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Floristic Diversity of Riparian Plants in Aswan Reservoir at the Extreme South of the River Nile, Upper Egypt : A Closed Ecological System

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The present study was undertaken to survey the floristic composition in the islands and shorelines in Aswan Reservoir, south of the River Nile at Aswan Governorate, Egypt. Four elements of vegetation were analyzed: floristic composition, lifespan, life form, and phytogeographical affinities. A total of 165 species were recorded belonging to 135 genera in 45 families of vascular plants, of which six species were new to the flora of Aswan and Nubia (Amaranthus spinosus L., Doellia bovei (DC.) Anderb., Eleocharis parvula (Roem. & Schult.) Link ex Bluff, Nees & Schauer, Haematoxylum campechianum L., Polygonum aviculare L., and Pithecellobium dulce (Roxb.) Benth.) The most represented families are Leguminosae, Poaceae, and Compositae. Species richness is highest in low-lying areas (shorelines) liable to flooding, compared to those of the islands in the river. The recorded flora consists of 50.91% perennials and 49.09% annuals. Therophytes and phanerophytes were the predominant life forms. Phytogeographical analysis revealed the prevalence of the pantropical (28.48%), palaeotropical (17.57%), and cosmopolitan (16.36%) plant species. Monoregional chorotype was represented by 29 species (17.58%) of the recorded flora with the Sudano-Zambezian species (11.52%) being the highest chorotype, while pure Mediterranean species were very poorly represented (3.63%). Biregional chorotype was represented by 25 species (15.15%), while the pluriregional chorotype was accounted for 2.43% of recorded species.

Keywords: Aswan Old Dam; Diversity; High Dam; Lifeform spectrum; Philae Island; Vascular flora; Water fluctuation.

Egypt is a riverain oasis generated by the River Nile in a region that was otherwise would have remained a vast barren desert with no vegetation [1,2]. The Nile River runs for about 6700 km through ten countries in north-eastern Africa and ends in Egypt where it flows for about 1200 km from Aswan to the Mediterranean coast [3,4]. The Nile River system has been subjected to extensive schemes of river control as the implementation of dams and barrages across the river and its tributaries, leading to changes in the natural hydrobiology with undoubted impact on the biota, especially flora and vegetation [1].

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In 1964, Aswan High Dam was established seven kilometers to the south of the old dam (Aswan Low Dam) in Upper Egypt, and brought the River Nile under full control, resulting in a smaller water body between the two dams, known as the Aswan Reservoir. A lower annual amplitude of water levels exhibited in Aswan Reservoir than in Lake Nasser, nevertheless there is an obvious diurnal fluctuation with a great amplitude of about 3 meters in the reservoir associated to the daily routine of water inflow via the High Dam turbines which have great effects on the plant life associated with the river [5].

Across the reservoir shoreline, several small dendritic side areas (khors) are present throughout mostly on the eastern side and a few small ones on the west, in addition to several granitic islands and associated superficial areas of water, typically the remains of part of the First Cataract of the Nile, flooded upon completion of the original Aswan Dam [6]. River Nile ecosystem along the reservoir is usually split up into three habitats: slope, water-edge, and open-water of the Nile Bank. Each of them has a distinctive flora. In addition, the vegetation of this reservoir is mainly on the shorelines and its different types of habitat are controlled by two main factors: moisture content and soil formation [6].

Around the world, riverain habitats have significantly modified from their own natural condition. One of the main reasons behind these changes is usually Dams, mainly because of their alteration of water and sediment regimes [7,8].

Fluctuations in hydrological patterns are important drivers for ecological systems [9]. Likewise, Dams have a potential effect on hydrochory in different ways, such as: modifying the hydrologic regime, influencing seed dispersal distance, its deposition sits along channel margins, and the availability and suitability of streamside habitat for seed germination and seedling establishment, they function as a physical barrier to the downstream movement of plant propagules, trapping and storing seeds in reservoirs and resulting in retention and high rates of seed mortality [10,11].

To best of our knowledge, no study examined the plant diversity in River Nile Reservoir systems. Aswan Reservoir provides a model to address community assemblage in a closed ecohydrological system. This study is the first to survey the floristic diversity of the riparian and aquatic plants in the Aswan Reservoir area, Aswan Governorate in Egypt. The current study aims to identify the floristic diversity, life forms, lifespan, and phytogeographic relationships of the aquatic and riparian plant species of the Aswan Reservoir area.

MATERIAL AND METHODS

Study Area

This study was performed in the Aswan Reservoir area, Aswan Governorate, between Aswan High Dam and Aswan Low Dam from September 2017 to January 2019. The study area located between latitudes 23° 58' 20" and 24° 02'

Table 1. Locations of the studied areas in Aswan Reservoir with their coordinates, human impact, number of stands, and quadrates

		Sites	Human impact	No. of Stands	No. of Quadrates	Coordinates Latitude(N)	Coordinates Longitude(E)
Eastern bank	1	El Shallal	Inhabited	10	100	24°01'47.55"	32°53'52.22"
	2	Bute El-Hasaya	Uninhabited	1	10	24°00'54.29"	32°53'30.81"
	3	Maezana Belal	Uninhabited	1	10	24°00'30.17"	32°53'21.88"
	4	High Dam Colony	Inhabited	3	20	23°59'03.69"	32°52'55.01"
	5	Philae Port	Uninhabited	1	10	24°02'02.03"	32°53'09.15"
Western bank	6	El Mahgar Valley	Uninhabited	3	30	24°00'17.62"	32°52'14.72"
	7	Tingar	Inhabited	2	30	24°59'37.85"	32°52'12.28"
Middle islands	8	Awad	Inhabited	1	5	24°01'43.26"	32°52'24.80"
	9	Heisa	Inhabited	2	10	24°00'19.88"	32°52'32.08"
	10	Bigga	Inhabited	1	10	24°01'15.69"	32°52'24.80"
	11	Agilkia	Uninhabited	2	20	24°01'17.31"	32°53'22.44"
Total				27	255		

19" N and longitudes 32° 51' 50" and 32° 54' 8" E, with 7.2 km length and an average width of 1.05 km.

