Floristic diversity and vegetation analysis of riparian and aquatic plants of the canals in the Sohag Governorate, Egypt

Ahmed Elkordy, Omer Elshikh & Naglaa Abdallah

Botany & Microbiology Department, Faculty of Science, Sohag University, Sohag 82524, Egypt, e-mail: Elkordy3000@yahoo.com (corresponding author).

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Abstract. This paper analyzes the five elements of vegetation: floristic composition, lifespan, life form, chorology, and species distribution of the riparian and aquatic flora of canals in the Sohag Governorate of Egypt. The riparian vegetation included 126 taxa belonging to 35 families and 95 genera. *Poaceae*, *Fabaceae* and *Asteraceae* were the dominant plant families (50.00 % of the total number of the plant taxa). Annuals claimed 57.94 % of all plant taxa, and 40.48 % were perennials. Therophytes and hemicryptophytes were the predominant life forms of riparian taxa. Monoregional and pleuriregional taxa dominated the vegetation along the canals of the Sohag Governorate, both with 29 species or 23.02 % of all identified taxa. Biregional taxa accounted for 20.63 % of all taxa. There were 11.11 % of cosmopolitan and 11.91 % of indigenous taxa to the tropical areas worldwide. Plants from the Palaeotropical Kingdom constituted 8.73 % of the riparian plant taxa. Plants originally distributed over the Mediterranean floristic region dominated in the canal riparian areas of the studied area, with 61 taxa or 48.41 %. Furthermore, this study identified 41 taxa of aquatic plants from 21 genera and 16 families that were free-floating, rooted and floating, or submerged plants.

Key words: Aquatic, biogeography, canal banks, chorology, diversity,flora, life form, riparian vegetation

Introduction

Floristic diversity is essential for life on Earth, especially in providing crucial ecological stability in any habitat (Cunningham & al. 2015). According to Boulos (1966, 1995, 1999, 2000, 2002, 2005, 2009) and Shaltout & Eid (2010), Egypt has more than 2145 species and approximately 220 subspecies and varieties of flowering plants, 175 taxa of mosses, and 13 taxa of liverworts.

Such very significant species diversity of Egypt results from two factors: (1) the unique geographical nexus of Asia and Africa involving at least four phytogeographical regions: African Sudano-Zambesian; Asiatic Irano-Turanian; Afro-Asiatic Saharo-Sindian, Euro-Afro-Asiatic Mediterranean, and (2) the existence of a wide variety of ecosystems which support terrestrial and aquatic life.

In Egypt, the main channels of River Nile provide an extremely important habitat and source of fresh water distributed by irrigation canals and returned in drainage channels. Most of these networks were constructed during the 19^{th} century and amount approximately to a total length of 48 000 km (Khattab 1992). These extensive waterways support the riparian and aquatic vegetation but little is known about how these channels control and effect plant community structure, floristic composition, and species diversity (Nilsson & al. 1989). According to Zahran & Willis (2003), the vegetation along canal banks are classified into three types: aggressive species, bank retainers, and soil erosion controllers. Aggressive species are characterized by rapid and robust growth that inhibits the growth and establishment of many slow-growing and smaller plants. Many plant species growing along the banks of the Egyptian surface waters, involving the irrigation and drainage canals, are aggressive, including *Trifolium resupinatum* L., *Cyperus laevigatus* L., and *Phyla nodiflora* (L.) Greene. These aggressive plants quickly and densely cover the bare soil. Furhtermore, *Saccharum spontaneum* L., *Cyperus alopecuroides* Rottb., *Arundo donax* L., and *Cyperus articulates* L. form stands of tall spreading reeds.

The plants involved in bank stabilization (retention) are mainly trees, such as *Vachellia nilotica* (L.) P.J.H. Hurter & Mabb., *Salix tetrasperma* Roxb., *Tamarix senegalensis* DC., *Ficus sycomorus* L., and *Ziziphus spina-christi* (L.) Desf.; and dwarf shrubs such as *Pluchea dioscoridis* (L.) DC., *Dysphania ambrosioides* (L.) Mosyakin & Clemants, and *Alhagi graecorum* Boiss. These plants give shade and often prevent other smaller plants from colonizing and settling in the area.

Soil erosion-control plants minimize erosion by root binding of soil particles. These soil controllers include *Imperata cylindrica* (L.) Raeusch. and *Desmostachya bipinnata* (L.) Stapf.

Several authors have analyzed vegetation along the canals and drains associated with the River Nile. Simpson (1932) was the first to describe the plants associated with irrigation canals in Egypt. Ḥasib (1951), Boulos & al. (1967), El Hadidi & Ghabbour (1968), Shaltout & El-Sheikh (1993) studied the vegetation structure on the banks of canals and drains in the center of the Nile Delta. Mashaly & al. (2003) researched the biodiversity and phytochemistry of weeds in different regions of the Nile Delta. Mashaly & El-Ameir (2007) investigated hydrophytes or submerged aquatic plants in the irrigation and drainage canals in some selected governorates in the Nile Delta and Nile Valley. Tork (2007) studied the ecology of aquatic vegetation in the northeast Nile Delta. El-Fiky (1974), Khedr (1989), Shaltout & El-Sheikh (1993), Shaltout & al. (1994), Khedr & El-Demerdash (1997), Al Sherif (2009), Mashaly & al. (2009), and Salama & Khedr (2014) analyzed vegetation along the irrigation and drainage canals associated with the northern Egyptian lakes and the Nile Delta. Mashaly & al. (2010) considered the habitats of canal riparian vegetation in some governorates in North Egypt. They concluded that in the northern part or Lower Egypt, the riparian taxa of drainage canals were dominant; on the other hand, the riparian taxa of irrigation canals claimed the second most abundant plant habitat.

The latest studies of the flora and vegetation structure of aquatic and riparian plants along the irrigation and drainage canals carried out in different regions of the River Nile in Egypt were summarized in Table 1.

According to several indices, biodiversity in Egypt is undergoing serious deterioration, including genetic diversity, numbers of species, and shifts in community structure (Egypt's Fifth National Report to the CBD, https://www.cbd.int/doc/world/eg/eg-nr-05-en.pdf). Many causes are responsible for impaired biodiversity, including global climate change, overexploitation, invasive species, pollution, and lack of financial and human resources to prevent habitat loss. Loss of and changes in plant habitat cause major alterations in terrestrial and aquatic ecosystems. Particularly, (1) pollution from industrialization, urbanization, cultivation, overgrazing, silviculture, and other anthropogenic activities; (2) wetland filling; (3) invasion of noxious plant species; and (4) drought and climate change influence or destruction of critical terrestrial and aquatic habitats, which in turn controls the species diversity (Ministry of State for Environmental Affairs 2014).

This study was the first to identify and analyze the vegetation of the riparian and aquatic plants associated with the canals and canal banks of the Sohag Governorate in Egypt. The aims of the present study are:

(1) To determine the floristic composition, life forms, lifespan, and phytogeographic relationships of the aquatic and riparian plant taxa identified along the canals and canal banks of the Sohag Governorate.

(2) To create a floristic baseline for the Sohag area, so as to evaluate the effects on habitats and plant diversity from major changes in the River Nile hydroperiod or hydrologic regime.

Study area

The Sohag Governorate lies midway between Cairo and Aswan in the Nile Valley. The Governorate is situated between latitudes 26°6'54" to 27°9'26"N and longitudes 31°13'18" to 32°36'50"E. Its total area is 1574 km^2, which extends for approximately 125 km along the banks of the River Nile, and the width of the Governorate ranges between 16 to 25 km (Fig. 1).

Table 1. A summarized comparison of current results with the results of other studies carried out in different regions of the River Nile in Egypt showing the number of recorded plant species, genera and families; and dominant families, life forms and chorotypes (all with the percentage of all taxa observed).

