta', *Ph.D. Thesis., Fac. Sci., Tanta Univ., Tanta, 232 pp.*

Ayyad, M.A. and El-Ghareeb, R.E.M.: 1982, 'Salt marsh vegetation of the western Mediterranean desert of Egypt', *Vegetatio,* **49:** 3-19.

Boulos, L.: 1999, 'Flora of Egypt', Vol. I (Azollaceae - Oxalidaceae). Al Hadara Publish., Cairo, 419 pp.

Boulos, L.: 2000, 'Flora of Egypt', Vol. II. Geraniaceae-Boraginaceae. *Al Hadara Publish., Cairo,* 352 pp.

Boulos, L.: 2002, 'Flora of Egypt', Vol. III. Verbinaceae-Compositae. *Al Hadara Publish., Cairo,* 373 pp.

Boulos, L.: 2005, 'Flora of Egypt', Vol. IV. Monocotyledons (Alismataceae-Orchidaceae). *Al Hadara Publish., Cairo,* 617 pp.

Canfield, D.E., Jr., Langland, K.A. Linda, S.B. and Haller. W.T.**:** 1985**,** 'Relations between water transparency and maximum depth of macrophyte colonization in lakes', *J. Aquat. Plant Manage.* **23:** 25-28.

El-Bana, M.I.: 2003: 'Environmental and biological effects on vegetation composition and plant diversity of threatened Mediterranean coastal desert of Sinai Peninsula', *Ph.D. Thesis, Faculteit Westenschappen, Universteit Antwerpen, Antwerpen,* 150 pp.

El-Fiky, A.M.: 1974, 'Studies on the ecology of water plants with special reference to *Eichhornia crassipes*', *M. Sc. Thesis, Fac. Sci., Cairo Univ., Cairo,* 131 pp.

El-Ghareeb, R. and Rezk, R.M.: 1989, 'A preliminary study on the vegetation of the coastal land at Bousseli (Egypt)', *J. Kuwait Univ. (Sci.),* **16:** 115-127.

El-Kady, H.F., Shaltout, K.H., El-Shourbagy, M.N. and Al-Sodany, Y.M.: 2000, 'Characterization of habitats in the north western part of the Nile Delta', *The First International Conference on Biological Sciences, Tanta Univ., Tanta,* 1: 144-157.

Engel, S. and Nichols, S.A**.:** 1994, 'Aquatic macrophyte growth in a turbid windswept lake', *J. Freshwater Ecol.* **9:** 97-109.

Galal, T.M.: 2005, 'Flora and vegetation of the northern lakes of Egypt', *Ph.D. Thesis, Fac. Sci., Helwan Univ., Cairo,* 285 pp.

Good, R.: 1947, 'Geography of the flowering plants', *1st ed. Longmans, London, 403 pp.*

Hassib, M.: 1951, 'Distribution of plant communities in Egypt', *Bull. Fac. Sci., Fouad I Univ.,* **29:** 59-261.

Hawksworth, D.L.: 1995, 'Biodiversity: Measurement and estimation', *Chapman and Hall, London, 140 pp.*

Heneidy, S.Z. and Bidak, L.M.: 2001, 'Multipurpose plant species in Bisha, Asir Region, Southwestern Saudi Arabia', *J. King Saud Univ.,* **13:** 11-26.

Hill, M.O.: 1979, 'DECORANA: A FORTRAN program for detrended correspondence analysis and reciprocal averaging', *Cornell Univ., Ithaca, New York,* 52 pp.

Hoyer, M.V.; and Canfield, D.E.; Jr., eds.: 1997, 'Aquatic plant management in lakes and reservoirs', Prepared by the North

American Lake Management Society (P.O. Box 5443, Madison, WI 53705-5443) and the Aquatic Plant Management Society (P.O. Box 1477, Lehigh, FL 33970) for U.S. Environmental Protection Agency, Washington, DC.

Hussian, A.M.: 2005, 'Ecological studies on phytoplankton composition of newly formed aquatic depression at Abu-Za'abal quarries region', *M.Sc. Thesis, Faculty of Science, Al-Azhar University, Egypt.*

Khedr, A.A.: 1989, 'Ecological studies on Lake Manzala, Egypt', *M.Sc. Thesis, Fac. Sci., Mansoura Univ., Mansoura,* 253 pp.

Khedr, A.A.: 1999, 'Floristic composition and phytosociology in a Mediterranean Deltaic lake (Lake Burullus), *Egypt', Ecol. Med.,* ***25 (1):*** *1-11.*

Kruscal, J. B.: 1964, 'Nonmetric multidimensional scaling: A numerical method', *Psychometrika,* ***29:*** *115-129.*

Magurran, A.E.: 1988, 'Ecological diversity and its measurements', *Croom. Helm., London,* 179 pp.

Rabeh, S.A. and Azab, E.A.: 2006, 'Bacterial indicators of both sewage pollution and trophic status in Abu-Za'abal lakes, Egypt', *Res. J. Microbiology* 1**(6):** 480-491.

Raunkiaer, C.: 1937, 'Plant life forms', Clarendon, Oxford, 104 pp.

Riemer, D.N.: 1984, 'Introduction to freshwater vegetation' AVI Publishing, Connecticut.

SPSS, Inc.: 1999' *SPSS 10.0 for Windows*: Statistics. SPSS Inc., Chicago, IL.

Täckholm, V.: 1974, 'Students flora of Egypt', 2nd edn. Cairo Univ. (Publ.), Cooperative Printing Company, Beirut, 888 pp.

Wickens, G.E.: 1977**,** 'The Flora of Jebel Marra (Sudan Republic) and its geographic affinities', Kew Bull. Add. Sen. V. HMSO, London, 198 pp.

WRI, UNEP, FAO, and UNESCO: 1992, 'Global biodiversity strategy: Guidelines for action to save, study, and use earth's biotic wealth sustainably and equatably, 1-18.

Zohary, M.: 1973, 'Geobotanical foundations of the Middle East', *Vols. 1-2, Gustav Fischer Verlag, Stuttgart,* 739 pp.