The wild vegetation was sampled in 11 localities, which were divided into three zones (Eastern bank, Western bank and Middle islands) representing the inhabited areas (for practicing cultivation) and uninhabited areas (natural vegetation). A total of 255 quadrates (1 × 1 m^2) located randomly within 27 stands were selected in the study area (Table 1, Fig. 1).

Species identification

Plant specimens were collected seasonally during intensive floristic surveys of the study area. The collected taxa were identified and named according to the available literature [12–20], and were updated according to [21] and the Kew Garden plantlist website (http://www.theplantlist.org). Life-form categories were identified [22–24]. Plant chorological affinities were defined [25–30]. Collections were pressed, dried, and deposited in the ASW at Aswan University in Egypt (herbarium acronyms [31]).

Similarity and dissimilarity between each pair of sites within the study area estimated [32]. Species richness (alpha-diversity) was calculated as the average number of species per stand [33].

RESULTS

Floristic composition

A total of 165 taxa of vascular plants were recorded from 27 vegetation stands in the study area, belonging to 135 genera in 45 families. Among them, six species are considered new records to the riverain flora in Aswan and Nubia (*Amaranthus spinosus* L., *Doellia bovei* (DC.) Anderb., *Eleocharis parvula* (Roem. & Schult.) Link ex Bluff, Nees & Schauer, *Haematoxylum campechianum* L., *Polygonum aviculare* L., and *Pithecellobium dulce* (Roxb.) Benth.), comparing with the earlier recorded flora from these regions [6,34–37] (Table 2).

Dicots were represented by 39 families (86,67 %) and 119 taxa (72,12%), while monocots represented by 6 families (13,33%) and 46 taxa (27,88%). Leguminosae (26 species=15.76%), Poaceae (25 species= 15.15%), and Compositae (14 species= 8.48%), were the most species-rich families. Cyperaceae and Amaranthaceae were represented by 5.45% (9 species) and 4.24% (7 species), respectively. Both Brassicaceae and Malvaceae were represented by 3.64% (6 species each), while Convolvulaceae, Euphorbiaceae, and Polygonaceae were represented by 3.03%

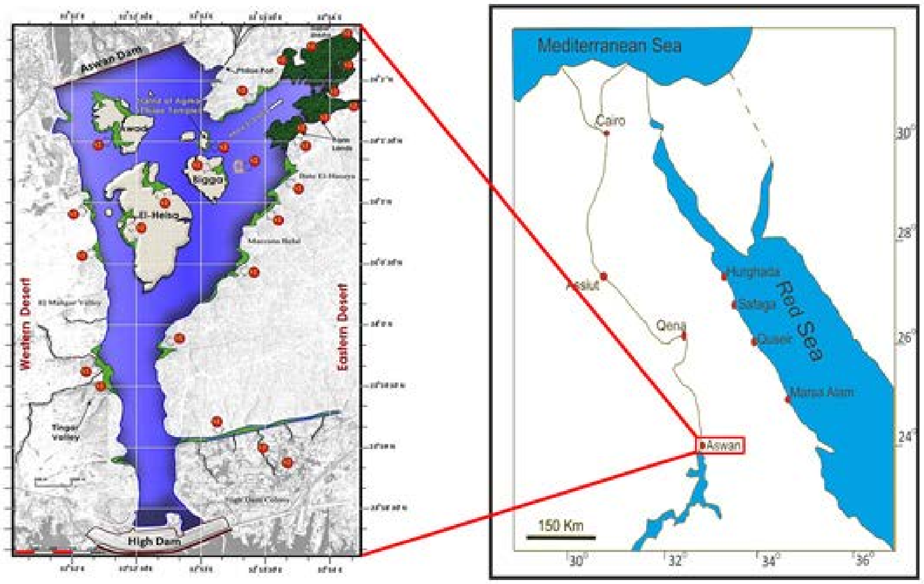

Fig. 1. Map of Aswan Reservoir showing the location of sampling sites (red) between Aswan Dam and High Dam, Aswan Governorate, Egypt. Water is shown blue, and vegetation is shown green

(5 species each). Apocynaceae, Cucurbitaceae, and Solanaceae were represented by 2.42% (4 species each). Four families were represented by three species (1.82%), meanwhile, seven families were represented by two species (1.21%). On the other hand, 21 families were poorly represented, having one species each (0.61%) (Fig. 2). The most common genera with a larger number of species were *Cyperus* L. with six species (3.64%), *Acacia* Mill. with five species (3.03%), *Euphorbia* L. with four species (2.42%, *Ipomoea* L. and *Senna* Mill. with three species each (1.82%). Regarding the lifespan, the majority of the recorded species during this survey were perennials with 84 species of the total recorded species (50.91%), followed by the annuals with 81 species (49.09%) (Fig. 3B, D).

Biological spectrum of species

Ten lifeforms were recorded in the current study. Therophytes were the most abundant lifeform (72 species= 43.64%), followed by phanerophytes (37 species= 22.42%), Chamaephytes (16 species= 9.70%), Geophytes-Helophytes (11 species= 6.67%), Hemicryptophytes (9 species= 5.45%), Hydrophytes and Geophytes with (7 species each= 4.24%), Helophytes (3 species= 1.82%), and Hydrophytes-Helophytes (2 species= 1.21%). While Parasites were represented by a single species *Cuscuta pedicellata* Ledeb (0.61%) (Table 2, Fig. 3A).