Study (location)	Species No.	Families No.	Genera No.	Dominant families	Dominant life forms	Dominant chorotypes
Current study (Sohag Governorate)	126	35.0	94.0	*Poaceae* (25.40%) *Fabaceae* (13.49%) *Asteraceae* (11.11%)	Th. (55.56%) Hem. (22.22%) Ph. (9.52%)	ME and IR-TR (17.46%) ME, IR-TR, ER-SR (15.87%) PAN (11.90%) COSM (11.11%)
Faried & Amro (2016) (Assiut Governorate)	71	30	85	*Poaceae* (25.4%) *Asteraceae* (11.3%) *Euphorbiaceae* (7.0%)	Th. (57.7%) Hem. (12.7%) Ph. (11.3%)	PAN (22.5%) COSM (21.1%) PAL (14.0%) ME, IR-TR, and ER-SR (9.9%)
Amer & al. (2015) (Beni-Suef Governorate)	151	48.0	116	*Poaceae* (19.87%) *Asteraceae* (9.94%) *Fabaceae* (9.28%) *Brassicaceae* (5.30%)	Th. (56.96%) Hy. (17.80%) Geo. (7.20%) Ph. (6.63%)	COSM (26.50%) PAL (15.20%) PAN (10.60%) ME and IR-TR (10.60%) ME, IR-TR, and ER-SR (9.90%)
El-Amier & al. (2015) (Damietta Branch of River Nile)	70	30	54	*Poaceae* (14.3%) *Chenopodiaceae* (14.3%) *Asteraceae* (11.4%)	Cr. (48.6%) Th. (34.3%) Ch. (11.4%)	COSM (18.6%) PAL (14.3%) PAN (14.3%) ME and IR (10.0%)
Hamed & al. (2012) (Qena Governorate)	161	53.0	123	*Poaceae* (17.40%) *Fabaceae* (9.94%) *Asteraceae* (7.45%)	Th. (51.55%) Ph. (13.04%) Geo. (11.18%) Hel. (11.18%)	PAN (31.67%) COSM (21.74%) PAL (18.63%) ME and IR-TR (8.08%)
Mashaly & al. (2010) (Northern Egypt)	108	28.0	87.0	*Poaceae* (18.26%) *Asteraceae* (15.56%) *Chenopodiaceae* (10.43%)	Th. (49.57%) Cr. (28.70%) Hem. (11.30%)	COSM (17.39%) PAN (16.52%) ME, IR-TR, and ER-SR (14.78%) PAL (12.17%)
Mashaly & al. (2009) (Nile Delta)	113	36.0	93.0	*Poaceae* (23.89%) *Asteraceae* (13.27%) *Chenopodiaceae* (8.85%)	Th. (48.67%) Geo. (14.16%) Hel. (11.50%) Hem. (9.73%)	COSM (19.74%) ME, IR-TR, ER-SR (19.74%) PAN (13.27%) PAL (12.39%)

Abbreviations: Life forms:Th. = therophyte, Hem. = hemicryptophyte, Ph. = phanerophyte, Ch. = chamaephyte, and Cr. = cryptophyte (Note: Some studies reported cryptophytes by subcategories, Geo. = geophyte, Hel. = helophyte, and Hy. = hydrophyte). Phytochoria: COSM = cosmopolitan, PAL = palaeotropical, PAN = pantropical, ME = Mediterranean, IR-TR = Irano-Turanian, and ER-SR = Euro-Siberian.

The subtropical climate of Egypt has been categorized from the south to the north as follows: dry desert climate (representative of the Assiut, Sohag, New Valley, and Aswan governorates), semi-arid warmer dry climate with an extended summer dry season (Bahtim), and Mediterranean climate (Sidi Barrani, Matruh Governorate) (Diabaté & al. 2004). According to the Worldwide Bioclimatic Classification System (http://www.globalbioclimatics.org), Egypt has a Mediterranean desertic continental climate, which means a dry climate with 0.2 mm annually of precipitation against the 30-year average annual rainfall (http://worldweather.wmo.int).

The seasonally variable rainfall in the Sohag Governorate ranges from zero mm in summer to 0.3 mm in winter. Despite such dry desert climate, rainfall may suddenly occur at an extreme rate (Kareim 2001).

With an average temperature of 22.5 °C, the climate in Sohag Governorate is warm. The minimum temperature usually occurs in January and the maximum in June, with temperatures ranging between 13.2 °C to 31.7 °C over the year, seasonal variation of relative humidity between 45 % to 60 % in winter and 25 % to 35 % in summer, at an annual average of approximately 40 %. (https://globalweather.tamu.edu/database 2016–2017.) (Fig. 2).

Geomorphology and topography of the Sohag Governorate

The Nile floodplain in the Sohag Governorate borders on limestone plateaus in the southwest and northeast. The three main geomorphological features of the Governorate have unique shape, pattern, and relief which could be summarized as follows: (1)

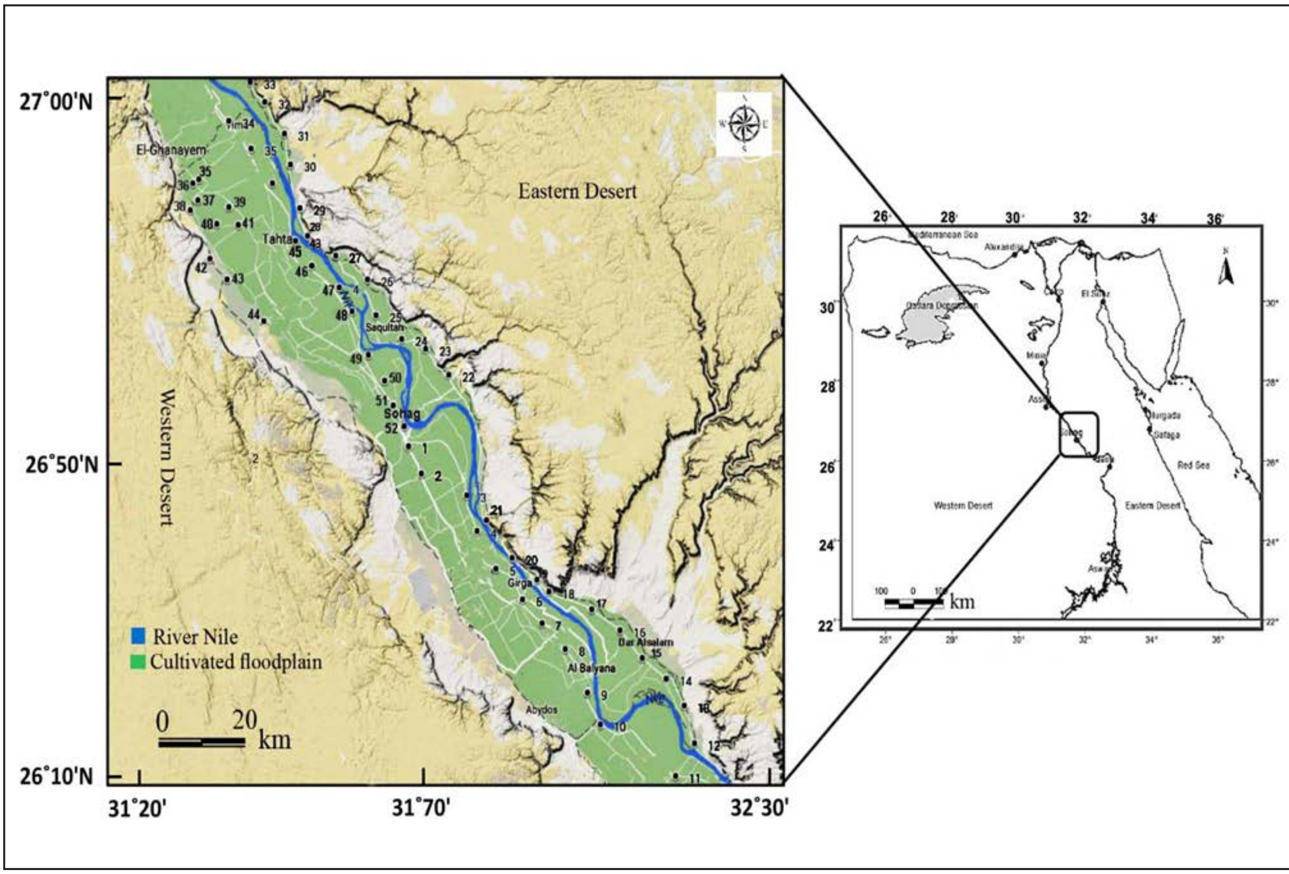

Fig. 1. Location map of Egypt showing the Sohag Governorate and distribution of 52 studied stands.