Phytogeographical affinities

Phytogeographical analysis of the 165 plant species surveyed in this study revealed that pantropical (47 species= 28.48%), palaeotropical (29 species=17.57%), and cosmopolitan (27 species=16.36%) chorotypes constituted the main bulk of the recorded flora (103 species=62%) of the total recorded flora. Mono-regional chorotype was represented by 29 species (17.58%), of which 19 species were Sudano-Zambezian. On the other hand, the bi-regional chorotype was represented by 25 species (15.15% of the total flora). Mediterranean-Irano-Turanian represented by 13 species (7.88%), while 11 species (6.66%) originally came from the Saharo-Sindian and Sudano-Zambezian chorotype, and only two species originated from Sudano-Zambezian and Saharo-Arabian regions (*Aerva javanica* (Burm.f.) Juss. ex Schult. and *Forsskaolea tenacissima* L.). Pluri-regional chorotype were represented by 2.43% (4 species) of the total recorded species. (Fig. 3C).

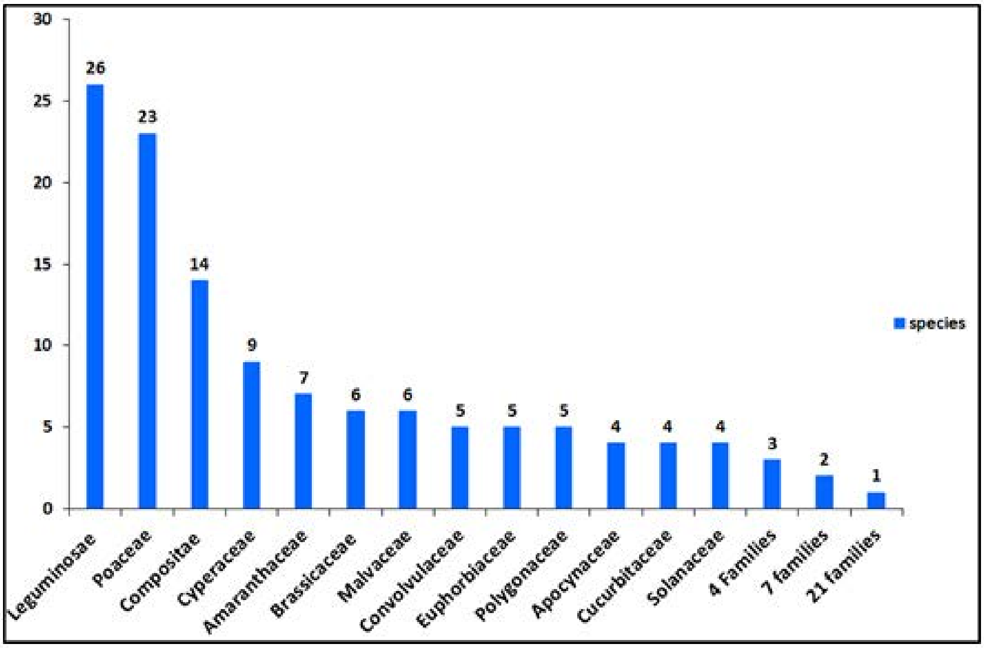

Fig. 2. Histogram showing the numbers of species in each of the 45 families of angiosperms surveyed in Aswan Reservoir area in Upper Egypt

Table 2. List of the recorded plant species in Aswan Reservoir area along with their families, life span, life form, chorotypes, and presence percentage

Family	Species	Life span	Life form	Chorotype	P%
Aizoaceae	*Trianthema portulacastrum* L.	Annual	Hydrophyte	PAN	66.6
Amaranthaceae	*Aerva javanica* (Burm.f.) Juss. ex Schult.	Perennial	Chamaephyte	SU-ZA + SA-AR	33.3
	Alternanthera sessilis (L.) R.Br. ex DC.	Annual	Hydrophyte-Helophyte	COSM	66.6
	Amaranthus blitum sub sp. *oleraceus* (L.) Costea	Annual	Therophyte	COSM	33.3
	A. spinosus L.*	Annual	Therophyte	NEO	33.3
	Chenopodium album L.	Annual	Therophyte	PAL	33.3
	C. murale L.	Annual	Therophyte	COSM	16.6
	Salsola imbricata Forssk. subsp. *imbricata*	Perennial	Chamaephyte	SU-ZA + SA-AR + IR-TR	66.6
Apiaceae	*Cyclospermum leptophyllum* (Pers.) Sprague	Annual	Therophyte	PAN	33.3
	Ammi majus L.	Annual	Therophyte	ME	16.6
Apocynaceae	*Calotropis procera* (Aiton) W.T.Aiton	Perennial	Phanerophyte	SA-SI	83.3
	Leptadenia arborea (Forssk.) Schweinf.	Perennial	Phanerophyte	SU-ZA	83.3
	Nerium oleander L.	Perennial	Phanerophyte	ME	33.3
	Oxystelma esculentum (L. f.) Sm.	Perennial	Hemicryptophyte	SU-ZA + SA-SI	16.6
Arecaceae	*Hyphaene thebaica* (L.) Mart.	Perennial	Phanerophyte	SU-ZA	83.3
	Phoenix dactylifera L.	Perennial	Phanerophyte	SU-ZA + SA-SI	83.3
Boraginaceae	*Echium rauwolfii* Delile	Annual	Therophyte	SU-ZA	16.6
Brassicaceae	*Brassica nigra* (L.) W.D.J.Koch	Annual	Therophyte	COSM	16.6
	B. tournefortii Gouan	Annual	Therophyte	ME + IR-TR	33.3
	Lepidium didymum L.	Annual	Therophyte	COSM	100
	L. coronopus (L.) Al-Shehbaz	Annual	Therophyte	ME + ER-SR + IR-TR	66.6
	Eruca sativa Mill.	Annual	Therophyte	SA-SI	33.3
	Rorippa palustris (L.) Besser	Annual	Therophyte	COSM	83.3
Casuarinaceae	*Casuarina equisetifolia* L.	Perennial	Phanerophyte	PAN	16.6
Ceratophyllaceae	*Ceratophyllum demersum* L.	Perennial	Hydrophyte	COSM	66.6
Convolvulaceae	*Convolvulus arvensis* L.	Perennial	Hemicryptophyte	PAN	16.6
	Cuscuta pedicellata Ledeb.	Annual	Parasite	COSM	100
	Ipomoea cairica (L.) Sweet	Perennial	Phanerophyte	PAL	33.3
	I. carnea Jacq.	Perennial	Phanerophyte	PAN	16.6
	I. eriocarpa R. Br.	Annual	Therophyte	PAN	16.6
Compositae	*Ageratum conyzoides* L.	Annual	Therophyte	PAN	100
	Bidens pilosa L.	Annual	Therophyte	PAN	100
	Doellia bovei (DC.) Anderb.*	Perennial	Chamaephyte	ME	16.6
	Erigeron bonariensis L.	Annual	Therophyte	COSM	16.6
	Pluchea dioscoridis (L.) DC.	Perennial	Phanerophyte	SU-ZA + SA-SI	100
	Lactuca sativa L.	Annual	Therophyte	ME + IR-TR	33.3

	L. serriola L.	Annual	Therophyte	ME + IR-TR	33.3
	Blumea viscosa (Mill.) V.M.Badillo	Annual	Therophyte	PAN	33.3
	Laphangium luteoalbum (L.) Tzvelev	Annual	Therophyte	COSM	83.3
	Pulicaria undulata (L.) C.A.Mey.	Perennial	Chamaephyte	SU-ZA + SA-SI	100
	Senecio aegyptius L.	Annual	Therophyte	SU-ZA	16.6
	Sonchus oleraceus L.	Annual	Therophyte	COSM	66.6
	Symphyotrichum squamatum (Spreng.) G.L.Nesom	Perennial	Chamaephyte	NEO	16.6
	Xanthium strumarium L.	Annual	Therophyte	SU-ZA	16.6
Cucurbitaceae	*Citrullus colocynthis* (L.) Schrad.	Annual	Hemicryptophyte	PAL	50
	Cucumis melo L.	Annual	Therophyte	PAL	16.6
	Cucurbita pepo L.	Annual	Therophyte	PAN	16.6
	Luffa cylindrica (L.) M.Roem.	Annual	Phanerophyte	PAN	16.6
Cyperaceae	*Cyperus alopecuroides* Rottb.	Perennial	Geophyte-Helophyte	PAN	16.6
	C. difformis L.	Annual	Therophyte	PAN	16.6
	C. laevigatus L.	Perennial	Geophyte-Helophyte	PAN	66.6
	C. longus L.	Perennial	Helophyte	ME	100
	C. michelianus subsp. *pygmaeus* (Rottb.) . Asch. & Graebn	Annual	Therophyte	PAL	33.3
	C. rotundus L.	Perennial	Geophyte-Helophyte	PAN	83.3
	Eleocharis geniculata (L.) Roem. & Schult.	Annual	Helophyte	PAN	66.6
	E. parvula (Roem. & Schult.) Link ex Bluff. Nees & Schauer*	Perennial	Hemicryp-tophyte	COSM	50
	Fimbristylis bisumbellata (Forssk.) Bubani	Annual	Therophyte	PAL	16.6
Euphorbiaceae	*Euphorbia forsskalii* J.Gay	Annual	Therophyte	SU-ZA + SA-SI	33.3
	E. heterophylla L.	Annual	Therophyte	COSM	16.6
	E. hirta L.	Annual	Therophyte	SU-ZA	100
	E. peplus L.	Annual	Therophyte	COSM	83.3
	Ricinus communis L.	Perennial	Phanerophyte	PAN	16.6
Haloragaceae	*Myriophyllum spicatum* L.	Perennial	Hydrophyte	ME + IR-TR	16.6
Juncaceae	*Juncus rigidus* Desf.	Perennial	Geophyte-Helophyte	COSM	16.6
Lamiaceae	*Mentha longifolia* (L.) L.	Perennial	Chamaephyte	PAL	33.3
	M. pulegium L.	Perennial	Therophyte	ME + IR-TR	16.6
Leguminosae	*Acacia farnesiana* (L.) Willd.	Perennial	Phanerophyte	NEO	83.3
	A. laeta R. Br. ex Benth.	Perennial	Phanerophyte	SU-ZA	16.6
	A. nilotica (L.) Delile	Perennial	Phanerophyte	SU-ZA	33.3
	A. tortilis subsp. *raddiana* (Savi) Brenan	Perennial	Phanerophyte	SU-ZA	50
	A. seyal Delile	Perennial	Phanerophyte	SU-ZA + SA-SI	50
	Alhagi graecorum Boiss.	Perennial	Chamaephyte	PAL	50
	Astragalus vogelii (Webb) Bornm.	Annual	Therophyte	SU-ZA +	16.6