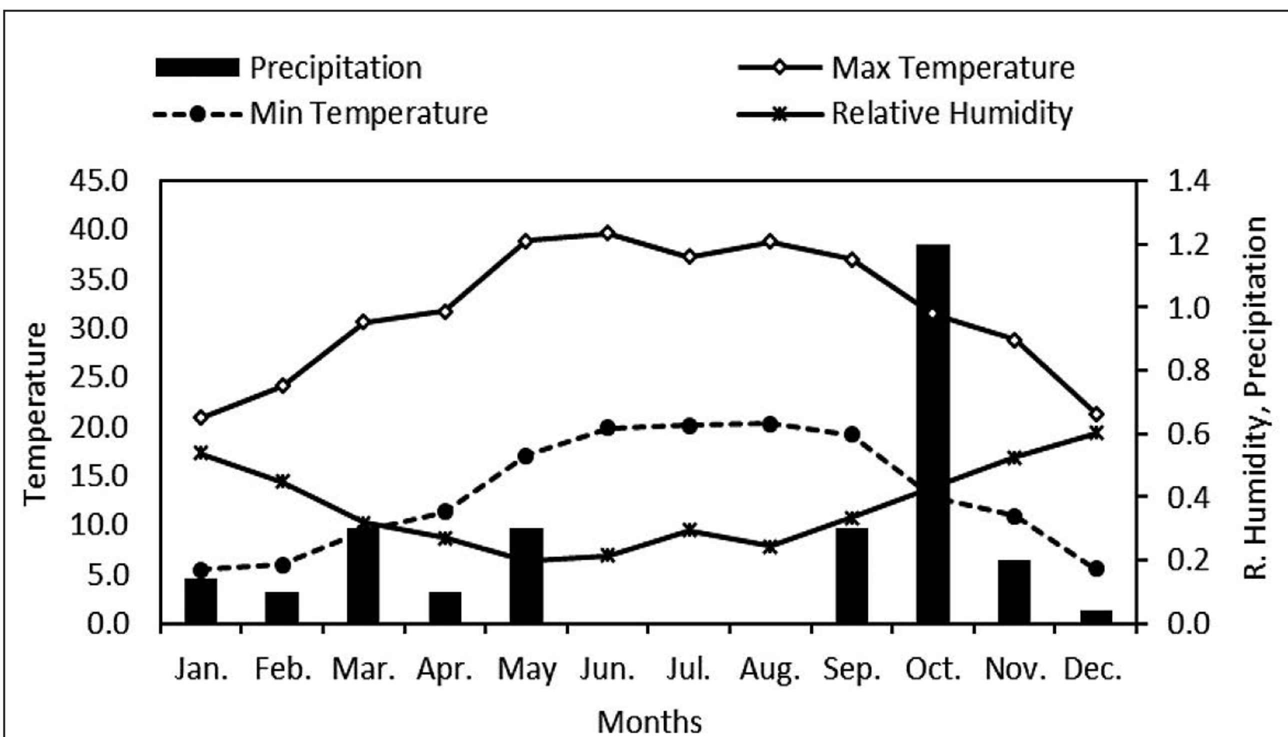

Fig. 2. Climatic diagram of the Sohag Governorate, showing the average maximum and minimum temperatures, precipitation and relative humidity during 2016–2017, according to Global Weather (https://globalweather.tamu.edu/database 2016–2017).

The intensely cultivated floodplain on both the east and west banks of the River Nile (shown in green in Fig. 1) represents mud and silt deposits dissected by the irrigation and drainage canals. (2) The lowland desert areas extended between the lower elevations of cultivatable land along both river banks and the higher limestone escarpments of the Western Desert and the Eastern Desert; the elevation of these lowlands varies between 70 m and 160 m above the mean sea level. (3) The limestone plateaus are part of the major Eocene plateau that presently forms the Western and Eastern Egyptian deserts. These limestone plateaus in the Sohag Governorate lie on an average at 200 m to 300 m above the mean sea level and gradually decrease in elevation northwards (Youssef & al. 2017).

The fertile Nile Valley in Egypt has seven distinct habitats. These habitats are the River Nile islands, canal banks, cultivated fields, wetlands, and surface water that includes the River Nile reservoirs, artificial and northern lakes in the Nile Delta (Zahran & Willis 2009).

Material and methods

This study has thoroughly surveyed the Sohag Governorate canals (irrigation and drainage) eight times over the years 2016 and 2017 by the stratified and random sampling method (Ludwig & Reynolds 1988). This investigation comprises 52 vegetation stands (10 × 10 m) randomly chosen to cover as much as feasible of the variation in aquatic and riparian vegetation along the canals and canal banks in the Sohag Governorate. The eight surveys of the 52 stands include records of the present plant species, plot latitude and longitude (using the Global Positioning System), and ecological notes (Fig. 1).

Life forms were identified for all observed species from regenerative sprouts emerging specifically during the two winter surveys, according to Raunkiaer (1934). Collected specimens of the plants in each of the 52 vegetation stands were identified according to the latest available literature (Täckholm 1974; Boulos 1966, 1995, 1999, 2000, 2002, 2005, 2009). The Herbarium of Sohag University SHG (Faculty of Science, Botany and Microbiology Department) hosts the specimens of each plant collected during the study.

Results

Floristic composition and lifespan of riparian taxa

Table 2 shows the 126 plant taxa collected from the 52 vegetation stands along of the canal banks in the Sohag Governorate. They belong to 95 genera and 35 families of vascular plants. Fifty percent of the collected taxa come from only three families: *Poaceae*, *Fabaceae*, and *Asteraceae*. Of all 95 identified plant genera in the Sohag Governate, 26 genera (27.66 %) belong to the family *Poaceae*, while the second strongest represented family in terms of identified genera and species comprises 12 genera (12.8 %) from *Asteraceae* and 11 genera (11.7 %) from *Fabaceae*. Three genera each have been identified from the families *Apocynaceae*, *Brassicaceae*, and *Convolvulaceae*. Two genera each have been identified from the eight families *Amaranthaceae*, *Chenopodiaceae*, *Euphorbiaceae*, *Malvaceae*, *Polygonaceae*, *Primulaceae*, *Solanaceae*, and *Verbenaceae*; and only one genus from each of the remaining 21 families (22.1 %) listed in Table 2.

In terms of the species richness within the recorded families along the canals in Sohag Governorate, only one family exceeded 30 species (*Poaceae*: 32 species) Table 2 and Fig. 3. The second and third most species-abundant families were *Fabaceae* and *Asteraceae,* with 17 and 14 species, respectively. Two families were represented by six species each: *Euphorbiaceae* and *Polygonaceae*. Another two families were represented by four species: *Brassicaceae* and *Convolvulaceae*; and five families had three species. Five families contained two species each. Finally, 18 families were represented by a single species only (monospecific or monotypic).

The recorded species were categorized into two major groups based on their lifespan. The majority of species listed in Table 2 (73 species or 57.94 % of all 126 species) were annual plants. The second longest lifespan recorded in this study belonged to the perennial plants (51 species or 40.48 % of all 126 species). Two species (1.59 %) identified in the Sohag Governorate had different lifespans depending on local climatic and growing conditions. *Sonchus asper* (L.) Hill survived as annual or biennial plant, abbreviated as ann. to bie., and *Senna occidentalis* (L.) Link survived as annual or perennial plant, abbreviated as ann. to per. (Table 2).

Table 2. Plant taxa (alphabetically arranged by families) identified along of the canal banks in the Sohag Governorate of Egypt, with lifespan, chorology, and life form

Sp. No.	Species	Family	Lifespan	Chorology	Life form
1	*Adiantum capillus-veneris* L.[LC]	*Adiantaceae*	Per.	ME, IR-TR, and ER-SR	Hem.
2	*Trianthema portulacastrum* L.	*Aizoaceae*	Ann.	AM	Th.
3	*Alternanthera sessilis* (L.) R. Br. ex DC. [LC]	*Amaranthaceae*	Ann.	ME and IR-TR	Th.
4	*Amaranthus hybridus* L.	*Amaranthaceae*	Ann.	COSM	Th.
5	*A. viridis* L	*Amaranthaceae*	Ann.	COSM	Th.
6	*Ammi majus* L.	*Apiaceae*	Ann.	ME	Th.
7	*Calotropis procera* (Aiton) Dryand.	*Apocynaceae*	Per.	SU-ZA	Ph.
8	*Cynanchum acutum* L. subsp. *acutum* [LC]	*Apocynaceae*	Per.	ME and IR-TR	Ph.
9	*Oxystelma esculentum* (L.f.) Sm	*Apocynaceae*	Per.	SU-ZA	Hem.
10	*Ageratum conyzoides* (L.) L.	*Asteraceae*	Ann.	AM	Th.
11	*Bidens pilosa* L.	*Asteraceae*	Ann.	ME, SA-SI, and ER-SR	Th.
12	*Centaurea calcitrapa* L.	*Asteraceae*	Ann.	ME, and ER-SR	Ch.
13	*Eclipta prostrata* (L.) L., Mant.	*Asteraceae*	Ann.	PAN	Th.
14	*Erigeron aegyptiacus* L.	*Asteraceae*	Ann.	ME	Th.
15	*E. bonariensis* L.	*Asteraceae*	Ann.	AM	Th.
16	*Lactuca serriola* L.	*Asteraceae*	Ann.	ME, IR-TR, and ER-SR	Th.
17	*Laphangium luteoalbum* (L.) Tzvelev	*Asteraceae*	Ann.	COSM	Hem.
18	*Pluchea dioscoridis* (L.) DC.	*Asteraceae*	Per.	SA-SI, and SU-ZA	Ph.
19	*Senecio aegyptius* L.	*Asteraceae*	Ann.	ME, IR-TR, and ER-SR	Th.
20	*Sonchus asper* (L.) Hill	*Asteraceae*	Ann. to bie.	ME	Th.
21	*S. oleraceus* (L.) L.	*Asteraceae*	Ann.	ME, IR-TR, and ER-SR	Th.
22	*Symphyotrichum squamatu*m (Spreng.) G.L. Nesom	*Asteraceae*	Per.	NEO	Ch.
23	*Xanthium strumarium* L.	*Asteraceae*	Ann.	COSM	Th.
24	*Trichodesma africanum* (L.) Sm. var. *africanum*	*Boraginaceae*	Ann.	SA-SI	Th.
25	*Lepidium coronopus* (L.) Al-Shehbaz	*Brassicaceae*	Ann.	ME and ER-SR	Th.
26	*L. didymum* L.	*Brassicaceae*	Ann.	COSM	Th.
27	*Rorippa palustris* (L.) Besser	*Brassicaceae*	Ann.	ME, IR-TR, and ER-SR	Th.
28	*Sisymbrium irio* L.	*Brassicaceae*	Ann	ME and IR-TR	Th.
29	*Chenopodium album* L.	*Chenopodiaceae*	Ann.	COSM	Th.
30	*C. murale* L.	*Chenopodiaceae*	Ann.	COSM	Th.
31	*Dysphania ambrosioides* (L.) Mosyakin & Clemants	*Chenopodiaceae*	Ann.	COSM	Th.
32	*Convolvulus arvensis* L.	*Convolvulaceae*	Per.	COSM	Hem.
33	*Cuscuta pedicellata* Ledeb.	*Convolvulaceae*	Ann.	IR-TR	Par.
34	*Ipomoea cairica* (L.) Sweet.	*Convolvulaceae*	Per.	PAL	Hem.
35	*I. carnea* Jacq.	*Convolvulaceae*	Per.	PAN	Ch.
36	*Cyperus alopecuroides* Rottb. [LC]	*Cyperaceae*	Per.	PAN	Hem.
37	*C. rotundus* L. [LC]	*Cyperaceae*	Per.	PAN	Geo.
38	*Bergia ammannioides* Roxb. ex Roth	*Elatinaceae*	Ann.	ME and IR-TR	Th.
39	*B. capensis* L.	*Elatinaceae*	Ann.	PAL	Th.
40	*Euphorbia helioscopia* L.	*Euphorbiaceae*	Ann.	ME, and ER-SR	Th.
41	*E. hirta* L.	*Euphorbiaceae*	Ann.	AM	Th.
42	*E. indica* Lam.	*Euphorbiaceae*	Ann.	SA-SI, SU-ZA, and IR-TR	Th.
43	*E. peplus* L	*Euphorbiaceae*	Ann.	ME, IR-TR, and ER-SR	Th.
44	*E. prostrata* Aiton.	*Euphorbiaceae*	Ann.	AM	Th.
45	*Ricinus communis* L.	*Euphorbiaceae*	Per.	PAL	Ph.
46	*Alhagi graecorum* Boiss.	*Fabaceae*	Per.	ME and IR-TR	Hem.
47	*Lathyrus aphaca* L.	*Fabaceae*	Ann.	ME, IR-TR, and ER-SR	Th.
48	*Lotus arabicus* L.	*Fabaceae*	Ann.	SA-SI and SU-ZA	Th.
49	*L. glaber* Mill.	*Fabaceae*	Per.	ME, IR-TR, and ER-SR	Hem.
50	*Medicago intertexta* (L.) Mill.	*Fabaceae*	Ann.	ME	Th.

Table 2. Continuation.

Sp. No.	Species	Family	Lifespan	Chorology	Life form
51	*M. littoralis* Loisel.	*Fabaceae*	Ann.	ME	Th.
52	*M. orbicularis* (L.) Bartal.	*Fabaceae*	Ann.	ME and IR-TR	Th.
53	*M. polymorpha* L. var. *polymorpha*	*Fabaceae*	Ann.	ME, IR-TR, and ER-SR	Th.
54	*M. rigidula* (L.) All.	*Fabaceae*	Ann.	ME	Th.
55	*M. sativa L.*	*Fabaceae*	Per.	ME, IR-TR, and ER-SR	Hem.
56	*Melilotus indicus* (L.) All.	*Fabaceae*	Ann.	ME	Th.
57	*Mimosa pigra* L.	*Fabaceae*	Per.	PAN	Ph.
58	*Senna occidentalis* (L.) Link	*Fabaceae*	Ann. To per.	PAN	Ph.
59	*Sesbania sesban* (L.) Merr.	*Fabaceae*	Per.	SU-ZA	Ph.
60	*Trifolium resupinatum* L.	*Fabaceae*	Ann.	ME and IR-TR	Th.
61	*Vachellia nilotica* (L.) P.J.H. Hurter & Mabb. [LC]	*Fabaceae*	Per.	SU-ZA	Ph.
62	*Vicia sativa* subsp. *sativa* L.	*Fabaceae*	Ann.	ME	Th.
63	*Schenkia spicata* (L.) G. Mans.	*Gentianaceae*	Ann.	ME and IR-TR	Th.
64	*Juncus subulatus* Forssk.	*Juncaceae*	Per.	ME	Hem.
65	*Ammannia senegalensis* Lam.	*Lythraceae*	Ann.	PAN	Th.
66	*Malva parviflora* L.	*Malvaceae*	Ann.	ME and IR-TR	Th.
67	*Sida spinosa* L.	*Malvaceae*	Ann.	PAN	Th.
68	*Glinus lotoides* L	*Molluginaceae*	Ann.	ME and IR-TR	Th.
69	*Ludwigia adscendens* subsp. *diffusa* (Forssk.) P. H. Raven [LC]	*Onagraceae*	Per.	SU-ZA	Hem.
70	*Oxalis corniculata* L.	*Oxalidaceae*	Ann.	COSM	Th.
71	*Plantago major* L.	*Plantaginaceae*	Per.	ME, IR-TR, and ER-SR	Th.
72	*Arundo donax* L.	*Poaceae*	Per.	ME and IR-TR	Geo.
73	*Avena fatua* L.	*Poaceae*	Ann.	COSM	Th.
74	*Brachiaria eruciformis* (Sm.) Griseb.	*Poaceae*	Ann.	PAN	Th.
75	*Crypsis schoenoides* (L.) Lam. [LC]	*Poaceae*	Ann.	ME, IR-TR, and ER-SR	Th.
76	*Cynodon dactylon* (L.) Pers.	*Poaceae*	Per.	PAN	Geo.
77	*Dactyloctenium aegyptium* (L.) Willd.	*Poaceae*	Ann.	PAL	Th.
78	*Desmostachya bipinnata* (L.) Stapf [LC]	*Poaceae*	Per.	SU-ZA	Hem.
79	*Digitaria sanguinalis* (L.) Scop.	*Poaceae*	Ann.	PAL	Th.
80	*Echinochloa colona* (L.) Link [LC]	*Poaceae*	Ann.	PAN	Th.
81	*E. crus-galli* (L.) P.Beauv.	*Poaceae*	Ann.	ME and IR-TR	Th.
82	*E. stagnina* (Retz.) P.Beauv.	*Poaceae*	Per.	PAL	Geo.
83	*Eragrostis aegyptiaca* (Willd.) Delile. subsp. *aegyptiaca*	*Poaceae*	Ann.	SU-ZA	Th.
84	*E. barrelieri* Daveau.	*Poaceae*	Ann.	ME and SA-SI	Th.
85	*Festuca arundinacea Schreb.*	*Poaceae*	Per.	ME, IR-TR, and ER-SR	Hem.
86	*Hordeum murinum* L. subsp. *leporinum* (Link) Arcang [LC]	*Poaceae*	Ann.	ME and IR-TR	Th.
87	*Imperata cylindrica* (L.) Raeusch.	*Poaceae*	Per.	ME, IR-TR, and SA-SI	Hem.
88	*Leersia hexandra* Sw.	*Poaceae*	Per.	ME, IR-TR, and ER-SR	Hem.
89	*Leptochloa fusca* (L.) Kunth.	*Poaceae*	Per.	PAN	Hem.
90	*Panicum coloratum* L.	*Poaceae*	Per.	SU-ZA	Ch.
91	*P. repens* L.	*Poaceae*	Per.	PAN	Geo.
92	*Paspalidium geminatum* (Forssk.) Stapf [LC]	*Poaceae*	Per.	PAL	Hem.
93	*Paspalum distichum* L.	*Poaceae*	Per.	AM	Hem.
94	*Phalaris minor* Retz.	*Poaceae*	Ann.	ME and IR-TR	Th.
95	*P. paradoxa* L.	*Poaceae*	Ann.	ME and IR-TR	Th.
96	*Phragmites australis* (Cav.) Trin. Ex Steud.	*Poaceae*	Per.	COSM	Geo.
97	*Piptatherum miliaceum* (L.) Coss.	*Poaceae*	Per.	ME	Hem.
98	*Poa annua* L.	*Poaceae*	Ann.	ME, IR-TR, and ER-SR	Th.
99	*Polypogon monspeliensis* (L.) Desf. [LC]	*Poaceae*	Ann.	ME, IR-TR, and SA-SI	Th.
100	*P. viridis* (Gouan) Breistr. [LC]	*Poaceae*	Per.	ME and IR-TR	Hem.
101	*Saccharum spontaneum* L. subsp. *spontaneum*	*Poaceae*	Per.	ME, IR-TR, and SA-SI	Geo.