				SA-SI	
	Cajanus cajan (L.) Millsp.	Perennial	Phanerophyte	SU-ZA	16.6
	Dalbergia sissoo DC.	Perennial	Phanerophyte	PAN	33.3
	Haematoxylum campechianum L.*	Perennial	Phanerophyte	PAN	33.3
	Indigofera oblongifolia Forssk.	Perennial	Chamaephyte	SU-ZA	16.6
	Lablab purpureus (L.) Sweet	Perennial	Chamaephyte	SU-ZA	16.6
	Leucaena leucocephala (Lam.) de Wit	Perennial	Phanerophyte	PAN	50
	Lotus arabicus L.	Annual	Therophyte	SU-ZA + SA-SI	33.3
	Medicago sativa L.	Perennial	Hemicryp-tophyte	PAN	16.6
	Melilotus indicus (L.) All.	Annual	Therophyte	COSM	33.3
	Pithecellobium dulce (Roxb.) Benth.*	Perennial	Phanerophyte	PAN	16.6
	Sesbania sesban (L.) Merr.	Perennial	Phanerophyte	PAL	100
	Senna didymobotrya (Fresen.) H.S.Irwin & Barneby	Perennial	Phanerophyte	PAN	33.3
	S. italica Mill.	Perennial	Chamaephyte	SU-ZA + SA-SI	16.6
	S. occidentalis (L.) Link	Perennial	Chamaephyte	PAN	50
	Tephrosia purpurea (L.) Pers. subsp. *apollinea* (Delile) Hosni & El Karemy	Perennial	Chamaephyte	PAN	83.3
	Trifolium alexandrinum L.	Annual	Therophyte	PAL	16.6
	T. resupinatum L.	Annual	Therophyte	ME + IR-TR	50
	Trigonella hamosa Del. ex Smith	Annual	Therophyte	ME + IR-TR	33.3
	Vicia faba L.	Annual	Therophyte	ME + IR-TR	16.6
Lythraceae	*Lawsonia inermis* L.	Perennial	Phanerophyte	SU-ZA	16.6
	Ammannia baccifera L.	Annual	Therophyte	PAL	66.6
Malvaceae	*Abutilon pannosum* (G.Forst.) Schltdl.	Perennial	Chamaephyte	SU-ZA	100
	Bombax ceiba L.	Perennial	Phanerophyte	PAL	16.6
	Corchorus olitorius L.	Annual	Therophyte	PAL	33.3
	Hibiscus sabdariffa L.	Annual	Therophyte	PAN	16.6
	Malva parviflora L.	Annual	Therophyte	PAN	50
	Sida alba L.	Perennial	Hemicryptophyte	PAL	16.6
Meliaceae	*Khaya senegalensis* (Desv.) A.Juss.	Perennial	Phanerophyte	SU-ZA	16.6
Molluginaceae	*Glinus lotoides* L.	Annual	Therophyte	PAL	66.6
Moringaceae	*Moringa oleifera* Lam.	Perennial	Phanerophyte	PAN	16.6
Myrtaceae	*Eucalyptus camaldulensis* Dehnh.	Perennial	Phanerophyte	AUS	33.3
	Psidium guajava L.	Perennial	Phanerophyte	PAN	100
	Syzygium cumini (L.) Skeels	Perennial	Phanerophyte	PAL	33.3
Nyctaginaceae	*Boerhavia repens* L.	Annual	Chamaephyte	PAL	33.3
	Bougainvillea glabra Choisy	Perennial	Phanerophyte	PAN	16.6
Onagraceae	*Epilobium hirsutum* L.	Perennial	Hydrophyte-Helophyte	PAL	16.6
Oxalidaceae	*Oxalis corniculata* L.	Annual	Geophyte-Helophyte	COSM	50
Papaveraceae	*Argemone mexicana* L.	Annual	Therophyte	PAN	33.3
Pedaliaceae	*Sesamum indicum* L.	Annual	Therophyte	PAL	16.6
Plantaginaceae	*Plantago lagopus* L.	Annual	Therophyte	ME +	16.6

				IR-TR	
	P. major L.	Perennial	Hemicryptophyte	COSM	33.3
Plantaginaceae	*Veronica anagallis-aquatica* L.	Perennial	Geophyte - Helophyte	COSM	66.6
Poaceae	*Arundo donax* L.	Perennial	Hydrophyte	ME + IR-TR	50
	Avena fatua L.	Annual	Therophyte	COSM	16.6
	Cenchrus biflorus Roxb.	Annual	Therophyte	PAL	66.6
	Chloris pycnothrix Trin.	Annual	Therophyte	SU-ZA	16.6
	Cynodon dactylon (L.) Pers.	Perennial	Geophyte	PAN	100
	Dactyloctenium aegyptium (L.) Willd.	Annual	Therophyte	PAL	33.3
	Dichanthium annulatum (Forssk.) Stapf	Annual	Geophyte	PAL	100
	Digitaria sanguinalis (L.) Scop.	Annual	Therophyte	PAN	33.3
	Echinochloa colona (L.) Link	Annual	Therophyte	PAN	33.3
	Eleusine indica (L.) Gaertn.	Annual	Therophyte	PAL	16.6
	Eragrostis cilianensis (All.) Vignolo ex Janch.	Annual	Therophyte	ME + SU-ZA + IR-TR	33.3
	Imperata cylindrica (L.) Raeusch.	Perennial	Geophyte	PAN	100
	Lolium perenne L.	Perennial	Therophyte	ME + IR-TR	33.3
	Panicum coloratum L.	Perennial	Geophyte	SU-ZA	16.6
	P. repens L.	Perennial	Geophyte	COSM	33.3
	Paspalidium geminatum (Forssk.) Stapf	Perennial	Geophyte	PAL	66.6
	Paspalum distichum L.	Perennial	Geophyte	PAN	50
	Phragmites australis (Cav.) Trin. ex Steud.	Perennial	Geophyte- Helophyte	PAL	100
	Poa infirma Kunth	Annual	Therophyte	ME	33.3
	Polypogon monspeliensis (L.) Desf.	Annual	Therophyte	COSM	50
	Setaria viridis (L.) P.Beauv.	Annual	Therophyte	COSM	16.6
	Sorghum × drummondii (Nees ex Steud.) Millsp. & Chase	Annual	Geophyte- Helophyte	SU-ZA	16.6
	S. virgatum (Hack.) Stapf	Annual	Geophyte- Helophyte	SU-ZA	16.6
Polygonaceae	*Emex spinosa* (L.) Campd.	Annual	Therophyte	PAN	33.3
	Polygonum aviculare L.*	Annual	Therophyte	ME + IR-TR	50
	Persicaria decipiens (R.Br.) K.L.Wilson	Perennial	Geophyte- Helophyte	PAN	66.6
	P. senegalensis (Meisn.) Soják	Perennial	Geophyte- Helophyte	PAN	66.6
	Rumex dentatus L.	Annual	Therophyte	PAN	50
Portulacaceae	*Portulaca oleracea* L.	Annual	Therophyte	PAL	83.3
Potamog- etonaceae	*Potamogeton perfoliatus* L.	Perennial	Hydrophyte	COSM	33.3
	P. crispus L.	Perennial	Hydrophyte	COSM	50
	Stuckenia pectinata (L.) Börner.	Perennial	Hydrophyte	COSM	50
Primulaceae	*Anagallis arvensis* L.	Annual	Therophyte	ME	83.3
Rhamnaceae	*Ziziphus spina-christi* (L.) Desf.	Perennial	Phanerophyte	ME + IR-TR	83.3
Rubiaceae	*Oldenlandia capensis* L.f.	Annual	Therophyte	PAL	33.3
Salicaceae	*Salix tetrasperma* Roxb.	Perennial	Phanerophyte	PAL	50