Table 2. Continuation.

Sp. No.	Species	Family	Lifespan	Chorology	Life form
102	*Setaria pumila* (Poir.) Roem. & Schult.	*Poaceae*	Ann.	ME, IR-TR, and SU-ZA	Th.
103	*Sorghum virgatum* (Hack.) Stapf	*Poaceae*	Per.	SA-SI	Th.
104	*Persicaria lanigera* (R. Br.) Soják	*Polygonaceae*	Per.	PAL	Hem.
105	*P. lapathifolia* (L.) Delarbre [LC]	*Polygonaceae*	Ann.	ME and ER-SR	Hem.
106	*P. maculosa* Gray	*Polygonaceae*	Ann.	PAL	Hem.
107	*P. salicifolia* (Brouss. Ex Willd) Assenov. [LC]	*Polygonaceae*	Per.	PAL	Hem.
108	*P. senegalensis* (Meisn.) Soják	*Polygonaceae*	Per.	PAL	Hem.
109	*Polygonum equisetiforme* Sm.	*Polygonaceae*	Per.	ME and IR-TR	Hem.
110	*Portulaca oleracea* L.	*Portulacaceae*	Ann.	COSM	Th.
111	*Anagallis arvensis* L. var. *arvensis*	*Primulaceae*	Ann.	ME, IR-TR, and ER-SR	Th.
112	*A. arvensis* L. *var. caerulea*	*Primulaceae*	Ann.	ME, IR-TR, and ER-SR	Th.
113	*Samolus valerandi* L. [LC]	*Primulaceae*	Per.	COSM	Hem.
114	*Ranunculus sceleratus* L.	*Ranunculaceae*	Ann.	ME, IR-TR, and ER-SR	Th.
115	*Ziziphus spina-christi* (L.) Desf.	*Rhamnaceae*	Per.	SU-ZA	Ph.
116	*Salix mucronata* Thunb.	*Salicaceae*	Per.	SA-SI and SU-ZA	Ph.
117	*S. tetrasperma* Roxb.	*Salicaceae*	Per.	NAT and CULT	Ph.
118	*Solanum americanum* Mill.	*Solanaceae*	Ann.	ME, IR-TR, and ER-SR	Hem.
119	*Withania somnifera* (L.) Dunal	*Solanaceae*	Per.	ME and IR-TR	Ch.
120	*Tamarix senegalensis* DC.	*Tamaricaceae*	Per.	SA-SI	Ph.
121	*Corchorus olitorius* L.	*Tiliaceae*	Ann.	PAN	Th.
122	*Typha domingensis* Pers.	*Typhaceae*	Per.	ME, IR-TR, and SA-SI	Hel.
123	*Phyla nodiflora* (L.) Greene	*Verbenaceae*	Per.	PAN	Ch.
124	*Verbena officinalis* L.	*Verbenaceae*	Per.	ME, IR-TR, and SA-SI	Ch.
125	*V. supina* L.	*Verbenaceae*	Ann.	ME, IR-TR, and SA-SI	Th.
126	*Tribulus terrestris* L.	*Zygophyllaceae*	Ann.	ME, IR-TR, and ER-SR	Th.

Abbreviations: symbols, and footnote.
Lifespan: Per. = Perennial, Ann. = Annual, and Bie. = Biennial, according to Boulos (1999, 2000, 2002, 2005 and 2009).
Phytogeographical kingdom, region, or chorotype of plants, according to Eig (1931-1932): ME = Mediterranean, IR-TR = Irano-Turanian, ER-SR = Euro-Siberian, AM = American, COSM = Cosmopolitan, SU-ZA = Sudano-Zambesian, SA-SI = Saharo-Sindian, PAN = Pantropical, NEO = Neotropical, PAL = Palaeotropical and NAT and CULT = Naturalized and Cultivated. Life forms, according to Raunkiaer (1934): Hem. = hemicryptophyte, Th. = therophyte, Ph. = phanerophyte, Ch. = chamaephyte, Par. = Parasite, Geo. = geophyte and Hel. = helophyte. LC = least concern.

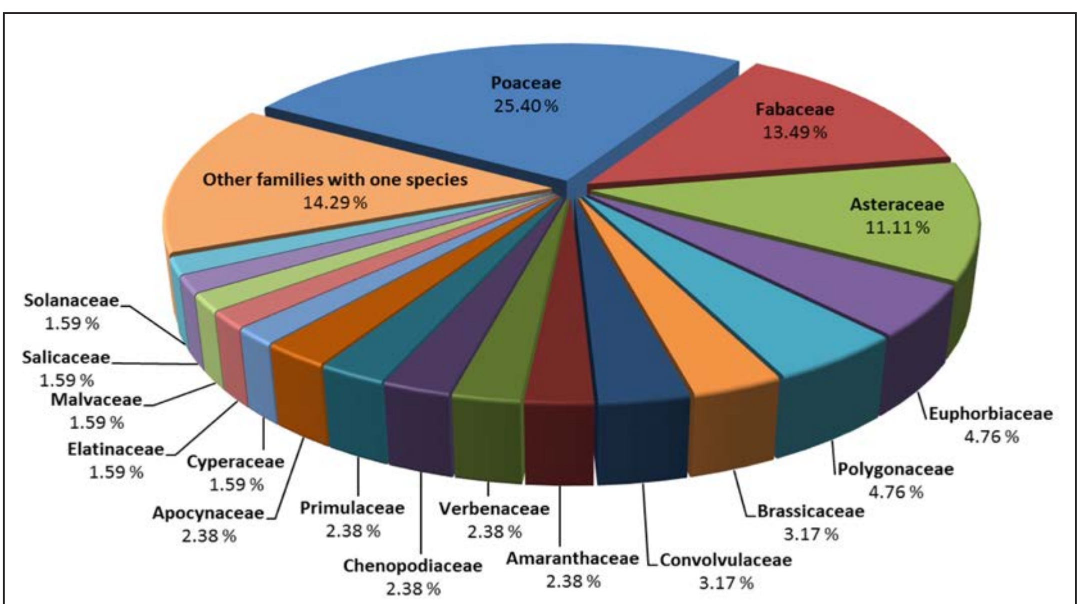

Fig. 3. Proportional contribution of plant families along the canals in the Sohag Governorate of Egypt.

Life forms

Seven life forms were observed in the current study, according to the classification of Raunkiaer (1934). Therophytes were the most frequently occurring life form of plants in the Sohag Governorate with 70 species, followed by hemicryptophytes with 28 plant species, phanerophytes with 12 species, chamaephytes, and geophytes with 7 species each (Table 2), and with respective percentages of 55.56 %, 22.22 %, 9.52 %, and 5.56 % respectively (Fig. 4). Helophytes, and parasitic plants were represented by a single species each: *Typha domingensis* Pers. and *Cuscuta pedicellata* Ledeb., respectively. These species claimed each 0.79 % of all recorded taxa.