Sapindaceae	*Cardiospermum halicacabum* L.	Annual	Therophyte	PAN	16.6
Solanaceae	*Solanum nigrum* L.	Annual	Therophyte	COSM	83.3
	Physalis angulata L.	Annual	Therophyte	PAN	100
	Datura innoxia Mill.	Annual	Therophyte	PAN	66.6
	Withania somnifera (L.) Dunal	Perennial	Chamaephyte	PAL	16.6
Tamaricaceae	*Tamarix aphylla* (L.) H.Karst.	Perennial	Phanerophyte	SA-AR + SU-ZA + IR-TR	16.6
	T. senegalensis DC.	Perennial	Phanerophyte	SU-ZA + SA-SI	100
Typhaceae	*Typha domingensis* Pers.	Perennial	Helophyte	PAN	50
Urticaceae	*Forsskaolea tenacissima* L.	Perennial	Hemicryptophytes	SU-ZA + SA-AR	33.3
Verbenaceae	*Lantana camara* L.	Perennial	Phanerophyte	PAN	100
	Phyla nodiflora (L.) Greene	Perennial	Hemicryptophyte	PAN	100
Zygophyllaceae	*Balanites aegyptiaca* (L.) Delile	Perennial	Phanerophyte	SU-ZA + SA-SI	33.3
	Fagonia indica Burm.f.	Perennial	Chamaephyte	SA-AR	16.6
	Tribulus terrestris L.	Annual	Therophyte	PAN	50

Legend: (*) = new records, P %= The mean presence percentages for each species. Chorotypes abbreviations: AUS: Australian, COSM: Cosmopolitan, ER-SR=Euro-Siberian, IR-TR: Irano-Turanian, ME: Mediterranean, NEO: Neotropical, PAL: Palaeotropical, PAN: Pantropical, SA-AR= Saharo-Arabian, SA-SI: Saharo-Sindian, SU-ZA: Sudano-Zambezian.

Similarity coefficient between the investigated islands

Regarding the entire flora of the study area, sites of El Shallal, Bute El-Hasaya, Tingar, and El Mahgar valley have the highest value of species richness (139, 77, 76 and 75 species, respectively). On the other hand, EL-Heisa, Philae Port and Awad islands have the lowest value of species richness (22, 22 and 19 species, respectively). There is a high similarity between the floristic composition of the following sites: Bute El-Hasaya vs High Dam Colony (96.00%), Awad island vs El Mahgar Valley (82.98%), El-Hasaya vs Maezana Belal (81.63%), Bute El-Hasaya vs. Awad island (81.01%), and EL-Heisa vs El Mahgar Valley (80.41%). However, the lowest similarity was between Bigga island vs Tingar (23.52%), Awad island vs El Shallal (22.78%), and Agilkia island vs Tingar (22.58%) (Table 3).

DISCUSSION

The current study attempted to survey plant species distribution and diversity in the islands and shorelines with dams and associated reservoir in the south of the River Nile at Aswan Governorate between the High Dam and Aswan Dam (Low Dam). Compared to the floristic composition of other Nile ecosystems in Aswan, the quantity of species recorded in this study (165 taxa species) is within the range, since 94 species of angiosperms were recorded in the first Cataract [35], 206 species were recorded in seven islands in the Nile stream north of Aswan dam until reaching Edfu [36], and 162 species were recorded in ten River Nile islands in the area between Aswan and Esna [38]. However, the floristic composition of these areas, vary with respect to the dominant plant families.

Interestingly, fieldwork and herbarium studies revealed that out of the 165 species recorded, six species were considered new to the flora of Aswan and Nubia (Table 2). The addition of these new species to the riverain flora in Aswan and Nubia from the study area can be related to the following factors: (i) a very little floristic surveys had been done in Aswan reservoir area, and (ii) human impact on the inhabited islands of the study area which resulted in the presence of seeds of ruderal weeds within the crop seeds which were derived from other agricultural areas in Egypt where the plants, seeds, manure, and agricultural equipment originated.

Table 3. The number and percentage of plant species belonging to the main floristic chorotypes and their relevant percent (%) recorded in the Aswan Reservoir area, Awan Governorate, Egypt

Chorotype	No. of plant species	Percentage (%)
Cosmopolitan	27	16.36
Neotropical	3	1.82
Palaeotropical	29	17.58
Pantropical	47	28.48
Total	106	64.24
Monoregional		
AUS	1	0.61
ME	6	3.64
SA-AR	1	0.61
SA-SI	2	1.21
SU-ZA	19	11.52
Total	29	17.58
Biregional		
ME+IR-TR	13	7.88
SU-ZA+ SA-SI	11	6.66
SU-ZA+SA-AR	2	0.61
Total	25	15.15
Pleuriregional		
ME+ SU-ZA+IR- TR	1	0.61
SU-ZA + SA-AR + IR-TR	2	1.21
ME + ER-SR + IR-TR	1	0.61
Total	4	2.43

Dam construction across a river is usually associated with catchment's biological and hydromorphological features and causes great changes in limnological regime, including chemical and physical changes and which in turn lead to the growth of riparian and island plant communities with a remarkable increase in the number of plant taxa comparing with the natural environment pre-existing the dam construction [39,40].

Based on the number of species, three major families comprised 38.18% of the total flora surveyed in the study area (Leguminosae, Poaceae, and Compositae), these families were also reported as most frequent families in the floristic composition across the River Nile and the associated irrigation and drainage canals in Egypt [5,35,37,41–43]. Moreover, Leguminosae, Poaceae, and Compositae were reported as the most frequent families in the floristic composition of the Nile islands at Aswan [44]. These three families were reported as the most dominant in eastern Ethiopia and northern Zambia [45,46], as well as in the flora of the Mediterranean and North Africa [47]. Moreover, the former three families were dominant in the floristic composition of the agro-ecosystem in Egypt [48,49]. This can be attributed to their wide ecological range of tolerance, efficient seeds dispersal capabilities, migration efficiency in addition to local conditions of water depth [50,51].

Table 4. Matrix of similarity coefficient, calculated between each pair of sites surveyed within the Aswan Reservoir area Awan Governorate, Egypt

Site Name	Sh	Bu	Ma	Hi	Ph	Mv	Ti	Aw	He	Bi	Ag
Sh	■	62.96	61.24	48,12	24.84	42.05	64.18	22.78	26.08	42.85	47.05
Bu	(68)	■	81.63	96.00	79.50	59.81	53.42	81.01	79.50	70.32	68.44
Ma	(64)	(60)	■	50.84	65.21	41.38	41.09	67.41	65.21	53.09	50.84
Hi	(45	(30)	(30)	■	42.85	24.39	42.19	44.77	42.85	32.96	31.25
Ph	(20)	(20)	(20)	(15)	■	30.92	30.61	73.17	68.18	46.15	42.85
Mv	(45)	(39)	(33)	(21)	(16)	■	51.65	82.98	80.41	66.10	63.41
Ti	(69)	(53)	(52)	(32)	(18)	(39)	■	29.47	28.57	23.52	22.58
Aw	(18)	(17)	(16)	(13)	(12)	(12)	(14)	■	78.05	51.61	47.76
He	(21)	(20)	(20)	(17)	(12)	(17)	(18)	(16)	■	58.46	54.28
Bi	(39)	(41)	(36)	(20)	(19)	(28)	(37)	(14)	(19)	■	70.33
Ag	(44)	(44)	(42)	(20)	(16)	(28)	(40)	(13)	(18)	(32)	■
Total number	**139**	**77**	**70**	**48**	**22**	**75**	**76**	**19**	**22**	**43**	**48**

• Bold numbers indicate the total number of species per site.
• Bracketed numbers indicate the common species for each pair of sites.
• Normal numbers indicate the quotient of similarity.
Sites abbreviated as follows: Sh: El Shallal, Bu: Bute El-Hasaya, Ma: Maezan Belal, Hi: High Dam Colony, Ph: Philae Port, Mv: El Mahgar valley, Ti: Tingar, Aw: Awad, He: EL-Heisa island, Bi: Bigga island, Ag: Agilkia island

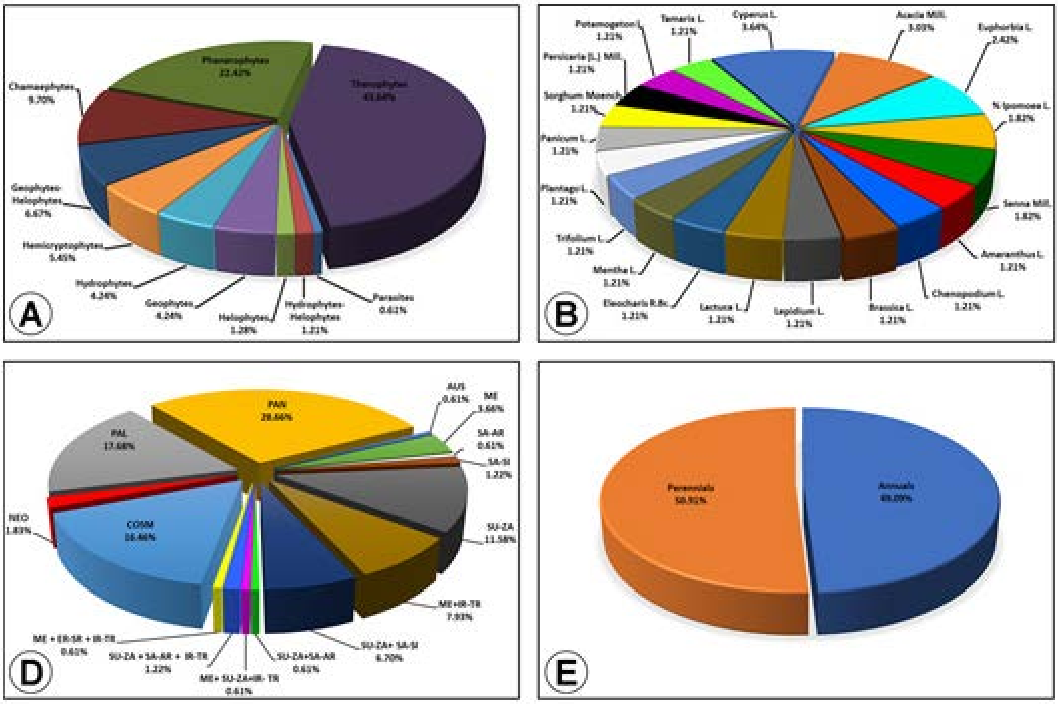

Fig. 3. A. Life form spectrum pf plant species recorded in the Aswan Reservoir area, **B.** Percentage of species in the study area relative to their genera, **C.** Chorological analysis, **D.** Duration analysis. For the abbreviations see Table 2