Chorological analysis

This chorological or phytogeographical analysis of the 126 plant taxa listed in Table 2 shows that the 58 monoregional and pleuriregional taxa collectively represent 46.04 % of all recorded plants (Table 3 and Fig. 5). Nineteen species (15.08 %) are monoregional. They are native to the Mediterranean region or to the Sudano-Zambezian region. Six other monoregional species (4.76 %) originate only in the American region and three species (2.39 %) only in the Saharo-Sindian region in which the Sohag Governorate lies. Pleuriregional taxa are primarily distributed into two groups of regions referred to as chorotypes: (1) Mediterranean, Irano-Turanian, and Euro-Siberian and (2) Mediterranean, Irano-Turanian, and Saharo-Sindian (Fig. 6).

Table 3. **Number and percentage of plant species (including subspecies and varieties) in the phytogeographical kingdom, region, or chorotype, defined according to Eig (1931, 1932), and observed along the canals of the Sohag Governorate of Egypt.**

Chorotype	No. of plant species	Percentage (%)
Cosmopolitan	14.00	11.11
Palaeotropical	11.00	8.73
Pantropical	15.00	11.91
Neotropical	1.00	0.79
Naturalized and cultivated	1.00	0.79
Total	**42.00**	**33.33**
Monoregional		
ME	10.00	7.94
SA-SI	3.00	2.39
SU-ZA	9.00	7.14
AM	6.00	4.76
IR-TR	1.00	0.79
Total	**29.00**	**23.02**
Biregional		
ME and IR-TR	18.00	14.29
ME and ER-SR	4.00	3.17
ME and SA-SI	1.00	0.79
SA-SI and SU-ZA	3.00	2.38
Total	**26.00**	**20.63**
Pleuriregional		
ME, IR-TR, and ER-SR	20.00	15.88
ME, SA-SI, and ER-SR	1.00	0.79
ME, IR-TR, and SU-ZA	1.00	0.79
ME, IR-TR, and SA-SI	6.00	4.76
SA-SI, SU-ZA, and IR-TR	1.00	0.79
Total	**29.00**	**23.02**

Note: phytogeographical regions are defined in Table 2.

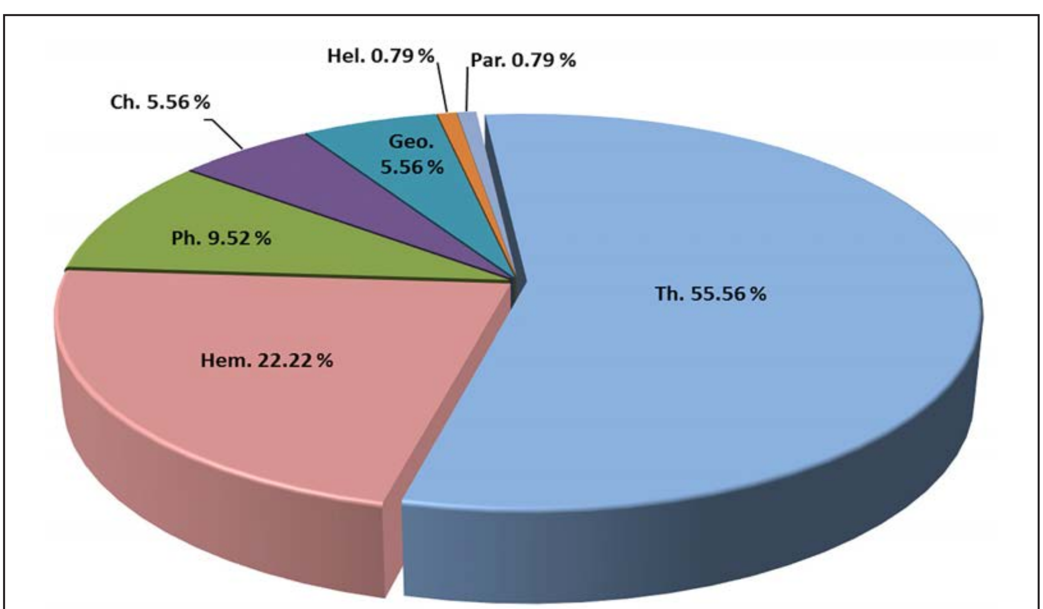

Fig. 4. Plant life forms of the recorded species in the Sohag Governorate.

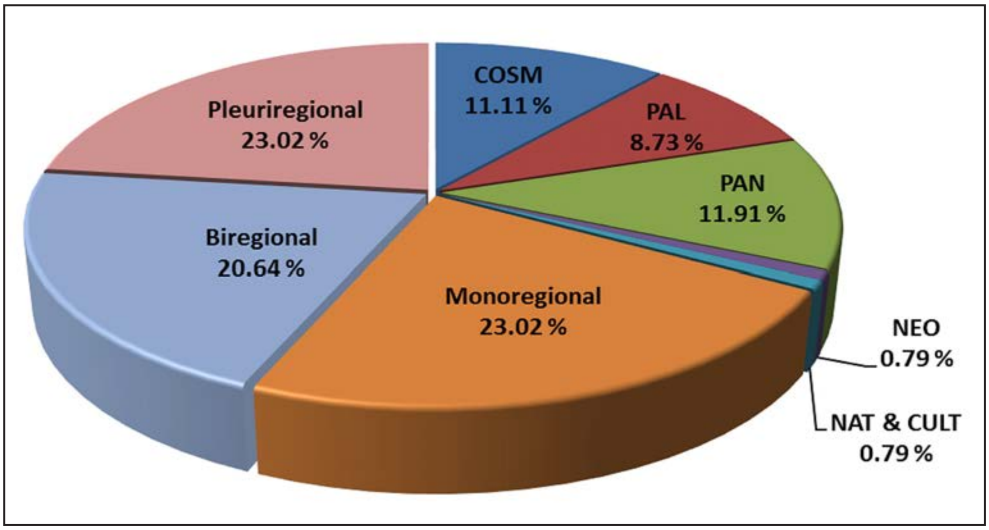

Fig. 5. Chorotypes of canal riparian vegetation in the Sohag Governorate of Egypt. Note: **COSM** = cosmopolitan, **PAN** = pantropical, **PAL** = palaeotropical kingdom, **NEO** = Neotropical region, **NAT & CULT** = Naturalized and cultivated species.

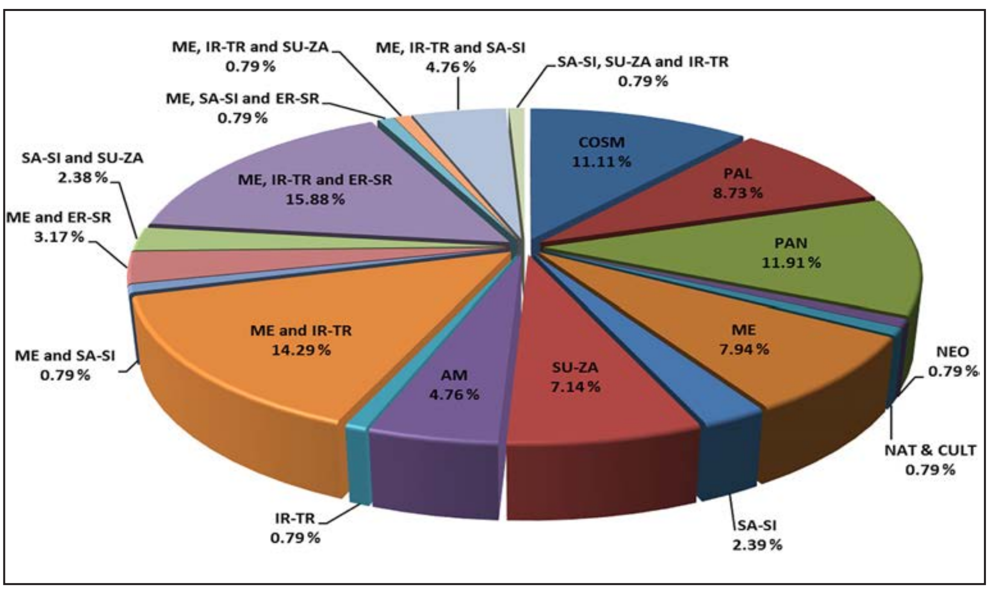

Fig. 6. Floristic regions and chorotypes from which originated the canal riparian vegetation in the Sohag Governorate of Egypt. Note: **ME** = Mediterranean, **SU-ZA** = Sudano-Zambesian, **AM** = American, **SA-SI** = Saharo-Sindian, **IR-TR** = Irano-Turanian, **ER-SR** = Euro-Siberian, **COSM** = cosmopolitan, **PAN** = pantropical, **PAL** = Palaeotropical Kingdom, **NEO** = Neotropical Kingdom, and **NAT & CULT** = Naturalized and cultivated species.

The pleuriregional plants of the Mediterranean, Irano-Turanian, and Euro-Siberian chorotype dominated the Sohag canal riparian flora with 20 species, (15.88 %). The second most numerous in the Sohag Governorate were six species (4.76 %) originally distributed in the Mediterranean, Irano-Turanian, and Saharo-Sindian regions. Three pleuriregional chorotypes – (1) Mediterranean, Saharo-Sindian, and Euro-Siberian; (2) Mediterranean, Irano-Turanian, and Sudano-Zambezian; and (3) Saharo-Sindian, Sudano-Zambezian, and Irano-Turanian – were represented by only one species (0.79 %) each, namely *Bidens pilosa*, *Setaria pumila*, and *Euphorbia indica*, respectively (Fig. 6). Biregional chorotypes accounted for 26 species, representing (20.63 %) of the total number of recorded species in the Sohag Governorate. Twenty-two species (17.46 %) originated from the biregional chorotype consisting of the Mediterranean and Irano-Turanian regions, and three species (2.39 %) originally came from the chorotype comprising the Saharo-Sindian and Sudano-Zambezian regions. Only one species (0.79 %) each originated from (1) the Mediterranean and Saharo-Sindian chorotype (*Eragrostis barrelieri*), (2) the Neotropical Kingdom (*Symphyotrichum squamatum*), and (3) the Naturalized and cultivated chorotype (*Salix tetra-sperma*).

Fifteen species, which originated from the pantropic chorotype and fourteen species, which were distributed worldwide as part of the cosmopolitan chorotype, collectively represented 23.02 % of all 126 listed species (Table 2). This study identified 11 species (8.73 %) along the canals of the Sohag Governate that originally came from the Palaeotropical Kingdom (Table 3 and Figs 5, 6).

Aquatic plants

According to Täckholm (1974), the Nile Valley had 35 species of aquatic plants that belong to 19 genera and 15 families. The present study of canals of the Sohag Governorate expands the list of the Nile Valley aquatic species to at least 41 species from 21 genera and 15 families (Table 4). Such increase in the species diversity could result from the ongoing invasion, intrusion, migration, and other means of establishment of alien species in the Nile Valley. However, earlier studies may not have been comprehensive enough so as to adequately survey all indigenous aquatic plants, especially in the smaller irrigation and drainage channels. Table 4 classifies these 41 aquatic species into three types: free-floating, entirely submerged, and rooted floating plants.

Some invasive freshwater weeds such as *Myriophyllum spicatum* L., *Eichhornia crassipes* (Mart.) Solms, *Potamogeton trichoides* Cham. & Schltdl., *Azolla filiculoides* Lam., and *Azolla caroliniana* Willd. have appeared and started spreading during the last 25 years, especially in Upper Egypt and along the River Nile channels and wetlands, irrigation and drainage canals. Freshwater hydrophytes with their characteristically very rapid growth rates cause serious problems. Ample Egyptian financial resources are spent every year to control the excessive plant biomass, either by dredging or by chemical control (Zahran and Willis 2009).

Endemism and threatened species

The *Red List of Threatened Species* (http://www.iucnredlist.org accessed 2018) by the International Union for Conservation of Nature and Natural Resources lists 17 out of the 126 riparian species recorded in Table 2 as species of Least Concern (LC) (marked by ^{LC} in Table 2).

Table 4. A list of recorded aquatic plants along of the Nile system, irrigation canals and drains in the Sohag Governorate, with families and habitats.

No.	Species	Family	Habitat
1	*Alisma plantago-aquatica* L.	*Alismataceae*	Rooted floating
2	*Alisma gramineum* Lej.	*Alismataceae*	Rooted floating
3	*Pistia stratiotes* L.	*Araceae*	Free-floating
4	*Azolla filiculoides* Lam.	*Salviniaceae*	Free-floating
5	*Azolla caroliniana* Willd.	*Salviniaceae*	Free-floating
6	*Ceratophyllum demersum* L.	*Ceratophyllaceae*	Submerged
7	*Ceratophyllum muricatum* Cham.	*Ceratophyllaceae*	Submerged
8	*Myriophyllum spicatum* L.	*Haloragidaceae*	Rooted floating
9	*Elodea canadensis* Michx.	*Hydrocharitaceae*	Submerged
10	*Najas graminea* Delile,	*Hydrocharitaceae*	Submerged
11	*Najas horrida* A. Braun. ex Magnus.	*Hydrocharitaceae*	Submerged
12	*Najas marina* var. *intermedia* (Wolfg. ex Gorski) Rendle.	*Hydrocharitaceae*	Submerged
13	*Najas minor* All.	*Hydrocharitaceae*	Submerged
14	*Najas pectinata* (Parl.) Magnus.	*Hydrocharitaceae*	Submerged
15	*Ottelia alismoides* (L.) Pers.	*Hydrocharitaceae*	Submerged or rooted floating
16	*Vallisneria spiralis* L.	*Hydrocharitaceae*	Submerged
17	*Lemna aequinoctialis* Welw.	*Lemnaceae*	Free-floating
18	*Lemna gibba* L.	*Lemnaceae*	Free-floating
19	*Lemna minor* L.	*Lemnaceae*	Free-floating
20	*Lemna perpusilla* Torr.	*Lemnaceae*	Free-floating
21	*Spirodela polyrrhiza* (L.) Schleid.	*Lemnaceae*	Free-floating
22	*Spirodela punctata* (G.Mey.) C. H. Thomps.	*Lemnaceae*	Free-floating
23	*Wolffia hyalina* (Delile) Monod.	*Lemnaceae*	Free-floating
24	*Utricularia inflexa* Forssk.	*Lentibulariaceae*	Free-floating
25	*Marsilea aegyptiaca* Wall.	*Marsileaceae*	Rooted floating
26	*Marsilea strigosa* Willd.	*Marsileaceae*	Rooted floating
27	*Nymphaea lotus* L.	*Nymphaeaceae*	Rooted floating
28	*Nymphaea nouchali* var. *caerulea* (Savigny) Verdc.	*Nymphaeaceae*	Rooted floating
29	*Eichhornia crassipes* (Mart.) Solms	*Pontederiaceae*	Free-floating
30	*Potamogeton crispus* L.	*Potamogetonaceae*	Submerged
31	*Potamogeton nodosus* Poir.	*Potamogetonaceae*	Submerged
32	*Potamogeton perfoliatus* L.	*Potamogetonaceae*	Submerged
33	*Potamogeton pusillus* L.	*Potamogetonaceae*	Submerged
34	*Potamogeton schweinfurthii* A. Benn.	*Potamogetonaceae*	Submerged
35	*Potamogeton trichoides* Cham. & Schltdl.	*Potamogetonaceae*	Submerged
36	*Stuckenia pectinata* (L.) Börner	*Potamogetonaceae*	Submerged
37	*Ranunculus peltatus* Schrank.	*Ranunculaceae*	Rooted floating
38	*Ranunculus rionii* Lagger.	*Ranunculaceae*	Submerged
39	*Ranunculus trichophyllus* Chaix ex Vill.	*Ranunculaceae*	Submerged
40	*Ruppia maritima* L.	*Ruppiaceae*	Submerged
41	*Zannichellia palustris* L.	*Zannichelliaceae*	Submerged

Furthermore, this study has found no hydrophytes or riparian plants along the canals in the Sohag Governorate that are endemic to Upper Egypt or the surrounding areas (known as Endemic or Near Endemic species, respectively). As a result, this study has found no indication of any plants that might be at risk of being threatened or endangered.

Discussion

The water currently available from the River Nile for irrigation and other uses presently supports diverse climax vegetation along the irrigation and drainage canals. This water available now for support of the climax communities is expected to decrease after the construction of a reservoir nearby the Grand Ethiopian Renaissance Dam, which would leave some irrigation and drainage canals almost or totally without water, thus affecting adversely the canal riparian and aquatic biodiversity.

Brassicaceae, *Poaceae*, *Fabaceae*, and *Asteraceae* were cataloged by Springuel (1981), Springuel & Murphy (1990) and Hamed & al. (2012) as the dominant families on selected Egyptian River Nile islands in the Qena Governorate and near Aswan. Ali (2014) and Amer & al. (2015) reported that *Poaceae*, *Fabaceae* and *Asteraceae* were the most dominant vegetation families on the Nile islands in central Egypt and the Aswan Governorate. Faried & Amro (2016) have found that *Poaceae* and *Asteraceae* were the major families based on the species number along the irrigation and drainage canals of the Assiut Governorate, just northwards of the Sohag Governorate (Table 1).