The percentages of distribution of species and genera per families are both strongly directed towards the smallest size classes. Means of 1.2 species per genus, 3.6 species per family and 2.8 genera per family were recorded in the flora of the studied area. These results agree with the findings of [41] regarding the flora of riverain islands in Upper Egypt, where means of 1.3 species per genus, 3.04 species per family and 2.8 genera per family were concluded.

The current study showed that the floristic composition of the Aswan reservoir area exhibited a high degree of monotypism. A total of 21 families (12.73 %) were represented by a single species. Moreover, 116 genera (85.93 %) were monotypic. This may be due to the fact that a few numbers of plants tolerate harsh environments in these areas. In the meantime, other plants could not survive in the severe physical disturbance in Aswan Reservoir caused by the daily water fluctuation.

Distribution of life form in this study was mostly dominated by therophytes (72 species=43.64%). This may be due to many factors such as short life cycle and high growth rate that enables them to resist substrate instability, their high ability to set seeds without the need of pollinator visit, ecological, genetic and morphological plasticity under high level of disturbance (water fluctuations, hot dry climate, topographic variation, biotic influence, and human activities) [52–57]. The recorded life form spectra agree with many previous studies conducted in different riverine habitats in Egypt [41,43,58–60].

Regarding the lifespan (duration), the percentage of perennials (50.91%) exceeded that of annuals (49.09%). This trend matching the finding of [58], however, disagrees with the spectrum reported for Nubian flora and for the Egyptian flora in general [23,36,61]. This may be due to the fact that perennial plants are adapted to the extreme habitat of the area (e.g., waterlogged, and water fluctuations over the year) [62].

Phytogeographical analysis of the 165 species surveyed in Aswan reservoir area showed that the pantropical, palaeotropical and cosmopolitan species, respectively were the most dominant in the study area (62.42% of the total flora). This agrees with the finding of [63] who reported that the major percentage of plants surveyed in the flora of Egypt belonged to the cosmopolitan, palaeotropical, and pantropical phytochoria. Similar results were obtained in different studies in the flora of Egypt concerned by the plants of River Nile and associated irrigation and drainage canals [36,41,60].

The Sudano-Zambezian chorotype was represented by 35 species (21.21% of the total flora recorded). While the Mediterranean chorotype was represented by 21 species (12.73%). These results were in line with other studies of the flora of Upper Egypt and Nubia, which reported that the Sudano-Zambezian elements exceed that of the Mediterranean ones in the entire flora [36,41]. Moreover, [19] reported that the percentage of Sahelian and Sudanian taxa (sensu [64]) is highest in Upper Egypt, while Mediterranean taxa are the lowest. This may be attributable to the narrow alluvial strips coupled with a dry and hot atmosphere in the study area which allows only a very limited movement of Mediterranean species to the Nubia [65].

The Irano-Turanian chorotype comprises 17 species (10.30%) including only 13 biregionals and four pluriregionals. The Saharo-Sindian elements represented by 13 species (7.88%) including two monoregional and 11 biregionals. The Saharo-Arabian elements represented by five species (3.03%) including one monoregional, two biregionals, and two pluriregionals, while the remaining taxa are belonging to Australian, Euro-Siberian, and neotropical regions. This combination of different floristic chorotypes with variable numbers of species can be attributed to different factors such as human impact, history of agriculture, water fluctuations and capability of certain floristic elements to penetrate the study area from different adjacent phytogeographical regions [66,67].

In studying of the spatial distribution of species in Aswan reservoir area, it was obvious that the number of species and their presence varied from site to another, even neighboring sites showed remarkable differences in their floristic composition. Species richness is highest in shorelines (El Shallal, Bute El-Hasaya, Tingar, and El Mahgar valley) liable to flooding, due to strong artificial and heterogeneity of these environments, compared to those of the islands in the river (EL-Heisa, Philae Port and Awad islands).

Regarding the similarity coefficient, the highest value was recorded between Bute El-Hasaya and High Dam Colony (96.00 %). This could be because of their close geographical position, and their exposure to the same conditions where they are uninhabited islands (Table 3). [68] reported that of the neighboring regions might have similarity their floristic composition if they were exposed to similar environmental conditions. However, the very low similarity was reported between Bigga island vs Tingar (23.52%), Awad island vs El Shallal (22.78%), and Agilkia island vs Tingar (22.58%), this may be due to the large distance between these sites. [69] stated that the influence of geographical distance on the floristic similarity between sites is probably related to the change of abiotic factors with the distance between them. Moreover, the dissimilarity maybe since each pair of these sites presents in different habitat and have a different human impact.

CONCLUSIONS

The vegetation of Aswan Reservoir catchment area is highly diverse, the high diversity in this section of River Nile may due to the combination of various environmental factors which is favorable for a wide range of plant species. Aswan Reservoir shows an ideal ecosystem as a study model, which provided many insights into how dams have an impact on vegetation structure over time and space. Anthropogenic activities in the studied area influenced the species diversity, which has affected the number of species recorded in each site. Also, water fluctuation may be on the main reasons for the presence of many species and several newly recorded ones.

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