Out of the 35 families identified by this study in the Sohag Governorate, 18 families (51.43 %) had only one species per family. According to Ḥasib (1951), the 553 species associated with the River Nile in Egypt accounted for 30 % of the entire flora known to be growing in Egypt at that time. The number of known species associated with River Nile in Egypt now exceeded 600 (Täckholm 1974; Boulos 1966, 1995, 1999, 2000, 2002, 2005, 2009).

The riparian life forms found along the canals of the Sohag Governorate show dominance of 70 therophyte species (55.56 %) consistent with the entire flora of Egypt (Ḥasib 1951).

The frequent occurrence of therophytes in the Sohag Governorate is due to the rapid life cycle of annual plants, limited availability of water, adverse humidity and other climatic conditions, biotic influence, and substrate instability (Shaltout & Al-Sodany 2008; Abd El-Ghani & al. 2017). The present study has also identified 28 species (22.22 %) of hemicryptophytes, 12 species (9.52 %) of phanerophytes, and 7 species (5.56 %) each of chamaephytes and geophytes. Only one species (0.79 %) each has been identified of helophytes and parasites in the surveyed 52 vegetation stands. Considering the floristic life forms across Egypt (Ḥasib 1951; Mashaly & al. 2010; Faried & Amro 2016), therophytes have been the most common life form reported in Table 2.

Such distribution of life forms observed in this study may be due to the destruction of riparian vegetation structure by humans and other animals. Furthermore, the annual removal of weeds and sediment from the canals and deposition on the banks repeatedly disturb the riparian and aquatic habitat (Shaltout & al. 1995; Tzanoudakis & al. 2006). Moreover, the dense canopy of the dominating tall growing species (such as *Phragmites australis, Arundo donax* and *Saccharum spontaneum*) inhibits the germination and growth of other species. All these impacts reduce the species diversity (Shaltout & El-Sheikh 1993).

Table 2 also shows the substantial number of hemicryptophytes (22.22 %) reported along the canals in the Sohag Governorate. No similarly high percentages of this low-lying vegetation have been reported from any other region of Egypt prior to the publication of this paper.

The limited number of trees and other perennials recorded in the present study could have resulted from extreme deterioration of the vegetation due to habitat loss and fragmentation caused by human activities, a fact also noted by other researchers (Kim & al. 2002; Salama & al. 2013).

Chorologically, the flora along the canals in Sohag Governorate in the Afro-Asiatic/Saharo-Sindian region is similar to the plants distributed in the three closest phytogeographical regions, including the (1) Euro-Afro-Asiatic/Mediterranean, (2) Asiatic/Irano-Turanian, and (3) African/Sudano-Zambesian (Eig 1931, 1932). The monoregional and pleuriregional plants were the most dominant among the 126 species identified in this study, with 23.02 % for each chorotype; followed by the biregional (20.63 %), pantropic (11.91 %), and cosmopolitan (11.11 %) chorotypes. Fewer species originated from the Palaeotropical (8.73 %) and finally from the Neotropical kingdoms (0.79 %), as well as from the naturalized and cultivated chorotype (0.79 %).

The monoregional chorotype includes 10 species from the Mediterranean region, nine species from the Sudano-Zambesian, six species from the American, three species from the Saharo-Sindian (*Sorghum virgatum, Trichodesma africanum* var. *africanum*, and *Tamarix senegalensis*), and only one species was native to the Irano-Turanian region (*Cuscuta pedicellata*).

The pleuriregional plants identified along the canals of the Sohag Governorate included 20 species native to the Mediterranean, Irano-Turanian, and Euro-Siberian chorotypes. These three regions together provided the most frequent origin of the pleuriregional plants recorded in this study. Six species were native to the Mediterranean, Irano-Turanian, and Saharo-Sindian chorotypes. One species in each of the following has been native to other pleuriregional chorotypes: (1) the Mediterranean, Saharo-Sindian, and Euro-Siberian (*Bidens pilosa*); (2) the Mediterranean, Irano-Turanian, and Sudano-Zambesian (*Setaria pumila*); and (3) the Saharo-Sindian, Sudano-Zambesian, and Irano-Turanian chorotype (*Euphorbia indica*).

The biregional chorotypes included 22 species from the chorotype consisting of the Mediterranean and Irano-Turanian regions, three species from the Saharo-Sindian and Sudano-Zambesian chorotype (*Lotus arabicus, Salix mucronata*, and *Pluchea dioscoridis*), and only one species was native to the Mediterranean and Saharo-Sindian chorotype (*Eragrostis barrelieri*).

This chorological analysis testifies to the dominance of 61 species (48.42 %) native to the Mediterranean region. These 61 species are (1) monoregional (10 species, 7.94 %); (2) bioregional, involving the Mediterranean and Irano-Turanian regions, and the Mediterranean and Saharo-Sindian regions (23 species, 18.26 %); and (3) pleuriregional, involving the Mediterranean and combinations of four other regions – Irano-Turanian, Euro-Siberian, Saharo-Sindian, and Sudano-Zambesian (28 species, 22.23 %).

The second highest number of plants native to other regions, 47 species (37.3 % out of the 126 species observed along the Sohag Governorate canals), is indigenous to the Irano-Turanian region. These 47 species were originally distributed across the floristic regions of North Africa and the Middle East as: (1) monoregional (one parasitic species, *Cuscuta pedicellata*, 0.79 %); (2) biregional with 22 species (17.47 %) individually distributed over both the Mediterranean region and the adjoining Irano-Turanian region; and (3) pleuriregional with 28 species (22.23 %) distributed over four different chorotypes of the Irano-Turanian region, combined with the Mediterranean, Euro-Siberian, Saharo-Sindian, and Sudano-Zambesian regions (Table 3).

The third largest group of 25 plant species (19.85 %) identified along the canals in the Sohag Governorate was indigenous to the Euro-Siberian region and, by extension, the chorotype was composed of the Mediterranean, Irano-Turanian, and Euro-Siberian regions. Plants from the other floristic chorotypes were seldom recorded in this study along the canals of the Sohag Governorate. These less frequently recorded plants included 15 species (11.91 %) native to the Saharo-Sindian region, in which Sohag is located, followed by 14 species (11.11 %) originating from the adjacent Sudano-Zambesian region, either as mono-, bi-, or pleuriregional chorotypes of all identified species. Species recorded along the canals with an extensive geographical range included species originating from the pantropical and cosmopolitan chorotypes, accounting for 15 and 14 species respectively, or 11.91 % and 11.11 % of the 126 species identified in the Sohag Governorate. Eleven species (8.73 %) originated from the Palaeotropical Kingdom and six species (4.76 %) from the American region, suggesting that the climatic influence of the Mediterranean Sea is more important than the effect of riparian soils bordering on the canals of the Sohag Governorate. Consistently, Mashaly & al. (2010) concluded that the climatic effects of the Mediterranean Sea exercised dominant influence on the riparian vegetation bordering on the irrigation and drainage canals in the Nile Delta. In the Aswan Governorate of Egypt, which is even farther from the Mediterranean Sea, however, El-Hadidi (1993) reported that most surveyed plants originated from the Palaeotropical Kingdom, the cosmpolitan, and pantropical chorotypes.

Conclusions

The floristic composition of Upper Egypt was not documented well. This study was the first chorological analysis to create a floristic baseline for the Sohag area, in order to evaluate the effect on habitats and plant diversity of the major changes in the River Nile hydroperiod or hydrologic regime. Some major Nile hydroperiod changes could have been caused by the dam construction upstream in the basin, climate changes, drought, and flooding. Half of the riparian vegetation along the canals of the Sohag Governorate originated from the Mediterranean floristic region. With a lifespan as brief as a few weeks, therophytes were the most frequently identified plant life form along the canals of the Sohag Governorate. The relatively low number of trees and other perennials seem to have been caused by habitat loss and fragmentation due to intensive human activities, including cultivation and urbanization.

The results obtained from the studied area indicate now necessary it is to consider the data belonging to the management of canals, phytogeographical origin, species migration, and adaptation mechanisms of the Egyptian species, so as to comprehend better how the current form of plant diversity in Egypt has arisen. In future, we suggest for the studies to focus further on the impact of the newly constructed bridges, texture and composition of sediment, as well as on agents that affect the water flow rate in rivers, irrigation and drainage canals. For better control management, rivers, canals, and drain ecosystems should be monitored for the purpose of prioritizing the management of ongoing overall changes and ecosystem dynamics.

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